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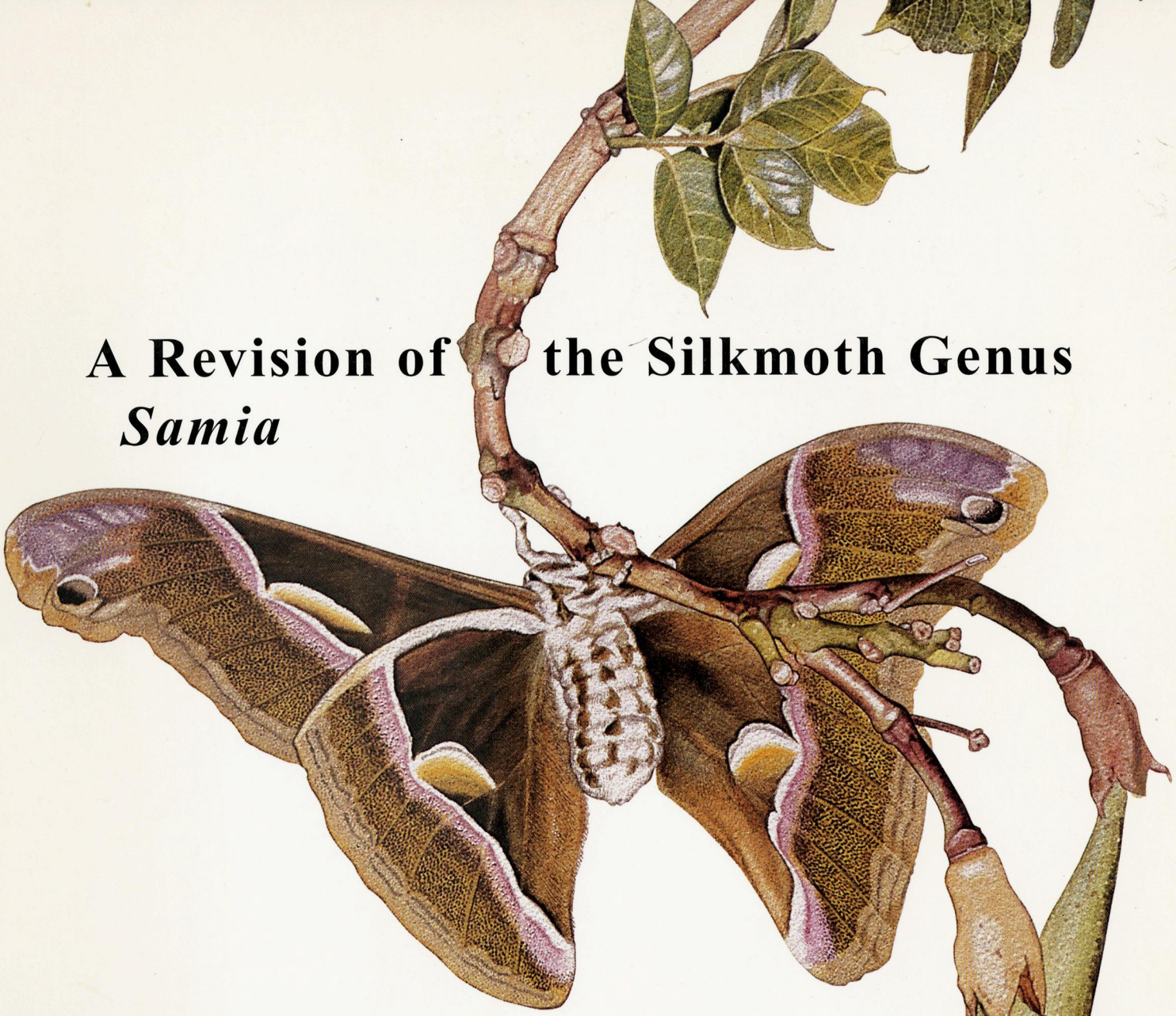
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# A Revision of the Silkmoth Genus *Samia*



Richard S. Peigler
and
Stefan Naumann



University of the Incarnate Word

# A Revision of the Silkmoth Genus Samia

*Richard S. Peigler*

*and*

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**University of the Incarnate Word**
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**Front cover:** *Samia cynthia* shown in natural repose. Transparent watercolor painting by John Cody, 1998.
**Back cover:** Mature larva of *Samia kohlli* from Cameron Highlands, West Malaysia. Male of *Samia watsoni* from Wuyi Mountains, Jiangxi Province, China. Female of *Samia canningi* from Heilongjiang Province, China. Background shows fabric of eri silk (from *Samia ricini*) from Imphal, Manipur, India; ghicha-spun yarn that was hand-woven. **Spine:** Mature larva of *Samia luzonica* from Mindanao, Philippines, reared and photographed by Christopher A. Conlan. **Covers** designed by Katie Yumol, a Computer Graphic Arts student at University of the Incarnate Word.

# FOREWORD

With technology drawing the world closer and closer together, globalization has become an increasingly vital component of the educational mission at the University of the Incarnate Word. Just a few years ago, for example, international students represented less than 1 percent of our enrollment and we had only limited academic exchange opportunities with institutions of higher learning outside the United States. We also lacked the physical and technological resources necessary to advance globalization on our campus.

Beginning in the mid-1990s, however, we embarked on an aggressive course of action to globalize the University, and the Incarnate Word at the outset of the 21st century is a much different place than it was at the close of the last century. International students from over two dozen countries comprise approximately 9 percent of our enrollment. We have established sister school agreements for reciprocal education with more than 70 universities in over 20 countries, many of them in Asia, a region that represents the future of world commerce.

We have also expanded our academic offerings to include Master's and Ph.D. degrees in international education and entrepreneurship. And in the past few years we have developed many physical facilities with globalization in mind. These include, or instance, the Dr. Burton E. Grossman International Conference Center that features state-of-the-art equipment that allows for instantaneous translations during conferences, and the Ann Barshop Natatorium, a swimming pool complex capable of hosting international competitions.

Our international commitment reached new heights with the opening in 2000 of the China Incarnate Word campus in Guangzhou, China, where students can earn an accredited Incarnate Word degree without leaving China. More recently, we launched joint academic initiatives in Beijing, Mexico City, and Taiwan.

The publishing of this book, then, is yet another significant chapter in our globalization efforts. It is an example of collaboration between international colleagues. It represents original scholarship on a topic involving Asia, an important step in extending our academic mission in that region of the world. And although books have been printed through the University (and before it, the College) in the past, this is the first scientific book ever published by Incarnate Word, a significant distinction that pushes forth the research component of the academic mission beyond our borders.

On behalf of the University of the Incarnate Word community, I congratulate Dr. Richard Peigler, Assistant Professor in the Department of Biology, and his co-author, Dr. Stefan Naumann of the Zoology Museum of Humboldt University in Berlin, Germany, for helping us attain this milestone. I wish them our best in their future endeavors.

Louis J. Agnese, Jr., Ph.D.
President
University of the Incarnate Word
San Antonio, TX
August 2002

*Dedicated to our friend Dr. Claude Lemaire*
*in appreciation of his voluminous work on*
*moths of the family Saturniidae*

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Lastly, we record our appreciation for the efforts of field collectors, who often worked under conditions of discomfort and even danger. The specimens that they collected and preserved are a permanent gift to science. Thus our study was greatly enhanced by specimens collected from more than two centuries ago to only a few months ago. We have tried to cite the names of as many field collectors as possible within the sections citing material examined, and we have also offered stray comments about a few historical collectors in our discussions under the various species.

# SUMMARY

The genus *Samia* Hübner (= *Philosamia* Grote) contains 19 known species that range mainly in tropical Asia, across a span of over 6,000 kilometers. One of these is a domesticated form in captivity. The large and beautiful moths include some of the better known Saturniidae, and are quite popular with collectors. Most of the historical and some recent literature treated all of the species as subspecies of *Samia cynthia* (Drury), the type species of the genus. The differences in biology, adult and larval morphology, chromosome numbers, and geographical distributions demonstrate that the genus contains many species, almost half of which were described as new in recent years The best known one is *S. cynthia*, commonly called the ailanthus silkmoth or cynthia moth. It is native to a large area of northeastern China, but is widely known because it was introduced to many countries around the world between 1858 and 1870, and successfully established and spread. Its primary host is ailanthus or tree-of-heaven (*Ailanthus altissima*), a Chinese tree that now grows commonly in cities in many parts of the world.

There are only three Palaearctic species, namely *S. cynthia*, native to Korea and northern China; *S. pryeri* (Butler), an endemic of Japan; and *S. watsoni* (Oberthür) found throughout much of China, at higher elevations. *Samia wangi* Naumann & Peigler flies in much of southern and central China and Vietnam. It is mainly a tropical species, but parts of its range extend into Palaearctic territory. The taxonomic relationship between *S. cynthia* and *S. wangi* presents a difficult but interesting problem, and we hope that this study will encourage Chinese entomologists to investigate the biology and distributions of these two species. As far as we know, the two are not sympatric and do not hybridize, but some specimens are difficult to identify. However, treating all of the populations of *S. cynthia* and *S. wangi* as one widespread and variable species is not satisfactory, because the differences between the male genitalia and wing patterns clearly indicate that at least two species are involved. *Samia wangi* occurs mainly in mountains and foothills, whereas *S. cynthia* is found in level lowlands. In most literature *S. wangi* was incorrectly called *S. walkeri*, but the latter name is a junior subjective synonym of *S. cynthia*, based on our examination of the type specimens of both names, including genitalia preparations of the two lectotypes. Two species are in Japan, the native *S. pryeri*, and the introduced *S. cynthia*. Most Japanese authors have called both of these *Samia cynthia pryeri*. Moths of *S. cynthia* are olive green, fading to golden tan. Moths of *S. pryeri* are dull brown, fading to darker brown. The eyespot mark in the apex of the forewing is smaller in *S. pryeri*, and differences in the pattern of the postmedian lines are easily seen between the two species. Based on specimens that we have examined and Japanese literature, we believe that *S. pryeri* does not exist on Hokkaido, but *S. cynthia* probably does occur on that island.

The remaining 15 species are tropical, belonging to the Oriental biogeographical region, and range from Pakistan and northern India across to the Philippines and throughout Indonesia down to the Moluccas, but not in New Guinea. The beautiful cinnamon colored *Samia canningi* (Hutton) is a widespread and variable species with a distribution that centers around the Himalayas, from Pakistan across Nepal, northern India to southern China and down to Thailand and Vietnam. Sympatric in the southeastern range of *S. canningi* is the large *S. kohlli* Naumann & Peigler, which also ranges down into Peninsular Malaysia. Closely allied to *S. canningi* is the rusty colored *S. fulva* Jordan from the Andaman Islands, in the Bay of Bengal.

*Samia ricini* (Anonymous) is a domesticated form that does not occur in the wild. The structure of the genitalia, wing pattern, and chromosome number demonstrate that it was derived from *S. canningi.* The main distinguishing feature of *S. ricini* is the diffusion of the abdominal white tufts, sometimes resulting in individuals with a solid white abdomen. It is afforded the rank of species for convenience of communication and stability of nomenclature, in the accepted tradition of naming other domesticated forms, such as the mulberry silkmoth (*Bombyx mori*) derived from *B. mandarina*, and the dog (*Canis familiaris*) derived from the wolf (*Canis lupus*). The original publication that validated the name *ricini* could not be determined by us thus far, so the authorship is cited as Anonymous. The main foodplant of *S. ricini* is castor (*Ricinus communis*), and the primary region where the silkworms are cultivated is the Brahmaputra River Valley in Assam. Textiles made from its silk are called eri silk or endi silk, which economically is the third most important silk in the world, after mulberry silk (from *B. mori*) and Chinese tussah silk (from *Antheraea pernyi*). India produced more than 800 metric tonnes of eri silk per year in the early 1990s, surpassing production of tasar silk (from *Antheraea paphia*). *Samia ricini* has been reared historically in Egypt, Lebanon, Cuba, Uruguay, France, Malta, Italy, and is currently being cultivated in Brazil, China, Japan, Korea, and northeastern India and neighboring regions. In the present work, literature on ericulture is reviewed in detail, and some textiles made from eri silk are shown in color. We also discuss historical uses of silk from other species of *Samia* in India, China, and Japan.

*Samia luzonica* (Watson) is a variable species found widely in the Philippines, whilst *Samia treadawayi* Naumann is endemic to the Philippine island of Palawan. *Samia tetrica* (Rebel) flies in Peninsular Malaysia and

on the island of Borneo. In Indonesia, several species have been discovered, including *S. abrerai* Naumann & Peigler from Bali and Java, *S. vandenberghi* (Watson) and *S. peigleri* Naumann & Nässig from Sulawesi, *S. naumanni* U. Paukstadt, Peigler & L. Paukstadt from the Sula Archipelago, *S. naessigi* Naumann & Peigler from Halmahera (northern Moluccas), *S. yayukae* U. Paukstadt, Peigler & L. Paukstadt from Timor, Alor, and Flores (Lesser Sunda Islands), and *S. ceramensis* (Bouvier) from Ceram (central Moluccas), in addition to the well-known *S. insularis* (Snellen van Vollenhoven) from Sumatra and Java.

The treatment under each of the 19 species provides deposition and label data on the type specimens for each name, detailed descriptions of the adult wing pattern and color, a description of the male genitalia, label data from museum specimens examined, a concise summary of the geographical distribution, an exhaustive synonymy, and other remarks. A total of 19 lectotypes is designated. The authors studied material in all of the major museums in North America and Europe, and located and examined all of the extant type material for valid names and descriptions. We examined about 450 genitalia preparations from specimens in the genus, and found the male genitalia to be very diagnostic. Naumann collected and observed *Samia* in Myanmar, Vietnam, Thailand, West Malaysia, on the Andamans, and on several Indonesian islands. Recently collected specimens with reliable field data have been received in large quantities from the Philippines, Indonesia, Thailand, Myanmar, and more than 20 provinces in China. Several species have been reared in captivity by both authors. In recent years, larvae have been reared of several species for which the immature stages were previously unknown, including *S. kohlli, S. tetrica, S. yayukae, S. vandenberghi*, and *S. fulva*. A persistent effort was made to cite and utilize as far as possible the literature in the Chinese, Japanese, and Korean languages. The exhaustive bibliography also consists of historical literature, all major taxonomic works that treat *Samia*, and numerous nontechnical, popular-level books and articles on the genus, the latter primarily pertaining to *S. cynthia* in Europe and the United States. We reject the use of trinomial nomenclature, and provide arguments against application of the subspecies concept in the genus *Samia*.

Although published field observations on *Samia* are minimal, there is a large body of literature in many languages in which *Samia* have been used as study animals in laboratories. We provide cursory summaries or brief mention of those topics, but the bibliography will direct interested readers to those sources. These include physical properties and molecular structure of the silk, diapause, cytogenetics, immature and adult morphology, molecular genetics, insect physiology, comparative growth on various hostplants, mating and ovipositional behavior, silk spinning behavior, and molecular structure of sex pheromones.

Hybridization in captivity is an interesting aspect of the study of Lepidoptera, and much of the work was carried out by amateurs. *Samia cynthia* has been successfully hybridized with *Callosamia angulifera* and *Callosamia promethea*, resulting in adult males, but no females. Other intergeneric crosses produced no adults. Regarding crosses between species within the genus *Samia*, many hybrids have been reared and named. Data from these crosses have been used to study the mechanisms of inheritance in traits such as wing scales, cocoon color, larval markings, and diapause. A listing of all known hybrid crosses, intergeneric and intrageneric, is given, with citations to literature where more details can be found.

All known hostplants in nature are tabulated for each species. A discussion is given on rearing requirements and alternate hostplants that can be used in captivity. Although many hostplants are used in nature, there is a clear preference for species of *Ailanthus* (Simaroubaceae) and various Rutaceae, Euphorbiaceae, and Lauraceae among those recorded in the Philippines, India, Japan, China, and Indonesia. Some, but not all, species of *Fraxinus*, *Syringa*, and *Ligustrum* (all Oleaceae) are good hostplants for larvae in captivity. All of the parasitoids known to attack the eggs, larvae, or pupae are listed. In the Hymenoptera, known parasitoids are in the Braconidae, Ichneumonidae, and several families of Chalcidoidea. In the Diptera, known parasitoids all belong to Tachinidae. Records of parasitism are primarily from the introduced populations of *S. cynthia* in Europe and the United States, but some pertain to native populations in Asia. Important parasitoids of *Samia* in Asia are species of *Xanthopimpla* (Ichneumonidae) attacking the cocoons, tiny wasps of the genus *Anastatus* (Eupelmidae) attacking the eggs, and a few species of Tachinidae known as uzi flies that attack the larvae. Uzi flies include *Exorista sorbillans*, *Blepharipa zebina*, and *Blepharipa sericariae*. Young larvae of *Samia* are sometimes also parasitized by various Braconidae in the *Apanteles* genus-group. Regarding predation, we cite several birds (mainly Corvidae) known to feed on the larvae and pupae. The cocoons hang from trees in open sight, because the spinning caterpillar firmly attaches its cocoon to the twig by a band of silk. There are independent reports of lepidopterists reducing populations by over-collecting the cocoons in Tokyo, Barcelona, Paris, Vienna, and some cities of the United States.

*Samia cynthia* was introduced into many countries around the world, mainly during the latter half of the nineteenth century. The introductions were always intentional, and usually with enthusiasm for establishing a local silk industry. Populations from a few of these introductions still persist in Slovenia, southern Switzerland, Austria, France, northern Italy, Japan, around the Black Sea in Georgia and Russia, and until recently a few

cities in the northeastern United States such as New York City and Philadelphia. The moths are mainly associated with urban centers, and are rarely found in rural areas. *Samia cynthia* appears to be almost extinct in the United States. Although there is still no proof, we believe it is because its populations were destroyed by *Compsilura concinnata* (Tachinidae), a parasitoid introduced from Europe to North America by the United States Department of Agriculture repeatedly between 1906 and 1986, mainly to control the gypsy moth (*Lymantria dispar*) and brown-tail moth (*Euproctis chrysorrhoea*), both of which were introduced from Europe. Other places where introductions occurred, but where *S. cynthia* never actually established or has already gone extinct include Colchester, England; the Ruhr Valley and Berlin, Germany; Barcelona, Spain; Sydney, Australia; Auckland, New Zealand; Toronto, Canada; Montevideo, Uruguay; near Rio de Janeiro, Brazil; and the United States cities of St. Louis, Missouri; Pittsburgh, Pennsylvania; New Haven, Connecticut; Dayton, Ohio. One of the limiting factors of this species is freezing temperatures, which is why it did not persist in northern cities like Boston, Massachusetts, and inland cities like Pittsburgh and St. Louis that do not have a warmer coastal climate. Country by country, we summarize the history, literature, and current status pertaining to all of these introductions.

*Samia* belongs to the tribe Attacini in the subfamily Saturniinae. Other genera in the Attacini include the Asian *Archaeoattacus* and *Attacus* (the immense and famous atlas moths), the Australian *Coscinocera* (hercules moths), the African *Epiphora,* and the four American genera *Rothschildia, Hyalophora*, *Eupackardia,* and *Callosamia*. Recent studies using electrophoretic techniques or analyzing mitochondrial and nuclear DNA sequences reveal that the sister-group of *Samia* is the genus *Callosamia*, which consists of three species in eastern North America. The phylogeny of the genus *Samia* is reviewed in some detail. Regarding the nomenclature, the name *Philosamia* has been widely used for the species of *Samia*, but the two names are objective synonyms, both being based on the same type species (*cynthia*). Therefore, it is incorrect to use the name *Philosamia*, because it is an invalid name (Code 1999, Article 10.6). In much earlier literature, especially in North America, the name *Samia* was incorrectly applied to the North American species now known as *Hyalophora*.

The biogeographical situation of the genus *Samia*, and its many species, fits well with models of speciation and dispersal. *Samia* is apparently of Asian origin, and the African *Epiphora* and North American *Callosamia* are probably derivatives from a *Samia*-like ancestor. The most plesiomorphic species is *S. watsoni*, considered to be the sister-species to the remainder of the genus. Within the genus, speciation has occurred primarily in connection with isolation on islands. In the Philippines, the Andamans, and on smaller islands of eastern Indonesia, only a single species occurs on each island. However, larger islands such as Java and Sulawesi have two species each, primarily endemic. The two Javanese species may be sister-species, but the two on Sulawesi are probably derived from separate ancestors. As expected, the one that occurs on many of the Philippine islands shows considerable geographical variation. Several more species exhibit geographical variation, notably those from the Himalayas and mainland of southeastern Asia, where mountain ranges provide barriers to gene-flow between populations. The two species found on Taiwan are both widespread in mainland China.

We hope that our revision will clarify many long-standing questions about the genus *Samia*, but by pointing out where more research and collecting are needed, we also hope it will stimulate other entomologists to make new discoveries about this famous genus of beautiful moths.

# ZUSAMMENFASSUNG

**Eine Revision der Seidenspinnergattung *Samia***

Die Gattung *Samia* Hübner (= *Philosamia* Grote) umfasst 19 bekannte Arten, die vorwiegend im tropischen Asien über eine Strecke von insgesamt etwa 6000 Kilometern verbreitet sind. Ein Taxon ist eine domestizierte Art. Einige dieser großen und auffälligen Nachtfalter gehören zu den bekanntesten Saturniidae und sind bei Züchtern und Sammlern weit verbreitet und geschätzt. In einem Großteil der historischen Literatur sowie auch von einigen aktuellen Autoren werden alle Arten der Gattung als Unterarten von *Samia cynthia* (Drury), der Typusart der Gattung, zitiert. Die unterschiedlichen Merkmale in der Morphologie der Präimaginalstadien und der Falter, die Chromosomenanzahl, die unterschiedliche Biologie und die verschiedene geographische Verbreitung lassen jedoch relativ klar erkennen, dass die Gattung aus einer Reihe gut definierbarer Arten besteht, von denen nahezu die Hälfte erst innerhalb der letzten Jahre beschrieben wurde. Die bekannteste Art ist wohl *S. cynthia*, auch als Ailanthusspinner bekannt. Diese Art stammt ursprünglich aus den nördlichen Teilen

Chinas, ist aber weit über diese Grenzen hinaus bekannt, da sie zwischen 1858 und 1870 in verschiedenste Länder über die ganze Erde verbreitet wurde und sich dort teilweise erfolgreich in freier Wildbahn etablierte und verbreitete. Die bekannteste Futterpflanze ist der Götterbaum (*Ailanthus altissima*), ursprünglich ein chinesischer Baum, der nun ebenfalls weit verbreitet in vielen Städten auf der ganzen Welt anzutreffen ist.

Innerhalb der Gattung gibt es nur drei paläarktische Arten: *S. cynthia*, ursprünglich in Nord-China und Korea beheimatet, *Samia pryeri* (Butler), die endemisch in Japan vorkommt, sowie *Samia watsoni* (Oberthür), die weit verbreitet in höheren Lagen von China zu finden ist. Eine weitere Art, *Samia wangi* Naumann & Peigler, fliegt in weiten Teilen des südlichen und zentralen China sowie in Vietnam; sie ist in erster Linie ein subtropischer Vertreter, einzelne Funde stammen jedoch auch aus südlichen paläarktischen Bereichen in China. Die Verwandtschaft von *S. cynthia* und *S. wangi* stellt ein schwieriges und interessantes Problem dar, und wir hoffen, dass unsere Ausführungen vor allem chinesische Entomologen motivieren werden, weitere Untersuchungen zur Biologie und Verbreitung der beiden Arten anzustellen. Nach unserem aktuellen Wissen kommen die beiden Arten nicht sympatrisch vor und bilden keine Freilandhybriden, einige Falter aus den Randzonen der beiden Arten sind jedoch schwierig zu identifizieren. Nichtsdestotrotz haben wir uns entschieden, die Populationen von *S. cynthia* und *S. wangi* nicht als die eines einzigen weit verbreiteten, sehr variablen Taxons zu interpretieren, da Unterschiede in den männlichen Genitalstrukturen und vor allem in der Flügelzeichnung sowie im Verhalten zeigen, dass wir es hier mit mindestens zwei Arten zu tun haben. *S. wangi* kommt eher im Berg- und Hügelland vor, während *S. cynthia* ein Flachlandvertreter ist. In einem Großteil der bisherigen Literatur wird *S. wangi* fälschlicherweise als *Samia walkeri* bezeichnet, dieser Name ist jedoch ein subjektives Synonym von *S. cynthia*, was wir auch anhand der Untersuchung des Typenmaterials dieser beiden Taxa, inclusive Genitalpräparaten der Lectotypen, feststellen konnten. Zwei Arten kommen in Japan vor: Die ursprünglich dort beheimatete *S. pryeri* und die eingeführte *S. cynthia*. Die meisten japanischen Autoren bezeichnen beide als *Samia cynthia pryeri*, obwohl sie sich auf den ersten Blick einfach unterscheiden lassen: Falter von *S. cynthia* sind olivgrün und verblassen zu einem hellolivbraun, während die von *S. pryeri* dunkel sepiabraun sind und mit der Zeit heller braun aufhellen. Der Augenfleck im Vorderflügelapex ist bei *S. pryeri* wesentlich kleiner, die Flügelocellen sind schmaler, und die Ausprägung der Postmedianbinde ist ebenfalls deutlich anders. Nach den uns vorliegenden Falterdaten und der uns bekannten japanischen Literatur müssen wir annehmen, dass *S. pryeri* im Gegensatz zu *S. cynthia* nicht auf der Insel Hokkaido vorkommt.

Die übrigen 15 Arten kommen in der tropisch-orientalischen Region vor; sie sind verbreitet von Pakistan und Nord-Indien im Westen bis hin zu den Philippinen und in Indonesien im Osten bis zu einigen Inseln der Molukken, nicht jedoch auf Neu-Guinea. Die hübsche zimtfarbene *Samia canningi* (Hutton) ist eine weit verbreitete und variable Art mit einer Verbreitung auf dem asiatischen Festland, von den westlichen Ausläufern des Himalayas in Pakistan über Nepal, Nord-Indien bis ins südliche China und herunter bis nach Myanmar, Thailand und Vietnam. Im südöstlichen Verbreitungsgebiet von *S. canningi* fliegt sympatrisch die grosse *Samia kohlli* Naumann & Peigler, die noch weiter südlich als *S. canningi* bis nach West Malaysia vorkommt. Nahe verwandt mit *S. canningi* ist die rostbraune *Samia fulva* Jordan von den Andamanen, einer Inselgruppe im Golf von Bengalen.

*Samia ricini* (Anonymus) ist eine domestizierte Form, die nicht in freier Wildbahn vorkommt. Die Genitalstrukturen, die Flügelzeichnung sowie die Chromosomenzahl zeigen, dass sie ursprünglich von *S. canningi* abstammt. Das typische Unterscheidungsmerkmal von allen anderen *Samia*-Arten sind die weißen Haarbüschel auf dem Abdomen, die bei einigen Individuen den Körper komplett bedecken und weiß aussehen lassen. Wir führen dieses Taxon hier auf Artrang wegen der damit deutlichen Bezeichnungsmöglichkeit und aus Gründen der Stabilität der Nomenklatur, und befinden uns damit in guter Tradition: Auch beim domestizierten Maulbeerseidenspinner (*Bombyx mori*), der von *Bombyx mandarina* abstammt, oder dem Hund (*Canis familiaris*), der vom Wolf (*Canis lupus*) abstammt, wird dies so gehandhabt. Die Originalbeschreibung, in der der Name "*ricini*" ursprünglich validisiert wurde, konnte von uns im Rahmen der Recherchen nicht bestimmt werden, daher wird die Autorenschaft als Anonymus zitiert. Die Hauptfutterpflanze von *S. ricini* ist der Wunderbaum oder Palma Christi (*Ricinus communis*). Die ursprüngliche Gegend, wo die Seidenzucht mit der Art begonnen wurde, ist das Brahmaputra-Tal in Assam. Die Seide, die aus den Kokons gewonnen wird, wird als Eri- oder Endi-Seide bezeichnet; in ihrer wirtschaftlichen Bedeutung liegt sie hinter der Maulbeerseide (hergestellt aus Kokons von *B. mori*) und der chinesischen Tussah-Seide (aus Kokons von *Antheraea pernyi*) weltweit an dritter Stelle. Allein Indien produzierte Anfang der neunziger Jahre des letzten Jahrhunderts mehr als 800 Tonnen Eri-Seide pro Jahr und übertraf damit noch die eigene Produktion der Tasar-Seide (aus Kokons von *Antheraea paphia*). *S. ricini* wurde unter anderem zur Seidenerzeugung in Ägypten, Libanon, Kuba, Uruguay, Frankreich, Malta und Italien gezüchtet, und wird derzeit hierfür noch in Brasilien, China, Japan, Korea und im nordöstlichen Teil von Indien sowie angrenzenden Staaten herangezogen. In der vorliegenden Arbeit wird die Literatur zur Eri-Seidenkultur vorgestellt und zusammengefasst, und einige Textilien aus Eri-

Seide werden farbig abgebildet; auch die historische Verwendung von Seidenkokons anderer Samia-Arten in Indien, China und Japan zur Seidenherstellung wird in diesem Rahmen besprochen.

*Samia luzonica* (Watson) ist eine relativ variable Art, die weit über die Inseln der Philippinen verbreitet ist, während *Samia treadawayi* Naumann endemisch nur auf der philippinischen Insel Palawan vorkommt. *Samia tetrica* (Rebel) fliegt auf der westmalayischen Halbinsel und auf Borneo. Von Indonesien mit seiner Vielzahl von Inseln wurden eine Reihe von Arten beschrieben: *Samia abrerai* Naumann & Peigler von Java und Bali, *Samia vandenberghi* (Watson) und *Samia peigleri* Naumann & Nässig von Sulawesi, *Samia naumanni* U. Paukstadt, Peigler & L. Paukstadt vom Sula- und Banggai-Archipel, *Samia naessigi* Naumann & Peigler von Halmahera (nördliche Molukken), *Samia yayukae* U. Paukstadt, Peigler & L. Paukstadt von Timor, Alor und Flores (Kleine Sundainseln), *Samia ceramensis* (Bouvier) von Ceram (zentrale Molukken), sowie die weitbekannte *Samia insularis* (Snellen van Vollenhoven) von Sumatra und Java.

Die Besprechung der 19 Arten beinhaltet jeweils folgende Informationen: Verbleib und Etikettentext des Typenmaterials für alle Taxa, ausführliche Beschreibung von Flügelmusterung und Färbung, eine Beschreibung der diagnostischen männlichen Genitalstrukturen, Etiketteninformationen des untersuchten Museums- und Sammlungsmaterials, eine Zusammenfassung der bekannten geographischen Verbreitung, eine ausführliche Synonymieauflistung, sowie andere ergänzende Informationen, beispielsweise zur Biologie. Insgesamt werden 19 Lectotypen designiert. Die Autoren untersuchten Material in allen größeren naturhistorischen Museen in Nordamerika und Europa und konnten sämtliches noch existierendes Typenmaterial der validen Taxa einsehen und untersuchen. Mehr als 450 Genitalpräparate wurden untersucht. Naumann beobachtete und sammelte Vertreter der Gattung *Samia* in Myanmar, Thailand, West Malaysia, auf den Andamanen und auf verschiedenen indonesischen Inseln. Sammlungsmaterial, das während der letzten Jahre gesammelt wurde und sehr genaue Funddaten aufweist, wurde in großen Mengen von den Philippinen, aus Indonesien, Thailand, Myanmar und mehr als 20 Provinzen in China importiert und untersucht. Verschiedene Arten wurde im Rahmen des Projektes von beiden Autoren gezüchtet; während der letzten Jahre wurden die bis dahin unbekannten Präimaginalstadien unter anderem von *S. fulva*, *S. kohlli*, *S. tetrica*, *S. vandenberghi*, und *S. yayukae* durch Zuchten dokumentiert. Ein besonderer Wert wurde bei der Vorbereitung der vorliegenden Arbeit darauf gelegt, auch Literatur in chinesischer, japanischer, koreanischer und russischer Sprache zu zitieren und zu nutzen. Die umfangreiche Bibliographie enthält neben diesen Werken auch wichtige historische Werke, alle bedeutenden taxonomischen Arbeiten, die sich mit *Samia* beschäftigen, sowie auch eine Vielzahl populärwissenschaftlicher Bücher und Artikel, die Informationen über die Gattung beinhalten; die letztgenannten beziehen sich meist auf die Populationen von *S. cynthia* in Europa und Nordamerika. Generell lehnen wir die Verwendung trinominaler Taxa in der Gattung *Samia* ab und liefern eine Reihe von Argumenten gegen ein Subspezies-Konzept.

Während Informationen zu Freilandbeobachtungen für die Gattung kaum zu finden sind, gibt es doch eine Reihe von Beiträgen in vielen Sprachen, die von einer Verwendung von *Samia* für Laboratoriumsuntersuchungen handeln. Diese handeln meist von Untersuchungen biophysikalischer Werte und der Molekularstruktur der Seide, von Experimenten zur Diapause, Zell- und Molekulargenetik, Physiologie, von vergleichenden Wachstumsstudien in Abhängigkeit von den Futterpflanzen, Paarungs- und Eiablageverhalten, Spinnverhalten beim Kokonbau und der Erforschung der Molekularstruktur der weiblichen Pheromone. Über diese Themen geben wir eine kurze Übersicht. Der interessierte Leser sei hier auf die Bibliographie, in der weiterführende Literatur zitiert wird, verwiesen.

Eine Reihe interessanter Hybridzuchten mit Faltern der Gattung *Samia* wurden bisher durchgeführt. *Samia cynthia* wurde erfolgreich gepaart mit *Callosamia angulifera* und *Callosamia promethea*, woraus männliche, aber keine weiblichen Falter resultierten. Weitere Paarungen zwischen *Samia* und Vertretern anderer Gattungen konnten bisher keine Hybridfalter hervorbringen. Eine Vielzahl intragenerischer Paarungen zwischen verschiedenen *Samia*-Arten wurde beschrieben, und diverse Hybridformen wurden benannt, auch wenn diese keine validen Namen im Sinne des Codes (2000) darstellen. Ergebnisse zur Flügelbeschuppung, Kokonfarbe, Larvalzeichnung oder Diapause aus diesen Zuchten wurden genutzt, um Mechanismen der Vererbung solcher Merkmale zu untersuchen. Alle bekannten inter- und intragenerischen Hybridzuchten werden aufgelistet, die dazu veröffentlichte Literatur wird für weitere Studien zitiert.

Alle bekannten Futterpflanzen werden für jede Art aufgelistet. Die optimalen Zuchtbedingungen und alternative Futterpflanzen für Zuchten in Gefangenschaft werden diskutiert. Obwohl im Freiland eine Vielzahl von Pflanzen angenommen werden, gibt es eine eindeutige Bevorzugung von Arten der Gattung *Ailanthus* (Simaroubaceae) und verschiedenen Arten von Rutaceae, Euphorbiaceae und Lauraceae unter den Angaben für Freilandfunde in den Philippinen, Indien, Japan, China und Indonesien. Einige, aber nicht alle Vertreter der Gattungen *Fraxinus* (Esche), *Syringa* (Flieder) und *Ligustrum* (Liguster) (alles Oleaceae) stellen gute Ersatzfutterpflanzen für die Aufzucht von Raupen dar. Sämtliche bekannten Parasiten an Eiern, Raupen und Puppen werden aufgelistet. Innerhalb der Hymenoptera sind dies Vertreter der Familien Braconidae,

Ichneumonidae und verschiedene Familien der Chalcidoidea. Bei den Diptera gehören sämtliche Vertreter zu den Tachinidae. Funde von Parasiten stammen vor allem von den in Europa und Nord-Amerika eingeführten Populationen von *S. cynthia*, einige Angaben stammen aber auch von Beobachtungen an asiatischen Freilandpopulationen. Häufigere *Samia*-Parasiten in Asien sind Kokon-attakierende Schlupfwespen der Gattung *Xanthopimpla* (Ichneumonidae), kleine Wespen der Gattung *Anastatus* (Eupelmidae), die die Eier parasitieren, und einige Raupenfliegen der Familie Tachnidae, bekannt als sogenannte "Uzi flies," die die Raupen angreifen. Uzi-Fliegen sind beispielsweise *Exorista sorbillans*, *Blepharipa zebina* und *Blepharipa sericariae*. Junge *Samia*-Raupen werden außerdem manchmal von verschiedenen Arten Braconidae aus der Gattung *Apanteles* parasitiert. Weitere Fressfeinde sind verschiedene Vögel, vor allem Corvidae, die Raupen und Puppen angreifen. Die Kokons hängen im Herbst häufig weit sichtbar an den Bäumen, da die Raupen ihre Kokons fest mit einem Seidenband an den Zweigen verankern; hierdurch ist ein einfaches Auffinden möglich, und es gibt verschiedene Literaturhinweise, die über Populationsrückgänge durch Übersammeln der Kokons durch Entomologen in Tokio, Barcelona, Paris, Wien und einigen Städten in Nord-Amerika berichten.

*Samia cynthia* wurde durch den Menschen von China aus in viele Länder auf der ganzen Erde verbreitet. Diese Einbürgerungen, meist geschehen in der zweiten Hälfte des neunzehnten Jahrhunderts, waren immer absichtlich und meist Versuche, eine lokale Seidenindustrie aufzubauen. Populationen, die hierauf zurückgehen, existieren heute noch in Slowenien, Österreich, der südlichen Schweiz, Frankreich, Nord-Italien, Japan, Georgien und Russland am Schwarzen Meer, und bis vor kurzem auch in einigen Städten wie New York oder Philadelphia im nordöstlichen Teil der Vereinigten Staaten. Die Art ist ein typischer Stadtflieger, Funde aus ländlichen Gebieten sind selten. *Samia cynthia* scheint in den USA nahezu ausgestorben zu sein. Auch wenn es keinen Beweis dafür gibt, so glauben wir doch, dass dies durch den Parasiten *Compsilura concinnata* (Tachinidae) verursacht wurde. Dieser Parasit wurde zwischen 1906 und 1986 mehrfach vom United States Department of Agriculture von Europa nach Nord-Amerika importiert, um die ebenfalls aus Europa eingeführten Schwammspinner (*Lymantria dispar*) und Dunkler Goldafter (*Euproctis chrysorrhoea*) in Amerika zu bekämpfen. *S. cynthia* wurde an vielen anderen Orten ausgewildert, unter anderem in Colchester (England), dem Ruhrgebiet und Berlin (Deutschland), in Barcelona (Spanien), in Sydney (Australien) und in Auckland (Neuseeland), in Toronto (Kanada), in Montevideo (Uruguay), in der Umgebung von Rio de Janeiro (Brasilien), sowie in St. Louis, Missouri, in Pittsburgh, Pennsylvania, in New Haven, Connecticut, und Dayton, Ohio (USA). Alle diese Einbürgerungsversuche haben aber nie zum Erfolg eines dauerhaften Vorkommens geführt, alle diese Populationen existieren nicht mehr. Einer der einschränkenden Faktoren für ein erfolgreiches Bestehen einer Population ist die Temperatur; starke Fröste wie im nördlichen Boston, Massachusetts oder im zentralen Flachland von Pittsburgh oder St. Louis, alle USA, erlauben kein Überleben; scheinbar ist das mildere Küstenklima vorteilhafter. Für sämtliche Länder, wo eine Einbürgerung bekannt wurde, fassen wir Details über die Geschichte, Literatur hierzu und den gegenwärtigen Status zusammen.

*Samia* gehört zum Tribus Attacini in der Subfamilie Saturniinae. Andere Gattungen der Attacini sind die asiatischen *Archaeoattacus* und *Attacus* (Atlasspinner), die indoaustralischen *Coscinocera* (Herkulesspinner), die afrikanischen *Epiphora*, sowie die vier amerikanischen Gattungen *Rothschildia*, *Hyalophora*, *Eupackardia* und *Callosamia*. Neuere Studien, die auf Elektrophorese-Techniken und Analysen von mitochondrialer und Kern-DNA beruhen, zeigen, dass höchstwahrscheinlich *Callosamia* mit seinen drei nordamerikanischen Vertretern die Schwestergattung zu *Samia* ist. Die phylogenetische Situation der Gattung *Samia* wird ausführlich betrachtet. Der Name *Philosamia* wurde und wird häufig in der Literatur für Arten dar Gattung *Samia* verwendet; beide Namen sind objektive Synonyme, beiden liegt die Typusart *cynthia* zugrunde. Es ist daher falsch, das jüngere Synonym *Philosamia* anzuwenden. Über lange Zeit wurde insbesondere in der nordamerikanischen Literatur das Name *Samia* fälschlicherweise den nearktischen Arten der Gattung *Hyalophora* zugeordnet.

Die biogeographische Verbreitung der Gattung *Samia* passt gut zu Überlegungen zur Artbildung und Ausbreitung von Taxa. *Samia* ist offensichtlich asiatischen Ursprungs. Sowohl *Samia* als auch die afrikanischen *Epiphora* und die nordamerikanischen *Callosamia* sind wahrscheinlich Abkömmlinge eines *Samia*-ähnlichen Vorgängers. Die plesiomorphste Art der Gattung ist *Samia watsoni*, die wir als Schwesterart zu allen übrigen Arten der Gattung betrachten. Innerhalb der Gattung fand eine Spezifizierung in erster Linie durch Isolierung von Inseln statt. Auf den Philippinen, den Andamanen und den kleineren Inseln des östlichen Indonesiens kommt jeweils nur ein Vertreter der Gattung auf einer Insel vor. Im Gegensatz dazu gibt es auf den größeren Inseln wie Java oder Sulawesi zwei endemische *Samia*-Arten; die zwei auf Java mögen Schwesterarten sein, diejenigen von Sulawesi stammen jedoch deutlich von unterschiedlichen Vorläufern ab. Wie zu erwarten, weist die über die vielen philippinischen Inseln verbreitete *S. luzonica* eine gewisse geographische Variabilität auf, genauso wie weitere weit verbreitete Arten des südostasiatischen Festlandes und der Himalaya-Ausläufer, wo hohe Bergzüge Schranken für eine Genaustausch zwischen verschiedenen Populationen einer Art bilden können. Die beiden Arten, die auf Taiwan vorkommen, sind ebenfalls auf dem chinesischen Festland weit verbreitet.

Wir hoffen, dass unsere Revision einen Grossteil der seit langem aufgekommenen Fragen zur Gattung *Samia* klären kann. Gleichzeitig soll sie aber auch ein zeigen, wo noch weitere Forschungstätigkeiten und systematische Aufsammlungen notwendig sind, und so anderen Entomologen ein Anreiz sein, neue Erkenntnisse zu diesen wunderschönen Nachtfaltern beizutragen.

# RINGKASAN

**Penyelidikan ulat sutera dari marga *Samia***

Marga *Samia* Hübner (=*Philosamia* Grote) mempunyai 19 jenis yang dikenal, terutama di bagian daerah tropis Asia tersebar sepanjang 6000 kilometer. Salah satu jenis ini telah dijinakan. Jenis kupu-kupu yang besar dan bagus ini termasuk jenis yang terkenal di keluarga Saturniidae dan sangat disukai oleh penernak dan pengoleksi serangga. Sebagian besar di sejarah kesusasteraan dan juga beberapa pengarang buku, mereka berpendapat semua jenis dari marga tersebut sebagai anak jenis dari *Samia cynthia* (Drury). Perbedaan ciri-ciri khas di dalam morfologi pradewasa dan induknya, jumlah kromosom, perbedaan biologi dan penyebaran geografinya yang luas maka dapat dilihat, bahwa di dalam satu marga terdiri dari beberapa jenis, dimana hampir separuhnya baru saja dipertelakan beberapa tahun terakhir ini. Jenis yang sangat terkenal adalah *S. cynthia*, yang juga dikenal sebagai kupu-kupu *Ailanthus*. Jenis tersebut berasal dari Cina bagian Utara, yang kemudian di sekitar tahun 1858 sampai 1870 banyak disebarkan ke Negara lain di seluruh dunia dan sebagian berhasil berkembang biak di alam bebas. Pohon yang terkenal sebagai makanan ulat sutera ini adalah Pohon Dewa (*Ailanthus altissima*). Pohon tersebut aslinya berasal dari Negara Cina, yang mana sekarang banyak ditemukan di Kota-kota di seluruh dunia.

Dari Benua Eropa dan Asia Barat di dalam satu marga ini hanya terdapat tiga jenis, yaitu jenis: *S. cynthia* aslinya berasal dari Negara Cina Utara dan Korea, *Samia pryeri* (Butler) yang endemicnya ditemukan di Jepang, seperti *Samia watsoni* (Oberthür) yang diketemukan tersebar di Dataran Tinggi Negara Cina. Satu jenis lainnya, yaitu *Samia wangi* Naumann & Peigler, terbang di Bagian Cina Selatan dan Cina Tengah seperti juga di Vietnam; Jenis ini terutama sebagai jenis tropis, sebagian penemuan berasal dari Daerah antara Benua Eropa dan Cina. Kaitan sistim Klasifikasi dari *S. cynthia* dan *S. wangi* menimbulkan suatu masalah yang sulit dan menarik dan kami berharap, bahwa penyelidikan kami ini untuk memacu semangat para ahli ilmu serangga terutama para ahli dari Cina, untuk selanjutnya meneruskan penyelidikan di bidang biologi dan penyebaran ke dua jenis tersebut. Berdasarkan penyelidikan kami yang terbaru menunjukan, bahwa ke dua jenis ini tidak simpatrik dan di alam bebas tidak bisa menyilang sendiri, beberapa spesies dari ke dua jenis ini susah untuk disamakan. Walaupun demikian kami mengambil kesimpulan, bahwa bukan hanya populasi *S. cynthia* dan *S. wangi* yang penyebarannya meluas, sangat bervariasi dan perbedaan struktur alat kelamin jantan dan terutama bentuk sayap menunjukan, bahwa jenis ini paling sedikit dua jenis. *S. wangi* hidup di daerah Perbukitan dan Pegunungan, sedangkan *S. cynthia* hidup di daerah yang datar. Selama ini di dalam kesusasteraan *S. wangi* dinyatakan sebagai *Samia walkeri* dan meskipun demikian nama tersebut menurut kenyataan adalah sinonim dengan *S. cynthia*, ini berdasarkan tipe materi ke dua jenis tersebut yang telah kami selidiki, termasuk preparasi alat kelamin jenis lektotipe nya.

Dua jenis terdapat di Jepang: Jenis aslinya, yaitu *S. pryeri* dan jenis yang didatangkan yaitu *S. cynthia*. Para pengarang ilmiah dari Jepang menyebut ke dua jenis ini sebagai jenis *Samia cynthia pryeri*, walaupun kesan pertama dari wujud jenis ini dapat dilihat perbedaannya: *S. cynthia* berwarna hijau buah zaitun yang agak pucat seperti warna hijau zaitun muda kecoklat-coklatan, sedangkan *S. pryeri* berwarna coklat tua yang berlanjut menjadi coklat muda. Tanda bintik mata pada ujung sayap depan *S. pryeri* lebih kecil, pola sayapnya juga lebih ramping dan perbedaan pola bentuk sayap posmedianya jelas dapat dilihat ada kelainan. Dari data-data semua yang kami dapati dan dari daftar kesusasteraan yang terkenal di Jepang bahwa *S. pryeri*, kebalikan dari *S. cynthia*, dia tidak hidup di Pulau Hokkaido.

15 sisa jenis yang lain terdapat di Daerah Gurun Tropis; Jenis tersebut banyak berkembang di Pakistan dan India Utara bagian Barat sampai ke Filipina dan Indonesia di bagian Timur sampai ke beberapa Pulau di Maluku, tetapi tidak sampai ke Irian Jaya dan Papua Nugini. *Samia canningi* (Hutton) yang cantik dan berwarna coklat muda seperti kayu manis adalah salah satu dari jenis yang banyak tersebar di Daerah Asia, di bagian Barat perbatasan Himalaya, di Pakistan melewati Nepal; India Utara sampai ke Negara Cina Selatan dan menyebar ke Negara Myanmar, Thailand dan Vietnam. Di Bagian Tenggara penyebaran *Samia canningi* sampai ke Malaysia

Barat. Yang berkaitan erat dengan *S. canningi* adalah *Samia fulva* Jordan yang berwarna coklat karat dari Daerah Andaman salah satu Pulau di Teluk Bengal.

*Samia ricini* (Anonymus) adalah salah satu jenis yang telah dijinakan dan tidak terdapat liar di hutan rimba. Struktur kelamin, corak sayap seperti juga jumlah kromosom menunjukan, bahwa aslinya *S. ricini* adalah dari *S. canningi*. Ciri khas untuk membedakan dengan jenis *Samia* yang lain adalah sejumlah rambut putih di sekitar perut, yang terkadang individu menutupi seluruh tubuh menjadi berwarna putih. Kami membuat tingkatan jenis, ini untuk mempermudah percakapan dengan alasan untuk stabilisasi tatanama, supaya kita berada dalam tradisi yang sempurna. Demikian pula ulat sutera (*Bombyx mori*) yang telah dijinakan berasal dari *Bombyx mandarina*, seperti halnya nama seekor anjing (*Canis familiaris*) yang namanya berasal dari Serigala (*Canis lupus*). Di publikasi aslinya nama "*ricini*" yang telah disyahkan, tetapi dalam penyelidikan kami, jenis ini statusnya tidak dapat kami tentukan, maka dari itu nama ricini oleh pengarang dianggap sebagai nama samaran. Makanan pokok *S. ricini* adalah Pohon Jarak (*Ricinus communis*). Daerah asal dimana ulat sutera pertama mulai diternakan adalah di Lembah Sungai Brahmaputra di Assam (India). Sutera yang berasal dari kepompong *Samia* biasa dinamakan Sutera Eri atau Sutera Endi. Dilihat dari segi ekonomi Sutera Eri mutunya masih di bawah Sutera yang berasal dari jenis ulat murbei (dari kepompong *B. mori*) dan Sutera Tussah dari Cina (dari kepompong *Antheraea pernyi*), dia berada di urutan ke tiga di seluruh dunia. Di awal tahun sembilanpuluhan India memproduksi Sutera Eri lebih dari 800 Ton, ini melebihi produksi mereka sendiri, yaitu Sutera Tasar (dari kepompong *Antheraea paphia*). Untuk produksi kain sutera *S. ricini* diternakan di Mesir, Libanon, Kuba, Uruguay, Perancis, Malta dan Itali, yang kemudian berlanjut di Brasil, Cina, Jepang, Korea dan India di sebelah Utara seperti juga Negara-Negara perbatasan sekitarnya. Di dalam skripsi ini kesusasteraan mengenai pengembang biakan Sutera Eri akan dibahas dan disimpulkan, dan beberapa contoh akan diperlihatkan di halaman berwarna, sejarah mengenai penggunaan kepompong Sutera jenis *Samia* yang lainnya di India, Cina dan Jepang juga akan dibahas.

*Samia luzonica* (Watson) adalah jenis yang agak bervariasi, yang banyak menyebar di Kepulauan Filipina, sedangkan *Samia treadawayi* Naumann bersifat endemik hanya ada di Pulau Palawan. *Samia tetrica* (Rebel) terbang di Malaysia Barat dan Kalimantan. Dari Indonesia, yang mempunyai banyak Pulau-Pulau telah dipertelakan jenis-jenis sebagai berikut: *Samia abrerai* Naumann & Peigler dari Jawa dan Bali, *Samia vandenberghi* (Watson), *Samia peigleri* Naumann & Nässig dari Sulawesi, *Samia naumanni* U. Paukstadt, Peigler & L. H. Paukstadt dari Kepulauan Sula dan Banggai, *Samia naessigi* Naumann & Peigler dari Halmahera (Maluku Utara), *Samia yayukae* U. Paukstadt, Peigler & L. H. Paukstadt dari Pulau Timor, Alor dan Flores, *Samia ceramensis* (Bouvier) dari Ceram (Maluku Tengah), seperti juga jenis yang terkenal *Samia insularis* (Snellen van Vollenhoven) dari Jawa dan Sumatera.

Pembahasan dari 19 jenis menghasilkan beberapa informasi sebagai berikut: Tempat penyimpanan dan data-data tipe untuk seluruh spesimen, selain itu dibahas secara terperinci dari kidentifikasi bentuk, corak dan warna sayap, serta penyuluhan diagnose struktur jenis kelamin jantan, data-data yang didapat dari koleksi Museum, ringkasan penyebaran geografinya yang telah dikenal, penjelasan daftar sinonim yang terperinci, seperti juga informasi pelengkap misalnya di bidang biologi. Jenis yang dinyatakan sebagai lektotipe semuanya berjumlah 19 jenis. Para pengarang melakukan penelitian di berbagai Museum yang terkenal di Amerika Utara dan Eropa dan pula mereka mendapat kesempatan untuk menyelidiki jenis tipe yang ada dan lengkap data-datanya. Lebih dari 450 jenis kelamin yang diselidiki. Naumann mengumpulkan dan mengamati jenis yang tergolong dalam marga *Samia*, yang ditemukan di Myanmar, Thailand, Malaysia Barat, Kepulauan Andaman dan di beberapa Kepulauan di Indonesia. Koleksi spesimen yang dikumpulkan beberapa tahun terakhir ini menunjukan data-data yang tepat, sebagian besar spesimen tersebut diimport dari Filipina, Indonesia, Thailand, Myanmar dan lebih dari 20 Propinsi dari Cina. Berbagai jenis ulat untuk keperluan penyelidikan diternakan oleh ke dua pengarang; Di tahun terakhir jenis ulat yang dahulu pra-dewasanya belum dikenal seperti misalnya *S. fulva, S. kohlli, S. tetrica, S. vandenberghi* dan *S. yayukae* sekarang dengan melalui penernakan, maka dapat didokumentasikan. Hal yang sangat berharga dalam proses persiapan dan penyelidikan, yaitu penukilan dan penggunaan kesusasteraan dalam bahasa Cina, Jepang, Korea dan Rusia. Di samping penelaan di dalam buku ini, tentu saja penunjangan kesusasteraan yang luas merupakan faktor yang ikut berperan dalam penyelidikan, seluruh penelitian yang penting di bidang taksonomi yang berhubungan dengan *Samia*, seperti juga di berbagai buku penelitian ilmiah yang terkenal, yang terakhir disebut, biasanya berhubungan dengan populasi *S. cynthia* di Benua Eropa dan Amerika Utara. Pada dasarnya kami menolak penggunaan daftar istilah trinominal dan kami memberikan alasan suatu konsep untuk anak jenis dari marga *Samia*. Walaupun informasi tentang pengamatan di lapangan untuk marga ini susah ditemukan, tetapi ada juga serangkaian hasil penelitian dalam berbagai bahasa yang behubungan dengan penyelidikan di Laboratorium mengenai marga *Samia* ini. Hal ini kebanyakan penelitian yang menyangkut nilai Ilmu Alam Organik dan struktur molekul dari Sutera, dari masa percobaan sampai masa pupa, proses pembelahan sel-sel dan molekul, bentuk jasmani serangga, pertumbuhan berdasarkan jenis tumbuhan yang

dimakan, perkawinan dan peneluran, perajutan jala dalam proses pembuatan kepompong dan penelitian struktur molekul dari feromon betina. Mengenai hal ini, kami memberi sedikit penjelasan. Untuk pembaca yang berminat, di sini kami akan tunjukan di dalam bibliografi di daftar kesusasteraan lengkap yang selanjutnya.

Penyilangan yang menarik terjadi pada *S. cynthia* yang berhasil dikawinkan dengan *Callosamia angulifera* dan *Callosamia promethea*, dimana hasilnya hanya jenis jantan saja, tidak ada jenis betina. Perkawinan antara *Samia* dengan marga yang lain sampai sekarang belum pernah berhasil. Berbagai perkawinan di antara beberapa jenis *Samia* banyak dibahas dan berbagai bentuk dari hasil penyilangan telah diberi nama, walaupun nama itu tidak syah menurut daftar istilah. Dari hasil penelitian sisik sayap, warna kepompong, gambar ulat atau masa pupa dari proses penernakan tersebut digunakan untuk menyelidiki mekanisasi sifat keturunan. Semua hasil penyilangan yang telah dikenal, baik intergenerik maupun intragenerik akan dikutip ke dalam suatu daftar kesusasteraan, yang maknanya sebagai penelitian di kemudian hari.

Seluruh daftar tanaman yang dimakan oleh setiap jenis akan didokumentasikan. Cara berternak yang baik dan alternatif makanannya di sini akan didiskusikan. Walaupun di alam bebas tumbuh berbagai tanaman yang dimakan, tetapi tanaman yang sangat disukai adalah jenis tanaman dari marga *Ailanthus* (Simaroubaceae) dan berbagai jenis Rutaceae, Euphorbiaceae dan Lauraceae, yang banyak ditemukan liar di Filipina, India, Jepang, Cina dan Indonesia. Hanya beberapa tanaman, tetapi tidak semua tanaman dari marga *Fraxinus, Syringa* dan *Ligustrum* (semuanya Oleaceae) merupakan tanaman yang cocok sebagai pengganti makanan untuk ulat tersebut. Semua parasit yang dikenal, yang ada di telur, ulat dan pupa akan didaftarkan. Di dalam Hymenoptera parasit itu termasuk ke dalam keluarga Braconidae, Ichneumonidae dan berbagai keluarga Chalcidoidea. Untuk jenis Diptera termasuk semua jenis yang mewakili Tachinidae. Penemuan parasit terutama berasal dari populasi *S. cynthia* yang dimasukan ke Eropa dan Amerika Utara, beberapa data-data juga berasal dari pengamatan populasi liar di Asia. Parasit *Samia* yang sering didapat di Asia adalah sejenis Lebah yang mengganggu kepompong yaitu dari marga *Xanthopimpla* (Ichneumonidae), lebah kecil dari marga *Anastatus* (Eupelmidae), yang hidup sebagai parasit di telur dan beberapa ulat lalat dari keluarga Tachinidae, terkenal sebagai yang suka menyerang ulat. Lalat Uzi misalnya *Exorista sorbillans*, *Blepharipa zebina* dan *Blepharipa sericariae*. Terkadang ulat *Samia* yang masih muda dibenalui oleh berbagai macam parasit jenis Braconidae dari marga *Apanteles*. Musuh lainnya adalah berbagai macam jenis burung, terutama Corvidae yang suka memakan ulat dan pupa. Di musim gugur kepompongnya kelihatan bergelantungan di pohon-pohon, ini dikarenakan ulat-ulat tersebut mengikat kepompongnya dengan cabang pohon. Dengan demikian kepompong itu mudah ditemukan dan juga dalam kesusasteraan di Tokyo, Barselona, Paris, Wien dan beberapa Kota di Amerika banyak diberitakan, bahwa situasi tersebut mengakibatkan menurunnya populasi kepompong, karena banyak pengoleksi serangga yang mengambil kepompong secara berlebihan.

*Samia cynthia* oleh manusia banyak disebarkan dari Cina ke Negara-Negara lain di seluruh dunia. Proses penyebaran *S. cynthia* ke Negara lain terjadi di sekitar pertengahan Abad ke 19. Ini terjadi karena disengaja, biasanya sebagai bahan percobaan untuk membuat pabrik kain sutera setempat. Usaha penenunan sutera yang masih berjalan sampai sekarang adalah di Slowenia, Austria, Swiss bagian Selatan, Perancis, Itali Utara, Jepang, Georgia, Rusia di bagian Laut Hitam dan belum lama ini juga di New York atau Philadelphia di bagian Timur Daya Amerika Serikat. Jenis ini kebanyakan terbang di pusat Kota dan sangat langka di daerah perkampungan. Di Amerika jenis *S. cynthia* diberitakan sudah punah. Walaupun tidak ada bukti atas kepunahan jenis ini, tetapi kami percaya, bahwa kepunahannya itu disebabkan oleh parasit *Compsilura concinnata* (Tachinidae). Parasit ini antara tahun 1906 dan 1986 beberapa kali diimport oleh Departement Agraria Amerika dari Eropa ke Amerika Utara, maksudnya untuk menanggulangi ngengat gypsy (*Lymantria dispar*) dan ngengat ekor emas (*Euproctis chrysorrhoea)* yang pernah terbawa masuk dari Eropa ke Amerika. Penyebaran *S. cynthia* di alam bebas banyak dilakukan di berbagai Kota-Kota di dunia seperti di Colchester (Inggris), Ruhr Lembah dan Berlin (Jerman), Barselona (Spanyol), Sydney (Australi) dan Auckland (Selandia Baru), Toronto (Kanada), Montevideo (Uruguay), di daerah sekitar Rio de Janeiro (Brasil), seperti di St. Louis, Missouri; Pittsburgh, Pennsylvania; New Haven, Connecticut; dan Dayton, Ohio (Amerika Serikat). Proses penyebaran serangga di alam bebas ini tidak mendapat hasil yang gemilang, semua populasi dari jenis ini tidak berkembang lagi. Faktor yang berperan penting adalah faktor suhu udara, suhu udara dingin dan beku di Boston bagian Utara, Massachusetts atau di bagian Tengah Dataran rendah di Pittsburgh atau St. Louis, seluruh Amerika Serikat, tidak memberikan kesempatan jenis ini untuk hidup bertahan lama. Hanya udara yang sejuk di bagian pesisir pantai banyak membawa keuntungan untuk bertahan hidup. Kami berusaha merangkum data-data di bidang sejarah, kesusasteraan untuk beberapa Negara, dimana proses penyebaran serangga yang dilakukan di alam bebas.

*Samia* termasuk rumpun Attacini di dalam anak keluarga Saturniinae. Marga yang lain dari Attacini adalah *Archaeoattacus* dan *Attacus* (kupu-kupu gajah), *Coscinocera* (kupu-kupu Herkules) dari Indo-Australi, *Epiphora* dari Afrika, seperti juga empat marga dari Amerika yaitu *Rothschildia, Hyalophora, Eupackardia* dan *Callosamia*. Penelitian terbaru yang berdasarkan Teknik Elektroforesis, analisa dari mitokondria dan Inti Atom-

DNA menunjukan, bahwa kemungkinan besar *Callosamia* dan juga ke tiga marga dari Amerika Utara masih ada hubungan saudara dengan marga *Samia*. Nama *Philosamia* banyak digunakan di dalam kesusasteraan sebagai marga *Samia*; Kedua nama tersebut adalah secara objektif sinonim, keduanya berdasarkan dari jenis tipe yang sama, yaitu *cynthia*. Maka dari itu salah apabila menggunakan *Philosamia* sebagai sinonim baru. Sebelumnya di dalam kesusasteraan dari Amerika Utara nama *Samia* dikategorikan sebagai jenis dari marga *Hyalophora.*

Penyebaran ilmiah dari marga *Samia* sesuai dengan pengamatan dalam hal pembentukan wujud dan penyebaran dari spesimen itu. *Samia* terbukti berasal dari Asia. Baik *Samia* maupun *Epiphora* dari Afrika dan *Callosamia* dari Amerika Utara kemungkinan besar berasal dari keturunan yang mempunyai ciri-ciri mirip dengan marga *Samia*. Sebagian besar jenis plesiomorfik adalah jenis *S. watsoni*, jenis yang kita anggap sebagai jenis yang mempunyai hubungan erat ke marga lainnya. Dalam satu marga terjadi suatu keistimewaan yang berdasarkan dari alam pemisah Pulau-Pulau. Di Filipina, Andaman dan Pulau-Pulau kecil di bagian Indonesia Timur ditemukan hanya satu jenis dari marga ini. Tetapi di Pulau-Pulau yang besar seperti Jawa dan Sulawesi ditemukan dua jenis *Samia*, kedua jenis yang ditemukan di Jawa kemungkinan ada hubungan saudara, sedangkan yang diketemukan di Sulawesi berasal dari keturunan yang berbeda. Seperti yang diharapkan, bahwa *S. luzonica* yang tersebar di beberapa Pulau di Filipina menunjukan variasi keluasan geografi, demikian halnya dengan jenis yang tersebar luas di Daerah Asia Tenggara dan Himalaya, dimana ketinggian Gunung menghambat pertukaran gen diantara satu dengan yang lain untuk terjadinya populasi. Dua jenis yang diketemukan di Taiwan, kedua jenis itu juga tersebar luas di Cina.

Kami berharap, bahwa revisi kami yang baru ini sebagian besar dapat memberikan penjelasan untuk pertanyaan-pertanyaan yang ada dalam marga *Samia*. Dengan terjawabnya pertanyaan-pertanyaan tersebut bukan berarti berakhirnya penyelidikan yang berharga ini. Selain itu revisi ini juga untuk dapat menunjukan dimana kekurangan yang masih ada dalam penyelidikan marga *Samia*, supaya para ahli serangga dapat memberikan hasil-hasil penemuan yang baru untuk jenis kupu-kupu yang cantik ini.

Diterjemah oleh Budiarto dan Laela Hayati Paukstadt

王蛾科(Saturniidae) 眉紋王蛾屬 (*Samia*)的修訂

眉紋王蛾屬全世界已知有19種，主要分佈於亞洲熱帶地區，其最長範圍達6000公里以上，其中一種是以人工養殖型態存在。這一類體型大而且美麗的蛾類包括王蛾科中最著名的一些種類，深為昆蟲蒐藏者所喜愛。大多數從前的著述和某些晚近的文獻皆將本屬全部種類視為眉紋王蛾 *Samia cynthia* (Drury)的亞種，這是本屬的指名種。然而由於本屬種類存在著許多生物學、成蟲和幼蟲形態、染色體數目和地理分佈等方面的差異，顯示本屬包含許多種類，最近數年間本屬幾乎有一半的種類被描述為新種。其中最有名的一種是眉紋王蛾(*S. cynthia*)，原僅分佈於中國東北部的廣大區域，但在1858年至1870年間被引介入全世界許多國家，並且成功地擴散其分佈區域。本種的主要寄主植物是天堂樹(*Ailanthus altissima*)，原產於中國的植物，現已普遍生長於全世界許多城市。

本屬僅有3個種是屬於舊北區系的種類，即 *S. cynthia* 分佈於韓國和中國北部，*S. pryeri* (Butler)日本特有種，*S. watsoni* (Oberthür)分佈於中國中南部大部份較高海拔山區。王氏眉紋王蛾 *S. wangi* 分佈於中國中南部大多數區域和越南。其主要是一個熱帶種類，但分佈範圍有一部份延伸入舊北區。眉紋王蛾(*S. cynthia*)和王氏眉紋王蛾(*S. wangi*)兩者間的分類問題既困難又有趣，希望將來有人能調查這2種的生物學和分佈範圍。我們作者目前僅知，這兩種既非同地分化種，也非雜交種，但有些標本卻很難鑑定。無論如何，將眉紋王蛾和王氏眉紋王蛾的全部族群視為廣泛分佈而且有個體變異的一個種類是有爭議的，因為兩者雄性生殖器和翅膀斑紋的差異皆清楚顯示出至少包含著兩個種。王氏眉紋王蛾主要活動於山區和山腳，眉紋王蛾則分佈於低平地區。大多數文獻皆將王氏眉紋王蛾錯誤記載成 *S. walkeri*，其實此學名是同種異名，因為作者們曾檢查過這兩種學名的模式標本。日本有兩個種分佈，本地種 *S. pryeri* 和引入種眉紋王蛾 *S. cynthia*。日本的大多數作者將兩種混合成一個學名 *S. cynthia pryeri*。*S. cynthia* 翅色橄欖綠色泛金黃褐色。*S. pryeri* 翅色灰褐色泛暗褐色。*S. pryeri* 前翅端部的眼斑比較小，且兩種中、後線有明顯的差別。根據作者們所檢視的標本和日本文獻，*S. pryeri* 並不分佈於 Hokkaido 島，而 *S. cynthia* 則可能分佈於該島。

本屬其餘的15種是熱帶性種，分佈於東洋生物地理區，範圍自巴基斯坦、印度北部、菲律賓、印尼全島到摩鹿卡(Moluccas)，但不分佈於新幾內亞。有美麗黃褐色的王蛾 *S. canningi* (Hutton)是分佈廣又有個體變異的種類，主要分佈在喜馬拉雅山周圍地區，從巴基斯坦、尼泊爾、印度北部到中國南部、泰國和越南。*S. canningi* 分佈範圍的東南區有一個大型的同地分化種 *S. kohlli* Naumann & Peigler，其分佈範圍並向下延伸至馬來西亞半島。在 Bengal 海灣的 Andaman 島上另有一個種 *S. fulva*，和 *S. canningi* 有近緣關係。

*S. ricini*(命名者未知)是人工養殖型品種而並不生活於野外。本種生殖器構造、翅膀斑紋和染色體數目俱顯示是演化自 *S. canningi*。其最明顯特徵是腹部白色毛簇擴張，有時是導源於某些個體具有堅硬的白色腹部。為了顧及命名之

相互關連性，其他類人工飼育品種俗名為狗(*Canis familiaris*)以顯示其源自於狼(*Canis lupus*)。作者目前仍未找出有效種名 *ricini* 的原初出版品，所以命名作者被記載為無名人氏。*S. ricini* 的主要寄主植物是(*Ricinus communis*)，其主要的人工飼育地區是在印度河薩姆(Brahmaputra 河谷)。其所生產的絲織品被稱為 eri 絲或 endi 絲，是全世界排名第三最具經濟重要性的絲產品，僅次於蠶絲(*Bombyx mori*)和中國 tussah 絲。(*Antheraea pernyi*)。印度在 1990 年代早期每年生產 800 公噸 eri 絲，產量超過另一種(*Antheraea paphia*)所生產的 tussah 絲。*S. ricini* 曾被人工飼養於埃及、黎巴嫩、古巴、法國、義大利等地，現今則被飼養於巴西、中國、日本、韓國、印度東北部及其鄰近地區。本書的工作是將有關 eri 絲文化的文獻詳細修訂，有些 eri 絲的編織品以彩色圖片呈現。作者們也探討 *Samia* 屬其他種類所產的絲在古代印度、中國和日本之利用情況。

*S. luzonica* (Watson)是廣泛分佈於菲律賓的個體變異品種，*S. treadawayi* Naumann 是菲律賓 Palawan 島的特有種。*S. tetrica* (Rebel)活動於馬來西亞半島和婆羅洲。印尼也發現有幾種分佈，包括 *S.abrerai* Naumann & Peigler 分佈於巴里島和瓜哇島，*S. vandenberghi* (Watson)和 *S.peigleri* Naumann & Naessig 分佈於 Sulawesi，*S. naumanni* U.Paukstadt, Peigler & L. Paukstadt 分佈於 Sula Archipelago，*S. naessigi* Naumann & Peigler 分佈於摩鹿卡北部，*S. yayukae* U. Paukstadt, Peigler & L. Paukstadt 分佈於 Timor 和 Flores，*S. ceramensis* (Bouvier) 分佈於摩鹿卡中部，外加著名的 *S. insularis* (Snellen van Vollenhoven) 分佈於蘇瑪托和爪哇。

本書在 19 個種的學名下方皆附記有模式標本貯放位置和標籤上的日期、成蟲翅膀斑紋和色彩的詳細描述、雄性生殖器的描述、博物館標本標籤上日期的檢查、地理分佈範圍的詳細統合、全部的同種異名和其他相關的記述，共記述了 19 個選模式標本。作者們曾赴北美洲和歐洲所有主要的自然史博物館研究標本，並且檢查所有模式標本的有效名和描述。作者們曾檢查本屬大約 450 個雄性生殖器。Naumann 曾收集和觀察分佈於緬甸、泰國、馬來西亞西部、Andaman 島和數個印尼島上的本屬種類。最近有得自菲律賓、印尼、泰國、緬甸和中國大陸 20 個省以上的大量標本，皆附有可靠的田野資料。兩位作者曾人工飼養數個種。最近數年，數種幼生期以前尚未瞭解的幼蟲曾被飼養，包括 *S. kohlli*, *S. tetrica*, *S. yayukae*, *S. vandenberghi* 和 *S. fulva*。本文是儘量設法將中國、日本、韓國和俄國文字記載的文獻加以整理，全部的傳記也包含歷史性的文獻，所有有關本屬的主要分類工作，以及許多非技術性的普及型書籍和文章，後者主要是有關於眉紋王蛾 *S. cynthia* 分佈於歐洲和美國的族群。作者們不採用三名的命名法規，並且對本屬許多的亞種理論提出反駁。

雖然迄今有關本屬的田野觀察報導仍頗少，但卻有許多不同語文撰寫的文獻報導有關本屬在實驗室裏的觀察記錄。作者們只提供了粗略的總論或簡要的提及這些項目，但是所附的參考文獻可激發讀者們進一步深入探討的興趣，其中包括身體的性質和絲的分子結構，滯育、細胞遺傳學、成蟲和幼蟲的形態、分

子基因、昆蟲生理學、不同寄主植物飼育的生長比較、交尾和產卵行為、吐絲行為和性費洛蒙的分子結構。

在人為控制下進行雜交實驗是研究鱗翅目的一項有趣項目，而且有很多工作已由業餘人士所完成。*S. cynthia* 已和 *Callosamia angulifera*, *C. promethea* 成功地雜交，生育出來的都是雄蟲而無雌蟲。其他屬間的雜交則無法養出成蟲。至於在 *Samia* 屬內各種之間已有許多雜交種曾被飼養和命名，這些資料已被使用在鱗片、繭色、幼蟲斑紋和滯育等遺傳機制的研究方面。本報告有一個統計表列出已曾做過雜交和基因互殖實驗的種類，並附有進一步研究的參考文獻目錄。

每種類皆製表列出所有已知在自然狀態下的寄主植物，並專門討論人工飼養時的注意要點和可替代的植物。本屬雖然在自然狀態下攝食許多種類寄主植物，但卻明顯地偏愛 Simaroubaceae 科 *Ailanthus* 屬的植物，和多種 Rutaceae 科、Euphorbiaceae 科和 Lauraceae 科植物(這類植物分佈於菲律賓、印度、日本、中國和印尼等地)。雖非全部，但 Oleaceae 科的 *Fraxinus* 屬、*Syringa* 屬和 *Ligustrum* 屬的某些植物種類卻是人工飼養幼蟲時的理想替代食物。會侵害本屬卵、幼蟲或蛹的寄生性昆蟲全部已知種類都有一個明列表。膜翅目中已知的寄生蜂類是小繭蜂科(Braconidae)、姬蜂科(Ichneumonidae)和小蜂總科(Chalcidoidea)中的幾個科。雙翅目中已知的寄生種類皆屬於寄生蠅科(Tachinidae)。寄生昆蟲的記錄主要是來自於被引入歐洲和美國的 *S. cynthia* 族群的觀察報導，但有些記綠則是來自於亞洲當地區的族群觀察。本屬(*Samia*)分佈在亞洲族群的重要寄生性昆蟲類是姬蜂科 *Xanthopimpla* 屬的種類，寄生於繭期；Euplemidae 科 *Anastatus* 屬的小型寄生蜂類是寄生於卵期；寄生蠅科(Tachinidae)有幾種是寄生於幼蟲，包括種類有 *Exorista sorbillans*, *Blepharipa zebina* 和 *Blepharipa sericariae*。本屬(*Samia*)幼齡幼蟲有時也會被小繭蜂科(Braconidae) *Apanteles* 屬群的種類所寄生。在天敵方面，已知有 Corvidae 科的幾種會捕食幼蟲和蛹。幼蟲織繭時會將繭很牢固地黏結在樹枝上。在日本東京、西班牙巴塞隆納、法國巴黎、維也納和美國某些城市都有鱗翅目學者報導過度採集本種的繭時，會導致族群的減少。

眉紋王蛾(*S. cynthia*)曾被引入世界上許多國家，主要時期是在 19 世紀下半世紀，引介的情況總是有計劃性地，且通常帶有一股建立當地絲織工業的熱情存在。這類引的族群迄今仍存在於 Slovenia、瑞典南部、澳洲、法國、義大利北部、日本、黑海區域和俄國，甚至於美國東北部的少數幾個城市(如紐約和費城)直到最近仍有這些引進族群的蹤跡。這些族群主要是活動於城市中心，而很少發現於鄉郊地區。眉紋王蛾在美國已幾近絕跡，雖然並無證據，但作者相信是一種寄生蠅 *Compsilura concinnata* 所造成的結果，這種寄生蠅是由美國農業部在 1906 年至 1986 年間不斷從歐洲引入北美洲，主要用來控制兩種蛾類(*Lymantria dispar* 和 *Euproctis chrysorrhoea*)，都是意外地從歐洲引入美國。某些地區雖然也曾引入眉紋王蛾，但卻未在當地建立起族群或已經絕滅的地區有：英國(Colchester)、柏林(德國)、西班牙(巴塞隆納)、澳洲(雪梨)、紐西蘭(奧克蘭)、

加拿大(多倫多)、烏拉圭、巴西，以及一些美國城市：聖路易斯市(密蘇里州)、匹茲堡市(賽夕維尼亞州)、新天堂市(肯內提卡州)、得坦市(俄亥俄州)。本種分佈範圍的限制因素之一是寒冷的天氣，這就是本種不分佈於波斯頓市、麻薩諸塞市等美國北部城市的原因，美國內陸某些城市(如匹茲堡市和聖路易市)則因不具有海岸城市比較溫暖的氣候而無本種蹤跡。作者針對各個國家有關本種的歷史、文獻和目前情況做了綜合性的介紹。

眉紋王蛾屬(*Samia*)屬於王蛾亞科(Saturniinae)Attacini 族。Attacini 族的其他屬包括分佈於亞洲地區的 *Archaeoattacus* 屬和 *Attacus* 屬(頗著名的 atlas 蛾類)，分佈於澳洲的 *Coscinocera* 屬，分佈於非洲的 *Epiphora* 屬，以及分佈於美國的 *Rothschildia*、*Hyalophora*、*Eupackardia* 和 *Callosamia* 等 4 個屬。最近利用電泳技術或分析粒腺體和 DNA 序列等技術，顯示眉紋王蛾屬(*Samia*)的近緣屬是 *Callosamia* 屬，該屬在北美洲東部地區分佈有 3 個種。眉紋王蛾屬(*Samia*)的系統發生在本書中做了某些詳細討論。至於命名方面，眉紋王蛾屬(*Samia*)的許多種類學名曾使用 *Philosamia* 這個屬名，實際兩者是同屬異名，皆源自於同樣的模式種名(*cynthia*)。惟使用 *Philosamia* 這個屬名是不正確的。在比較早期的文獻裏(尤其是在北美洲地區)，*Samia* 這個屬名則被誤用在現已知應為 *Hyalophora* 屬的北美洲某些種類上。

眉紋王蛾屬(*Samia*)許多種類的生物地理情況，頗符合種的形成和散播準則。眉紋王蛾屬(*Samia*)顯然是起源於亞洲地區，而非洲的 *Epiphora* 屬和北美的 *Callosamia* 屬則可能源自於類似眉紋王蛾屬(*Samia*)的祖先。最形態相似的種類是 *S. watsoni*，被認為是本屬殘存種類的姐妹種。在本屬(眉紋王蛾屬)中，種的形成主要是和島嶼的孤立和隔離有關聯。譬如在菲律賓群島、安得曼群島(Andamans)和西印度群島的小島上，每個島上都只有一個種類。比較大的島(如爪哇島和 Sulawesi 島則各分佈有 2 個種。且主要是特有種。爪哇島上的 2 個種可能是姐妹種(近緣種)，然而在 Sulawesi 島上的 2 個種則可能分別源自於不同的祖先。正如預料，分佈在菲律賓許多島嶼上的種類顯現出頗多的地理性變異。分佈在喜馬拉雅山區和東南亞大陸地區的其他幾個種也顯現出地理性的變異，因為不同山系造成族群之間基因互通的隔離。分佈在台灣的 2 個種皆廣泛分佈於中國大陸。

作者們希望藉由整理本屬的工作而澄清許多長期被誤導的問題，當作者們指出在那方面仍有待更多的研究和採集努力時，希望能激發更多的昆蟲學者們能進一步去發掘這些著名又美麗的蛾類的祕密。

翻譯：王效岳

シンジュサン属の総説

*Samia* Hübner ( ＝*Philosamia* Grote) シンジュサン属は、熱帯アジアの全長（横幅）6000km 以上の範囲に 19 種が知られている。それらの内の１種は人為的に飼育された種である。この大きく美しい蛾は、ヤママユガ科の中でも一番よく知られており、同好者の間でも親しまれている。以前は、属の模式種である *Samia cynthia* (Drury) の亜種とされていたものが、最近の文献では種に昇格されるようになった。生態、成虫および幼虫の形態、染色体数、地理的な分布などの違いにより、本属に多数の種が含まれていることが証明されている。それらの種の約半数は最近新種として記載されたものである。

本属の中で最もよく知られている *Samia cynthia* は普通 ailanthus silkmoths または cynthia moth と呼ばれている。この種の野生種は中国北東部の広い範囲に分布しているが、世界中の広い地域で知られている。それは、世界の多くの国に１８５８年から１８７０年の間に紹介され飼育が成功して広まったためである。本種の食樹はシンジュで、この中国原産の木は現在では世界のいろんな町に植栽されている。

旧北区に分布する３種のうち *Samia cynthia* の野生種は朝鮮と中国北部に分布し、*S. pryeri* (Butler)は日本固有、*S. watsoni* ( Oberthür)は中国の高地に分布する。

*Samia wangi* Naumann & Peigler は、中国の中部および南部とベトナムに産する。この種の主要な産地は熱帯で、旧北区の北部の範囲には産しない。*S. cynthia* と *S. wangi* の分類学上の関係は、難しく興味深い問題である。我々は、この２種の研究に対し中国の昆虫学者を奨励して生態や分布などの調査をすることを望んでいる。我々はこの２種が同所的に分布していないことや互いに交雑しないことを知っているが、いくつかの標本の同定には苦慮する。しかしながら *S. cynthia* と *S. wangi* のすべての個体群を論じるには、分布地域が広大で、しかも変異がよくわかっていない。なぜなら、両者の区別点は、雄交尾器と翅の色彩斑紋だからである。*S. wangi* の発生地は山地および山麓で、その点 *S. cynthia* は低地である。以前の文献で *S. wangi* は、*walkeri* と呼ばれたが、その名は後模式標本の交尾器を検した結果、*S. cynthia* のシノニムである。日本には *S. pryeri* が産する。*S. pryeri* は、以前は *S. cynthia* に含まれ、日本の多くの文献で *S. cynthia pryeri* として扱われてきた。*S. cynthia* は地色が金色をおびた黄褐色に変化するオリーブ色だが、*pryeri* では、地色がこげ茶色に変化するくすんだ茶色である。前翅翅頂付近の眼状紋は、*pryeri* の方が小さいこと、外横線の走り方に違いがあることが両者の区別点である。我々が検した標本と日本の文献を基に考えると、我々は北海道には分布していないと信じている。しかし、北海道のものはおそらく *cynthia* でもないと思う。

後の 15 種は、パキスタン、北インドからフィリピン、インドネシアを通りモルッカまで分布しているが、ニューギニアからは知られていない。美しい赤茶色の種である *S. canningi* (Hutton)は、パキスタン・ネパール・北インドなどヒマラヤの周辺に広く分布しており、南はタイ・ベトナムまで産する。マレー半島には、大型の *S. kohlli* Naumann & Peigler が産する。アンダマンには、*canningi* とよく似ているが、赤さび色の *S. fulva* Jordan が産する。*Samia ricini* （命名者不明）ヒマサン（＝エリサン）は、野生の分布はしられていない。交尾器の構造、斑紋のパターン、染色体数などは、*canningi* に由来すると思われる。ヒマサンと他の種の大きな違いは、ヒマサンは腹部が白色を呈するところである。この種は、研究者間の交流や分類学上の安定のためにカイコとクワゴ、イヌとオオカミのように別種としてあつかった方が便利だろう。我々は *ricini* の名の原記載を現在まで特定できていないのでその著者はあいまいになっている。*Ricini* の主食樹はヒマである。

ヒマサンはアッサムの主にブラマプトラ川流域で飼育されている。ヒマサンの絹糸の織物はエリ・シルク eri silk と呼ばれ、マルベリー・シルク mulberry silk（カイコガ）、中国のタッサー・シルク tussah silk（*Antheraea pernyi*）に次いで世界で三番目に重要な絹製品である。インドでは 1990 年代初めに年間 800 トンのエリ・シルクが生産され、タサール・シルク（タサールサン）の生産をしのぐ。ヒマサンは歴史的にはエジプト、レバノン、キューバ、ウルグアイ、フランス、マルタ島、イタリアで飼育されてきたが、現在ではブラジル、中国、日本、韓国、インド北部およびその周辺地域で飼育されている。本研究では、エリサンによる養蚕の文献を詳しく概観し、エリ・シルクで作られた織物をカラーで図示した。さらに、インド、中国および日本における、*Samia* 属の他種から作られた絹の歴史的な利用方法を議論した。

*Samia luzonica* (Watson) はフィリピンに広く分布する変異の多い種である。一方、*Samia treadawayi* Naumann はフィリピンのパラワン島の固有種である。*Samia tetrica* (Rebel)はマレーシア半島とボルネオ島で見られる。インドネシアでは、スマトラ島とジャワ島に分布し、よく知られている *S. insularis* (Snellen van Vollenhoven) に加えて、*S. abrerai* Naumann & Peigler がバリ島とジャワ島から、*S. vandenberghi* (Watson)と *S. peigleri* Naumann & Nässig がスラウエシ島から、*S. naumanni* U. Paukstadt, Peigler & L. Paukstadt がスラ諸島から、*S. naessigi* Naumann & Peigler がハルマヘラ島（モルッカ諸島北部）から、*S. yayukae* U. Paukstadt, Peigler & L. Paukstadt がティモール島とフローレス島（小スンダ諸島）から、*S. ceramensis* (Bouvier)がセラム島（モルッカ諸島中部）からそれぞれ発見されている。

19 種それぞれについて、タイプ標本の保管場所とラベルのデータ、同定に有用なオス交尾器の記載、検討した博物館所蔵標本のラベルのデータ、正確な分布域、網羅的なシノニムのデータおよびその他注釈を示した。また、計 19 のレクトタイプを定めた。検討材料は北アメリカとヨーロッパにあるすべての主要な博物館に収められている標本である。また、現存する有効名のタイプ標本と原記載を探索して検討した。450 枚の本属のオス交尾器のプレパラートを作成した。Naumann はミャンマー、タイ、マレーシア西部、アンダマン諸島およびインドネシアのいくつかの島で *Samia* を採集・観察した。信頼できる採集データのついた最近の標本を、フィリピン、インドネシア、タイ、ミャンマー、20 州以上の中国の標本から受け取った。数種については我々が飼育した。最近、*S. kohlli, S. tetrica, S. yayukae, S. vandenberghi, S. fulva* など、これまで幼生期が判明していなかった種が飼育されている。また、中国語、日本語、韓国語、ロシア語の文献も可能な限り示した。この網羅的な参考文献目録には、歴史的な文献、*Samia* 属を扱った全ての主要な分類学的研究、多量の一般向けの本や記事が含まれる。一般向けの文献は、主にヨーロッパやアメリカの *S. cynthia* に関係したものである。著者らは三語式の学名の使用を却下し、*Samia* 属における亜種概念の適用に対する意見を述べた。

*Samia* 属の野外での観察記録はほとんどないが、研究施設で実験動物として用いられた *Samia* については、様々な言語で書かれた多くの文献がある。著者らはこれらの話題についての簡単な要約や言及を行ったが、興味を持った読者のために文献目録に原典を示した。ここには絹の物性や化学構造、休眠、細胞遺伝学、幼虫および成虫の形態学、分子遺伝学、昆虫生理学、寄主植物による成長の比較、交配行動や産卵行動、吐糸行動、性フェロモンの分子構造などが含まれる。

人工交雑は鱗翅目の研究の興味深い側面であり、多くの研究がアマチュアによってなされている。*Samia cynthia* は *Callosamia angulifera* や *Callosamia promethea* と交雑可能だが、交雑個体は全てオスでメスは得られない。その他の属間交雑では交雑成虫は得られていない。*Samia* 属内の種間交雑では、多くの雑種が飼育され、名前がつけられている。交雑のデータは、鱗粉、繭の色、幼虫の斑紋、休眠などの形質の遺伝機構の研究に使用されている。属間および属内における既知の交雑の全リストを示すとともに、詳細に関する文献を示した。

自然状態における既知の食餌植物を各種について表で示した。また、飼育する際の必要事項や代用できる食餌植物について議論した。多くの植物が自然状態で用いられているが、ニワウルシ（シンジュ）属（ニガキ科）のほか、多くのミカン科、トウダイグサ科、クスノキ科を明らかに好むことがフィリピン、インド、日本、中国、インドネシアからの記録

から知られている。トネリコ属、ハシドイ属、イボタノキ属（モクセイ科）の数種は、飼育の際に良い食餌植物になる。卵、幼虫および蛹に攻撃する全ての既知の寄生性昆虫をあげた。既知の寄生性の膜翅目はコマユバチ科、ヒメバチ科とコバチ上科の数科である。寄生性の双翅目は、既知種のすべてがヤドリバエ科に属する。寄生の記録は主にヨーロッパやアメリカに移入された *S. cynthia* 集団からのものだが、アジアの自然集団からの記録もある。アジアにおける重要な *Samia* の寄生者は、繭を攻撃するフシヒメバチの仲間である *Xanthopimpla* 属（ヒメバチ科）、卵を攻撃する *Anastatus* 属（ナガコバチ科）、幼虫を攻撃するヤドリバエの数種で、ヤドリバエには *Exorista sorbillans* クワゴヤドリバエ、*Blepharipa zebina*、*Blepharipa sericariae* が含まれる。ヤドリバエはウジ・フライ(uzi flies)と呼ばれる。*Samia* の若齢幼虫は、しばしばコマユバチ科の *Apanteles* 属群の様々な種にも寄生される。捕食について、数種の鳥類（主にカラス科）が幼虫や蛹を食べることが知られているので示した。繭は開けた場所の木からぶら下がる。なぜなら、吐糸した幼虫は絹の帯によって枝と繭をつなぐからである。繭の乱獲による個体群の減少が、東京、バルセロナ、パリ、ウィーン、アメリカのいくつかの都市からそれぞれ報告されている。

*Samia cynthia* は世界に多くの国々に、主に 19 世紀後半に移入された。移入は意図的なもので、地元の絹工業を成立させるための熱狂的なものであった。移入された集団のいくつかは、スロベニア、スイス南部、オーストリア、フランス、イタリア北部、日本、グルジアやロシアの黒海周辺に残っており、ニューヨークやフィラデルフィアなどアメリカ合衆国北部でも最近まで残っていた。これらの蛾は主に都市中央部に固執し、郊外ではまれである。*Samia cynthia* はアメリカ合衆国ではほぼ絶滅したようである。証拠はないものの、我々は *Compsilura concinnata* ノコギリハリバエ（ヤドリバエ科）によって絶滅したと考える。ノコギリハリバエは、1906 年から 1986 年まで、アメリカ農業省によってヨーロッパからアメリカに移入されたハエである。このハエは、どちらもヨーロッパから偶然移入されてしまった *Lymantria dispar* マイマイガや *Euproctis chrysorrhoea* ドクガの一種をコントロールするために用いられた。*S. cynthia* が移入されたもの、土着しなかった地域、およびすでに絶滅した地域は以下のとおりである。イギリス：コンチェスター、ドイツ：ルール側流域、ベルリン、スペイン：バルセロナ、オーストラリア：シドニー、ニュージーランド：オークランド、カナダ：トロント、ウルグアイ：モンテビデオ、ブラジル：リオデジャネイロ周辺、アメリカ：ミズーリ州セントルイス、ペンシルバニア州ピッツバーグ、コネティカット州ニューハーベン、オハイオ州デイトン。限定要因の一つは低温耐性である。マサチューセッツ州ボストンのような北部の都市、ピッツバーグやセントルイスの内陸の都市のように温暖な沿岸気候ではない地域では集団が維持できない。移入の歴史、文

献、現状を国ごとに要約した。

*Samia* 属は Saturniinae ヤママユガ亜科、Attacini ヨナグニサン族に属する。ヨナグニサン族にはこのほか、*Archaeoattacus* 属および *Attacus* 属（巨大なことで有名なヨナグニサン）、オーストラリアの *Coscinocera* 属(hercules moths)、アフリカの *Epiphora* 属、アメリカの *Rothschildia, Hyalophora, Eupackardia, Callosamia* の 4 属が含まれる。最近の電気泳動による研究や、核およびミトコンドリア DNA 配列の解析により、*Samia* 属の姉妹群が *Callosamia* であることが明らかになった。*Callosamia* は北アメリカ東部から 3 種が知られる属である。*Samia* 属の系統関係について一部細部まで概説した。命名規約によると、*Philosamia* という属名は *Samia* 属の種に広く用いられていたが、この属は同じ種(*cynthia*)を模式種とする客観シノニム関係になっている。ゆえに、*Philosamia* は無効名であり、この名称を使うのは誤りである。初期の、特に北アメリカの文献では、*Samia* という名称が現在 *Hyalophora* 属として知られている北アメリカの種に誤って用いられていた。

*Samia* 属およびそれに属する多くの種の生物地理的な状態は、種分化と放散というモデルによく合致する。*Samia* 属は明らかにアジアが起源であり、アフリカの *Epiphora* 属と、北アメリカの *Callosamia* は *Samia* 属に近縁な祖先種から分化したものであろう。最も祖先的な種は *S. watsoni* で、本属の残りの種の姉妹種と推定されている。属内では、種分化は主に島嶼における隔離に関係する形で主に生じてきた。フィリピンのアンダマン諸島やインドネシア東部の小さな島々では、各島には 1 種しか見られない。しかし、ジャワ島やスラウエシ島のような大きな島では 2 種が分布し、その多くが固有種である。ジャワ島の 2 種は姉妹種と推定されるが、スラウエシの 2 種は異なる祖先から分化したのであろう。予想されるように、多くのフィリピンの島々で見られる 1 種は激しい地理的変異を示す。この他数種が地理的変異を示す。特に、ヒマラヤや東南アジアの大陸側など、山脈によって集団間の遺伝的浮動が妨げられた場所での変異が著しい。台湾の 2 種はどちらも大陸側の中国にも広く分布する。

我々はこの総説が *Samia* 属に関する積年の問題の多くを解決することを願う。また、さらなる研究と収集が必要であることを指摘し、この美しい蛾を含む有名な属について、他の昆虫学者が新たな発見が喚起されることを願う。

（日本語訳　岸田泰則　・　神保宇嗣）

# RÉSUMÉ

**Revision du Genre *Samia***

Le genre *Samia* Hübner (= *Philosamia* Grote) compte 19 espèces répandues principalement en Asie tropicale sur plus de 6 000 kilomètres. L'une de ces espèces est domestiquée et n'existe plus qu'en élevage. Ce groupe de beaux et grands papillons de nuit comprend quelques-uns des Saturniidae les plus connus et les plus recherchés des collectionneurs. La plupart ont été cités en littérature sous le nom de *Samia cynthia* (Drury) ou rapportés à des sous-espèces de ce dernier. Une étude récente de la biologie, de la morphologie des chenilles et de l'adulte, des chromosomes et de la répartition géographique a permis d'établir que le genre contient en fait de nombreuses espèces dont la plupart n'ont été décrites que dans les dernières années. La plus connue est *Samia cynthia*, appelé communément « ver à soie de l'ailante » ou cynthia. Cette espèce, originaire du nord-est de la Chine a été importée dans les années 1858 à 1870 dans de nombreux pays à travers le monde où elle s'est acclimatée et parfois répandue; elle vit sur l'ailante ou vernis du Japon, arbre lui même originaire de Chine et très implanté dans les régions urbaines.

Il n'existe que trois espèces paléarctiques, *Samia cynthia*, natif de Corée et de Chine septentrionale, *S. pryeri* (Butler), endémique au Japon et *S. watsoni* (Ch. Oberthür), vivant en Chine en haute altitude. *Samia wangi* Naumann et Peigler vole dans une grande partie de la Chine méridionale et au Vietnam; essentiellement tropical, il présente une extension de sa répartition en région paléarctique et la position relative en taxonomie de cette espèce et de *S. cynthia* pose un problème difficile mais intéressant, ici signalé aux entomologistes chinois dans le but de les inciter à se pencher sur la biologie et la répartition des deux espèces. Autant que nous le sachions celles-ci ne sont pas sympatriques et elles ne s'hybrident pas; même si certains exemplaires peuvent être difficiles à identifier, elles ne peuvent pas être considérées comme conspécifiques, en raison des différences observées dans la structure des armures génitales mâles et dans la forme des ailes. *Samia wangi* vit principalement en région montagneuse, alors que *S. cynthia* vole en plaine. Le premier a été incorrectement cité sous le nom de *S. walkeri* qui s'est avéré être un synonyme subjectif récent de *S. cynthia*, après examen des types des deux taxa et comparaison des armures génitales mâles des deux lectotypes. Il existe deux espèces au Japon, *S. pryeri* et *S. cynthia*, respectivement indigène et importée. La plupart des auteurs japonais ont cité l'une et l'autre sous le nom de *S.cynthia pryeri. S. cynthia* est vert olive et, fané, tend à jaunir, *S. pryeri* est brun terne et tend à foncer. La tache apicale de l'aile antérieure est plus petite chez *S. pryeri* et on note des différences dans la configuration de la rayure postmédiane chez les deux espèces. D'après le matériel examiné et les écrits des auteurs japonais, nous pensons que *S. pryeri* est absent d'Hokkaido, alors que *S. cynthia* y existe probablement.

Les 15 autres espèces sont tropicales, inféodées à la région biogéographique orientale, et répandus du Pakistan et du nord de l'Inde jusque aux Philippines et à travers l'Indonésie jusqu'aux Moluques mais n'atteignant pas la Nouvelle-Guinée. Le beau *Samia canningi* (Hutton), couleur cannelle, est variable et il est largement répandu avec une répartition qui tourne autour de l'Himalaya, puis s'étend du Pakistan à travers le Nepal et le nord de l'Inde, jusqu'au sud de la Chine et enfin en Thaïlande et au Vietnam. Le grand *S. kohlli* Naumann & Peigler et *S. canningi* sont sympatriques dans la partie sud-orientale de l'habitat de ce dernier dans la péninsule malaise. De couleur rouille *S. fulva* Jordan des Iles Andaman, dans le Golfe du Bengale, est un proche parent de *S. canningi.*

*Samia ricini* (Anon.) est une forme domestiquée, n'existant pas dans la Nature. D'après la structure des genitalia, la forme des ailes et le nombre des chromosomes cette espèce descend de *S. canningi*; son principal caractère distinctif est la présence sur l'abdomen de touffes de poils blancs qui chez certains individus vont jusqu'à faire paraître le corps entièrement blanc. Il est donné à *S. ricini* le rang d'espèce pour des raisons de convenance et dans l'intérêt de la stabilité de la nomenclature, par analogie avec d'autres formes domestiquées comme le ver à soie (*Bombyx mori*), issu de *B. mandarina* et le chien *Canis familiaris*, dérivé du loup (*Canis lupus*). L'auteur de la publication où *ricini* a été proposé originellement est resté anonyme. La plante nourricière usuelle de *S. ricini* est le ricin (*Ricinus communis*), et la région où l'élevage est le plus pratiqué est la vallée du Brahmapoutre en Assam. La soie obtenue est nommée soie eri ou soie endi; elle est économiquement la troisième en importance mondialement, après celle du ver à soie (*Bombyx mori*) et la soie tussah, produite en Chine par *Antheraea pernyi*. L'Inde produisait annuellement plus de 800 tonnes de soie eri dans les années 1990, dépassant la production de soie tasar (d'*Antheraea paphia*). *Samia ricini* a été élevé historiquement en Egypte, au Liban, à Cuba, en Uruguay, en France, à Malte et en Italie et l'est encore actuellement au Brésil, en Chine, au Japon, en Corée, et dans le nord-est de l'Inde et les contrées voisines. La littérature sur l'ériculture est passée en revue dans le présent ouvrage et des échantillons d'objets textiles à base de soie eri sont illustrés en couleur. L'usage fait historiquement de la soie produite par d'autres espèces du genre *Samia* est également relaté.

*Samia luzonica* (Watson) est une espèce variable trouvée abondamment aux Philippines où *Samia treadawayi* Naumann est endémique à Palawan. *Samia tetrica* (Rebel) vole en Péninsule malaise et à Borneo. Plusieurs espèces ont été découvertes en Indonésie dont *S. abrerai* Naumann & Peigler de Bali et Java, *S. vandenberghi* (Watson), *S. peigleri* Naumann & Nässig de Sulawesi, *S. naumanni* U. Paukstadt, Peigler & L. Paukstadt de l'Archipel de Sula, *S. naessigi* Naumann & Peigler d'Halmahera (nord Moluques), *S. yayukae* U. Paukstadt, Peigler & L. Paukstadt de Timor, Alor et Flores (Iles de Sunda), et *S. ceramensis* (Bouvier) de Ceram (Moluques centrales), en plus du bien-connu *S. insularis* (Snellen van Vollenhoven) de Sumatra et de Java.

Le traitement des 19 espèces indique le nom des collections où sont déposés les spécimens typiques et les données mentionnées sur les étiquettes de tous ces exemplaires. Il comprend une description détaillée de l'habitus et des armures génitales mâles (qui présentent de très bons caractères) et mentionne les données relevées sur les étiquettes des specimens examinés dans le musées; la répartition géographique de chaque espèce est brièvement analysée. Les synonymies sont citées exhaustivement et des remarques diverses sont exprimées. Le matériel conservé dans tous les principaux musées européens et nord-américains a été examiné. Les armures génitales d'environ 450 spécimens du genre *Samia* ont été étudiées avec chez le mâle des résultats très positifs. Naumann a récolté et observé les *Samia*, en Thaïlande, en Malaisie occidentale, dans les Iles Andaman, à Myanmar et dans plusieurs îles indonésiennes. Des exemplaires récoltés récemment et présentant des données géographiques fiables et précises ont été reçus en grande quantité des Philippines, d'Indonesie, de la Thaïlande et de Myanmar, ainsi que de plus de 20 provinces chinoises. Plusieurs espèces ont été élevées en captivité par les auteurs; les états préimaginaux de plusieurs d'entre elles étaient jusqu'ici inconnus, dont ceux de *S. kohlli*, *S. tetrica*, *S. yayukae*, *S. vandenberghi* et *S. fulva*. Un effort a été fait pour citer et utiliser le plus largement possible la littérature en langage chinois, japonais et coréen. La bibliographie exhaustive comprend également la littérature ancienne, tous les travaux de taxonomie importants relatifs au genre *Samia* et de nombreux ouvrages non techniques de littérature populaire, ainsi que les articles publiés sur *S. cynthia* en Europe et aux États-Unis. Nous avons rejeté l'usage de la nomenclature trinominale, en justifiant cette prise de position par les arguments qui concluent à l'inadéquation du concept de sous-espèce au genre *Samia*.

Alors que les observations sur le terrain n'ont fait l'objet que de très peu de publications, il existe une importante littérature en de nombreuses langues témoignant de l'usage des *Samia* en laboratoire. Nous donnons des aperçus de ces divers travaux vers lesquels la bibliographie orientera les lecteurs que les sujets traités pourront intéresser. Parmi eux les recherches sur les propriétés physiques et la structure moléculaire de la soie, la diapause, la cytogénie, la morphologie aux stades adultes et préimaginaux, la génétique moléculaire, la physiologie de l'insecte, la croissance comparée sur diverse plantes hôtes, le comportement sexuel, l'élaboration du cocon, la structure moléculaire des phéromones.

L'hybridation en captivité est un des aspects intéressants de l'étude des Lépidoptères et beaucoup du travail dans ce domaine est l'œuvre d'amateurs. *Samia cynthia* a été croisé avec succès avec *Callosamia angulifera* et *Callosamia promethea*; il n'a été obtenu que des mâles. Les autres croisements intergénériques n'ont produit aucun adulte. Les croisements entre espèces du genre *Samia* ont donné de nombreux hybrides qui ont été élevés et nommés. Les données obtenues à partir de ces expériences ont servi à l'étude du mécanisme de l'hérédité dans des domaines tels que la modification de la structure des écailles, la coloration des cocons, l'ornementation des chenilles et la diapause. Une liste des hybrides, inter- et intragénériques, obtenus a été établie avec les références correspondantes en littérature pour plus de détails à cet égard.

Les plantes hôtes en nature sont indiquées pour chaque espèce, ainsi que les plantes de remplacement pouvant être offertes en captivité. Quoique beaucoup de plantes hôtes soient utlilisées en nature, on constate une préférence évidente pour les divers *Ailanthus* (Simaroubaceae) et différentes Rutaceae, Euphorbiaceae et Lauraceae, parmi celles répertoriées des Philippines, de l'Inde, du Japon, de la Chine et de l'Indonésie. Plusieurs mais pas tous les frênes (*Fraxinus*), lilas (*Syringa*) et troènes (*Ligustrum*) peuven être acceptés en captivité. Tous les parasites connus pour s'attaquer aux œufs, chenilles et chrysalides sont cités. Les Hymenoptères parasites appartiennent aux Braconidae, aux Ichneumonidae et à plusieurs familles de Chalcidoidea. Tous les Diptères parasites sont des Tachinidae. La plupart des données ont été obtenues de populations de *S. cynthia* en Europe et aux États-Unis mais certaines sont à rapporter à des populations asiatiques. Les principaux parasites de *Samia* en Asie sont des *Xanthopimpla* (Ichneumonidae) qui s'attaquent aux cocons, des petites guêpes du genre *Anastatus* (Eupelmidae) qui infestent les œufs et quelques Tachinidae connues sous le nom de mouches uzi (*Exorista sorbillans*, *Blepharipa zebina* et *B. sericariae*) qui se développent sur les chenilles. Les jeunes larves de *Samia* sont également parasitées en Asie par des Braconidae du groupe-genre *Apanteles*. Parmi les prédateurs sont à mentionner les oiseaux, surtout des Corvidae connus pour manger les chenilles et les chrysalides. Les cocons pendent des arbres, attachés par la chenille à une branche par un long cordon soyeux, et sont ainsi très visibles, d'où le constat de populations menacées par les prélèvements des lépidoptéristes à Tokyo, Barcelone, Paris, Vienne et certaines villes des États-Unis.

*Samia cynthia* a été introduit dans de nombreux pays à travers le monde, surtout pendant la dernière moitié du dix-neuvième siècle. Cette introduction fût toujours intentionnelle et faite dans l'enthousiasme dans l'espoir de créer une industrie de la soie. Quelques populations issues de ces tentatives d'acclimatation ont subsisté en Slovénie, Suisse méridionale, Autriche, France et Italie du nord, autour de la Mer Noire en Géorgie, au Japon et encore récemment dans quelques villes des États-Unis, dont New York et Philadelphie. L'espèce vit essentiellement dans les zones urbaines et est rarement vue en région rurale. Elle est presque éteinte aux États Unis; bien que le fait reste à confirmer, nous pensons que cette diparition est imputable à l'introduction d'Europe, entre 1906 et 1986 de *Compsilura concinnata* (Tachinidae) par l'US Department of Agriculture, principalement pour contrôler la prolifération des "Liparis", *Lymantria dispar* et *Euproctis chrysorrhoea* (le cul-doré), tous deux importés aux États-Unis. D'autres introductions ont eu lieu, sans que *S. cynthia* se soit établi, ou dans des agglomérations où il a diparu, comme à Colchester, en Angleterre, la Ruhr et Berlin, en Allemagne, à Barcelone, Sidney, Auckland, Toronto, Montevideo, près de Rio de Janeiro et aux États Unis, à Saint Louis (Missouri), Pittsburgh (Pennsylvanie), New Haven (Connecticut), Dayton (Ohio). Un des obstacles à la prolifération de l'espèce est le froid hivernal qui explique qu'elle n'ait pas résisté à Boston (Massachusetts) et dans les villes de l'intérieur comme Pittsburgh et Saint Louis qui ne bénéficient pas du climat marin. Nous avons relaté, pays par pays, l'histoire, de toutes ces introductions, cité la littérature qui s'y rapporte et rendu compte de leur état actuel.

*Samia* appartient à la tribu des Attacini dans la sous-famille des Saturniinae. Les autres genres inclus dans les Attacini sont les genres asiatiques *Archaeoattacus* et *Attacus* (où entrent la plupart des plus grands Lépidoptères), le genre australien *Coscinocera* (autres espèces géantes), le genre africain *Epiphora* et les quatre genres américains *Rothschildia*, *Hyalophora*, *Eupackardia* et *Callosamia.* Les études utilisant les techniques récentes (électrophorèse, analyse de l'ADN) confirment que le groupe-frère de *Samia* est le genre *Callosamia* qui comprend trois espèces du nord-est des États-Unis. La phylogénie du genre *Samia* est revue à la lumière des données nouvelles. Le genre *Philosamia* Grote 1874 a été longtemps utilisé en littérature pour les espèces ici étudiées, alors que, dans le même temps *Samia* était adopté à tort pour les espèces américaines du genre *Hyalophora*. *Philosamia* qui est un synonyme objectif récent de *Samia* Hübner [1819], les deux genres étant fondés sur la même espèce type *Phalaena cynthia* Drury, est, de ce fait, inutilisable. *Desgodinsia* Ch. Oberthür 1914 est un homonyme récent de *Desgodinsia* Senna 1894 (Coleoptera); la création d'un nom de remplacement serait inutile, *D. watsoni*, espèce type du genre et *Samia cynthia* étant congénériques.

La répartition géographique du genre *Samia* et de ses membres se présente comme un bon modèle de spéciation et de dispersion. *Samia* est apparemment d'origine asiatique et dérivé du genre africain *Epiphora*. Et le genre nord-américain *Callosamia* est lui-même probablement dérivé d'un ancêtre proche de *Samia*. L'espèce la plus plésiomorphe est *S. watsoni*, considéré comme l'espèce-sœur du reste du genre. Au sein de ce dernier la spéciation a résulté principalement de l'isolement insulaire. Les Philippines, les Andaman et les petites îles de l'Indonésie orientale ne comptent qu'une seule espèce dans chaque île. Les îles plus grandes comme Java et Sulawesi abritent chacune deux espèces, principalement endémiques. Les deux espèces javanaises peuvent être considérées comme espèces-sœurs mais les deux représentants du genre à Sulawesi paraissent dérivés d'ancêtres séparés. Comme on pouvait le prévoir l'espèce rencontrée dans de nombreuses îles des Philippines est géographiquement très variable. Plusieurs autres espèces présentent des variations géographiques, notamment celles vivant dans l'Himalaya et le sud-est asiatique continental où le relief est facteur d'isolement génétique. Les deux espèces habitant Taiwan sont largement répandues en Chine continentale.

Nous souhaitons que cette révision apporte des réponses aux nombreuses interrogations que l'on se posait depuis longtemps au sujet du genre *Samia,* et surtout qu'en mettant l'accent sur les points qui restent à approfondir et demandent davantage de récoltes, ce travail incite les entomologistes à élargir leurs investigations, dans la perspective de nouvelles découvertes sur ce genre asiatique justement attractif de beaux papillons nocturnes.

Traduction française par Claude LEMAIRE

# INTRODUCTION

Moths of the genus *Samia,* sometimes called crescent moths, are some of the largest and arguably among the most beautiful of all moths in the world. They have long been favorites with those who collect and rear Lepidoptera. They have been hybridized with frequent success, providing scientific information and mere enjoyment to those who carried out the hybrid crosses. Because a freeze-tolerant species, *Samia cynthia*, was introduced to and became established in Europe and North America more than 140 years ago, the genus is routinely included in popular-level entomological books, and thus has become known to thousands of entomologists and laypersons outside of Asia where the moths are native. Another tantalizing aspect of the introduced populations is their association with a venerable "weed" tree, the ailanthus or tree-of-heaven, both the moth and the tree being noteworthy because they have been urban dwellers in places like New York City and Paris.

Simply stated, the distribution of *Samia* is East Asian. It ranges along the Himalayas from Pakistan to Vietnam, covering all of tropical southeastern Asia, but not far southward into peninsular India. In China it ranges in the eastern half of that vast country, but mainly the eastern third. It reaches into the Palaearctic territory of Korea, Japan, and northeastern China, but not far eastern Russia. The genus ranges in all of the Philippines and almost all of Indonesia, except for Irian Jaya (western New Guinea), this latter zone being part of the Papuan subregion of the Indo-Australian region. Thus, biogeographically the genus can be described as covering virtually all of the Oriental region and an eastern section of the Palaearctic region. With the exception of one Japanese species and two Chinese species, the other species are all tropical or subtropical, and have little or no tolerance for freezing temperatures.

*Samia* have been considered to have value to humans because they are often reared in laboratories where studies are done on insect physiology and genetics. More significantly, at least four of the species have been exploited for the silk that their cocoons contain. The usage of silk of species in India, Japan and China is a small part of the cultural heritage of those countries. Eri silk is produced in several Asian countries and accounts for millions of dollars in foreign exchange currency for the countries that produce and market it. Most eri silk is produced in northeastern India; the majority is used locally, including in neighboring Bhutan.

This revision is necessary because of the current taxonomic confusion that persists about the genus. Eight new species have been described in the past ten years. The following authors stated or at least implied that a modern taxonomic revision was needed for this genus: Ferguson (1972), Lemaire (1978), Holloway (1987), Pinratana and Lampe (1990), Allen (1993), Paukstadt et al. (1993, 1995, 1998), Tuskes et al. (1996), and Nässig et al. (1996a). Stone (1991) confounded most of the hostplant records under the umbrella of "*S. cynthia* ssp." but in the absence of a modern revision, such a treatment was perhaps his best option.

A study of the present scope would not have been possible ten years ago. Recent intensive collecting in Indonesia and the Philippines has made available a lot of new material. Equally significant, Chinese field collectors are now making insect specimens available on the market from many areas of China. Visits by Peigler to The Natural History Museum in London and the Muséum National d'Histoire naturelle in Paris in 1995 and to the National Museum of Natural History (Smithsonian Institution) in Washington in 1996 were disappointing in particular regard to the *Samia* those great collections held from mainland China. Although hundreds of pinned specimens from China were found, the majority consisted of series labeled simply as coming from Peking [Beijing] or Shanghai, with smaller lots labeled Hong Kong, Szechwan [Sichuan], and Ning-po [Ningbo]. Thus much of the material from China available in western collections represented just a few sources that are urban centers and/or on the East Coast. Fortunately, the problem was rapidly solved; in the past few years Naumann received hundreds papered specimens of *Samia* from most of the Chinese provinces where the genus occurs, providing a concise picture of what the species are and where they occur. Regarding the material available to us collected in the far flung regions of Indonesia, virtually none of it was available in western collections until the last decade. Naumann's study of Chinese Saturniidae has resulted in the discovery of several new species (e.g. Naumann 1998a, Naumann & Bouyer 1998, Naumann 2001, Naumann & Kishida 2001).

As far as possible, we were also able to clarify if not solve existing taxonomic problems for *Samia* in other parts of its range. The taxonomic situation for the Philippines and Indonesia is now fairly clear, except that additional material for study from eastern Indonesia is desirable. Likewise, the main questions pertaining to India, Japan, Taiwan, Thailand, and West Malaysia have been answered to our satisfaction. However, the area comprising tropical southeastern Asia (Xizang, Yunnan, Guangxi, Sichuan, Guangdong, Vietnam, Myanmar [formerly Burma], Laos, and Cambodia) is still somewhat confusing, and we hope that future workers will carry out additional studies on those populations to solve some of the remaining problems.

Our synonymies are exhaustive, so that it is possible to see virtually every name under which a particular

species has appeared in the literature, the generic combination for each name, and how widely or rarely each name has been published. In the study of Lepidoptera, there has always been broad overlap of the recreational activities of amateurs and the technical research by professionally trained entomologists. A concerted effort has been made in this revision to cite and utilize literature published in Korean, Chinese, Japanese, and Russian, as well as works in English by Indian authors. We have endeavored to cite all of the pertinent historical literature; we have also cited as far as possible most of the classic and some of the current literature that would be considered popular-level and non-technical, since advanced entomologists are almost always first exposed to these latter works. Indeed, sometimes it is the powerful illustrations in books rather than the organisms themselves that spark one's interest in a taxonomic group. Peigler's first introduction to *Samia* was in 1958 in a little book by Zim and Cottam (1956), followed by Mitchell and Zim (1964), and later in others he borrowed from public and school libraries including Teale (1945), Swain (1955), Lutz (1935), Robertson-Miller (1912), Holland (1917), and in 1966 he had his first look at exotic saturniids in Werner (1956). Naumann's introduction to *Samia* and other Saturniidae was through books by Staněk (1975, 1977a) and Rein and Zech (1967). By contrast, Claude Lemaire (personal communication to Peigler, 26 January 2002) wrote that during his childhood "*Samia cynthia* certainly much contributed to my interest in Saturniidae.....*Samia cynthia* (and *Saturnia pyri*) occurred in the garden of my family countryhouse at Champigny-sur-Marne near Paris, and I used to rear it every year until the Second World War."

Mislabeled material can always detract from the value of a major taxonomic revision, especially since such errors become perpetuated in literature for a long time. In the revision of *Attacus* by Peigler (1989), a genus related to *Samia* and ranging over much of the same area, several label data that were cited are now known to be erroneous. Examples include the citations of *Attacus caesar* from Palawan, *A. wardi* from Queensland, and *A. aurantiacus* from Vogelkop, New Guinea. A more recent record of *A. atlas* from Sumbawa is now known to be wrong, and unfortunately was published too hastily without verification. We do not believe the recent report (Fukuda 2001) of *Archaeoattacus edwardsii* (White) from Borneo to be correct; it is yet another example of material mislabeled accidentally by carelessness, or by intent to increase market value. We have been careful to watch for the possibility of mislabeled material of *Samia*, and report it herein with appropriate skepticism or rectification. For example, Bouvier's *manillensis*, purported to be from Manila (Philippines), is an obvious *S. canningi* from the Himalayas. Some commercial collectors and dealers impede our knowledge by intentionally or inadvertently mislabeling specimens, leading to erroneous records that become entrenched in the literature.

One long-held concept for *Samia* is that all of the named taxa are really subspecies or varieties of a single species, namely *Samia cynthia*. Workers including Hans Rebel, Eugène-Louis Bouvier, Adalbert Seitz, and J. Henry Watson all published several papers on *Samia*, but were adamant in their views that all forms belong to *S. cynthia*, whilst placing *S. watsoni* in a separate genus. This archaic concept has been viewed as ostensibly false in the past 50 years by most authors, although a few Indian (Arora & Gupta 1979), American (Collins & Weast 1961, Ferguson 1972) and British (Watson & Whalley 1975, Gardiner 1982, Baxter 1992) authors persisted in the notion that the genus contains just one wide-ranging and variable species, instead of several species. Werner (1956), whose widely known, popular-level book has appeared in German, French, and several English editions, actually referred to three different species (*canningi*, *cynthia*, and *ricini*) in a brief paragraph of text for *Samia cynthia*. Ironically, some of the *earliest* authors were explicit in their writings that they considered the genus to contain more than one species, as for example Guérin-Méneville (1860a) who wrote about *S. ricini*, *S. cynthia*, and *S. insularis*. Confusion of the species has led to confusion of the silks. Many authors (i.e., Seitz 1928) referred to silk of *S. cynthia* as eri silk, but the two silks have a quite different history of exploitation, as we discuss later. With the recent realization that more than one species of *Samia* co-exists at single localities in West Malaysia, Java, and Sulawesi, to name a only few, the notion of subspecies in *Samia* has become impossible to support.

The concept of subspecies, and therefore the use of trinomials in nomenclature, dominated systematics during the twentieth century. Whenever two closely related species were found to be allopatric, they were routinely assumed to be subspecies. In the Saturniidae, trinomials were made fashionable toward the end of the nineteenth century by Lionel Walter Rothschild (1868-1937), who specialized in birds and showy groups of Lepidoptera (Arctiinae, Saturniidae, Sphingidae, and Papilionidae). Judging from the comments by Munroe (1955), Dr. Rothschild was strongly influenced to accept subspecies by his cohort Karl Jordan (1861-1959). In a brief taxonomic discussion on the genus *Samia*, Rothschild (1895: 37) complained that Hampson (1892) was rejecting trinomials, suggesting that he contributed to the taxonomic confusion by refusing to recognize subspecies. Birds are highly mobile organisms, often occurring as allopatric populations, and therefore are often treated as subspecies, which some consider geographical races, but this approach is in fact also losing ground among today's ornithologists. The American ornithologist Ernst Mayr was a dominant figure in biosystematics study and thinking during much of the twentieth century, and no doubt contributed greatly to the widespread

employment of the subspecies concept for many animal groups by taxonomists. For the order Lepidoptera, the great series edited by Adalbert Seitz (1860-1938) entitled *The Macrolepidoptera of the World* (Die Gross-Schmetterlinge der Erde; Les Macrolépidoptères du Globe) made full use of trinomials, as parts were continuously published during the first half of the twentieth century, and consequently it had a major impact on taxonomic thinking and practices (see Peigler & Classey 2000).

In their classic treatise on American Papilionidae, Rothschild and Jordan (1906: 428-432) laid out their rationale for employing the concept of subspecies, some of which has merit, but those authors clearly stated their belief that subspecies are incipient species. On the contrary, we believe that the subspecies concept has hindered the knowledge of Saturniidae by forcing taxonomists to view allopatric populations in a restricted way, resulting in classifications that neither reflect the phylogeny of a group nor the current status of various taxa. An insightful essay on this matter was offered by Oberprieler (1988), and another instructive discussion pertaining to the species concept was published by Lödl and Arenberger (1994). Incidentally, the biological species concept, relied on so heavily by Tuskes et al. (1996) in their treatment of Nearctic Saturniidae, has also lost ground in modern systematics; much of the theory and methodology employed by Tuskes et al. was characterized as "long-outdated Mayrian evolutionary taxonomy" by Goldstein (1997) in his review of their book. Certainly the application of trinomials (and implicitly the subspecies concept) has reached ridiculous levels in the taxonomy of butterflies (Rhopalocera) by lepidopterists. Roepke (1932) illustrated almost 250 Javanese butterflies and cited *all* of them by trinomial names. Four "subspecies" of the European saturniid *Graellsia isabellae* (Graells) have been named, in addition to the nominotypical one, all illustrated in color by Rougeot & Viette (1978), yet Ylla (1997) did not accept any infraspecific taxa in his definitive treatise on that species. In the present revision of *Samia*, both authors are in full agreement that attempts to apply subspecies (trinomials) and the biological species concept would contribute nothing to our understanding of the taxonomy of this moth group. Pinratana and Lampe (1990: 32) and Oberprieler (1995) also rejected subspecies in their books on Saturniidae. Covell (1984: 27) cited almost no subspecies among the hundreds of moth species treated in his field guide. In the checklist of European Lepidoptera edited by Ole Karsholt and Józef Razowski, names for subspecies were not included (Schintlmeister 1996). World catalogs for other major groups of moths by Poole (1989) and Scoble (1999), for Noctuidae and Geometridae respectively, treated trinomials as synonyms. These trends suggest that the subspecies concept is finally undergoing a demise within taxonomy of Lepidoptera, especially for moths, both as a nomenclatural tool and to attempt understanding of the actual organisms, i.e., subspecies are not incipient species. However, one final point that we wish to add here is that we believe the contributions by Ernst Mayr to evolutionary biology are considerable, and largely valid. In this work we cite certain ideas from a recent edition of one of his classic books (Mayr 1999).

A further taxonomic problem infecting the literature on *Samia* is that the incorrect generic name *Philosamia* has been commonly applied, again by visible workers on the genus such as Rebel, Bouvier, Watson, and others. Nowadays, some workers persist in using that wrong name in their publications, and there appears to be no interest by some authors in correcting the problem. It is ironic that many researchers in sericulture and applied entomology will expend so much time and energy investigating their study animals (often a single species), but fail to be certain that they are using the correct scientific names for them in their publications.

While the above two problems pertaining to the nomenclatural history of *Samia* are frustrating, we accept the fact that many synonyms have been generated by amateurs who proposed names for minor variations (geographical, or occurring within single populations) and aberrations. This is more or less inevitable among showy Lepidoptera, and will remain a problem as long as taxonomy is "democratic." In contrast to this situation, we find "professional" workers like Bouvier who showed misunderstanding or no understanding of the purpose of scientific names, namely that they are supposed to represent populations of real organisms so that we can communicate effectively and make predictions about them. Bouvier would often take a single specimen and record how it differed phenotypically from other individuals, and then propose a new name for the single specimen. In this manner, he proposed hundreds of names, affecting most genera of Saturniidae, of which only a small percentage represents valid taxa, the others being synonyms that other authors must contend with long into the future. Although the International Code of Zoological Nomenclature does not require that names proposed for hybrids and infrasubspecific names such as forms and aberrations (many of them quadrinomials) be treated in a revision, we have dealt with them nonetheless, in an attempt to account for all names proposed in the genus *Samia*. Such names have no standing in formal taxonomy; they are unavailable for taxonomic usage, and their type specimens, if any were designated, are not valid in the sense of the Code (Code 1999, Articles 10.2 and 45.5). Still, these names occasionally appear in the literature or on labels of specimens in collections, and we intend that this revision should be a source for finding the answer to what the original authors of those names intended.

All of the aforementioned remarks should leave no doubt that a taxonomic revision of the genus *Samia* is

sorely needed, and we believe that our work presented herein, despite its many shortcomings, will be a major step forward in the knowledge of this intriguing and popular group of beautiful moths.

To conclude this introduction, we wish to offer some comments pertaining to conservation and deforestation in Asia. During recent decades the tropical rainforests of the world have been disappearing at a rapid rate, mainly due to lumber industries and the human population explosion. This worldwide devastation has had severe ecological consequences globally, such as the effects of "El Niño" a few years ago. We now hear reports of "Asia's brown cloud," caused by air pollution on a massive scale, which will lead to acid rain that will damage forests. Especially in the main range of most *Samia* species, the tropical and subtropical areas of Southeast Asia, heavy deforestation proceeds with more and more human settlements, as Naumann has observed firsthand on several expeditions. Those effects could particularly be seen during his visits to Sulawesi in the same areas in subsequent years, but also on separate visits on the Indonesian islands of Java, Bali, Lombok, Peleng, Sanana, Ambon, Halmahera, as well as in West Malaysia, Thailand, Myanmar, in southern parts of India including the Andaman Islands, and Sri Lanka. Focussing on Indonesia (because it was visited most often, not because the situation in the other mentioned countries is any better), several aspects need to be emphasized.

Firstly, not all areas which are without forests today, had forests in the historical past. Wallace (1869) reported in the Gilolo chapter of his famous book *The Malay Archipelago* on the grasses in lowlands around that small village; seen today, one would immediately assume that recent deforestation had occurred, but it was the same situation more than 100 years ago. Needless to say, nevertheless, much lumbering is now done on Halmahera. During Naumann's expedition in 1997 most larger dipterocarp trees were cut in the rainforest of the northwestern part, followed by small, privately managed agricultural plots, and from sunrise to sunset the sound of power saws was heard from the forest. Secondly, in a volcanic region like Indonesia, huge catastrophes happen occasionally that influence the ecosystem of not only but mostly that area. For example, we could mention the eruption and destruction of Pulau Krakatau [=Krakatoa] in 1883 (Whitten et al., 2000: 343 ff.) which devastated the flora and fauna of the small island itself and the nearby coastal areas of Sumatra and Java; similar effects, although not so extreme, have happened with other volcanoes in Indonesia and the Philippines, in historical times. Such events present possibilities to study the reorganization of an ecosystem and the recolonization by plants and animals (see also our discussion under *Samia insularis*). However, as Whitten et al. (2000: 346) wrote, "It may well take a thousand years or more before the forest on Krakatau becomes properly mature but, at the present rates of destruction, there is no evidence to suggest that a pool of 'parent' primary lowland forest trees will exist anywhere in Lampung, South Sumatra or West Java in even 100 years time." Again, all this should not detract from the fact that most deforestation is man-made. Detailed discussions can be found in the several volumes of *The Ecology of Indonesia Series*, e.g. Whitten et al. (1997, 2000). Although there are several conservation projects in that country, the threats are described in detail by Whitten & Whitten (1992: 21 ff.): first the big lumber companies build the access roads to the remote areas, then the following people cut the first pockets, and eventually the first settlements grow faster and faster. Unfortunately, there is a huge demand for such timber in industrialized countries like the United States and Japan, and ones in Europe.

What does all this mean for studies of tropical silkmoths? On the one hand, there are the changes of habitats, but on the other hand, the conditions generally unrecognized as favorable to survive as a tropical silkmoth. Some of the Saturniidae are accustomed to fruit trees, some kinds of which are introduced to islands from far away; e.g. *Samia insularis* sometimes was found to be a pest in tea plantations in Java, and certain species of Saturniidae have increased, based on captures at lights during recentmost years in Sulawesi, especially in rural garden areas where they were nearly unknown in former times or in more remote areas (e.g. *Antheraea rosemariae* Holloway, Nässig & Naumann). *Cricula trifenestrata* (Helfer) is a pest in many fruit tree plantations (Naumann 1995). Nässig et al. (1996a) mentioned for the Saturniidae of Sumatra different grades of "Kulturfolgerstatus." On the other hand, there are the more specialized species, probably mainly from the remote areas at higher altitudes like *Samia peigleri* or *Samia watsoni* which are probably more subject to habitat destruction, and thus more likely to become extinct due to human deforestation. Generally, not enough is known about ecology of Saturniidae in the tropics to predict the consequences of habitat alteration on their continued existence. Related discussions will be found below in the section on ecology and rearing.

**Literature Review**

Literature on the Lepidoptera is voluminous, and there are thousands of papers and more than two dozen books dealing particularly with Saturniidae, popularly known as wild silkmoths, giant silkworm moths, royal moths, and emperor moths. A brief review of some of the classic literature on Saturniidae was presented by Peigler (1989: 3-5), of which an abridged and updated account is given here. Some authors (Werner 1956: 121; Oberprieler 1995: 2; Lemaire & Minet 1999: 337) have stated that the family Saturniidae takes its name from Saturn, the ringed planet, because the eyespots on the hindwings of many saturniids are surrounded by concentric

rings. We offer a different opinion about the origin of the name Saturniidae. Since the family name is derived from *Saturnia*, the question should be "What is the origin of the generic name?" It was proposed by German botanist Franz Paula von Schrank in 1802. Rougeot (1971: 81) wrote that Saturn was the surname of Juno, the mythological Roman goddess, who was accompanied by a peacock [in Rougeot's words: "nommé d'après le surnom de JUNON qu'un Paon accompagnait."]. Peacock is part of the vernacular names in several languages of the three European species of *Saturnia*. Juno (Hera to the Greeks) was the daughter of the Titan named Saturnus (Kronos to the Greeks), the ancient Roman deity of sowing and harvesting (agriculture). The connection between peacock and Saturn is therefore tenuous, and it may be impossible to know Schrank's reasoning. We suppose that the origin of the name *Saturnia* is simply one more example of naming these moths after mythological personalities with no particular appropriateness, in this case Saturnus. The planets in our solar system were *also* named after mythological figures.

Several works have been published in the years since Peigler's (1989) summary of literature on Saturniidae. Foremost among these are generously illustrated works by Oberprieler (1995) on African Saturniidae, D'Abrera (1995, 1998) on the world saturniid taxa, and Lemaire (2002) on the Hemileucinae. Lemaire's earlier revisions covered the American subfamilies Arsenurinae (1980) and Ceratocampinae (1988), and the American representatives of the Saturniinae (=Attacinae) (1978). Cody's (1996) wonderful paintings of living saturniids provide welcome relief from the pinned specimens shown in virtually every other book. Several publications on Chinese Saturniidae have appeared during the past 20 years in journals and in books that are parts of faunal series, co-authored by Zhu Hongfu (Hong-Fu Chu) and Wang Linyao (L.-Y. Wang), which we cite throughout this revision (Zhu & Wang 1982, 1983, 1993, 1996). In his preface to Lemaire's (2002) latest revision, Dan Janzen wrote a colorful essay on the value of Saturniidae to scientists and naturalists alike, as well as some biographical points about Lemaire himself. The high quality of research and presentation in works by Ferguson (1972) on Nearctic saturniids, Wolfe (1993) on Mexican *Copaxa,* and Ylla (1997) on *Graellsia isabellae,* sets a standard that is difficult to match. On the other hand, a recent checklist to African Saturniidae, unfortunately containing lectotype designations and misspellings, is an example of how dismal the final product can be when one rushes and self-publishes. Unfortunately, some other works by recent authors in Europe, Asia, Africa (Natal), and North America are poor in terms of their taxonomy, but it can be said that our knowledge of the Saturniidae continues to accumulate rapidly, and those who attempt to acquire a complete collection of books and monographs on these splendid moths will find the task increasingly expensive and challenging.

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# MATERIALS AND METHODS

**Collections Consulted**

The following institutional collections were consulted for the present study. Most were visited by one or both authors, but we did not have the opportunity to visit the institutions in Japan, Australia, China, and Scandinavia. Photographs or loans of important specimens were sent by curators of those collections.

AS - Institute of Zoology, Academia Sinica, 19 Zhongguancun Lu, Haitien, Beijing, People's Republic of China

AMNH - American Museum of Natural History, Department of Entomology, Central Park West at 79th Street, New York, New York 10024

ANIC - Australian National Insect Collection, CSIRO Entomology, P. O. Box 1700, Canberra, A.C.T. 2601, Australia

BMNH - The Natural History Museum [formerly British Museum (Natural History)], Department of Entomology, Cromwell Road, London SW7 5BD, England

CMNH - Carnegie Museum of Natural History, Section of Invertebrate Zoology, 4400 Forbes Avenue, Pittsburgh, Pennsylvania 15213

DEI - Deutsches Entomologisches Institut im Zentrum für Agrarlandschafts- und Landnutzungsforschung (ZALF), Schicklerstraße 5, D-16225 Eberswalde, Germany.

DMNS - Denver Museum of Nature & Science [formerly Denver Museum of Natural History], Department of Zoology, 2001 Colorado Boulevard, Denver, Colorado 80205

FMNH - Field Museum of Natural History, Division of Insects, Roosevelt Road at Lake Shore Drive, Chicago, Illinois 60605

IOJ - Institute of Jamaica, Natural History Division, 12-14 East Street, Kingston, Jamaica

LACM - Natural History Museum of Los Angeles County, Department of Entomology, 900 Exposition Boulevard, Los Angeles, California 90007

MHNG - Muséum d'Histoire naturelle de Genève, CP 6434, CH-1211 Genève 6, Switzerland
MHNL - Muséum d'Histoire naturelle de Lyon, 28, Boulevard des Belges, F-69006 Lyon, France
MMUS - Macleay Museum, University of Sydney, Sydney, New South Wales, 2006, Australia
MNHN - Muséum National d'Histoire naturelle, Laboratoire d'Entomologie, 45 bis, rue du Buffon, F-75005 Paris, France
MTD - Staatliche Naturhistorische Sammlungen Dresden, Museum für Tierkunde, Königsbrücker Landstraße 159, D-01109 Dresden, Germany
MZB - Museum Zoologicum Bogoriense, Balitbang Zoology, Puslitbang Biology, (LIPI, Indonesian Institute of Sciences), Jalan Raya Bogor- Jakarta, km 46 Cibinong, Bogor, Java, Indonesia
NHMW - Naturhistorisches Museum Wien, Burgring 7, A-1040 Vienna, Austria
NHRS - Naturhistoriska Riksmuseet, Box 50007, S-10405 Stockholm, Sweden
NSM - National Science Museum, Department of Zoology, Ueno Park 7-20, Tokyo 110, Japan
RMNH - Nationaal Natuurhistorisch Museum, Naturalis [formerly Rijksmuseum van Natuurlijke Historie], Darwinweg, NL-2300 RA Leiden, The Netherlands
ROM - Royal Ontario Museum, Centre for Biodiversity and Conservation Biology, 100 Queen's Park, Toronto, Ontario M5S 2C6, Canada
SAF - Shaanxi Academy of Forestry, Yangling, Shaanxi 712100, People's Republic of China
SEEC - Société Entomologique d'Egypte, 14 Ramses Street, Cairo, Egypt
SEHU - Systematic Entomology Laboratory, Hokkaido University, Sapporo 060-8589, Japan
SMFL - Senckenberg-Museum, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany
TAMU - Texas A&M University, Department of Entomology, College Station, Texas 77843
TM - Taiwan Provincial Museum, Department of Zoology, 48 Hsu Chou Road, Taipei, Taiwan
TNM - National Museum of Natural Science, 1 Kuan-Chien Road, Taichung, Taiwan
UMO - Hope Entomological Collections, Oxford University Museum of Natural History, Parks Road, Oxford OX1 3PW, England
USNM - National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560
ZFMK - Zoologisches Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany
ZMA - Instituut voor Systematiek en Populatiebiologie (Zoölogisch Museum), Afdeling Entomologie, Plantage Middenlaan 64, NL-1018 DH Amsterdam, The Netherlands
ZMHU - Zoologisches Museum der Humboldt-Universität Berlin, Invalidenstraße 43, D-10115 Berlin, Germany
ZMUC - Zoologisk Museum, University of Copenhagen, Universitetsparken 15, DK-2100 København-Ø, Denmark
ZSM - Zoologische Staatssammlung München, Münchhausenstraße 21, D-81247 Munich, Germany

In addition to these institutional collections, the following individuals kindly made data from their collections available for this study: Martin Beeke (Hille, Germany), Ronald Brechlin (Pasewalk, Germany), Ulrich Brosch (Hille), Roy O. Kendall (San Antonio), Yasunori Kishida (Tokyo), Steve Kohll (Kayl, Luxembourg), Rudolf Lampe (Nürnberg), Claude Lemaire (now in MNHN), Swen Löffler (Lichtenstein, Germany), Frank Meister (Prenzlau, Germany), Laela Hayati Paukstadt (Wilhelmshaven, Germany), Bernard Turlin (Andresy, France), Roberto Vinciguerra (Palermo), Thomas J. Witt (Munich), and Andreas Zwick (Tübingen, Germany). The Witt collection is pledged to the Zoologische Staatssammlungen München.

Through our collections-based research, this study highlights the holdings of large natural history museums that are replete with history and tradition. However, as museums compete with an increasingly diverse array of choices that the public has to spend its time and money for entertainment and informal education, the museums struggle to survive, and sometimes we see changes in mission, exhibitions, programming, and even names. Museums that have changed their names in recent years include those in Denver, Eberswalde, Leiden, London, Los Angeles, and Washington. In an effort to promote stability and avoid confusion, we retain a few of the traditional acronyms such as BMNH, LACM, RMNH, and USNM.

In this revision we attempt to follow the rules and recommendations of the new edition of the International Code of Zoological Nomenclature, and where appropriate, some of the articles are cited, usually with the indication "the Code (1999)" or "(Code 1999)" in the text, and that is also how it can be located in the

bibliography. The authorship of this code is the International Commission on Zoological Nomenclature, and the new rules took effect on 1 January 2000. The official German translation, also cited in the bibliography, was published in 2000.

**Genitalia Preparations**

Generally attempts were made to follow the procedures of preparation and conservation which are used in most major museums today, which means that all sclerotized parts of the cut abdomen part should be kept with the preparation. Most genitalia preparations were mounted on microscope slides which were divided into three areas: firstly an identification label with number and information on the specimen dissected, secondly a cover slip over the male or female genitalia, and thirdly one over the abdominal pelt. For large series of the same species from the same locality, some preparations are kept in 1.5 ml plastic microvials containing 96% ethanol.

To get standardized preparations for compartive examination over long periods of time showing all details of genitalia structures as described, e.g. in Ferguson (1971) or Scoble (1992), the same concentrations, temperatures, and durations should be used. The male abdomens are put into test tubes with 4% NaOH solution and heated at around 90˚C for about one hour, female abdomens for a somewhat shorter period. After this procedure with heating around 10 abdomens at a single time in different numbered tubes, the softened abdomens are washed in 60-70% propanol, and cleaned with a soft brush. The abdominal pelt is removed, and the genitalia are cleaned more intensively on their outer and inner sides and, after opening the claspers, the position of movable parts such as the aedeagus should be noted. For mounted male genitalia, we removed the aedeagus from the remainder of the genitalia to have better view of the juxta and the structures of the vesica, in fluid preparations it is kept within the other structures to show the original position. The vesica in most cases needs to be inflated by injecting some alcohol in the anterior part of the aedeagus, near the ductus ejaculatorius, with a very small syringe. Before mounting, further dehydration should be carried out with higher concentrated alcohol (90% propanol) for a short time, before the genitalia are prepared for mounting on the slides with Euparal Essence® for final embedding. After embedding, the preparation must be kept level for several weeks, because the Euparal hardens quite slowly.

**Illustrations and Text**

The maps were drawn by Paul Vallejo using Adobe Illustrator 9.0. The color figures were scanned at a high resolution directly from the original 35 mm and 60 mm positive color transparencies (plus a few glossy prints) by Clear Visions. The composite plates of pinned adults may be disappointing to some readers because of differing backgrounds and inconsistent scale, but we believe that it is important to illustrate specimens from many institutional collections, using our photographs that were taken on different occasions. Film larger than 60 mm was used by Rick Wicker, photographer at the Denver Museum of Natural History, to provide better detail in some figures of the large textiles. The figures of genitalia were photographed in Berlin and scanned at University of the Incarnate Word at 600 dpi using an Epson Perfection 2450 Photo scanner, and those plates assembled with Adobe Photoshop - Epson Twain 5.54A Elements. The female genitalia were photographed in fluid, prior to embedding, and the plates assembled as above. The text was prepared using WordPerfect® Office 2002 by Corel, and converted to PDF files by Troy Knickerbocker. The font is Times New Roman at 10 point.

# TAXONOMY OF THE GENUS *SAMIA*

## *Samia* Hübner

*Samia* Hübner 1819 ("1816"): 156 (type species: *Phalaena Attacus Cynthia* Drury, 1773). Grote 1865: 226. McCook 1891: 52. Packard 1895: 41. Eliot & Soule 1902: 231. Jordan 1911a: 130. Seitz 1918: 62. Seitz 1928: 503. Lhomme 1923-1935: 622. Matsumura 1931: 731. Bollow 1932: 129. Dupont & Scheepmaker 1936:173. Bouvier 1936: 316. Sonan 1937: 203. Bock 1938: 24. McDunnough 1938: 41. Michener 1952: 490. Werner 1956: 69. Zim & Cottam 1956: 156. Collins & Weast 1961: 115. Rougeot 1971: 116. Ferguson 1972: 212. Esaki 1973: 225. Gómez & Fernández 1976: 202. Mitchell & Zim 1977: 155. Lemaire 1978: 127. Peigler 1978: 191. Rougeot & Viette 1978: 122. Arora & Gupta 1979: 49. Allen 1981: 111. Barlow 1982: 49. Gardiner

1982: 212. Fletcher & Nye 1982: 145. Inoue et al. 1982: 316. Covell 1984: 50. Lampe 1984: 5. de Freina & Witt 1987: 399. Holloway 1987: 112. Gómez de Aizpúrua 1988: 27. H. Y. Wang 1988: 46. Peigler 1989: 13. Pinratana & Lampe 1990: 5. Chou 1990: 41. Stone 1991: 34. Owada & Wang 1992: 41. Carter 1992: 234. Allen 1993: 55. Zhu & Wang 1993: 257. Bertaccini et al. 1994: 154. Vives 1994: 415. Naumann 1995: 24. Cody 1996: 12. Edwards 1996: 265. Nässig et al. 1996a: 27. Peigler 1996: 121. Peigler & Wang 1996: 60. Tuskes et al. 1996: 184. Zhu & Wang 1996: 163. Gupta 1997: 419. Nässig & Treadaway 1998: 250. D'Abrera 1998: 78. Lemaire & Minet 1999: 341. Park & Tshistjakov 1999: 167. Deml 2000: 177. Jost et al. 2000: 388. Singh & Benchamin 2000: 1. Arnett 2000: 770. Peigler & Baird 2001: 1. Naumann & Peigler 2001: 75. Regier et al. 2002: 11. Singh & Benchamin 2002: 20.

*Semia*, Kishida 1977a: 3. [misspelling]

*Sanira,* Morral & Segura 1991: 14. [misspelling]

*Philosamia* Grote 1874: 258 (type species: *Phalaena Cynthia* Drury, 1773); a junior objective synonym of *Samia*. Rondot 1887: 75. Butler 1889: 6. Kirby 1892a: 748. Swinhoe 1892: 245. Grote 1895: 267. Rothschild 1895: 37. Grote 1896: 1. Sonthonnax 1901: 133. Rebel 1910: vol. 2: 132. Watson 1910: 24. Packard 1914: 240. Watson 1915: 280. Mosher 1916: 155. Holland 1917: 81. Forbes 1923: 674. Rebel 1924: 111. Bouvier 1927: 921. Bouvier 1928b: 677. Draudt 1929: 715. de Joannis 1929: 523. Schüßler 1933-1934: 24, 517. Lutz 1935: 153. Danilevsky 1940: 26. Crotch 1956: 128. Forster & Wohlfahrt 1960: 134. Inoue 1961: 659. Yang 1978: 434. Jolly et al. 1979: 7. Chowdhury 1982: 6. Fletcher & Nye 1982: 145. Nam 1982: 221. Zhu & Wang 1983: 410. Baxter 1992: 55. van Schendel 1995: 5. Ye & Hu 1996: 30. Ruffo: 1998: 168. Maida & Ziesmann 2001: 17.

*Phylosamia,* Broszkus & Bodenstein 1950: 99. Harz 1973: 50. [misspelling]

*Philosemia,* de Zayas 1989: 62. [misspelling]

*Philosoma*, Yang 1978: 436. [misspelling]

*Philosomia,* Steeg 1939: 50. Rajkhowa 1996: 37. [misspelling]

*Philosamia* (*Attacus*), Hawkes 1916: 51. Hawkes 1918: 135. Hawkes 1922: 111.

*Samia* (*Philosamia*), Lemée 1950: 39. Villiard 1969: 144. Dirig 1975: 30.

*Desgodinsia* Oberthür 1914: 56 (type species: *Desgodinsia Watsoni* Oberthür, 1914); a junior homonym of *Desgodinsia* Senna, 1894, in the Coleoptera. Watson 1923: 172. Rebel 1925b: 171. Bouvier 1928b: 676. Mell 1935: 363. Bouvier 1936: 312. Rougeot 1955: 86. Rougeot 1971: 116. Fletcher & Nye 1982: 145.

*Saturnia* Schrank (type species: *Bombyx Pyri* [Denis & Schiffermüller], 1775), Westwood 1837: 12. Duncan 1841: 141. Boisduval 1854: 755. Costa 1854: 3. Chavannes 1855: 327. Hutton 1855: 169. Motschulsky 1858: 163. Hutton 1859a: 28. Rössler 1859: 420. Guérin-Méneville 1862: 341. Mulder 1862: 163. van Westmaas & de Graaf 1862: 117.

*Bombyx* Linnaeus (type species: *Phalaena Mori* Linnaeus, 1758), Olivier 1790: 30. Anonymous 1854: 29. Darwin 1859: 213. Guerin-Meneville 1860a: 6. Stewardson 1861: 525. Roy 1864: 6. Tegetmeier 1866: 15.

*Phalaena Attacus*, Drury 1773: 9. Cramer 1775: pl. 39.

*Phalaena*, Donovan 1798: 82. Roxburgh 1804: 43. Buchanan 1833: 214. Helfer 1837: 45.

*Cynthia*, Anonymous 1980: 73.

*Hyalophora* Duncan (type species: *Phalaena Cecropia* Linnaeus, 1758), Grant & Miller 1995: 46. [error in determination]

*Platysamia* Grote (type species: *Phalaena Cecropia* Linnaeus, 1758), Rau & Rau 1929: 84. Mell 1935: 363.

*Antheraea cynthia*, Hofmann 1887: xviii. [*lapsus*]

*Attacus* Linnaeus (in part) (type species: *Phalaena Bombyx Atlas* Linnaeus 1758), Gmelin 1784: 914. Walker 1855: 1221. Hutton 1867: 347. Hutton 1859b: 242. Moore 1858: 409. Moore 1859: 33. Felder & Felder 1862: 34. Girard 1868: lxxii. Simmonds 1869: 599. Koch 1873: 96. Strecker 1875: 103. Depuiset 1877: 100. Butler 1879a: 5. Wardle 1880a: 218. Wardle 1881b: 5. Kirby 1883: xxvii. Stack 1885: 214. Cotes & Swinhoe 1887: 224. Ballard 1891: 177. Figuier 1892: 247. Hampson 1892: 17. Nolan 1892: 193. Kirby 1897: 99. Clément 1899: 103. Clément 1900: 69. Tutt 1902: 291. Voelschow 1902: 68. Haly et al. 1903: 1. Scherdlin 1906: 77. Tutt 1906: 26. Froggatt

1907: 257. Watt 1908:1011. Moreau 1915: 270. Leefmans 1930: 98. Rougeot 1947: 74. Kalyanan 1967: 53. Bhargava & Narian 1972: 237. El-Shaarawy et al. 1975: 82. Dunsmore 1993: 59.

*Attacus* (*Bombyx*), Standfuss 1896: 303.

*Attacus* (*Saturnia*), Snellen van Vollenhoven 1862a: 15.

*Attacus* (*Philosamia*), Silbermann 1897: vol. 1: 317.

*Atticus*, Froggatt 1897: 253. [misspelling]

**Nomenclature of the Genus**

It is somewhat surprising that a group of common and wide ranging insects such as the *Samia* was not cited by Linnaeus and Fabricius (1787, 1793), who obtained insect specimens from collectors all around the world. The first published references to the insects that we now call *Samia* were by Drury (1773) and Cramer (1775). Although the generic name *Samia* was proposed as early as 1819 by Hübner, the name received only sparse and inconsistent usage for more than a century. Even today some writers persist in using the incorrect name *Philosamia*. This is notably so for amateur lepidopterists, sericulturists, and those who study insect physiology and biochemistry, i.e., groups who traditionally have little or no training in and understanding of zoological nomenclature. Most works in the past 30 years that can be considered taxonomic have used the correct generic name for the group. Our generic and species synonymies support the above comments. Some of the authors who wrote the most significant taxonomic works on the genus in the twentieth century also used the name *Philosamia*, including J. Henry Watson, Hans Rebel, Hans Schüßler [=Schüssler], and Eugène-Louis Bouvier, although Bouvier eventually abandoned the name *Philosamia* in deference to *Samia* in his final 1936 monograph.

Jakob Hübner (1761-1826) of Augsburg, Bavaria, published significant monographs embellished with hand-colored plates, in which he proposed hundreds of generic names for Lepidoptera (Rebel 1910: A82). He worked at a time soon after Linnaeus and Fabricius (a student of Linnaeus) when the number of known species within the order Lepidoptera was low enough that they could all be classified into only a handful of Linnaean genera, such as *Papilio*, *Bombyx*, *Noctua*, *Geometra*, etc., most of the moth names in combination with *Phalaena* (e.g., *Phalaena Bombyx*). As material of new species was increasingly being received in Europe from all over the world, Hübner correctly saw the need to propose many new genera, but his contemporaries did not share his foresight and generally did not accept the new names (Kirby 1897). Hübner's type specimens eventually went to the natural history museum in Vienna (Naturhistorisches Museum Wien) but the collection was destroyed there by a fire in 1848 (Kudrna & Wiemers 1990). When the name *Samia* was proposed by Hübner (1819 ["1816"]) he included three nominal species, all of which he erroneously attributed to Cramer. The dating of Hübner's *Verzeichniss bekannter Schmettlinge* was established in Opinion 150 by the International Commission on Zoological Nomemclature (Hemming 1943). The spelling Schmettlinge was a colloquial and archaic form of the German word Schmetterlinge, not a printing error. The three nominal species that Hübner included were *cynthia*, *cecropia*, and *promethea*. The original generic diagnosis was given as "Die Mittezierde aller Flügel sehr nachlässig, aber am Ende der Schwingen ein deutliches schwarzes Augenfleckgen." Our Figure 224 shows Hübner's page 156 containing the actual original description of the genus, with the typescript in Old German (Altdeutsch). The type species is *Phalaena Attacus Cynthia* Drury (1773: 10, index), first designated by Grote (1865: 228, footnote).

Before the concept of the genus solidified, regardless of the name applied, these insects were first considered to be silkmoths (*Bombyx*, *Saturnia*) and later "small atlas moths" (*Attacus*). The synonymy shows that many authors, including a few recent ones, treated the *Samia* as being congeneric with the atlas moths. In fact, one of the common names applied to *Samia wangi* is "lesser atlas moth" (Hill & Cheung 1978).

One of the more unfortunate nomenclatural errors was the application of the name *Samia* to the North American moths we now call *Hyalophora* Duncan. This was done in many widely disseminated major works such as Dusuzeau and Sonthonnax (1897), Packard (1914), Holland (1917 and earlier editions), Draudt (1929), Schüßler (1933-1934), and Lutz (1935), and no doubt forced those and many other authors to resort to the name *Philosamia* for the Asian group, for it is obvious that the two groups are not congeneric. The generic name *Hyalophora* has had an extremely complex and controversial history, the particulars of which were outlined by Michener (1952), Ferguson (1972), Lemaire (1978), and Fletcher and Nye (1982: 79-80), and thus need not be repeated here. We do not agree with Fletcher and Nye that the authorship of the name *Hyalophora* is to be credited to both Duncan and Westwood, but see Kirby (1897: xvii-xxii). The taxa that are considered now to belong under *Hyalophora* are *cecropia* (Linnaeus), *columbia* (S. I. Smith), *gloveri* (Strecker), and *euryalus* (Boisduval) (= *rubra* Neumögen & Dyar), and a generic synonym is *Platysamia* Grote. The name *Samia* has also been applied occasionally to other Attacini, such as in the original descriptions of *Callosamia securifera*

(Maassen) and *Callosamia angulifera* (Walker) (see Schüßler 1933-1934: 746).

Collins and Weast (1961: 115) included some of the African *Epiphora* such as *albida* (Druce) and *vacuna* (Westwood) in the generic concept, following Packard (1914); this combination of African and Asian species probably became generally accepted with the publication of Kirby's (1892a: 748-749) catalog, who treated both sets under the name *Philosamia*, followed by Dusuzeau and Sonthonnax (1897). Earlier, Plötz (1880) had described an African species (*ploetzi*) under the generic name *Samia*, considering it to be congeneric with *S. cynthia*. Occasional inclusion of African species under *Samia* (as *Philosamia*) persisted (e.g. Karsch 1892, Sonthonnax 1901, Holland 1920: 315-316). Rothschild (1895: 37) separated these African species under his new generic name *Drepanoptera*. The latter name is not considered valid for nomenclatural and phylogenetic reasons, and we now consider all of the African species to belong to *Epiphora*; see Fletcher and Nye (1982: 54), Peigler (1989:108-109) and Oberprieler (1997).

When he first proposed the name *Philosamia*, Grote (1874: 258) tried to designate *cecropia* (Linnaeus) as the type species of *Samia*, an invalid designation (D'Almeida 1943: 129). Grote (1895: 267) eventually settled on using the names *Philosamia* for the *cynthia* species-group and *Samia* for the *cecropia* species-group, synonymizing his own *Platysamia* that he had proposed for the *cecropia* species-group in an earlier paper (Grote 1865). Despite the errors and inconsistencies by Grote, the name *Samia* became the valid generic name for the genus containing *cynthia* and its allies when Grote designated *cynthia* as its type species in 1865. Strecker (1875: 103) also pointed out that Grote had changed his concept of the name *Samia*. The fact that Grote later designated *cynthia* as the type species of *Philosamia* when he first proposed that generic name, meant that the name *Philosamia* became a junior *objective* synonym of *Samia*, for both names have the same type species! The matter was laid to rest once and for all in the authoritative work on generic names of moths by Fletcher and Nye (1982: 145). As an aside, Kirby (1892a) indicated the type species of *Philosamia* to be *walkeri*, which he considered to be a separate species from *cynthia*.

According to Eliot and Soule (1902: 231), who tried to offer translations of all the scientific names of the lepidopterans they covered, the name *Samia* derives from "Samian" and has no appropriateness to the moths. Samian (from the Latin *Samius*) refers to an object or native or inhabitant of Sámos, a Greek island in the Aegean Sea, near the coast of Turkey. We consider that this proposed origin of the generic name of the moths is likely, because Linnaeus, Hübner, and other contemporary entomologists often applied names of personalities from ancient Greek and Roman mythology to large butterflies, moths, and beetles, particularly Papilionidae, Saturniidae, Sphingidae, and Scarabaeidae. Later, the name served as a root for more generic names proposed in Saturniidae, such as *Callosamia, Philosamia, Platysamia*, and *Metosamia*. The word Samia is also used occasionally as a woman's given name, and it also is the name of a town in western Kenya. There is no doubt that the suite of species that we assign to the genus *Samia* forms a monophyletic assemblage, obvious to anyone viewing the actual insects. As explained under our discussion of the phylogeny below, the nearest relatives of the genus are the African *Epiphora* and the North American *Callosamia* and *Hyalophora*.

**Vernacular Names**

The primary common names in the English language for *Samia cynthia* are "cynthia moth" and "ailanthus silkmoth." Both names have had wide usage and are still commonly used today in the United States and other English-speaking countries. In reference to the crescentic discal marks, a French common name is "le croissant" (Rougeot & Viette 1978), and in Dutch, "de sikkelvlinder" (the sickle moth) (Dupont & Scheepmaker 1936), the latter applied to *Samia insularis* and *S. cynthia*. Below are some common names used for species of *Samia* in various languages. The Taiwanese names were coined by Hsiau Yue Wang (see Peigler & Wang 1996). Most other Chinese names below are from Zhu and Wang (1996). The two names from Myanmar cited under *S. canningi* were told to Naumann by local people in May 2001 when he showed them cocoons found on avocado trees (see Figure 141).

*Samia cynthia*: cynthia moth, ailanthus silkmoth, ailanthus silkworm, cynthia silkmoth, chun cán (chū cán) (Chinese: ailanthus silkworm), le croissant (French: the crescent), le ver à soie de l'ailante (French), Ailanthusspinner (German), sikkelvlinder (Dutch), bombice dell'ailanto (Italian), bálványfa-pávaszem (Hungarian), zhōng guō méi wén wáng ér (Taiwan: Chinese crescent emperor moth), ga-joong na moo go-chi nabang (Korean: ailanthus tree silkworm moth), ajlantov prelec (Serbo-Croatian)

*Samia wangi*: lesser atlas moth (English in Hong Kong), méi wén wáng ér (Taiwan: crescent emperor moth)

*Samia pryeri*: Japanese ailanthus silkmoth, mitsugi kaiko (Japanese), shinjusan (Japanese: ailanthus silkworm), rìběn chū cán (Chinese: Japanese ailanthus silkworm)

*Samia canningi*: fagara silkmoth (a name also applied to *Attacus atlas*), Fagara-Seidenspinner (German), kuān dài chū cán (Chinese: wide-banded ailanthus silkworm), yín dù fěn dài méi wén wáng ér (Taiwanese: Indian powdery-banded crescent emperor moth), ak si ek (Myanmar: star excrement), ngal dak (Chin language in

Myanmar: bell of the enemy)

*Samia insularis*: xì dài chū cán (Chinese: narrow-banded ailanthus silkworm), sikkelvlinder (Dutch)

*Samia watsoni*: jiǎo bān chū cán (Chinese: angled-spot ailanthus silkworm), dà méi wén wáng ér (Taiwanese: large crescent emperor moth), Taiwanshinjusan (Japanese: Taiwanese ailanthus silkworm)

*Samia yayukae*: yìn ní zhí dài méi wén wáng ér (Taiwan: Indonesian strait-banded crescent emperor moth)

*Samia peigleri*: yìn ní xì méi wén wáng ér (Taiwan: Indonesian narrow crescent emperor moth)

*Samia ricini*: eri silkmoth, bì má cán (Chinese: castor silkworm), bì má méi wén wáng ér (Taiwanese: castor crescent emperor moth), pimajoo nooe nabee (Korean: castor silkworm butterfly), pimajoo nooe nabang (Korean: castor silkworm moth), le bombyx du ricin (French), ver à soie du ricin (French), erisan (Japanese), himasan (Japanese: castor silkworm), Erispinner (German), Erie-Seidenspinner (German), Rizinusspinner (German), Ricinusseidenraupe (German: castor silkworm), bombice del ricino (Italian), bicho-da-seda da mamona (Portuguese). Other forms of the word eri in the Assam region include eria, arrindi, andi, and endi, the last being the main one used in Bhutan. Words like endi, eri, and arrindi actually mean the castor plant, so that, for example, eri silk, endi silk, and Eri-Seide actually mean castor silk. The words ricin, ricino, and Rizinus also refer to the castor plant (genus *Ricinus*).

**Generic Description**

This subsection provides formal morphological descriptions of all stages of *Samia*, followed by additional remarks discussing these and their associated physiology.

**Adult.** Large moths, with forewing length ca. 60 mm to 85 mm; antennae quadripectinate in both sexes (Figs. 225-226), but last few segments bipectinate; length of rami in male only slightly longer than in female; antennal cones on terminal 8-9 segments of male, 13-14 segments of female; sutures on head indistinct; labial palpi 3-segmented, apical segment shortest; galeae fused into a feeble proboscis about 3 mm long; epiphysis present in both sexes (Figs. 227-228), prominent, but not exceeding length of foretibia; tibial spurs and tarsal spines present, in female only a terminal pair of tarsal spines; arolium and pulvilli well developed, claws simple. Sexual dimorphism very reduced except for wing shape; wings rounded; ground color various shades of reddish brown, dark olive green, grayish brown or dark brown, usually fading to golden brown or tan; prothoracic collar white; antemedian area ground color, unmarked; antemedian line white, sharply angled, extending slightly onto veins M3 and Cu1a; postmedian area ground color, sometimes with darker shading, otherwise unmarked; discal marking a prominent crescent or triangle, dark yellow distally, transparent proximally and surrounded by white; prominent postmedian line straight, curved, or undulate, consisting proximally to distally of black, white, and lavender or rose bands; postmedian area ground color, strongly sprinkled with black specks; apex of forewing quite falcate or at least slightly produced, with prominent purplish blue patch, small white zigzagging line, and black oval eyespot with white edge on costal side; submarginal line of forewing weak, straight, or undulate; submarginal markings of hindwing weak bands, usually broken by veins. Male genitalia with well developed bifurcated uncus; gnathos absent or weak; transtilla, anellus, and juxta well developed; valves with two prominent lobes, the upper one broad and rounded or squared, the lower one projecting into a straight or curved point; sacculus rounded or elongated; aedeagus with no, one, or two cornuti on the vesica. Female genitalia with eighth tergite large; lamella antevaginalis straight; ductus bursae broad, sclerotized posteriorly, membranous anteriorly; ductus seminalis arising from right-hand side of base of bursa.

The most useful and detailed morphological descriptions were given by Michener (1952: 490-491) and Lemaire (1978: 126-127), and some of the above is extracted from their work. Other valuable morphological figures and descriptions for the genus *Samia* include those of Arora and Gupta (1979: 49-52), Ferguson (1972: 214), and Bouvier (1936: 313-314). Passarin d'Entrèves & Zunino (1976: 231) showed a close-up view of the head of a live specimen of *S. cynthia*. A detailed study of the nervous system of adult *S. ricini* was published by Singh (1975). Close-up photographs of male and female antennae of *S. cynthia* can be found in Jost et al. (2000: 259), and we provide the same for *S. wangi* (Figs. 225-226). Tutt (1902: 289) provided a key to antennae of several genera, and separated *Samia* from *Callosamia* and *Hyalophora* by noting that female antennae in *Samia* have the distal pair of pectinations longer than the proximal pair, on the proximal antennal segments. The moths are non-feeding, but a rudimentary proboscis is present in some genera of Attacini (Peigler 1989), and a digestive system is well-developed in the closely allied genus *Callosamia* (Pyle 1940), so probably also exists in *Samia*. The proboscis of *Epiphora ploetzi* (Plötz) was found to be the same as that in *S. cynthia* (Taylor 1957). Photographs of de-scaled legs mounted on microscope slides are shown in the present work for *Samia wangi* (Figs. 227-228).

Unfortunately, green is a fugitive color on the wings of certain Lepidoptera (Cook et al. 1994). Fresh specimens of *S. cynthia, S. wangi*, and others are a rich, dark, army green color, or in *S. pryeri* a rich grayish

green, all of which fade to a golden brown. Specimens photographed while still alive, or ones that have been kept in total darkness, yield the best subjects for accurate illustration, although the green is also eventually lost in darkness. Examples of fresh green or grayish green specimens were shown by Jordan (1911a), Holland (1917), Seitz (1928: pl. 55C), Esaki (1973), Gómez and Fernández (1976: 203, upper), Barlow (1983: pl. 9, fig. 2), Holloway (1987), Peigler and Wang (1996: 71-71), Jost et al. (2000: pl. 18), and in our own Figure 8. Regrettably, the specimens of *Samia* shown in the color figures of Werner (1956), Ferguson (1972), Rougeot and Viette (1978, 1983), Covell (1984), Carter (1992), Bertaccini et al. (1994), Tuskes et al. (1996), Zhu and Wang (1996), and Park and Tshistjakov (1999) are all faded, and do not do justice to the brilliant olive overtones seen on fresh specimens. As with the *Samia* specimens shown by D'Abrera (1998), the pinned specimens figured in the present work are a mixture of both faded and fresh material, because it is important to show some of the historical material, especially type specimens. The paler green coloration on the wings of the saturniids in the genus *Actias* and geometrids of the subfamily Geometrinae is also well known to fade rapidly, resulting in specimens that appear less striking than their living counterparts. The Geometrinae have a pigment called geoverdin (Cook et al. 1994), and many other green moths in various families have a second type that is destroyed by alkali but partially restored by acidic treatment (Ford 1955: 5-6). The green in *Samia* is an overtone, and does not appear to us to belong to either of the two categories of green pigmentation discussed by Ford. Most *Samia* fade to a lighter shade of brown, but we have noticed that pinned specimens of *S. pryeri* actually darken with age.

The wing pattern of *Samia* was discussed in detail by Henke (1936) in his voluminous treatise on saturniid wing markings. Different elements of the markings were considered to have their origin in the evolution of the attacine wing pattern, and components of the *Samia* wing was compared with other Attacinae. Unfortunately, Henke based the *Samia* part of his work on specimens of the very variable *Samia ricini* (pls. 5-7), which he believed to be *S. cynthia*. Nijhout (1978: 123) pointed out that the dorsal surface of the forewing in *Samia* exhibits a complete central symmetry system, but not on the ventral surface.

A meticulous series of experiments on the development of wings in *S. cynthia* was published by Henke (1933), who showed that wing buds are even present in the thorax of the 5$^{th}$ instar larva (Henke's fig. 1c). Various experiments were carried out on the pupae of the moths resulting in wings that were undersized, deformed in shape or outline, or with altered patterns. For example, Henke found that the development of the wing ocellus is independent from the complete venation, and that the deposition for the ocellus is finished already some days before pupation of the larva. The deposition for lighter pattern elements in the apical forewing parts is present already in the mature larva, and is irreversible. The apical ocellus was found to be a combined element, with depositions both from an inner part of the lighter apical line and a black bordered part of the outer wing margin. Henke's work has broad application for those investigating anatomical development and physiology in other Lepidoptera.

In the male genitalia, several characteristic sclerotized structures can be found; for the terms of those we follow Ferguson (1971: 7) with some small modifications by Lemaire (1978: 26) and Peigler (1989: 22). The uncus is the dorsal structure; it generally is bifid in all Attacini but we found some genitalia of *Archaeoattacus staudingeri* to have a third dorsal central process, and also a single *Samia kohlli* from China had such a process. The uncus is generally understood to be part of, or emerging from, the tegumen of abdominal segment 10 (Michener 1952: 353), but in *Samia* it is clearly distinct from the tegumen. Farther ventrally is found a structure called the transtilla. Its central portion is largest in size, and there are lateral processes, ending near the origin of the costal or dorsal margin of the valves, the two lateral movable harpes or claspers which hold the female abdomen during mating and usually have a protection function for the more internal genital structures when closed. No gnathos, a ventral lateral internal process of the uncus, was found in *Samia*, as with *Callosamia*, *Attacus*, and *Epiphora*; this structure, which was separated by Lemaire from the transtilla, was found to be fused only in *Archaeoattacus* and *Rhodinia*, and less so in *Rothschildia* and *Hyalophora*. The valve in *Samia* genitalia has three more or less developed processes, a dorsal process which generally is the least developed, a median process and a ventral process. Basad to the ventral process is the sacculus, an invagination of the ventral margin of the valve. On the inner margin all around the valve, from near the lateral parts of the transtilla down to the sacculus, we find areas of small bristles which protect the internal area when the valves are closed. The ninth sternite of the abdomen forms a vinculum, which is elongated in most species to form a saccus. The central juxta forms a dorsally open ring through which the aedeagus (also spelled aedoeagus; referred to by French authors as *pénis*) passes, which is surrounded in that area by a movable membrane, the anellus. The aedeagus is a ring-like structure with a proximal ventral process, the caecum penis, and ends distally with a more or less sclerotized structure and an inflatable membranous vesica which usually bears cornuti or sclerites on its surface. Through the aedeagus passes the ductus ejaculatorius, which sometimes can be seen on preparations as a pointed membranous structure beside the vesica. The most diagnostic structures in the male genitalia of *Samia* were

found to be the form of the processes of the valves, the saccus, the dorsal process, the size of the aedeagus, and the vesica. Overall size is not significant, because smaller specimens have correspondingly smaller genitalia.

For the female genitalia, the structures are typical for Saturniidae, which are Ditrysian lepidopterans. The oviduct and oviporus on abdominal segment 9 are situated dorsad to the bursa copulatrix, and ventrad to the ostium bursae, a ventral copulatory pore between segments 7 and 8. This is surrounded by sclerotized genital plates or sterigma, which can be divided into an anterior lamella antevaginalis and a posterior lamella postvaginalis. From this the ductus bursae leads to a bulbous bursa copulatrix. Generally there are differences in size and shape of the corpus bursae, but a signum was not found on this structure in *Samia*. There are two pairs of internal apophyses, arising from the anterior edges of segments 8 (anterior apophyses or anapophyses) and 9 (posterior apophyses or postapophyses), which support the ovipositor by providing longitudinal muscle attachments (Scoble 1992). The ovipositor is short and rounded in saturniids, a function of oviposition onto leaves and stems. It is telescoped into the abdomen and extruded during oviposition. The ovipositor is divided into two lateral lobes, the papilles anales, bearing short bristles (Lemaire 1978: 27). In the genus *Samia* we found diagnostic differences in the development of the papilles anales and their surface structure of short bristles and hair bases. There are also differences in the form of the lamella postvaginalis, lamella antevaginalis, and lengths of the apophyses. In *Samia watsoni*, the size and form of the bursa copulatrix was noticeably different from those of its congeners. Preparation and interpretation of female genitalia are more difficult than those of the males, because they have less sclerotized structures, and are more easily damaged before preparation by mold (see Peigler 1989: 23), and after preparation when mounting on slides.

**Egg.** Döring (1955: 116) cited the dimensions of the egg of *S. cynthia* to be 2.0 mm long, 1.66 mm wide, and 1.38 mm high. He described it as: "Mikropylrosette 12 blättrig, 2 positive Blattkränze, Blattform zugespitzt. Mikropylrosette winzig, liegt gering vertrieft. Eifarbe gelblich, grünlich und graublau ineinander fließend. Auf jeder Breitseite 2 gebogene hellgraue Striemen und ein Fleck. In Mikropylzone auch ein hellgrauer Fleck." [Micropyle rosette with 12 leaf-like pointed parts, compounded from 2 positive circles. The micropyle rosette very small, and somewhat depressed. The color of the egg confluent, yellowish, greenish and bluish, on each broad side 2 curved light grayish bands and a spot. Inside the micropylar zone also a light grayish dot.] The micropyle, surrounded by a rosette-like ultrastructure is on one end, and the chorion is covered by honeycomb-like reticulations. Magnified eggs including the micropylar regions were figured by Döring (pl. 33, fig. 316) and Reddy et al. (2001). Reddy et al. (2001) gave a detailed picture of the embryonic development of the larvae of *S. ricini* within the egg, complete with time lines, and 14 drawings.

**First instar larva.** Head dark brown; integument yellow, with numerous blackish scoli and prominent mottling between scoli on each segment; dorsal and subdorsal scoli (4 total) on prothorax set in a dark patch; dorsal and subdorsal scoli on segments T1 to A7, and A9 with 5 spines, the central one usually with a dark zone near the apex; lateral scoli with 7 spines; dorsal pair fused into one large central scolus on eighth abdominal segment, bearing 8 spines; segment A10 with only a pair of scoli, bearing 8 spines each; prolegs with 12-14 crochets; anal patch darkened. Length of larva at end of first instar ca. 6-8 mm.

**Mature larva.** Head and thoracic legs solidly dark green; clypeus, mandibles, and antennae with blue; integument light or pale green, with whitish powder on dorsum; prothorax (T1) with small blue or white tubercles corresponding to dorsal, subdorsal, and subspiracular, scoli, black markings ventrally and at base of legs, spiracles black; mesothorax (T2) with same arrangement, but the blue tubercles equal to half the length of abdominal scoli; metathorax (T3) and first seven abdominal segments (A1-A7) with prominent blue, yellow, orange, or white scoli 2-3 mm long, ca. 1 mm wide at base, tapering to a blunt point, sometimes with a few tiny spines radiating from the tips; subspiracular tubercles sometimes with black bases; tiny subventral scoli on T1, T2, and T3; spiracles black; prolegs blue and yellow; ca. 50 short crochets, in two rows; anal prolegs and anal shield also blue and yellow, colored differently than integument; black specks or markings on integument varying considerably according to species. Length of mature larva ca. 45-60 mm.

The foregoing description is based on the species for which the larvae are known. Passarin d'Entrèves & Zunino (1976: 259, 261) gave close-up color photographs of the head, thoracic legs, and abdominal prolegs of a mature larva of *S. cynthia*. Other colored figures of larvae of that species were published by many authors including Packard (1914, pls. 1-2, all stages), Zim and Cottam (1956), and Pyle (1975). Mature larvae of several species of the genus were shown in color by Peigler and Wang (1996), including *S. canningi, S. ricini, S. wangi,* and *S. yayukae*, with earlier instars of the latter two. Color photographs of the larval stages of *S. vandenberghi* were given by Naumann (1995: pl. 1), of *S. insularis* and *S. tetrica* by Nässig et al. (1996b: pls. 1, 6), of *S. fulva* by Mohanraj et al. (1998), and of *S. abrerai* by Paukstadt and Paukstadt (2000). The mandibular teeth in the mature larva of *S. cynthia* are reduced, with the margin bluntly serrate (Passoa & Passoa 2000, table 1). No thoracic defensive glands found in certain *Attacus* and no urticating hairs or bristles on the scoli are

known in any larvae of *Samia*. Students interested in studying larval trends and morphology of Notodontidae and Bombycoidea should not ignore the exhaustive writings and figures by Packard (1876, 1893, 1895, 1904b, 1905, 1914), whose work sometimes goes unappreciated as modern workers rediscover characters reported by him long ago. Packard's (1914: 244) apparent statement that the first instar larva bears only two scoli on the ninth abdominal segment appears to us to be incorrect, but his figures (pl. 1, figs. 2-2a) show four scoli on the ninth segment, agreeing with material we have studied.

Characters such as large black mottles on the integument, blue vs. white (or yellow) integument, and color of hemolymph (yellow vs. white) are apparently controlled by single alleles (Hawkes 1918). According to Wu (1962), who made numerous crosses of *S. ricini*, black mottling is dominant over lack of markings, blue integument is dominant over white, and yellow hemolymph is dominant over white. He found that the basic Mendelian law of independent assortment applied, and believed that the genes for these traits are on three separate chromosomes. Although we did not make any controlled crosses of the various color forms of *S. ricini*, our own rearings did support the conclusions of Wu, because we observed blue larvae to be about three times more common than white ones, and mottled larvae about three times more common than unmarked ones. Wu found that the gene for white integument combined with the gene for yellow hemolymph resulted in larvae that had yellow instead of white integuments. He also made some crosses using *S. cynthia*, and found that the small black spots on the integument are dominant over no spots, but recessive to large mottles seen in pure *S. ricini*.

For our colored illustrations we have chosen to use the available space to illustrate the larval stages of some species that are less known and have rarely been reared, which are *Samia vandenberghi*, *S. tetrica*. *S. luzonica*, *S. fulva, S. yayukae*, and *S. kohlli*. The larval stages of *S. cynthia* have been shown by several authors starting with Packard (1914), and those of *S. wangi* were documented in color by Hsiau Yue Wang (Wang 1988, 1994, Peigler & Wang 1996). We are still not certain regarding some of the published illustrations of larvae of *S. pryeri* and *S. canningi*, due to occasional possible confusion with *S. cynthia* or *S. ricini*, and we have not reared those two species ourselves. As far as we know, the mature larvae of *S. canningi*, *S. pryeri*, and *S. wangi* do not differ markedly in appearance from that of *S. cynthia*. Most caterpillars of the remaining species are truly beautiful with their red, orange, or coral pink scoli, sometimes set against bluish integuments.

**Pupa.** Color yellowish brown, darker on dorsal surface; maxillae along midline, about one-third the length of wings; invaginations for anterior arms of tentorium distinct; clypeo-labral suture indistinct; dorsal median thoracic line distinct on all segments; wings with distal margins elevated; hindwing visible along entire dorsal margin of forewing, with the margin weakly wavy; two dorsal rows of tubercle scars; surface of thorax and abdomen with minute, indeterminate, transverse striations, visible only under magnification; abdominal segments 8-10 tapering sharply; cremaster absent; length about 20-30 mm.

Mosher (1916) enumerated detailed descriptions of what she considered to be generic and specific characters of the pupa of *S. cynthia*, yet stated that there is only one species in the genus. In her key to genera, she separated the Saturniini from the Attacini by defining the latter as having a body that is cylindrical in outline, lateral margins of the movable abdominal segments as being parallel, and the absence of stout curved spines in the cremaster. A drawing depicting the ventral view of a pupa of *S. cynthia* was published by Jost et al. (2000: 370, fig. 184), and a color photo of the same was given by Gómez de Aizpúrua (1988: 30). Mohanraj et al. (1998) described the pupa of *Samia fulva*, along with color photographs of the dorsal and ventral sides. As a matter of interest, we examined a pupa of *S. luzonica* to compare its characters with those of Mosher's descriptions of *S. cynthia*, and observed that all of the generic characters agreed. Under the species characters, the differences pertain mainly to the positions of the imprints of the antennae and prothoracic and mesothoracic legs. The imprints of the maxillae and all legs are narrower in *S. luzonica*, and the antennal imprints extend more posteriorly. The formal description in the previous paragraph highlights some of the main generic features pointed out by Mosher. The pupa of *Samia* has a tooth on the first axillary sclerite used by the adult moth to cut open the cocoon when it emerges, and this tooth resembles those of *Attacus* and *Antheraea* more than other Japanese saturniids (Miyata 1974).

**Cocoon.** Compact; pendant; wrapped within one or more leaves or leaflets, depending on the size of the leaves and leaflets, attached to twig by strong band of silk, spun along or enveloping the petiole, sometimes several centimeters. Pre-formed exit opening (German: Reuse) at top (anterior) end, silk converging in the opening, cut by mandibles of larva during construction. Shape elongated, roughly oval in the main body. Outer silk usually ruffled but sometimes smooth. Color varying from dark brown to reddish brown to gray to tan, in most species pale ashy gray or beige. Inner surface varnished dark brown, smooth. Main body ca. 35-60 mm long, ca. 15-20 mm wide.

As far as known, all species construct a compact cocoon of the same basic design. In the cultivated strain (*S. ricini*), the peduncle is lacking, with color pure white or brick red, silk more abundant and loose, and shape

puffy. Cocoons of *S. cynthia, S. wangi*, and *S. pryeri* are probably indistinguishable. Cocoons of *S. canningi* are usually larger, and light brown with reddish cast. Cocoons of *S. fulva*, *S. yayukae*, and other Indonesian and Philippine species are generally smaller and darker brown. Cocoons are still unknown for *S. watsoni, S. peigleri, S. ceramensis*, and *S. treadawayi*. In large, pinnately compound leaves like ailanthus, sometimes two or more cocoons are spun in different leaflets on the same leaf. The cocoons of *Samia* are similar in construction and appearance to those of *Callosamia promethea* and some *Epiphora* (*E. ploetzi* and *E. antinorii* (Oberthür)). Compared to *Samia*, there is more variation in the basic form of cocoons in *Callosamia* and *Epiphora*, some species of the latter making rounded and compact ones as are seen in *Eupackardia* and many *Rothschildia*. Cocoons of *Attacus, Coscinocera*, and *Archaeoattacus* are quite similar to those of *Samia*, but considerably larger and thicker, and usually darker. A classic work on cocoon construction by saturniids was published by Lounibos (1976), who used *Antheraea pernyi* (Guérin-Méneville) and *Hyalophora cecropia* as models, but most findings of the study are applicable to *Samia*.

**Generic Diagnosis**

**Adult.** The most characteristic feature of *Samia* is the crescentic markings (discal spots), one in the center of each wing. These usually consist of parallel white and yellow crescents, often narrowly edged with black, and the white portion may be transparent. Accessory fenestrae are virtually always absent, except that weak ones were noted in the hindwings of one male of *S. watsoni*. Size of moths considerably smaller than those of *Coscinocera*, *Archaeoattacus*, and *Attacus*, and forewing apices generally much less falcate than in the latter two genera. There is a well-developed black eyespot on the forewing in cell $R_5$, but none (except in *S. watsoni*) at the subcostal edge, as seen in *Archaeoattacus*. The black spot in cell $R_5$ is shared by *Callosamia*, *Epiphora*, and *Hyalophora*, transformed to a red dash in *Attacus* and a red blurry streak in *Coscinocera*. Ground color generally golden brown or tan, rarely dark rusty red as in *Attacus* or blackish plum as in *Coscinocera*. The abdomen in *Samia* has prominent white tufts, one pair per segment, more developed in females. Other Attacini are solidly colored on the dorsal sides of their abdomens, or may have white rings (*Hyalophora*, a few *Epiphora*) or two white longitudinal lines (*Archaeoattacus*, a few *Rothschildia*). The tornus of the hindwing tapers to a point in *Samia*, more so than in any other genus of Attacini.

**Larva.** Mature larvae of *Attacus* and *Archaeoattacus* superficially resemble those of *Samia* by having well-developed scoli roughly equal in size and white wax on a blue-freckled integument. However, those of *Samia* are smaller in size when mature, often have black spots on the integument, but lack the dark patches on the anal prolegs seen in *Attacus* and *Archaeoattacus*. *Samia* also differs from *Attacus* by lacking subventral scoli, which in *Attacus* are present on all thoracic and the first two abdominal segments. *Attacus* has long lateral scoli and short (buttons or flattened) dorsal ones on the thorax, but the dorsal ones are longer in *Samia* and *Archaeoattacus*. The larvae of *Archaeoattacus* have black markings on the longer dorsal thoracic scoli, not seen in *Samia*. Larvae of all species *Samia* differ significantly from those of American genera (*Hyalophora*, *Rothschildia*, *Eupackardia*) by having slender, tapering thoracic scoli, whereas in the American ones the scoli are usually bulbous tubercles (Fig. 123), bearing prominent spines (German: Sternwarzen), or extremely reduced in some *Rothschildia*. Dorsal thoracic scoli in *Callosamia* are like those of *Samia*, but the subdorsal ones and all abdominal ones are extremely reduced, except for a median one on the 8$^{th}$ abdominal segment (Fig. 130). Larvae of some species of *Epiphora* are structurally similar to those of *Samia*, but lack the white wax on the integument, and in some species like *E. rectifascia*, the dorsal scoli of the meso- and metathorax and first abdominal segments are also better developed than the remaining abdominal ones (Seydel 1939: 1329-1330, fig. 59). Some *Epiphora* such as *E. manowensis* (Gschwandner) and *E. boolana* Strand have larvae that greatly resemble those of *Samia* (Figs. 124-125), whereas others such as *E. bauhiniae* (Guérin-Méneville) (Fig. 126) do not. Larvae of *Coscinocera* (Fig. 122) are immediately distinguishable from those of *Samia* by having very long and slender scoli, and a prominent brown and yellow patch on the anal proleg.

# PHYLOGENY OF THE TRIBE ATTACINI

The genus *Samia* clearly belongs to the tribe Attacini. This tribe is a monophyletic clade within the subfamily Saturniinae, along with other tribes such as Saturniini (*Actias, Argema, Graellsia, Saturnia*, *Copaxa, Cricula, Antheraea, Syntherata, Antherina, Ceranchia*, etc.) and Bunaeini (*Bunaea, Nudaurelia, Imbrasia, Gynanisa, Heniocha, Eochroa*, etc.). The subfamily Saturniinae, comprising mainly the extensive tribes Attacini, Saturniini, and Bunaeini, accounts for most of the large and famous Saturniidae. Saturniinae is also now believed to include the tribe Micragonini (Minet 1994, Oberprieler 1995, Regier et al. 2002), which was long

considered a subfamily called Ludiinae, plus a tribe Micragonini that contained only the genus *Micragone* (Bouvier 1928b, 1936; Rougeot 1955; Pinhey 1972). The more primitive subfamilies and tribes within the Saturniidae were variously treated and figured by Packard (1914), Michener (1952), Rougeot (1955), Pinhey (1972), Ferguson (1972), Oberprieler (1995), Bouvier (e.g., 1928b, 1936) and Lemaire (1978, 1980, 1988, 2002), and more monographs by Bouvier not cited in this revision. The higher classification of Saturniidae remained fairly stable in the twentieth century, but recent studies by Minet (1994) brought some modifications, such as inclusion of the tropical American Oxyteninae and Cercophaninae, formerly considered to be separate families. We concur with Minet in bringing these two taxa into the family concept of the Saturniidae. The phylogeny of the Asian genera *Rhodinia* and *Loepa* has been of particular interest as regards their position near Attacini or within Saturniini; for ideas on this, consult the works of Henke (1936), Peigler (1989), and Friedlander et al. (1998). Attacini and *Rhodinia* share the characteristic submarginal line of the forewings, transparent eyespots in center of wings, larvae with milky integuments, cocoons with peduncles and pre-formed exit valves, etc. The cocoon of *Epiphora bauhiniae* shows the same hole at its lower end as found in *Rhodinia*. Ramos and Peigler (1999) demonstrated that the silk of *Rhodinia* resembles silks of Attacini more than those of other Saturniini. Phylogenetic trees based on gene-sequencing proposed by Shimada et al. (1995) placed *Rhodinia* closer to Attacini than Saturniini, but other trees placed *Rhodinia* within Saturniini. The supposed relationship between *Rhodinia* and Papuan *Pararhodia* (Bouvier 1936) has not been verified, and we do not accept it. Incidentally, there is no known fossil record for the Saturniidae, so we are forced to rely entirely on the living forms to reconstruct their phylogeny. One putative fossil from Colorado was examined and rejected by Peigler (1989).

The currently accepted classification of the genus is as follows: Kingdom Animalia, Phylum Arthropoda, Subphylum Mandibulata, Class Insecta, Subclass Endopterygota, Order Lepidoptera, Suborder Glossata, Infraorder Ditrysia, Superfamily Bombycoidea, Family Saturniidae, Subfamily Saturniinae, Tribe Attacini, Genus *Samia* (Common 1990: 82-84; Minet 1994). Fortunately, no subgenera have been proposed.

In 1980 to 1983 Peigler (1989) carried out a cladistic analysis of the tribe Attacini, using characters of larvae, pupae, cocoons, adult morphology and behavior, geographical distribution, etc. The resulting cladograms were judged to be satisfactory. An interest in Peigler's work in 1981-1983 was shared by lepidopterist Dr. Timothy Friedlander, then a fellow graduate student with Peigler in entomology at Texas A&M University. More than 15 years later with the opportunity to conduct a molecular genetic analysis in the same moths, Friedlander and others at the University of Maryland invited Peigler to participate in a new phylogenetic analysis of the tribe Attacini. The results of the new analysis using gene-sequencing revealed some flaws but also supported other aspects of that original work, which had been based mainly on morphology. Those ongoing studies on bombycoid phylogeny are based on the sequences in two genes known as elongation factor 1-$\alpha$ and dopa decarboxylase, which have about 1240 and 1051 nucleotides, respectively.

The current hypothetical phylogeny of the genus *Samia* can be summarized as follows, based on the molecular work carried out at the University of Maryland (Friedlander et al. 1998; Regier et al. 2002). The tribe Attacini is monophyletic, and is the sister group to the tribe Saturniini. *Rhodinia* is correctly placed in the Saturniini, but is the sister group to all other taxa in that clade. Within the Attacini, *Hyalophora* is the sister group to *Samia* plus *Callosamia*, and *Epiphora* is the sister group to those three genera. The relationship of *Samia* to its nearest relatives can be expressed as: ((*Callosamia* + *Samia*) + *Hyalophora*) + *Epiphora*. By this model we can see that the superficially similar wing pattern shared by *Hyalophora* and *Epiphora antinorii* is plesiomorphic for the clade *Hyalophora* + *Callosamia* + *Samia* + *Epiphora*, as predicted by Ferguson (1972: 244). In stating differences found between various *Hyalophora* and *Callosamia promethea*, Clark (1999) hypothesized a separate line of evolution between the two genera. In her study of allele frequency for 18 loci in *Hyalophora cecropia* and all three species of *Callosamia*, Johnson (1993) found that *Hyalophora* shared only one allele at a single locus with *Callosamia*, and also postulated that *Callosamia* may be more closely related to *Samia*. Michener (1952), followed by Pease (1960), placed *Hyalophora*, *Callosamia*, and *Eupackardia* as subgenera under *Hyalophora* (sensu lato), an arrangement that is now known to be entirely unnatural. Pease was therefore obliged to find characters uniting *Hyalophora* with *Callosamia*, but separating them from *Samia*, in his key to first-instar larvae.

Features shared by *Samia* and *Callosamia* but not *Hyalophora* pertain to cocoon structure, hostplant selection, falcate forewings in males, tiny white eggs, yellow first-instar larvae, black spots on integument of mature larvae (Packard 1895: 40-41), sex pheromone, and similar structure of the male genitalia. Although we believe that *Samia* shares an ancient association with ailanthus, its association with Rutaceae and probably Lauraceae predates dispersal of the primordial form of *Callosamia* into the New World. Ailanthus grew widely in western North America during the Tertiary, but was already extinct before the Pliocene (Tidwell 1998: chart 3), we believe long before the ancestor of *Callosamia* arrived via the Bering Land Bridge. Lemaire and Peigler (1982) pointed out

the nearly identical submarginal lines on the forewings of *Samia watsoni* and *Epiphora rectifascia* Rothschild and *E. ploetzi*. A valuable discussion of phylogeny of Attacini was by Oberprieler (1997), whose focus was on the genus *Epiphora*. His arguments that *Epiphora* may be closely related to *Attacus* supports a hypothesis that *Epiphora* is a more ancient lineage that gave rise to *Samia* to the East, rather than vice-versa. Moreover, the proboscis (Taylor 1957) and the molecular data (Friedlander et al. 1998, Regier et al. 2002) also support the hypothesis that *Samia* is derived from *Epiphora,* by placing *Epiphora* as the sister-group to the clade containing *Samia*, *Callosamia*, and *Hyalophora*. Traits of *Callosamia* that separate it from *Samia* include melanic and diurnal males (resulting in sexual dimorphism), greatly reduced abdominal scoli (Packard 1895: 40), reduced fenestrae and postmedian lines in all four wings, less falcate forewings especially in females, deviant cocoons (large inflated ones in *C. securifera* and lacking peduncles in *C. angulifera*), and the apparent absence of a proboscis (Taylor 1957).

The tribe Attacini consists of the following nine genera, all of which were beautifully illustrated by D'Abrera (1998):

1. *Attacus* - 14 known species, all from tropical Asia and Australia, including 3 endemic to the Philippines, 2 endemic to India, 1 endemic to northern Australia, 7 endemic to Indonesia, and 1 (*A. atlas* (Linnaeus), the type species) with a widespread distribution.
2. *Coscinocera* - about 5 species from Australia, New Guinea, Moluccas, and New Britain. The close resemblance between the mature larvae of this genus and the recently described larva of *Attacus dohertyi* Rothschild provides further support of the close relationship of the two genera. See Figure 122.
3. *Archaeoattacus* - 2 species, consisting of *A. edwardsii* (Figs. 89, 219), the type species, from mainland tropical Asia, and *A. staudingeri* (Rothschild) (Fig. 220) from the Greater Sunda Islands and West Malaysia. The hypothesis by Peigler and Wang (1996) that the latter probably also occurs on Bali was based on a misidentification of *A. edwardsii* by Peigler; the Balinese artist clearly used the figure of Whalley (1988: 47) as a model. The life history of *A. staudingeri* was described by Häuser et al. (1996) with color figures. Larvae fed in captivity on *Prunus, Syringa*, and *Ligustrum*. Although lack of accessory fenestrae is a valid character for this genus, a male of *A. edwardsii* (Tanah Rata, West Malaysia, July 1995, Peigler collection) shows small yellow accessory fenestrae, one in each forewing, lacking any transparent components, ca. 11 mm long on the upperside, and ca. 6 mm on the underside.
4. *Samia* - 19 species from Himalayas and Japan down to the Moluccas. There are cases where more than one species can be found sympatrically.
5. *Callosamia* - 3 species in eastern North America. Beautiful photographs of the living adults of all three species were shown by McCord (1987). See Figures 95, 130, and 223.
6. *Hyalophora* - 4 species ranging over most of the United States, into Mexico and Canada. We propose 4 instead of 3 species for this group, in keeping with our rejection of subspecies. See Figures 123 and 221.
7. *Eupackardia* - 1 or more species from Texas and Arizona to Guatemala.
8. *Rothschildia* - about 25 species from Texas and Arizona to Argentina. See Figure 218.
9. *Epiphora* - about 15 species in sub-Saharan Africa, but absent on Madagascar. The intrageneric relationships were outlined by Oberprieler (1997), and several species were treated and illustrated by Pinhey (1972). See Figures 90-94, 124-126, and 222.

In each tropical biogeographical realm, one or two genera of Attacini are present and, by the standards of Saturniinae, are fairly rich in species. These are *Rothschildia* in the Neotropical region, *Epiphora* in the Ethiopian region, and *Samia* and *Attacus* in the Oriental region. Following the usage of such taxonomic data to define rates of evolution (Ridley 1996: 576-578), it could be interpreted that these genera evolved faster than others in the tribe. Our interpretation is somewhat otherwise, as follows. Tropical groups of moths probably speciate more rapidly, because of greater diversity (i.e., species packing) and possibly more opportunities for isolation to occur among mountains, savannas, and on islands. *Archaeoattacus* may have only two extant species because it is a relict taxon, instead of being a younger taxon, the plesiomorphies of *Archaeoattacus* supporting this hypothesis. *Hyalophora* and *Callosamia* possibly have few species because they are younger taxa, and have withstood dramatic changes including glaciation, which the tribe did not survive in Europe if it ever existed there. Another noteworthy feature about *Samia* is the uniformity of the facies among the various species, not differing nearly so much as when we compare the extremely unlike forms of *Rothschildia* and *Epiphora*. For example, if *R. zacateca* (Westwood), *R. betis* (Walker), *E. lugardi* Kirby, and *E. albida* were the only known species in those genera, they would likely be classified into four different genera instead of two. *Attacus* likewise shows a fair amount of deviation from the normal groundplan for that genus. The shortened and rounded wing form that characterizes specimens of taxa such as *Epiphora lugardi*, *E. antinorii*, females of *Callosamia* and *Eupackardia*, and all *Hyalophora*, does not exist in *Samia*.

# ABERRATIONS AND MUTANTS

We have not noted gynandromorphic specimens in museum collections nor are we aware of any reports in the literature, except for a casual reference by Riechmann (1928b). Such specimens would not be easily noticed because the sexual dimorphism is not pronounced, especially regarding the differences in width of the male and female antennae. The following aberrations and mutant strains have been found in museums by us, or cited in the literature. None of the varietal or aberrational names proposed for them have any standing in zoological nomenclature, and should not be used on labels of specimens or in publications.

Rothschild (1895: 37) stated that "*P*[*hilosamia*] *iole* (Westw.) is simply a monstrosity of *P. walkeri* (Feld.),..." We agree that *iole* is an aberration, but we consider it to belong under *Samia ricini*, as discussed under the latter taxon. Rothschild also considered *guerini* and *obscura* to be aberrations of *P. lunula*, which he considered to be the correct name for *ricini*. We agree with Rothschild that *obscura* and *guerini* are also aberrations and do not represent valid taxa.

Schüßler (1926) reported an aberrant female of *S. cynthia* among stock he reared from the United States, in which the white tufts on the abdomen were fused into a mass, as is routinely seen in *S. ricini*. He named this form ab. *alboabdominalis*.

Bryk (1938) illustrated a teratologically abnormal female of *S. cynthia* having a double apex of the left forewing, complete with two black eyespots and two white zigzag lines. The venation of the wing was also shown in an accompanying line drawing.

Remington (1958) reported and figured on specimens of *S. cynthia* from Connecticut in which the postmedian and antemedian lines are variously reduced, blurred, and fused. A cross between a male and female showing this aberrant phenotype resulted in the conclusion that it is probably caused by an autosomal recessive allele. Remington was not aware that such aberrations had been reported in earlier literature (Kaiser 1919, Riechmann 1928a, b, Schüßler 1928, Henke 1936, pls. 6-7). Similar specimens for *Attacus atlas* are known, such as the ones figured by Dupont and Scheepmaker (1936: 169) and Carter (1992: 221), as well as in other Attacini (Schüßler 1928). The specimen of *S. ricini* shown by Seitz (1928: pl. 52) also shows signs of thisgenetic mutation. The same pattern aberration showing the antemedian line fusing with the postmedian line as was reported in *S. cynthia* by other authors, cited above, was also found by Kaiser (1919) in *S. pryeri*. It is also likely that the aberration of *S. canningi* named *andrewesi* by Debauche (1929) showed some features of this wing pattern abnormality. Convergence or even fusion of the antemedian and postmedian lines in these attacine genera evidently is not rare.

In the Carnegie Museum of Natural History is a female of *S. cynthia* from Philadelphia (year unknown; collected by Joseph Steiger) with dark chocolate brown coloration, conferring a remarkable resemblance to a female of the African *Epiphora vacuna*. A similar and truly beautiful aberrant, a perfect specimen with purplish coloring, is in the Zoologisches Museum der Humboldt-Universität Berlin. Laurent (1918) reported rearing two specimens from Philadelphia that had very dark wings, and the pink and white components of the postmedian lines were lacking. These would agree with the Steiger specimen cited above, which came to the Carnegie Museum (Accession 20359) through an exchange with the Academy of Natural Sciences in Philadelphia. Another female in the Carnegie Museum we consider to be a melanic specimen, with very dark postmedian areas; its label data are Pittsburgh, Pennsylvania, 30 June 1955, Leo F. Dippold.

Crotch (1956: 130) described a variety of mutant with new colors of the larvae and moths of *S. canningi*. Larvae had black bars in place of oval dots. The wing patterns in the adults were of the dark form of *S. canningi* often called *obscura*. Chowdhury (1982: 55) repeated the comments of Crotch. Crotch applied the name *reversa* to the strain having dark postmedian areas. We have seen this genetic pattern in other members of the genus, especially in *S. ricini*. Crotch further called a strain *obversa* with a different pattern of dark and light areas of the wings.

The so-called aberrations of *S. cynthia* that were described and named by Mezger (1928a, b) are totally insignificant, and fall within the normal range of variation of the species. His variety *viridis* represented a fresh, unfaded specimen. Mezger's stock was from the United States, sent as cocoons to him in Europe. The same comments apply to the so-called forms named by Lének (1958), of which Naumann examined and photographed the "types" in the museum in Vienna.

# *SAMIA* IN ART AND CULTURE

The most important aspect of *Samia* in human culture is, of course, the sericultural exploitation, which is described in detail in a later section. *Samia* has also been used in some Asian cultures as a source of food for humans, particularly pupae of *S. ricini* in northeastern India and Nepal (Chowdhury 1982, Dunsmore 1993, DeFoliart 1995). Jolly et al. (1979: 157) and Sahay et al. (1997) cited details of the nutritional value of pupae of *S. ricini* as follows. Pupae contain about 60% crude protein, 5-8% free amino acids, including citrulline, cystine, methionine, aspargin, β-alanine, homoarginine, and hydroxyproline; 26% total lipid, including glycerol trioleate, neutral lipid, phospholipid, and cholesterol; vitamins including pyridoxal, riboflavin, thiamine, ascorbic acid, and folic acid; and minerals like calcium, iron, and phosphorus. Pre-pupae are extracted alive from the cocoons through the pre-formed exit valve, making the processing of the silk easier and cleaner.

When cultivating *Bombyx mori* (Linnaeus) for silk, it is always necessary to kill the pupae to exploit the silk in the cocoon. This is not true for *Samia ricini*, because cocoons from which moths have exited are also suitable for processing into yarn. Therefore, cultivating eri silk has sometimes been favored by persons whose religious practices forbid the taking of life, such as by Buddhists in Sri Lanka (Braine 1904: 33) and Bhutan (Myers & Bean 1994: 189).

The nitrogen in pupal powder and other waste and byproducts of sericulture have been used for nutritional supplements for poultry, swine, and fishes (Jolly et al. 1975: 89). Excess adults of eri silkmoths beyond those needed to maintain the cultures have been fed to poultry in Sri Lanka (Braine 1904: 37).

Eggs of *Samia ricini* are used in China to culture *Anastatus* sp. (Eupelmidae) and *Trichogramma dendrolimi* Matsumura, tiny parasitic wasps used in biological control against forests pests of *Dendrolimus sibiricus* Tschetv. and *D. punctatus* (Walker) (Lasiocampidae). Pathogens, namely *Beauveria* sp. and *Bacillus thuringiensis* Berliner, are also cultivated in larvae or pupae of *S. ricini* to use against the same pine pests in China (Anonymous 1980: 73).

The silk glands of mature caterpillars of *S. ricini* can be stretched 3-4 meters and have good tensile strength. These have been used in medical procedures for sutures, according to Jolly et al. (1975: 89) and Sahay et al. (1997).

Depictions of *Samia* have adorned postage stamps on at least three occasions. The first was in a set of three stamps issued by North Korea in 1965 showing *Bombyx mori* with a mulberry leaf, *Samia ricini* with a castor leaf, and *Antheraea pernyi* with oak leaves, the latter two valued at 10 chon each. *Samia cynthia* was featured on a stamp valued at 1 rival from Ajman (United Arab Emirates) in 1972, that was among a large set of stamps showing Lepidoptera copied directly from the book by Werner (1956). In 1991 North Korea again issued a set of stamps showing its wild silkmoths, including one of *Samia ricini* under the name *Attacus ricini*, valued at 30 won, and showing a sprig of castor in the background. This latter set also included *Antheraea pernyi*, *A. yamamai* (Guérin-Méneville), *Actias artemis* (Bremer), *Bombyx mori*, and sericulturist Dr. Kye Ung Sang. The souvenir sheet version of this set was illustrated by Masó and Pijoan (1997: 295).

The well known artist Dr. John Cody of Kansas, who specializes in Saturniidae as subjects for his art (Cody 1996), has produced several large paintings in transparent watercolors showing moths of *Samia cynthia* and *S. ricini*, some since his book was published in 1996. One recent painting of *S. cynthia* was released by him as a limited edition print in 1998, and is featured on the front cover of the present work. A colorful painting of a *Samia canningi* in flight can be seen in the book by Linsenmaier (1972: 211). Dr. Walter Linsenmaier (1917-2000) of Ebikon, Switzerland, was deservedly one of the most admired entomological and ornithological artists of the twentieth century. Fine illustrations of *Samia* as pen and ink drawings have also been published on several occasions (e.g., Rondot 1887: 103-104; Fauvel 1897: pl. 4 [same figure shown by Rondot, p. 103]; Beutenmüller 1898: pl. 21; Anonymous 1959; Lutz 1935: pl. 30), as well as engravings (e.g., Holland 1917: 81). We have also seen an exquisite porcelain sculpture of a moth of *S. cynthia*, in full colors, perched upon porcelain driftwood, and signed by the artist, made by the famous firm W. Goebel Porzellanfabrik of Coburg, Bavaria.

Lepidoptera are now reaching the public in another increasingly common venue, namely in insect zoos (arthropodaria) and butterfly houses. Hundreds of cocoons of *Samia* are shipped to these educational facilities in Europe and the United States from the Philippines and West Malaysia. Butterfly houses in Britain often exhibit Lepidoptera livestock from India (Collins 1987). Peigler observed living specimens of *Samia luzonica*, *S. tetrica,* and *S. ricini* on public display in the Butterfly Pavilion & Insect Center, Westminster, Colorado, in 1995-1997. All such material is invariably labeled as *Samia cynthia*.

## RESEARCH IN BIOCHEMISTRY AND INSECT PHYSIOLOGY

Species of *Samia* are among a handful of large, easily-available Saturniidae that are used in research programmes in laboratories around the world. These are mainly *S. cynthia* stock from the United States and Europe plus Japan, *S. pryeri* stock used in Japan, and *S. ricini* used in several countries, but mainly Japan. Dozens of papers appear each year in the literature on physiological, genetic, and biochemical studies using *Samia* as research animals. We only cite a small sample of these studies here, for they have little or no bearing on the taxonomic aspects of the genus. We hope that scientists who publish these studies will all eventually refrain from using the incorrect generic name *Philosamia* and from citing *pryeri* and *ricini* as subspecies of *S. cynthia*.

In insects, diapause may be controlled and terminated by factors such as temperature, moisture, or photoperiod (daylength). Some of the pioneer work on insect diapause by Carroll Milton Williams (1968) used *S. cynthia* as the primary study animal. Wu (1962), cited above for his work on genetics of *S. ricini*, also made some crosses using *S. cynthia*, and found that pupae of the hybrids did not diapause, suggesting that lack of diapause in *S. ricini* may also be dominant, and implying the possibility that diapausing strains of *S. ricini* can be developed. In *Samia*, diapause is controlled by photoperiod, but also by a sex-linked gene (Saito 1994a). Studies in Vienna on the introduced urban population of *S. cynthia* by Pammer (1965, 1966), Nopp and Pruscha (1978), and Nopp-Pammer and Nopp (1967, 1968) have revealed much about the factors that determine diapause of this species. The 4$^{th}$ instar is the main one that is sensitive to diapause control. They concluded that diapause in the Viennese population of *S. cynthia* is controlled primarily by photoperiod, and secondarily by temperature and quality of food. Day lengths longer than 15.5 hours prevent diapause at temperatures of 20-27$^{o}$ C. Shorter day lengths induce diapause, unless larvae are kept above 30$^{o}$ C. Pupae always diapause when larvae are reared at a day length of less than 8 hours. Temperatures below 20$^{o}$ C induce diapause regardless of the photoperiod. Slayter (1953) arrived at similar conclusions as those of the Austrian workers cited above. Their observations also agree with those of Peigler in Texas where short summer days induced diapause and of Naumann in Germany where long summer days did not. Hormonal aspects of pupation and diapause were studied by Quo and Pan (1964), and physiological differences between diapause of *S. ricini* and that of another species (*S. cynthia* or *S. pryeri*) was treated by Hayakawa and Chino (1981). Daylength and temperature also have an effect on the chemistry of ailanthus leaves, which may also be a factor in determining whether pupae enter diapause (Mauchamp 1989). Pupae of several kinds of Saturniidae are well known to remain in diapause for two, three, or even more consecutive winters; some of these are the European species of *Saturnia* (including *Eudia*), the North American *Hyalophora* and *Callosamia*, and a few others (Lucas 1838:177; Standfuss 1896), but such prolonged diapause is very rare or absent in *Samia*.

The white waxy powder that is found on mature larvae of most species of *Samia* was studied by Bowers and Thompson (1965), working with *S. ricini*. Most of the substance is a mixture of two straight chain saturated alcohols, i.e., 99.4% *n*-triacontanol ($C_{30}H_{62}O$) and 0.6% *n*-octacosanol ($C_{28}H_{58}O$). The white waxy material confers the appearance of a mass of sporulating fungus. Effective camouflage is virtually impossible in a highly polyphagous species, such as in many *Attacus* and some *Samia*, so other strategies like resemblance to an inedible fungal mass might enhance fitness by reducing avian predation.

*Samia ricini* has been used as a study animal in several Japanese laboratories for workers investigating its sex pheromone (Takeda 1950, Tomida & Ishii 1968, Tomida & Mayaesawa 1992). Tomida and Ishii conducted a series of experiments, concluding that the pheromone is an unsaturated carbonyl compound. The chemical name for the sex pheromone of *Samia ricini* is (4*E*,6*E*,11*Z*)-4,6,11-hexadecatrienal (Bestmann et al. 1989). Further tests of isomers of this were carried out by Tomida and Mayesawa (1992) whose results suggest that the presence of 6,11 double bonds is required for male response; see also Tomida and Fuse (1993). Priesner's (1968) early classic study that surveyed the pheromone groupings of many Saturniidae indirectly demonstrated that the pheromone of *Samia* is probably closest in its biochemical structure to those of *Callosamia* and *Epiphora*.

Culturing the large caterpillars of *Samia ricini* in laboratory colonies is easily accomplished, and it serves as a study animal for many facets of insect physiology and biochemistry. Papers describing the nervous system were published by Bhargava and Narian (1972) and Singh (1975 and references cited therein). Encapsulation in larval tissue was tested by Takahashi and Enomoto (1987, 1995). Our colleague Histoshi Saito (1994b, 1998a) of the National Institute of Agrobiological Sciences in Tsukuba has an ongoing research programme studying the pigments and hemolymph of various Saturniidae. Blue larvae of the eri silkmoth gain their color from the pigment biliverdin. The scoli of some species of *Samia* (*luzonica*, *kohlli*, *watsoni*, etc.), as well as certain scoli in *Callosamia*, *Epiphora*, and *Hyalophora,* are yellow, red, or orange colored. This coloration is known to be imparted by carotinoids, such as primarily β-carotine (Mummery et al. 1976). *Samia ricini* was also part of the

study by Sauman and Reppert (1996) who studied the molecular structure and effects of prothoracicotropic hormone in *Antheraea pernyi*. Other research on how ecdysteroids control gut-purging just prior to cocoon-formation was reported by Fujishita et al. (1982). There are dozens more papers in the scientific literature that testify to the importance of *Samia* to basic entomological research.

# CYTOGENETICS

A moderate amount of research has been published on the cytogenetics within the genus *Samia*, mostly by Asian workers. These studies consist mainly of simply reporting the chromosome numbers of the various taxa, but the data are useful for our taxonomic study. The modal number for Saturniidae is $n = 31$, which is the number for many species in the genera *Saturnia, Actias, Hyalophora, Antheraea, Cricula*, and even *Automeris*, the latter belonging to the subfamily Hemileucinae (Belyakova & Lukhtanov 1994). *Callosamia promethea* (Drury) has a lower number, namely $n = 19$. This reduced number supports the hypothesis that *Callosamia* is closely related to *Samia*.

The chromosome number for *S. cynthia* is $n = 13$, based on stock from northeastern China (Liaoning, Shandong, and Shanghai) and Korea examined by Yosida (1953) and Wu (1962), and material studied by other workers which probably included United States stock (see below). The chromosome number for *S. wangi* from Taiwan is $n = 13$. Material from Zhejiang showed 14 pairs, and could have been either *S. cynthia* or *S. wangi* (Wu 1962). When Wu (1962) crossed *S. ricini* with what he called *S. cynthia walkeri*, he observed one trivalent and 12 bivalent chromosomes in the hybrids. The number for *S. canningi* (Khasi Hills, Meghalaya, India), *S. ricini* (Korea and India), and *S. pryeri* (Japan) is $n = 14$. The studies done in India were by Narang and Gupta (1979a, b), and workers in Korea and Japan are cited by Belyakova and Lukhtanov (1994). The above supports the following taxonomic opinions, which we have derived using information aside from the cytogenetic data: (a) *S. cynthia* and *S. pryeri* are not conspecific, (b) *S. cynthia* is most closely allied to *S. wangi*, (c) The taxon we call *S. ricini* was originally derived from *S. canningi* in India, but some cultures probably also contain genes obtained from *S. pryeri*. Schulman (1978) studied the spermatogenesis of *Samia cynthia*.

# BIOLOGY

**Hostplants**

The term hostplant is used here to indicate plants on which the larvae feed. Following many lepidopterists and coleopterists, we restrict the word foodplant to mean a source of food for the adult insect. Thus adult beetles feed on foodplants, butterflies and many kinds of moths take nectar from foodplants, but by this definition Saturniidae do not have foodplants, since they take no nourishment in the adult stage. However, the words hostplant and foodplant are widely used interchangeably in the literature when pertaining to what caterpillars eat. The botanical name authorship, plant family, and key synonyms are given in the Hostplant Appendix for most of the plants cited in this subsection.

Larvae of the genus *Samia* are not as polyphagous as are those of some other Attacini such as *Attacus atlas* and *Hyalophora cecropia*. Most of the species of *Samia* that have been commonly reared (*pryeri*, *ricini*, *cynthia*, and to a lesser extent *wangi* and *canningi*) are best termed oligophagous, meaning that they have an intermediate range of hostplant acceptance. Much less is known about the hostplant preferences in nature and captivity of those species of *Samia* that inhabit more tropical areas like the Philippines and Indonesia. It is possible that some tropical *Samia* are more restricted in their hostplant selection, as we know for some other Attacini like *Callosamia securifera*, *C. angulifera*, and *Hyalophora columbia.*

The hostplants of *Samia* provide some insight into the phylogeny of the genus, as will be seen below. As a group, the genus *Samia* favors only a handful of plant families. Analyzing sequencing data from the *rbcL* gene, Chase et al. (1999) demonstrated a phylogenetic relationship between Rutaceae and Simaroubaceae. Many records from both tropical and subtropical areas of Asia are for plants in the Simaroubaceae, Lauraceae, Euphorbiaceae, and Rutaceae. The Lauraceae are all trees or shrubs, some evergreen and some deciduous, whereas in the Euphorbiaceae those exploited usually lack milky latex, like Chinese tallow (*Triadica sebiferum* Small [=*Sapium sebiferum*]) which is a woody deciduous tree, and castor bean (*Ricinus communis*), a large herbaceous plant that can be almost tree sized and almost perennial. Cassava, also called tapioca (*Manihot esculenta*), and *Jatropha* are further euphorbs used for rearing *Samia ricini* in India. Certain Euphorbiaceae are chosen in Africa by *Epiphora*. In the Rutaceae, there are at least seven species of *Zanthoxylum* (=*Fagara* in

part; = *Xanthoxylum*) recorded for *Samia* in India, China, Indonesia, Japan, and France. Hoptree (*Ptelea trifoliata* Linn.), another member of the Rutaceae, was once reported to be a foodplant of *Samia cynthia* in the northeastern United States (Beutenmüller 1898). In southern Texas and Mexico, larvae of *Rothschildia lebeau* (Guérin-Méneville; = *R. forbesi*) feed on lime prickly-ash (*Zanthoxylum fagara* (L.) Sarg.). In June 2000, Peigler carried out some non-quantitative trials by placing eggs and newly hatched larvae of *S. cynthia* on several plants he had established in his backyard in Texas. The stock was from Matsumoto, Japan. Besides ailanthus, foods which yielded rapid larval growth were corktree (*Phellodendron amurense*), Chinese corktree (*Phellodendron chinense*), and Chinese prickly ash (*Zanthoxylum simulans*), all in the Rutaceae. Plants which gave very poor to moderate growth included sweetgum (*Liquidambar styraciflua* L.), Chinese sweetgum (*Liquidambar formosana*), tuliptree (*Liriodendron tulipifera*), Chinese tuliptree (*Liriodendron chinense* (Hemsl.) Sarg.), buckthorn (*Rhamnus frangula* L.), pawpaw (*Asimina triloba* (L.) Dunal., Annonaceae) and others mentioned in the discussion below.

A conspicuous overlap exists between the suite of hosts selected by Papilionidae and *Samia*. Some are toxic, containing iridoid glycosides, and most are highly resinous or even contain milky latex (Powell et al. 1999). Examples of these include Lauraceae, Oleaceae, Rutaceae, Euphorbiaceae, and Apocynaceae. Overcoming toxic and viscous fluids by the caterpillars is often accomplished by cutting the stem or leaf with their mandibles to drain resin canals, or at least reduce vascular pressure before feeding (Powell et al.). This may explain why larvae in some foodplant trials carried out by Peigler grew well on detached castor leaves (*Archaeoattacus edwardsii*) whilst others grew poorly under sleeves on castor leaves that were still attached to the growing plants (*Samia wangi*, *Samia cynthia*, *Atteva punctella*, *Eupackardia calleta*), as briefly discussed in the section on castor below. Historical and recent literature from India indicates that *S. ricini* is always reared on cut leaves of castor, instead of on leaves of the live plants still rooted in the ground.

Although ailanthus is not a suitable food for *Callosamia*, it is sometimes accepted by *Hyalophora cecropia* (Linnaeus), and is an excellent food for caterpillars of *Attacus* and *Archaeoattacus* in captivity. It is not known whether ailanthus trees (*A. excelsa* in India and *A. altissima* in China and the United States) are ever used by these large Attacini (*Attacus* and *Archaeoattacus*) in nature. Ailanthus was not accepted by *Eupackardia calleta* (Westwood) (Peigler, personal observation), a species otherwise somewhat polyphagous.

In temperate zones like Japan and northern China where *Samia* is native and Europe and North America where *Samia* is introduced, some plants are apparently selected by ovipositing females besides ailanthus, although the latter remains the preferred host. These alternate foods include Lauraceae, Magnoliaceae, and Oleaceae, and coincide to favorite choices of *Callosamia*. In North America, cocoons of *Samia cynthia* have reportedly been found on sassafras (*Sassafras albidum*, Lauraceae), spicebush (*Lindera benzoin*, Lauraceae), tuliptree (*Liriodendron tulipifera*, Magnoliaceae), and ash (*Fraxinus* spp., Oleaceae). As Forbes (1923) put it, "Caterpillar on Ailanthus, rarely straying to wild cherry and other *promethea* foods." In captivity these plus others like privet (*Ligustrum* spp., Oleaceae) and lilac (*Syringa vulgaris* L., Oleaceae) provide acceptable foods for larvae of most temperate and tropical species of *Samia*. To this list may also be added the genus *Prunus* (Rosaceae), containing the wild cherries and wild plums, some of which serve as primary hosts for *Callosamia promethea* (Drury), and probably occasionally *Samia cynthia* in the United States. The suite of so-called *promethea* foods was also listed by Beutenmüller (1898), Eliot and Soule (1902), and Lutz (1935). Oleaceae are also favorites of other Attacini including *Rothschildia*, *Eupackardia, Attacus*, and *Archaeoattacus*. We found only a single record for *Samia* selecting Rubiaceae, although *C. promethea* and *Rothschildia orizaba* (Westwood) both favor buttonbush (*Cephalanthus occidentalis* L., Rubiaceae) in nature. Larvae of *S. cynthia* of stock from Matsumoto, Japan, did not grow rapidly on buttonbush in San Antonio, Texas, compared to their siblings on ailanthus. In 1969, Peigler reared a brood of *Samia cynthia* in South Carolina in which some larvae were fed on ailanthus and others on sassafras, both groups kept under identical conditions. The ones on sassafras were only half grown when their siblings on ailanthus began to spin their cocoons, and the cocoons on ailanthus were larger. Specimens of Italian stock reared by Martin Beeke in Germany on *Ligustrum* were smaller than siblings reared on ailanthus. Many of the European trees and shrubs cited in this discussion can be identified using the well-illustrated guide by Polunin (1980), published in several European languages.

Hostplant data strongly reinforce the hypothetical phylogeny that places *Samia* and *Callosamia* as sister-groups, and this pair of genera as the sister-group to *Hyalophora*. *Hyalophora* favor willow (*Salix*), maple (*Acer*), Rhamnaceae, and several other plants, but plants in those groups are rarely if ever used by *Callosamia* or *Samia*. Conversely, the suite of plants shared by the latter two genera, namely Magnoliaceae, Lauraceae, and Oleaceae, are not usually accepted by *Hyalophora*. *Hyalophora cecropia* is highly polyphagous, yet its larvae will not accept or grow well on ailanthus, tuliptree, sassafras, or various species of *Magnolia* (Peigler, personal observations). It would not be surprising to discover that larvae of *Samia* in Asia feed in nature on *Liriodendron chinense* and *Liquidambar formosana*, although no such records are known to us. Larvae of *Callosamia*

*promethea* from central Ohio reared in San Antonio, Texas, by Peigler grew well and matured on those two East Asian trees.

New hostplant records for *Hyalophora cecropia* are not difficult to discover. Using stock from Bexar County, Texas, in 2001, Peigler found that the larvae grew well and matured successfully on Indian hawthorn (*Rhaphiolepis indica* (L.) Lindl., Rosaceae), a common ornamental shrub. *Callosamia angulifera*, generally viewed as monophagous on tuliptree, has been sporadically reported to feed on other trees including sassafras and wild cherry (*Prunus*) (Beutenmüller 1898, Covell 1984), but Lampe (1999) reared larvae of this moth in Germany on an ornamental apple (*Malus* 'Hillieri'). In August 2002 Peigler placed three third-instar larvae of *C. angulifera* (stock from Carbondale, Whitfield Co., Georgia) on leaves of *Magnolia fraseri* Walter, a montane tree that grows in the primary habitat of the moth. They each immediately consumed about one square centimeter of foliage, but became ill and died within 24-48 hours, evidence that this plant is toxic to *C. angulifera*. Siblings from the same brood matured successfully on tuliptree.

The earlier literature contains several erroneous reports of hostplants for *Samia cynthia* in North America and possibly Europe and China. These can usually be traced back to Jordan (1911b) and were perpetuated by Packard (1914), Collins and Weast (1961), Gardiner (1982), and many other authors. They were probably based on cocoons found on these plants, spun by larvae which wandered off of nearby ailanthus trees before spinning. We reject the following plants as true hostplants: *Laburnum* (Fabaceae), walnut (*Juglans*, Juglandaceae), sycamore (*Platanus*), and dogwood (*Cornus*, Cornaceae). Rougeot (1971) reported *Forsythia* (Oleaceae) as a food in France, but Peigler offered this plant to larvae of *Samia cynthia* and considers it to be totally unsuitable for larval development. Packard (1914: 242) indicated that a larva had been reared to maturity on dogwood; we doubt it. Tietz (1972) went to the extreme in listing hostplant records which were originally based on cocoon finds: the larva fed on a nearby plant and strayed onto the "false hostplant" before making its cocoon. For example, the report by Tietz of *C. promethea* feeding on arbor vitae (*Thuja*, Cupressaceae) is certainly incorrect. Some of the hostplants for *Samia* in Asia enumerated by Holloway (1987) are also incorrect; specifically we do not believe celery (*Apium*, Apiaceae) and the palm *Trachycarpus* (Arecaceae). Sarkar's (1988) listing of *S. ricini* eating thebow (*Hodgsonia heteroclita*) in the gourd family seems highly unlikely. It is especially unfortunate that erroneous hostplant records continue to be perpetuated repeatedly in the literature. Arora and Gupta (1979) cited several of the above erroneous plants, as well as many valid records, and several questionable plants that may or may not be correct. Their sources included old literature, label data on specimens, and field reports. Some plants are European, others Indian. The records could refer to *S. cynthia*, *S. canningi, S. wangi,* or *S. ricini*. Although their work is not widely available, their hostplant lists were repeated by Stone (1991), whose book has been widely distributed. Therefore, we cite here these questionable records, with corrected spellings and updated botanical nomenclature. The most doubtful ones include celery, hollyhock (*Althaea rosea* Cav.), Persian lilac (*Azadirach indica*), hornbeam (*Carpinus betulus* L.), amaltas girimalah (*Cassia fistula* L.), and English walnut (*Juglans regia* L.). Ones given by Arora and Gupta that are probably correct (but for which species of *Samia*?) are Indian privet (*Lawsonia inermis* var. *alba*), barberry (*Berberis* sp.), privet (*Ligustrum robustum* Blume), apple (*Malus sylvestris* L.), cherry (*Prunus avium* L.), and plum (*Prunus domestica* L.). The taxonomy of the genus *Ligustrum* is badly confounded by American horticulturists, especially regarding the names *japonicum* and *lucidum*.

Reports of elderberry (*Sambucus*), linden or lime (*Tilia*) (Huwe 1893, Lutz 1935, Steeg 1939), and nannyberry (*Viburnum lentago*) (Beutenmüller 1898) we believe are likely correct. Stone (1991) gave a possibly valid report of *S. cynthia* eating staghorn sumac (*Rhus typhina* L.), but we omit it from our Hostplant Appendix because we do not know if the record was based on rearing or field collecting. Anacardiaceae is plausible because it is one favored by some other Attacini such as *Rothschildia* and *Attacus*. The report of jujube (*Ziziphus jujuba*, Rhamnaceae) by Arora and Gupta (1979) could refer to *S. cynthia* or *S. wangi* in China, or to *S. canningi* in India. It is surely a valid record, for it coincides with utilization of that family by other Attacini: *Hyalophora cecropia* favoring buckthorn (*Rhamnus frangula*) in Colorado, *H. euryalus* on *Ceanothus* in California, and several *Epiphora* choosing *Ziziphus* and *Maesopsis* in Africa (Seydel 1939, Pinhey 1972). It would not be surprising to learn that *Samia watsoni* in China uses *Ziziphus* as a larval food. It was recently reared in captivity in Taiwan on *Liquidambar formosana,* but it is not known if that tree is used as a food in nature by *S. watsoni*; nevertheless, that tree grows commonly in the area where the adult female was collected and the livestock derived.

At this point, it may be useful to summarize our views as to which are the best ones to offer larvae in this genus. In general, ailanthus (any species) is the best food for *Samia*. *Cinnamomum camphora*, *Persea*, *Ligustrum* (but not wax-leaf privet [*L. lucidum*] with flat, dark green leaves, because it appears to be toxic), *Zanthoxylum*, and *Phellodendron* are also usually excellent. The following genera should be useful where the preferred ones are not available: *Syringa, Jatropha, Lindera*, *Sassafras, Liriodendron, Magnolia* (some species,

but not *M. grandiflora* L., *M. fraseri, M.* × *soulangeana, M. kobus*, *M. sieboldii*, and *M. stellata*), *Fraxinus, Prunus, Citrus, Triadica*, *Ricinus*, and *Liquidambar*. Plants that may yield adult moths but which are not likely to give optimal growth are in the genera *Sambucus, Rhus, Malus, Tilia, Rhamnus,* and probably *Populus*. Plants that are not suitable to offer are *Photinia* (Rosaceae), *Forsythia, Acer, Quercus, Betula, Salix, Laburnum*, *Lonicera*, and *Cornus*. Experienced rearers know that half-grown or last-instar caterpillars accept and grow on a wider variety of plants than do newly hatched larvae. Thus, it is best to start larvae on an optimal food whenever possible.

Almost all of the hostplants of *Samia* are aromatic plants with essential oils and spicy fragrances in their leaves, stems, barks, or roots. Well-known examples are in the Lauraceae, such as bark of *Cinnamomum camphora*, roots of *Sassafras albidum*, and leaves of *Lindera*. Strong odors are also evident when one crushes the leaves and fruit rinds of Rutaceae like *Citrus* and *Zanthoxylum*. Species of *Zanthoxylum* are sources of spices sporting common names like Szechwan pepper, Japanese pepper, and Indonesian lemon pepper. Also aromatic are *Liquidambar* and certain kinds of *Prunus*.

The overall picture suggests that Rutaceae, Euphorbiaceae, and Rhamnaceae are ancient associations for *Samia*, shared by the African *Epiphora*, whereas Lauraceae and Magnoliaceae have been exploited more recently in Asia, and these were the likely hosts of the ancestors of *Callosamia* that moved from Asia into North America by way of a Bering Land Bridge, sometimes called Beringia. *Hyalophora* appears to have become more adapted to feeding on other taxa such as *Salix*, *Acer*, Betulaceae, and even a few conifers in the Pinaceae, but retains its ability to exploit Rhamnaceae. It therefore appears that *Hyalophora* represents an earlier migration from Asia into the New World, based on foodplant data. The polyphagous *Callosamia promethea* is not recorded from any North American species of *Zanthoxylum* nor hoptree *(Ptelea trifoliata*) (Tietz 1972), and mature larvae from Portage County, Wisconsin, reared in 2002 would not accept hoptree, corktree (*Phellodendron amurense*), nor *Ailanthus altissima* in Texas. Thus the genus *Callosamia* has maintained its ancestral association with Lauraceae, Magnoliaceae, and Oleaceae, but has possibly lost its ability to efficiently feed on Rutaceae and Simaroubaceae. In Africa, larvae of *Epiphora* do not utilize the native Simaroubaceae of the genus *Kirkia*, nor accept *Ailanthus* (R. Oberprieler, pers. comm.).

Rutaceae is probably a plesiomorphic association for the whole tribe Attacini, because some species of *Rhodinia* (Saturniini) specialize on *Phellodendron*, and *Rhodinia* shares critical characteristics with Attacini as enumerated previously. The Chinese *Loepa oberthuri* (Leech) has also been reported on *Citrus* and other Rutaceae (Zhu & Wang 1993), *Loepa* being another genus of Saturniini with attacine features. According to Chou (1990: 155), the author Bao Cui, writing prior to the year 300 A.D., alluded to *feng die*, a moth as big as a bat in size, black in color, having spots on the body, and feeding in orange trees south of the Yangtze River. This appears to be an ancient reference to *Archaeoattacus edwardsii*, because the suite of traits given by Bao does not apply to other moths, including large dark noctuids in the genera *Erebus* (= *Nyctipao*) and *Phyllodes* (Catocalinae), none of which are recorded on Rutaceae (Poole 1989). Species of *Attacus* and *Rothschildia* also select Rutaceae (Ferguson 1972: 225; Peigler 1989: 137; Stone 1991).

Brief discussion pertaining to the biogeography of the most preferred food trees and the fossil record of their past distributions may be of interest here. As stated above, we believe that the association of *Samia* with Simaroubaceae/Rutaceae is plesiomorphic. Based on fossil finds, the genus *Ailanthus* occurred widely in western North America from the Early Eocene through the Oligocene (Graham 1999: 200). Distinctive samaras, seeds that are identified as belonging to this genus, have been found commonly in Succor Creek, Trout Creek, and Stinking Water formations, all of the Miocene of Oregon and Idaho, and in the Green River formation of the Eocene of Utah, Colorado, and Wyoming. *Ailanthus* fossils also have been found in Florissant, central Colorado; Ruby and Beaverhead, Montana; Clarno, Oregon; and Chalk Bluff, California (Tidwell 1998: Chart 3; 143-144). Fossils from the Brandon lignite flora in Vermont have also been ascribed to *Zanthoxylum* in the Oligocene to Early Miocene (Graham 1999: 223).

The fossil record of key Magnoliaceae and Lauraceae, namely tuliptree, camphor, and sassafras, is also abundant in western North America. However, some of the leaf fossils traditionally placed within *Liriodendron* and *Sassafras* are less certain, as it is now apparently believed by some paleobotanists that other genera of ancient plants may have shared those characteristic leaf shapes. Older fossils previously assigned to *Liriodendron* are now sometimes classified as *Liriophyllum* (fossil leaves that resemble tuliptree but may not be), such as those from the Upper Cretaceous deposits of British Columbia. However, Miocene fossils classified as tuliptree are believed to be correctly determined, and Graham (1999) cited *Liriodendron* and *Sassafras* in several tables and text passages. The species of camphor with triveined leaves, both extant and fossil, probably belong under the genus *Phoebe* instead of *Cinnamomum*, but those two genera in the Lauraceae are closely related. Leaves identified as *Sassafras* have been collected in at least nine fossil deposits in western North America. It

was recently found that many of the samaras long identified as *Ptelea*, actually belong to *Diplodipelta*, an extinct genus of plants in the Caprifoliaceae (Tidwell 1998: 140-144). None of these genera range today in western North America. In present day eastern Asia, living representatives of all of them occur, namely *Ailanthus, Cinnamomum, Liriodendron,* and *Sassafras*, but only the latter two have living representatives in eastern North America. *Ptelea* does not occur in Asia, but many other Rutaceae do. At some time, probably after the Pliocene, the ancestor of *Callosamia* entered North America from the Northwest via Beringia, and undoubtedly exploited some of its Asian hostplants in western North America, but *Ailanthus* was probably already extinct. As that region became increasingly drier, those trees and moths disappeared from the West but survived in the East.

Japanese workers have developed artificial diets for eri silkworms. This topic was summarized by Chowdhury (1982: 33-34), who said that the resulting cocoons were the same as those from normal rearing on castor. The recipe for this diet includes 5.5 grams dried castor leaf powder, 1 g powder of Kinako (parched soybean), 1 g sucrose, 1.5 g agar-agar, 5 ml inhibitor solution, and 20 ml water. Artificial rearing media for laboratory cultures of insects are being constantly developed and improved, primarily in Japan.

**Ailanthus.** A detailed study of the genus *Samia* should include information pertaining to its primary host genus, *Ailanthus.* The genus contains about ten species of trees primarily found from the Solomon Islands, New Guinea, and northern Australia to the Himalayas and northern China (Hu 1979). The generic name comes from aylanto, a Moluccan word meaning "reaching to heaven." Besides the famous *Ailanthus altissima* (Miller) Swingle (Figs. 138-139), some of the other species are the rare *A. fordii* Nooteboom; *A. vilmoriniana* Dode from western China, and established at the Greifswald Botanical Garden in Germany and the Royal Botanical Gardens at Kew in England; *A. giraldii* Dode from western China; *A. grandis* Prain (= *A. integrifolia* Lam.) from Assam to Vietnam and Java; *A. triphysa* (Dennst.) Alston *(=malabarica*,*= imberbiflora*) from the Andaman Islands and southern India, and often cultivated in Sri Lanka, Australia, and southeastern Asia; and *A. excelsa* Roxburgh from all over India, probably introduced to areas of that country beyond its natural range. We are grateful to Malcolm Walker (pers. comm. to Peigler, April 1993) of High Wycombe, England, for his comments on the taxonomy of this genus. A brief review of the genus *Ailanthus* was included by Chowdhury (1982). It would not be surprising to find that some species of *Ailanthus* are larval foods of *Samia* in eastern Indonesia, but we stress that no such records are known to us. Rondot (1887: 80) quoted F. B. Forbes as observing two species of *Ailanthus* in China, the common *A. altissima,* and one he saw in central China that he called *A. malabarica* (a junior synonym of *A. triphysa* if the identification and taxonomy can be trusted).

Comments pertaining to the fossil record of this plant genus are given above in our discussion on hostplants. Our color Figure 137 shows a fossil samara of *Ailanthus lesquereuxi* Cockerell from the Green River formation in Wyoming, considered to be Middle Eocene (Uintan) in age, i.e. 46 to 43 million years ago. A fossil seed of ailanthus of Miocene age from Europe was figured by Kramer (1995: 118). Graham (1999: 208, 259) figured a samara of *Ailanthus americana* Cockerell from Florissant in central Colorado (Late Eocene---Early Oligocene) and listed *Ailanthus indiana* from Succor Creek of southeastern Oregon (Late Miocene).

A primary common name for *Ailanthus grandis* is barpat. It has limited value in forestry in the Bengal region (Guhathakurta & Ghosh 1972). While in Colorado, Peigler received seeds from S. N. Chowdhury (under U.S.D.A. permit no. 37-73955) and found that seedlings grew well in pots. Larvae of *Samia cynthia* and *S. ricini* matured well on the large leaves. Peigler responded to a request in 1993 from the Parks & Recreation Department of Lakeland, Florida, by sending seeds and seedlings to them, so it is possible that this tree was successfully introduced into the United States. The huge samaras are 10-12 centimeters long. The gum resin has been used in traditional medicine in Nepal and India (Hung et al. 1995).

Maharukh, a Hindi name for *Ailanthus excelsa*, grows commonly in the Himalayas, even as far west and north as Gujarat and Punjab, and is probably the primary host for *Samia canningi* in some areas. In India it is also called barkesseru and ardu. Misra et al. (1991) considered *A. excelsa* to be a valuable forest tree and *S. canningi* to be a pest of it. The tree and its seeds closely resemble those of *A. altissima*, which has been introduced from China to Assam (S. N. Chowdhury, pers. comm. to Peigler). Peigler also received seeds of *A. excelsa* from Chowdhury, but had difficulty germinating the seeds and the few plants obtained died within a few weeks. The leaves have even been considered to be a viable source of protein for human consumption (Nag & Matai 1994). The tree has been a source of commercial gum resembling tragacanth (Watt 1908: 95). *Ailanthus excelsa* is one of three secondary foods used for eri silkworms in Assam and neighboring states, the primary one being castor bean.

*Ailanthus altissima* (*=glandulosa, =japonica*) (Figs. 138-139), also called copal tree due to its resinous property, is well known around the world because it flourishes wherever it has been introduced. The main common names in English are tree-of-heaven and ailanthus, and in German, Götterbaum. In China, the tree is known as chū (Fauvel 1895: 36), and its name in Japan is shinju. Peigler has seen the trees growing in many

parts of the United States, like St. George, Utah, and other places like the city of Durango in western Mexico. This species grows in the Argentine cities of Tucumán and Buenos Aires (Hu 1979). It is extremely competitive and well adapted to the harsh urban environment because of its aggressive and extensive root system (Almeida et al. 1995). Although usually reported to be an urban tree, it grows in forests along highways in the southern Appalachians in the Carolinas, and in the countryside of northern Italy and other regions of Europe. Its habitat in China is reported in the botanical literature to be montane forests. Weast (1989) observed it growing in Auckland, New Zealand. It tolerates freezing climates, being common in Beijing, Berlin, Boston, Denver, and Toronto. In warmer climates, it may be less competitive, because it appears to be somewhat displaced by chinaberry (*Melia azedarach* L., Meliaceae) in disturbed habitats in San Antonio, Texas, although ailanthus is not rare in central San Antonio. Rondot (1887: 76) stated that it is not native to Japan. Seeds were first sent to France and England in 1751 by a French missionary in China named Pierre Nicolas le Chéron d'Incarville (1706-1757), and Philip Miller raised some of the first seedlings in Chelsea. The species was introduced to the United States in 1784 around Philadelphia. Some books state that the tree was introduced to the West as a food for silkworms (Zim & Martin 1961; Passarin d'Entrèves & Zunino 1976: 238), but actually the ailanthus was established in Europe and North America more than 75 years prior to the first introduction of *S. cynthia* from China. *Ailanthus altissima* was also brought directly from China to California by Chinese miners in the middle of the nineteenth century (Tidwell 1998: 144). A comprehensive discussion of the botanical and historical aspects of the tree and its introductions was published by Kramer (1995). Peigler (1993a) presented a less detailed, popular-level article on ailanthus. Pierre d'Incarville also sent dead specimens of *Samia cynthia* to England in 1751, as indicated in our section on type specimens for that species.

*Ailanthus altissima* has large compound leaves, which if broken off individually, keep well in water when rearing larvae of *Samia*. Young trees, which grow up to two meters per year, have single thick trunks crowned by a mass of the large compound leaves, almost giving the effect of palms. Each leaflet has a pair of warty glands at its base, serving to rid the plant of excess sugars and thus favorably regulating photosynthetic activity (Bory & Clair-Maczulajtys 1990). Crushed leaves have a strong, characteristic odor. The plant has been used extensively in Traditional Chinese Medicine (Hu 1979). Many people first learn to recognize this tree by the clusters of twisted samaras (Fig. 137) that persist all winter on female trees.

Anonymous (1930) and Pyle (1975) wrote that "paradise tree" is another common name for *Ailanthus altissima*, but that name actually applies to a different tree (see below) in the Simaroubaceae, native to Florida. The error was repeated by Frank (1986), citing Pyle, but the confusion is understandable, given the synonymy of the words paradise and heaven in the English language.

Remarkably, *Ailanthus altissima* is fed upon by very few insects in North America. Besides *S. cynthia*, the only Lepidoptera known by us to feed on its leaves are the fall webworm (*Hyphantria cunea* (Drury), Arctiidae) and the white-marked tussock moth (*Orgyia leucostigma* (J. E. Smith), Lymantriidae), both highly polyphagous, as well as the specialized *Atteva punctella* (Cramer) (Yponomeutidae: Attevinae) (Tietz 1972: 824). Another insect that feeds on foliage of ailanthus trees in the eastern United States is a scarab called the Asiatic garden beetle (*Maladera castanea* (Arrow)). The beetle feeds in the adult stage on several plants, including soybeans. In Biasca, Switzerland, ailanthus was reported to be a host for *Saturnia pyri* [Denis & Schiffermüller] by Jost et al. (2000: 383). One of the reasons that Alberto Zilli (pers. comm. to Peigler, 19 September 2002) attempted to introduce *S. cynthia* to Rome in 1994 was because it was hoped to be a possible biological control agent against *A. altissima*, considered to be weed trees with root systems that could damage foundations of historical buildings.

The native *Atteva punctella* has shifted to ailanthus from its original hosts in Florida, the paradise-tree (*Simarouba glauca* DC.) and allthorn (*Castela* spp.) in Mexico, Arizona, southeastern California, and southern Texas, all native members of the Simaroubaceae. The taxonomy has been confounded, but apparently all populations from North America including southern Florida belong to the single species *A. punctella*; synonyms include *aurea* (Fitch), *floridana* (Neumögen), *gemmata* (Grote), and *exquisita* Busck. However, Arnett (2000: 677) considered the oldest correct name for this insect to be *Atteva pustulella* (Fabricius), and its group was elevated to family level, i.e. Attevidae, tropical ermine moths. Although the species does not survive harsh winters, the little moths are blown northward from Florida, southern Texas, and Mexico at least as far as New York (Forbes 1923: 340) and Nebraska by weather fronts each spring and summer, and establish temporary breeding populations on ailanthus trees. Peigler often observed larvae of this attractive moth in late summer causing defoliation of small ailanthus trees in Greenville, South Carolina. The slender brown caterpillars make a communal web, thus their common name "ailanthus webworms." These webs are transparent, so that larvae and pupae can easily be seen within. The moths are commonly attracted to lights, but are also active by day, feeding on flowers, protected by aposematic coloration. They can be readily recognized by the black, white, and scarlet

checkerboard pattern on the forewings. The moths were illustrated in color by Holland (1917: 424, pl. 48) and Covell (1984: 431, pls. 61-62). Peigler collected specimens in San Antonio, Texas, at lights at night, on goldenrod (*Solidago*, Asteraceae) flowers during day, and as larvae and pupae on ailanthus. In India, *Atteva fabriciella* Swederus is reported to be a defoliator of ailanthus, where the trees are native (Misra 1993). Other species of *Atteva* occur in Australia (Common 1990: 204, pl. 3). The genus consists of about 50 named species, most in the Indo-Australian region, but up to ten in South America and Mesoamerica (Watson & Whalley 1975). An informative paper on the North American *Atteva* was published by Powell et al. (1973). *Atteva* probably has more potential than *Samia* as biological control agents of ailanthus.

In 1999-2002 Peigler grew seedlings of *Kirkia wilmsii* Engl. and *K. acuminata* Oliv., two southern African trees in the Simaroubaceae. Larvae of *Samia cynthia* and *S. ricini* refused to feed on those two plant species. Larvae of *Atteva punctella* collected on ailanthus in San Antonio were offered leaves of castor bean but refused them. Others were also placed on leaves of seedlings of *Kirkia wilmsii* and *K. acuminata*. These were also generally refused, but half-hardened stems of *A. wilmsii* were cut by the larvae, and the detached portions with leaves were covered by webbing. In Australia, caterpillars of *Atteva niphocosma* Turner feed in webs on *Polyscias murrayi* (Araliaceae) (Common 1990: 204), and *Samia* also utilize certain Araliaceae. These limited observations enhance our belief that the choices of hostplants for *Samia* and *Atteva* coincide closely, being determined by secondary plant chemicals. It also appears that larvae of *Samia* and *Atteva* do not accept all members of the Simaroubaceae. Plants of *Castela* and *Simarouba* were not available to us to offer larvae of *Samia*. Other records for *Samia* using Simaroubaceae in nature come from Japan where Nakajima (1987) listed *Picrasma* as a food for *S. pryeri*, and from the Andamans where Mohanraj et al. (1998) collected 20 cocoons of *S. fulva* on *Picrasma javanica*.

**Castor.** The well-known castor plant (*Ricinus communis* Linnaeus) (Fig. 140) is grown worldwide in tropical and temperate climates, often as an ornamental plant in private gardens because of its massive leaves and rapid growth. Although in the spurge family (Euphorbiaceae), it does not contain milky sap. It is generally considered to be herbaceous, and usually grown from seeds as an annual, but may grow up to 10 meters tall and live for several years. In the Himalayas, the castor plants grow up to elevations of over 1800 meters. Common names in various languages include palma christi, castor bean, castor-oil (English), hima (Japanese), toogoma (Japanese: Chinese sesame), ricin (French), ricino (Spanish, Italian), rícino (Portuguese), higuera del diablo (Spanish), higuera infernal (Spanish), higuerilla (Spanish), frijol de castor (Spanish), pimajoo (Korean), Wunderbaum (German), Rizinus (German), eri (Assamese), arund (Assam), ander (Nepali), bi ma zi (Chinese), chamaling shing (Dzongkha), wonderboom (Dutch), jarak (Malay), jarak kaliki (Bahasa Indonesia), erandi (Himachal Pradesh), and mamona (Portuguese).

The seeds (castor beans) are highly poisonous, as they contain ricin, but when their oil is extracted at low temperatures, it is not toxic. Castor oil has been used medicinally. There has been some debate among botanists whether the plant was originally native to Africa or Asia, but it has been cultivated on both continents for thousands of years. Watt (1908: 915-923) gave an exhaustive account of the history of its cultivation and uses, especially for India. Seeds have been found in Egyptian tombs over 4000 years old. It may be of interest to entomologists to point out that the seeds have a shape, color, pattern, and gloss that cause them to closely resemble engorged female hard ticks (Arachnida: Acari: Ixodidae). Carolus Linnaeus noted the similarity, because the name of one Eurasian tick is *Ixodes ricinus* (L.), found on sheep and cattle. *Castor* is the generic and Latin name for beaver. Historically, oil from beavers was used medicinally, and later oil from the seeds was a substitute, thus the word castor became applied to the plant in the English language.

Although there is probably only a single species of *Ricinus*, there are many cultivars. Some have leaves that are deeply cut, others more rounded. Some have considerable red pigmentation; others are pure green. Many of these varieties have been given names (e.g., 'Carmencita', *africanus*, *coccineus*, *cambodgensis*, *sanguineus*, *zanzibarensis, macrocarpus, purpureus, gibsonii, hybridus panormitans, laciniatus, macrophyllus*, and *borboniensis arboreus*), and some have erroneously been considered to be distinct species or subspecies by some authors. Adair and Adair (1931) found no appreciable differences in growth and size of larvae of *Samia ricini* reared on different varieties of castor.

*Ricinus communis* is unquestionably the most ideal plant for rearing larvae of *Samia ricini* (Biswas & Das 2001), the cultivated strains of the insect having evidently become especially adapted to this one host. Recent rearings of other Attacini by Peigler in Texas revealed this to be an excellent plant also on which to rear larvae of *Archaeoattacus edwardsii*. Although stated by Collins and Weast (1961) to be a good food for *Eupackardia calleta*, larvae of stock from southern Texas would not accept it. The stock reared by Collins and Weast was likely from Arizona, where one of the natural foodplants is Mexican jumping bean (*Sapium biloculare* (S. Wats.) Pax) (Weast 1989: 30), another plant in the Euphorbiaceae, whereas no euphorbiaceous plants are known to be

used in Texas by *E. calleta*. It was more surprising to observe that larvae of *S. cynthia* (Matsumoto, Japan) and *S. wangi* (Sichuan, China) reared by Peigler refused to accept or grew quite slowly on castor bean. However, see our earlier comments pertaining to rearing on detached leaves of castor.

Several other insects that feed on *Ricinus communis* in India were listed by Sarkar (1988: 8), who also briefly covered diseases of the plant. In the massive volume by Maxwell-Lefroy and Howlett (1909), biological and distributional data are presented on the following insects that attack castor in India, most of which are considered minor or major pests. The life cycles of three are shown on color plates, as indicated below. The castor butterfly (*Ariadne merione* (Cramer), Nymphalidae, =*Ergolis merione*) (1909: pl. 31); *Pericallia ricini* (Fabricius) (Arctiidae) a pest of castor, found all over India; *Achaea melicerta* (Drury) (Noctuidae: Catocalinae), a common pest of castor; *Euproctis fraterna* Moore (Lymantriidae); *Altha nivea* (Walker), *Thosea cana* (Walker), and *Parasa lepida* (Cramer), which are three species of Limacodidae; *Trabala vishnou* Lefebvre (Lasiocampidae); the castor seed caterpillar (*Dichocrocis punctiferalis* Guenée, Pyralidae) (1909: pl. 50) of which the larvae bore into seeds and stems; the two leaf rollers *Depressaria ricini* Stainton and *D. ricinella* Stainton (Depressariidae); a leafhopper or greenfly named *Empoasca flavescens* Fabricius (Homoptera: Cicadellidae) that distorts new growth; and the mealy wing (*Trialeurodes ricini* Misra, Homoptera: Aleyrodidae) (1909: pl. 81). Corbet and Pendlebury (1956: 192, pl. 39, fig. 86) listed a butterfly they called the angled castor (*Ariadne ariadne* Linnaeus) as eating castor in West Malaysia, and Roepke (1932: 77) reiterated that it lives on castor in Java. In North America, at least 12 Lepidoptera have been documented to feed on castor, mainly in the Arctiidae and Noctuidae (Tietz 1972: 975). In Australia, *Achaea janata* (Linnaeus) and *A. serva* (Fabricius) of the Noctuidae attack castor, the former considered a pest when the plant is grown commercially (Common 1990: 453-454, fig. 46.10). The Australian arctiid *Amsacta marginata* (Don.) also feeds on castor in Australia (Common 1990: 435, pl. 19, fig. 7; fig. 43.20). In Africa, more species in the same genera of moths exploit castor, such as *Achaea catella* Guenée and *Euproctis punctifera* Walker. The nomenclature of the Noctuidae cited above was updated using Poole (1989).

**Parasitoids**

Species of *Samia* are attacked by parasitic insects in the orders Diptera and Hymenoptera. These insects lay their eggs in or on the eggs, larvae, or pupae (within cocoons) of the *Samia* host, and are called parasitoids because they almost always cause the death of the host. (A true parasite does not kill its host.) The parasitoids of *Samia* were tabulated by Peigler (1996) in a catalog covering those known to attack Saturniidae. Most of the data summarized below are based on earlier reports in literature.

General discussions on this topic for the uninitiated reader were given by Shaw (1990), Fukaya (1994: 162), and Peigler (1996). Several authors who published monographs on Saturniidae cited numerous records for parasitoids in their texts, including Tutt (1902: 333), André (1908), Aue (1933), Collins and Weast (1961), Rougeot (1971), Peigler (1989), Tuskes et al. (1996), and Zhu and Wang (1996). A significant number of the parasitoids listed below pertain to species native to Europe and North America that attack the adventive populations of *Samia cynthia*. In most cases, they have broad host ranges (like most chalcidoids and some tachinids), or specialize on other Saturniidae, such as *Enicospilus americanus* and *Conura maria*, or especially on other Attacini, such as *Gambrus nuncius*. We thank Dr. David Wahl of the American Entomological Institute (Gainesville, Florida) for updating some of our nomenclature of the Ichneumonidae. In the following tabulation, the final family (Tachinidae) belongs to the order Diptera, and all others are in the Hymenoptera.

**Ichneumonidae.** *Acropimpla persimilis* (Ashmead) is a Palaearctic species attacking *S. cynthia*, *S. pryeri*, and other Lepidoptera in Korea, Japan, China, and far eastern Russia.

*Iseropus himalayensis* (Cameron) (=*Gregopimpla himalayensis*) ranges widely in eastern Asia, and has been reared from *S. pryeri* and *S. cynthia*. From a single cocoon of *Gastropacha orientalis* (Lasiocampidae) collected in Japan, 51 females and 5 males were reared (Yukinari 2000).

*Apechthis capulifera* (Kriechbaumer) (=*Pimpla japonica*) is a Eurasian wasp recorded as parasitizing *S. pryeri* by Aue (1933: 155). Other host records include *Caligula japonica* (Butler) (Saturniidae), *Lymantria dispar* (Lymantriidae), and several Lasiocampidae and Rhopalocera.

*Pimpla disparis* Viereck (=*Coccygomimus disparis*) is a wasp reported to attack *S. cynthia* in Japan and Korea. The host record was cited correctly by Zhu and Wang (1996: 98), but erroneously as *S. walkeri* by Peigler (1996). *Pimpla luctuosa* Smith (=*Coccygomimus luctuosus*), as pointed out by Peigler (1996), has host reports from Japan and various regions of China, so could belong under *S. pryeri*, *S. wangi, S. cynthia*, or all three. *Pimpla parnarae* Viereck (=*Coccygomimus parnarae*) is recorded from various Bombycoidea in China and neighboring areas. A record for *S. cynthia* was from Japan, so could refer to that introduced species, or to the indigenous *S. pryeri*.

*Xanthopimpla brullei* Krieger was listed by Townes and Chiu (1970) from *S. cynthia* in Jakarta, Java, but

Peigler (1996: color fig. 1) transferred the host record to *S. insularis*. The Paukstadts reared one from a cocoon of *S. luzonica* from Boac, Marinduque Island, Philippines, on 22 August 1987, which yielded a new host record and a range extension for the parasitoid. We obtained a series of both sexes of *X. brullei* that emerged from cocoons in a cage of a dealer in Bandung, West Java, in late March 2000. Naumann collected these from the cage, containing cocoons of both *Attacus atlas* and *S. insularis*. Voucher material of *X. brullei* from this source was deposited in some institutional collections (FMNH, LACM, TAMU). In addition to *Attacus* and *Samia*, this parasitoid attacks *Cricula* on Sulawesi (Naumann 1995) and other Indonesian islands.

An unidentified species of *Xanthopimpla* was found to parasitize cocoons of *Samia fulva* in the Andamans by Mohanraj et al. (1998). This species could not be identified using the figures and keys in Townes and Chiu (1970), so possibly represents an undescribed species. Another reference to an unidentified *Xanthopimpla* was given by André (1908: 77) for *S. insularis* in Java. Reports of *X. pedator* attacking Saturniidae are probably misidentifications for *X. brullei*. In handbooks and guides to ericulture (Jolly et al. 1979, Chowdhury 1982, Sarkar 1988) we found no reports of *Xanthopimpla* being reared from *Samia ricini*, probably because those cocoons are protected from the ovipositing wasps, and harvested soon after they are spun. The sesiid moth *Specosesia pedunculata* Hampson, described from Sikkim, appears to be a mimic of *Xanthopimpla* wasps, and was figured in color by Gaede (1933: pl. 94h).

*Gambrus nuncius* (Say) is found in eastern North America, specializing on the three species of *Callosamia*. It is not surprising that it would adopt the introduced *S. cynthia* as a host, because the cocoons of *C. promethea* and *S. cynthia* are much alike. Two other species of *Gambrus* are specialized on *Antheraea polyphemus* (Cramer) and *Hyalophora*, but are not recorded from *S. cynthia* or *Callosamia*. These data offer an additional piece of evidence to support the hypothesis that *Samia* and *Callosamia* are sister-groups. Females of *Gambrus* oviposit into their hosts as they spin their cocoons; the wasps possibly locate the hosts by the odor of fresh silk. The wasps are generally black with orange legs, and several to many adults emerge from a single host cocoon. See illustration of Dickerson (1901: 142) showing parasitoid cocoons packed within a host cocoon. Peigler (1996: fig. 2) showed an adult of *Gambrus* in color. The ichneumon shown in our Figure 148 looks like a *Gambrus*, so it might represent an Asian species that is not listed above.

*Enicospilus americanus* (Christ) (=*Eremotylus macrurus*) is a large orange wasp commonly reared from most of the Nearctic Saturniinae, especially in the East. An egg is deposited into the host larva, but the parasitoid larva matures and completely consumes the host only after the host spins its cocoon, and then the parasitoid pupates within the host cocoon. Considering its specialization on large Attacini and other Saturniinae, it is not surprising that it became a significant parasitoid in introduced populations of *S. cynthia* in the United States. Specimens of *Enicospilus americanus* were illustrated by Dickerson (1901: 141), Eliot and Soule (1902: pl. [2]), Collins and Weast (1961), and in color by Peigler (1996: fig. 3). Peigler located a male of this parasitoid labeled "from *cynthia* cocoons from KNY Sheerer [Instruments] Company; May 24, 1908" in the University of Nebraska Museum, Lincoln, Nebraska.

There are hundreds of species of *Enicospilus* native to the regions in Asia where *Samia* occurs. Some of these probably attack *Samia*, but since most available specimens of these parasitoids were collected at lights instead of reared, we still have no host records for *Samia* in Asia.

**Braconidae.** *Apanteles* sp. recorded as attacking *Samia walkeri* in Hong Kong (Peigler 1996) must now be corrected to *Samia wangi*. The tiny black wasps of *Apanteles*, *Cotesia*, and allied genera lay their eggs in caterpillars. The parasitoid larvae mature and exit the caterpillar, spinning their white or yellowish cocoons individually and attached to the integument of the host, or in a mass near the dying host.

*Cotesia dictyoplocae* (Watanabe) was recorded to parasitize larvae of *S. cynthia* in the vicinity of Seoul, Korea. This parasitoid has been reported to attack the saturniids *Caligula japonica* (Moore) and *Antheraea pernyi* in Japan and northeastern China. As many as 20 to 30 wasps may emerge from a single host caterpillar, and they spin and attach their cocoons to the integument of the host, emerging about 5 days later (Kim 1960: 300). This species was not cited by Peigler (1996), and was transferred from *Apanteles* to *Cotesia* by Papp (1990).

Wullschlegel (1863) observed a microgastrine braconid parasitizing *S. cynthia* in Switzerland. He referred to "Inquilinen" as small wasps emerging in large numbers that had pupated on the skin of the caterpillar.

**Chalcididae.** *Conura maria* (Riley) (=*Spilochalcis mariae*). This wasp is yellow with black markings, and has the inflated tibiae that characterize the Chalcididae. It is one of the main parasitoids of Saturniinae in North America, and apparently exerted considerable selection pressure on urban populations of *S. cynthia*. It prefers hosts with hanging cocoons, and is reared commonly from *Callosamia*, *Rothschildia, Antheraea polyphemus*, and *S. cynthia*, but rarely from *Hyalophora*. It has been treated by several authors (Pergande *in* Packard 1914: 247, Collins & Weast 1961, Frank 1986, Weast 1989), and was shown in color by Peigler (1996: fig. 5).

A new host record for *Conura maria* was recently found when 26 wasps emerged 9-10 October 2001 from a

cocoon of *Actias luna* (Linnaeus) that Robert Russell Allen, a student of Peigler, found attached to a lower branch of sweetgum (*Liquidambar styraciflua*) at Stubblefield Lake, Walker County, Texas, on 22 September 2001. *Callosamia promethea* and *Antheraea polyphemus* maintain populations at the same locality. Still another previously unpublished host record for this well-known parasitoid of *Samia cynthia* was obtained when 10 wasps emerged from a cocoon of *Agapema dyari* Cockerell on 9-10 October 2002, which had been collected as a mature larva on *Condalia ericoides* (Gray) M. C. Johnst. (Rhamnaceae) at Fort Davis, Jeff Davis County, Texas, on 16 March 2002 by R. R. Allen and R. S. Peigler. *Conura maria* had previously been reared from *Agapema anona* (Ottolengui) from Arizona (Peigler 1996). The pinned lots from Stubblefield Lake and Fort Davis with the associated host cocoons were deposited in the Natural History Museum of Los Angeles County. It is noteworthy that the emergence dates for these two rearings in San Antonio were identical.

*Brachymeria* are large black chalcidid wasps that have been reared from the cocoons of *S. wangi* in Hong Kong by Hill and Cheung (1978: 73). Other chalcids, possibly of this genus, have been reared from cocoons of *S. canningi* from Assam in 1993 (Peigler 1996: 57). No voucher material was available to enable us to determine the species of these parasitoids. Naumann (1995) reared *Brachymeria* from a cocoon of *Cricula trifenestrata kransi* Jurriaanse & Lindemans from Tondano, Sulawesi, in August 1994.

**Euplemidae.** *Anastatus bifasciatus* Fourcroy is a tiny insect supposedly ranging from Korea to Europe and down into eastern Africa. It was recorded as parasitizing eggs of *S. cynthia* in northern Italy by Arzone (1971b). She found a clump of 12 eggs of *S. cynthia* on ailanthus in August, and from these, 4 caterpillars hatched, but from the remaining eggs 3 males and 4 females of *A. bifasciatus* emerged later (in early September), 1 parasitoid per host egg. Development of the parasitoid requires about 2 months in the host egg. Other species of *Anastatus* were reported as being mass-reared in China in eggs of *S. cynthia* and *S. ricini* for biological control against some species of *Dendrolimus* (Lasiocampidae), which are forest pests (Anonymous 1980: 73).

*Mesocomys menzeli* (Ferrière). This parasitoid is known to attack eggs of *Attacus atlas* and some other Saturniidae in tropical Asia. The report of it in *S. ricini* from Java is erroneous, and is corrected here to *S. insularis* (see Peigler 1996: 62). Some Dutch authors reported *S. insularis* incorrectly under the name *S. ricini* (Dammerman 1919: 118; Menzel 1925: 32).

**Trichogrammatidae.** *Trichogramma dendrolimi* Matsumura, like *Anastatus* above, has been mass-reared in eggs of *S. ricini* and *S. cynthia* in China to use against *Dendrolimus* (Anonymous 1980: 73).

**Scelionidae.** Several species of *Telenomus* have been recorded as parasitizing eggs of Saturniidae in South America, North America, and eastern Asia (Peigler 1996). An unidentified species of *Telenomus* (subgenus *Aholcus*) was reared from eggs of *S. fulva* in the Andamans (Mohanraj et al. 1998).

**Pteromalidae.** *Eupteromalus arzoneae* Bouček is a tiny hyperparasitoid attacking the tachinid *Pales pavida* (see below) in Italy (Arzone 1971a). Ovipositing females are able to select larvae of *S. cynthia* that contain maggots of *P. pavida*. When the maggot emerges from the primary host, it drops to the ground and forms a puparium in the soil. About three weeks later the adults of *E. arzoneae* emerge by chewing a small hole in the side of the puparium of *P. pavida*. About 9-18 hyperparasitoids emerge from a single tachinid.

**Tachinidae.** *Exorista sorbillans* (Wiedemann) is a name that is currently being used to refer to several closely related species, so a taxonomic study of this group is needed. It is one of various species called the uzi fly in sericulture, and can cause significant loss of wild silkworms. Sarkar (1988: 31-32) and Chowdhury (1962, 1982) were among several Indian authors who discussed this parasitoid attacking *S. ricini*. It is also recorded from *S. cynthia* and many other Lepidoptera (Peigler 1996: 75-76). Flies in the related genus *Blepharipa* such as *B. zebina* (Walker) and *B. sericariae* Rondani are also known as uzi flies, and attack many saturniid caterpillars that are cultivated for their wild silk in eastern Asia. Kojima et al. (1963) reported *B. sericariae* parasitizing *Samia pryeri*. Our Figure 148 shows some pinned flies that likely belong to one or more of the aforementioned tachinid species.

*Exorista japonica* (Townsend) was cited by Hiroshi Shima on the Internet as being a parasitoid of *S. pryeri*. As stated elsewhere in this revision, records for *S. pryeri* from Japan must be checked to see if they actually refer to the introduced *S. cynthia*. Although not recorded to attack *Samia* and not cataloged by Peigler (1996), *Exorista grandis* Zetterstedt possibly attacks adventive populations of *S. cynthia* in Europe. A living adult was shown by Jost et al. (2000: 377) that had emerged from a cocoon of *Saturnia pavonia* (Linnaeus). It also attacks *S. pyri* [Denis & Schiffermüller] and *S. spini* [Denis & Schiffermüller] and has appeared in the literature under several synonyms (*pavoniae* Zett., *major* Rondani, *saturniae* Robineau-Desvoidy, *festinata* R.-D.).

*Pales pavida* (Meigen) is one of the tachinids that lays microtype eggs on the foliage of the hostplant so that they will be injested by the host caterpillars. The parasitoid ranges widely across Eurasia, attacking a wide range of lepidopterous hosts. In northern Italy, it parasitizes *S. cynthia*. After the eggs hatch in the midgut, the larvae move to the silk glands of the host where they spend the first instar. They then migrate toward the integument and form a respiratory hole. Larvae of *S. cynthia* containing these maggots (usually 1-9) spin weak cocoons,

usually without peduncles. The maggots form puparia within the host cocoon and adult flies emerge about two weeks later through its pre-formed exit valve (Arzone 1970, 1971a). *Pales pumicata* (Meigen) also attacks *S. cynthia* in Europe (Arzone 1970).

*Winthemia tricolor* (van der Wulp) is a tropical American tachinid that was apparently reared in a laboratory culture of *S. cynthia*. It is not normally a parasitoid of *Samia*. *Winthemia datanae* (Townsend) is also not a parasitoid of *S. cynthia* in North America, but was listed as doubtful by some American authors (see Peigler 1996: 86-88).

*Lespesia frenchii* (Williston) (=*Frontina frenchii*) is a fly found across North America, and commonly reared from Saturniidae and other families of moths and butterflies. It is known to parasitize *S. cynthia* in North America (Packard 1914, Collins & Weast 1961).

*Compsilura concinnata* (Meigen). Although Peigler (1996) overlooked that this species had been recorded to attack *S. cynthia* in Europe, such was found more than a century ago, as indicated in a list tabulated by Arzone (1970: 208). It is known to attack at least 15 species of Saturniidae in its native Europe and in North America where it was introduced on several occasions by the U. S. Department of Agriculture for biological control of the gypsy moth (*Lymantria dispar* (Linnaeus), Lymantriidae). Nontarget hosts include Saturniidae in the subfamilies Hemileucinae, Ceratocampinae, Saturniinae, and in Africa the tribe Bunaeini (Saturniinae). Numerous other nontarget hosts of butterflies and other families of moths are recorded. Peigler believes that selection pressure by *C. concinnata* is the primary reason that *Samia cynthia* has gone extinct (or almost so) in North America. The work of Boettner et al. (2000) suggests that the parasitoid succeeds primarily in forests and ecotones, and it has not been recorded from *S. cynthia* in urban centers like Philadelphia and New York. However, host larvae are usually killed at a young age, at least always prior to cocoon formation, so amateur lepidopterists would have probably overlooked its presence. See also Burgess and Crossman (1929) and our additional comments under the treatment of United States populations of *S. cynthia* (p. 89).

Lastly, an unidentified species of Tachinidae was cited to attack *S. wangi* in Hong Kong (Hill & Cheung 1978: 73).

**Diseases**

Several infectious diseases are recorded to cause mortality in *Samia*, primarily causing economic losses to ericulture based on *Samia ricini*. The pathogens include viruses, bacteria, and fungi. Most of these infect other Saturniidae, in nature and especially in captivity if conditions are humid and crowded. Some primary silkworm diseases have French names (i.e., grasserie, pébrine, flacherie). Collins and Weast (1961) devoted a chapter on diseases in their book on Nearctic saturniids. Cotes (1890) must have had some interest and training in microbiology, because he also provided many details about diseases affecting silkworms. Some more recent books dealing with wild silks published in India (Jolly et al. 1975, 1979; Chowdhury 1982; Sarkar 1988; Mohanty 1998) devoted sections to this topic. Diseases can also lead to disappointment by amateur lepidopterists attempting to rear Saturniidae in captivity. Some useful tips for avoiding or controlling these diseases were offered by Villiard (1969: 12) and Gardiner (1982: 24-29). Mrs. T. Reeta Luikham has been conducting research on viruses at the Regional Tasar Research Station, in Imphal, Manipur, India. A brief list of several diseases of Saturniidae with a special focus on *Samia* follows.

**Viruses.** Infection is generally by ingestion of spores on foliage. The larva becomes limp and the body contents liquify. One viral disease is flacherie, known in Assam as mukhlaga and in Bengal as kala shira (Cotes 1890: 134). It is common in *Samia ricini*, and larvae usually die before spinning (Chowdhury 1982: 59). It can account for 14-30% loss of a crop, is least common during January to March, and most common during April to June (Jolly et al. 1979: 152). Other viruses that attack Saturniidae include NPV (nuclear polyhedrosis virus) and GV (granulosis virus) (Ylla 1997: 201). Peigler has observed NPV to cause significant mortality in some species of *Hemileuca* (Saturniidae) where larvae were reared under humid or crowded conditions, or where wild populations were exposed to cold, rainy weather. Another French name for a silkworm disease caused by NPV is grasserie, to which *Samia ricini* is resistant but *Samia canningi* is susceptible (Jolly et al. 1975: 86). A concise summary of the viruses known to attack insects can be found in the book by Saxena and Srivastava (2001: 275-281).

**Bacteria.** Several species of *Bacillus* attack caterpillars, the best known being *Bacillus thuringiensis*, commonly called BT and used for biological control of lepidopterous pests of forests and agro-ecosytems. It has a broad host range, but some other bacilli are more host specific, with the ability to infect certain, perhaps most, Saturniidae. Collins and Weast (1961: 99-100) and Ylla (1997: 201) discussed several bacterial diseases of saturniids, whereas Saxena and Srivastava (2001: 282-288) covered bacterial infection of insects in general.

**Protozoa.** The disease pébrine is caused by a species of *Nosema*, which is a microsporidian protozoan. It is not *Nosema bombycis* Naegeli, because the *Nosema* in eri silkworms (*Samia ricini*) does not infect *Bombyx mori*.

Chowdhury (1982: 60) stated that the spores of the *Nosema* infecting eri silkworms are oval, narrow at both ends, and 2 microns wide and 3-3.5 microns long, whereas the spores of *N. bombycis* are up to 2.3 microns wide, and 3.6-3.8 microns long. Jolly et al. (1979: 152) gave different measurements for spores of *Nosema* infecting *Samia ricini*, namely 3.2-4.6 microns long and 1.5-2.1 microns wide. Although eri silkworms are somewhat immune to this disease, it can do great damage to a colony if precautions are not in place to prevent infection and spread. Silk glands become infected, flimsy cocoons are made, and adults are weak and poorly formed. Transmission is both oral and transovarian (Saxena & Srivastava 2001: 265). In Assam, the disease is called phutukia.

**Fungi.** Eri silkworms are fairly resistant to fungal infections caused by *Botrytis*, leading to the silkworm disease known as muscardine (Chowdhury 1982: 62; Sarkar 1988: 27-29), and known in Bengal as chuna according to Cotes (1890: 134). Fungal diseases can kill caterpillars rapidly because the mycelium can fill the tracheae, causing suffocation (Collins & Weast 1961: 101). A dead larva will often become covered by powdery white or army green sporulation.

## ECOLOGY AND REARING

If the reader looks critically at the bibliography, it will be seen that no paper exists that can be considered a modern, quantitative field study on the ecology of any species of *Samia*. There are numerous anecdotal reports on the ecology of these insects, and some good studies in the laboratory. Other studies in Europe and the United States give some ecological data, even field observations, but they pertain to urban, and/or non-native populations of *Samia cynthia*. Much remains to be learned about these moths. We strongly encourage entomologists in Asia to conduct good field studies on *Samia*, but at the same time, we must acknowledge that such studies are almost entirely lacking for the large and common saturniids in Europe and North America, with the exception of work on *Hyalophora* by Collins and on *Graellsia* by Ylla (see below).

Leading experts on ecology of Saturniidae include the two Americans Michael M. Collins and Daniel H. Janzen. Those intending to conduct field studies on the biology and ecology of saturniids would be well-advised to consult their writings. Janzen (1984) published a now classic paper that dealt with phototaxis, host plant preferences, and wing shape, with a focus on the tropical species in Costa Rica. He has worked intensively during the past 20 years to assemble a massive data base on the hostplants and parasitoids of saturniids and other moths of Costa Rica. Collins (see Collins & Weast 1961, Collins 1997) contributed significantly to the introductory chapters of the book by Tuskes et al. (1996), and there the focus was primarily on the temperate species in North America. The book by Josep Ylla i Ullastre (Ylla 1997) we believe to be the most in-depth treatise on a single species of Saturniidae, wherein he investigated numerous facets of the ecology and ethology of *Graellsia isabellae* (Graells) in Catalonia. The field work in Indonesia during the 1990s by Ulrich Paukstadt and his associates has greatly enhanced the knowledge of tropical Asian Saturniidae, with many new data for foodplants, parasitoids, habitat characterizations, seasonal flight times, descriptions of immatures, discovery of new species, and geographical distributions. Kirby Wolfe of California has made numerous collecting trips to Central and South America, describing new species and new life histories of Neotropical saturniids. Eurides Furtado in Brazil and Manuel A. Balcázar-Lara in Mexico are also actively advancing our knowledge of Neotropical Saturniidae with their frequent publications.

Many Saturniidae have analogous images among other Lepidoptera, as for example many Ceratocampinae and Hemileucinae resembling certain Lasiocampidae, some *Actias* resembling *Cercophana*, some *Hemileuca* resembling some *Dysphania* (Geometridae), other *Hemileuca* resembling some Lemoniidae, *Arsenura* resembling *Ascalapha* (Noctuidae), and so forth. For *Samia* the closest form within Saturniidae is probably the Neotropical genus *Rhescyntis* (see Draudt 1929: pls. 123, 134; Lemaire 1980: pls. 53-58; Izersky 1999c: pl. 13). The large brown, nocturnal moths with prominent whitish postmedian bands in the genus *Lyssa* (=*Nyctalemon*) (see M. Gaede [1929] *in* Seitz 1928: pls. 69-71; Barlow 1982: pl. 47) of the Uraniidae fly in many areas of the Indo-Australian region, and we hypothesize that they are analogous to *Samia* in size, shape, pattern, and coloration. During light trapping in tropical Asia, similar behaviors in flight pattern and attraction to lights by *Samia* and *Lyssa* were observed by Naumann. Although moths of the genus *Lyssa* contain toxins derived from their larval foods that deter avian predation, field studies in tropical Asia would be necessary to demonstrate any mimicry by *Samia*. Regardless of whether sympatric or allopatric, these parallelisms ostensibly derive from natural selection. In his introductory remarks to chapters on various families in *The Macrolepidoptera of the World*, Adalbert Seitz enthusiastically pointed out such analogues. Remarkable parallelisms between the larvae of unrelated groups of Lepidoptera are also known. Larvae of Indo-Australian Attacini, including those of *Samia*, resemble in form the toxic caterpillars of large Papilionidae in the genera *Ornithoptera* and *Troides*, as

already noted by Peigler (1989: 90), and as shown in color by Lucas (1838: pl. 455) and many later authors.

The submarginal area of the wings in *Samia* may mimic a caterpillar, to deflect the attacks of birds away from the body of the moth (Grant & Miller 1995). Large ochre yellow abdomens of females of *Samia*, adorned with white punctations, resemble the abdomens of large spiders like *Argiope* (Araneidae) and *Nephila* (Tetragnathidae); this image is enhanced by the postmedian lines which suggest the legs of a spider sitting in an orb web. The black and white eyespots on the forewing apices of all *Samia* give the illusion of a snake head, something which has long been pointed out for certain Attacini by other authors. For those surveying avian predation of Saturniidae in temperate ecosystems, it may be worth consulting a list of 33 passerine birds that Zhu and Wang (1996: 100-101) cited as attacking saturniids in China. A few of the species and several of the genera of birds that they listed are also found in the United States and Europe. A further informative paper worth consulting, well illustrated in color, pertaining to defense strategies of larvae and adults of saturniids, was published by Oberprieler and Nässig (1994).

Ovipositional behavior varies within the genus. Normally, females in the wild fly during the night selecting appropriate hosts on which to oviposit, and lay eggs in small masses of perhaps 10 to 30 (Fig. 132). An artifact of long-term culture is seen in *S. ricini* wherein the females do not move about very much as they oviposit, with the result that their eggs are deposited in a tall mass of row upon row around their abdomens, forming small "walls" (Fig. 133). This was described and illustrated by several authors including Saito (1993) and Peigler and Wang (1996: 96). Newly hatched larvae of *Samia* generally do not eat their eggshells, but those of many other species of Saturniidae do so.

Larvae of *Samia* do well in warm and humid conditions, and tolerate some crowding, but also need ventilation (Collins & Weast 1961, Villiard 1969). Larvae do not drop from the foodplant when disturbed, nor are they difficult to detach; both extremes are found among larvae of Saturniidae. However, when removing them from the branch, it is necessary to detach each proleg individually and carefully to prevent injury. As is normal for saturniids, the larvae of *Samia* are quite gregarious immediately after eclosion, and remain so until the final stage, which is the fifth instar. Larvae rest by preference on the underside of leaves, and will even sit on tops of leaves when a cut branch of the foodplant is inserted into a container of water in a position that is lopped over with the underside facing up. Larvae position themselves in small groups, side by side, usually with their heads oriented toward the outer edge of the leaf. Such behavior is also normal for *Callosamia*, *Hyalophora*, and *Epiphora*, but first-instar caterpillars of *Archaeoattacus edwardsii* and probably all *Attacus* sit on the underside of the leaf in a J-shaped position, scattered apart, a behavior which probably enhances their resemblance to bird droppings.

Pupae should not be subjected to freezing temperature, except for those of *S. cynthia*, and even those should not be exposed to temperatures below -15° Celsius (= +5° Fahrenheit). Cocoons kept in the laboratory or in captivity require misting or wetting occasionally to prevent the pupae from dying from desiccation.

As far as known, all species are nocturnal, with females emitting pheromone and males responding only during darkness. Reports by a few American authors that *S. cynthia* is diurnal are incorrect, as we discuss under that species. Mating behavior of *Samia* was described by Miyata et al. (2003) as belonging to the category they called face-to-face posture. All species of *Samia* are known to be phototactic, which accounts for the majority of material in collections from Indonesia, Thailand, the Philippines, and remote areas of China. We have no information about isolating mechanisms, but since most of the taxa are allopatric, these may not be under strong selection pressure to maintain the integrity of the genomes of the various species.

Domestication for centuries results in striking physical and behavioral changes between the original wild and cultivated populations (see Tazima 1984). The genus contains a good example of this phenomenon, namely *Samia ricini*. This insect withstands crowding, indoor rearing, and is more disease resistant compared to its wild progenitor *S. canningi*. The adults do not fly. The cocoons contain more silk, and lack peduncles. The white form of the cocoon has no camouflage, as is the case of *Bombyx mori*. The ovipositional and mating behavior differ between the two. It is clear that *S. ricini* cannot exist in nature, and its continued existence is entirely dependent on human care.

# SERICULTURE

## Genus *Samia*

One of the reasons that the genus *Samia* is of great interest is that certain species produce cocoons that are used to make cloth. Some aspects of this topic are historical, whereas others pertain to modern wild silk industries in several countries. Wild silks is a term used to refer to any and all silks produced by species besides *Bombyx mori*, and are sometimes called non-mulberry silks. The distinction between mulberry silk (called "pat" in India) and wild silk has been known to westerners since at least the early part of the eighteenth century (Lesser 1742: 151). Worthwhile reviews of the subject were published by Cibot 1777; Wardle 1881a; Stack 1885; Rondot 1887; Cotes 1890, 1891-1893; Fauvel 1895; Watt 1908; André 1908; Watson 1911; Maxwell-Lefroy 1917; Handschin 1946 a, b; and Jolly et al. 1979. Peigler (1993b) summarized the wild silks of the world in an article that pointed out that the species used consist mostly of a handful of Saturniidae in Asia, with several kinds of Lasiocampidae and Notodontidae exploited in Equatorial Africa, Botswana, Madagascar, historical Mexico, and ancient Greece. Undoubtedly, the most important wild silk species is the tussah silkmoth (*Antheraea pernyi*) of China, with the tropical tasar silkmoth (*Antheraea paphia* (Linnaeus), =*A. mylitta* (Drury)) being the most widely cultured in India, although the amount of silk harvested from it is now exceeded by *Samia ricini*. Therefore, *Samia ricini* probably ranks as the world's second most important wild silkmoth, whose annual yield far exceeds the muga silkmoth (*Antheraea assamensis* (Helfer)) of Assam and the tensan silkmoth (*Antheraea yamamai*) of Japan, the latter also grown in Korea and China for the Japanese market. Wild silk culture extends back into ancient times in India (Nayak & Guru 1998), and it is actively promoted for both cultural and economic reasons by the modern government of India through the Central Silk Board. In the Himalayan belt, still another wild silk known as oak tasar or temperate tasar is being grown and marketed at significant levels. It is the product of a hybrid strain resulting from crosses between *Antheraea roylii* Moore and *A. pernyi*, and is called *Antheraea proylei* by Indian authors.

Most of the information pertaining to sericulture in the genus *Samia* pertains to *S. cynthia, S. pryeri, S. canningi*, and *S. ricini*, as outlined below. An interesting exception belongs under *S. insularis*, for which Naumann found the evidence in the Nationaal Natuurhistorisch Museum (Leiden). In a glass-top case there are pinned specimens of *S. insularis* from Java, two pinned empty cocoons, a mass of combed silk floss, a sizable skein of spun yarn, and a small piece of brown woven fabric. Apparently a Dutch entomologist carried out some experiments on the silk of that Indonesian moth. Although *Samia* cocoons are common in many parts of the Philippines and Indonesia, the people of those countries do not share the long cultural traditions of sericulture that characterize their neighbors in Japan and mainland Asia. Similar glass-top storage cases kept in the entomology collection of the Muséum National d'Histoire naturelle (Paris), show samples of wild silks at various stages of the process, from cocoons to fabrics (see Figures 147-148). One case (Fig. 147) contains a light beige sample of ailanthus silk sent there by Father Fantoni, the Italian priest who introduced *Samia cynthia* from Shandong to Turin in 1856 (Bouvier 1936: 318). It also contains a darker brown sample bought by the Russian mission in Beijing. The label reads: "Soie grège de l'ailante achetée a Pékin par la mission Russe."

The center of wild silk culture is northeastern India, and several kinds are produced in the region, including muga, eri, tropical tasar, temperate tasar, and fagara silks. The term fagara was probably coined by British colonialists in the nineteenth century, because the name does not appear to belong in the ancient sericultural traditions of India. The word comes from the plant genus *Fagara*, an archaic name for *Zanthoxylum* (Fauvel 1895: 34, 70), a plant on which cocoons of *Samia canningi* could be collected most commonly (Cotes 1891-1893: 74). Fagara silk is a name that now mostly refers to that of *Attacus atlas* from the Assam region (Arora & Gupta 1979: 44; Jolly et al. 1979: 5). Silk of *Attacus atlas* has been exploited on a minor scale in northern India and tropical China, with some recent experimentation being carried out in Taiwan and on the Ryukyu Islands of Japan, as Peigler learned at the 2nd International Symposium on Wild Silks in August 1994. It is a dark brown or reddish brown coarse silk. It is even possible that cocoons of *Archaeoattacus edwardsii* have been used from time to time, and some historical textiles in museums may eventually be found to contain silk from this latter species, which was formerly common in the same areas. Incidentally, Naumann found that silk of *Attacus taprobanis* Moore has been used experimentally and on a small scale when he visited Sri Lanka in 1996.

Despite the taxonomic confusion of various Attacini, it is certain that *some* fagara silk has been the product of cocoons of *Samia canningi* in the Himalayan region. Those reddish brown colored cocoons (Fig. 135) yield a light brown or beige yarn, resembling processed silk of strains of *Samia ricini* that produce brick red cocoons. The brick red color of some cocoons of *S. ricini* probably results from the genetic combination of the genes for white in *S. ricini* and gray from another species such as *S. canningi* or *S. cynthia*, based on hybrid crosses carried out by Wu (1962) and Peigler. Hawkes (1916, 1922) also studied white vs. reddish coloration in cocoons of *S.*

*ricini* and *S. cynthia*. Because of the poor state of knowledge of the taxonomy of these Saturniidae in tropical Asia, both historically and even today, it is difficult to know if any passages of literature refer exclusively to *S. canningi*. Eventually, some textiles in museum collections may answer these questions with fiber analysis by scanning electron microscopy (Ramos & Peigler 1999). Any references to "ailanthus silk" from the Assam region would probably refer to *S. canningi*, although again, *Ailanthus* is also a food of *Attacus atlas*. Cotes (1891-1893: 74) differentiated between the cultivated *S. ricini* and the wild *S. canningi*, but called the latter *S. cynthia*. For the wild moth, he reported that its cocoons had recently appeared in the Calcutta market, where they were known as "junglies."

Sericulture potential accounts for the widespread attempts to introduce *S. cynthia* to many countries around the world in the nineteenth century, and the widespread cultures of *S. ricini* that have been reported in the literature. We will deal with those introductions and cultures under the treatments of these two respective species. One (*S. cynthia*) is tolerant of freezing temperatures, whereas the other (*S. ricini*) is disease resistant when mass-reared. Neither of these advantages exists for most of the other taxa in the genus, so they have not been successfully introduced far from their native lands.

We employ the term "cynthia silk" to mean that which is obtained from the cocoons of *Samia cynthia*. It was named ailantine (Brady 1868) or ailanthine (Wallace 1866: 240) by a few English-speaking authors. Guérin-Méneville (1860b: 10) called it aylanthine and cynthiane. However, many of the references to this silk being used in China actually pertain to *Samia ricini*, especially in recent decades. Several more names for cynthia silk and the products produced from it were listed by Brady (1868: 27), but we refrain from repeating them here, because we believe that some or most in his list actually pertain to tussah silk (from *Antheraea pernyi*) cultivated in Shandong.

American authors commented that *S. cynthia* "was imported from China, where a coarse grade of silk is obtained from its cocoons" (Zim & Cottam 1956), "strong and serviceable fabrics are manufactured from it in China" (Holland 1917), and it "may someday give us cheap and durable silk" (Robertson-Miller 1912). As we are not able to make full use of literature written in Chinese, our only references to sericulture of *S. cynthia* in China comes from a few historical French authors (see below) and the English translation of the nice book by Chou (1990), who gave this account: "Cynthia silkworm (*Samia cynthia pryeri* [*sic*]) was reared mainly in the region of the present-day Shandong Province, but usually on a small scale. And up to this day it is still a problem to tell the exact starting time of cynthia silkworm breeding. In ancient Chinese literature there can be found here and there the confusion between tussah silkworm [*Antheraea pernyi*] and cynthia silkworm. Only in Qing Dynasty, in a 'Decree' of the eighth year (1743 A.D.) of the reign of Emperor Qianlong, cynthia silkworm began to be distinguished from the tussah silkworm. In the Decree, cynthia silkworm is called *chun can* and people are encouraged to engage in cynthia silkworm breeding. A detailed description of the morphological differences between the cynthia silkworm and the tussah silkworm can be found in the book *Ye Can Lu* (Record of Wild Silkworms) written by Wang Yuanting" (Chou 1990: 41-42). Wallace (1866: 240) stated that silk of *S. cynthia* was produced in Shandong and other provinces in large quantities, and its importation into Europe was greatly increasing. Clugnet (1877: 33-34), quoting a work by L. Strauss (*La Chine, son histoire, ses ressources*), gave Shandong and Henan as the primary centers for cynthia silk production, resulting in 5000 bales (annually?).

We believe that the utilization of silk from *Samia cynthia*, and probably also from *S. wangi*, began many centuries ago. Zhu and Wang (1983: 410) indicated that cultivation of *S. cynthia* for its silk has had a long history in Shandong Province. Shandong (=Shantung) was also cited as the center for cynthia silk culture by Cibot (1777), Rondot (1887: 77-90), and Fauvel (1895), Rondot specifying the village of Ninghaizhou (which he spelled Ning-haï-tchéou). Silk of *S. cynthia* was sometimes stated to be very dark (i.e., black silk; soie noire) (Fauvel 1895: 73). Rondot (1887: 82) indicated that various authors had referred to cynthia silk from ailanthus as being whitish, blonde, gray, brown, and from *Zanthoxylum* as being dark gray, almost black. He wrote that cocoons from ailanthus were called "yu kièn," whereas those from *Zanthoxylum* had the odor of pepper and were called "tsiao kièn" and that the latter were rather rare in Shandong, collected mainly around Tsi-mé or Tchi-mé in the department of Laï-tchéou-fou (his French spellings). Rondot (p. 84) cited a report from F. P. Smith that cynthia silk was commonly collected from *Zanthoxylum alatum* in the provinces of Sichuan, Hubei, and Shaanxi. Wild silkworms were also known from ailanthus in Hubei, according to Francis W. White, a customs officer at Hank'ou [now vicinity of Wuhan] (Rondot, p. 78, footnote). Based on our understanding of the geographical distributions of *S. cynthia* and *S. wangi*, these reports would appear to verify our belief that silk of *S. wangi* has also been commonly exploited in historical times in some parts of China.

We believe it is likely that cultures of *S. cynthia* and *S. wangi* were transported and introduced by humans between various districts in China over the centuries, which if true, may complicate attempts to define the natural (original) distributions of those two species. It is clearer that the range of *Antheraea pernyi* has been greatly expanded throughout China by human intervention, particularly in the twentieth century. Sericulture of *Samia*

*ricini* has displaced that of *S. cynthia* in China, we assume due to its great advantages of disease resistance and higher-yielding cocoons that are more easily processed (see our remarks below pertaining to *S. ricini* in China). However, considering one report from China (Anonymous 1980: 73-74), we feel that most references to "cynthia silk" in China prior to the 1940s do indeed refer to *S. cynthia* instead of *S. ricini*. In conclusion, we do not believe that silk from *S. cynthia* and *S. wangi* is presently exploited by people in China. Wallace (1866) provided a detailed account of how to prepare cocoons of *S. cynthia* so that they can be successfully reeled. His discussion included cocoons that still contained viable pupae, as well as spent (emerged) ones. Although his process can apparently successfully yield an amount of reeled cynthia silk, it is probably no more economically feasible today than it was in Wallace's time. Still, for spinners and sericulturists who enjoy experimenting with cocoons and wish to try to reel those of *S. cynthia*, Wallace's writings may be worth consulting. The claim by Tegetmeier (1866) that cocoons of *S. cynthia* could be reeled off in one continuous fiber by the Chinese was probably incorrect. Likewise, Depuiset (1877: 101) wrote that "les Chinois, cependant, possèdent un moyen pratique de dévider ces cocons."

Characteristics of silk of *S. wangi* were outlined by Fauvel (1895: 78). Chemical properties of silk of *S. cynthia* and *S. ricini* were cited by Silbermann (1897: vol. 2: 169-170). Silbermann wrote that silk of *S. cynthia* is brownish, sometimes twisted; the gummy coating is grainy and long segments of fiber are not commonly seen. Degumming is accomplished by strong simmering in copper oxide ammonium. Regarding silk of *S. ricini*, Silbermann wrote that it has a flattened fiber, the double fiber being 45-55 μm wide and 4-6 μm thick, with a light surface appearance, and riddled with canals. Eri silk is said to contain 15-20% sericin and 80-85% fibroin (Chowdhury 1982: 36). There is variation of physical properties between the silk of *S. cynthia* and that of *S. ricini*, and even within different sources of *S. ricini* sampled from Assam, Bihar, China, Japan, and Vietnam (Iizuka & Itoh 1997 and Iizuka et al. 1997). A single eri cocoon produces about 0.5 grams of spun yarn. The denier of eri silk is 2.5, the tenacity 3.5 g/d, and elongation 22.2% (Jolly et al. 1975: 88-89). Somewhat differing values were given as 3.17 for denier (thread size), 2.85 for tenacity, and 29.8 for elongation percent, measured at 22°C and 65% relative humidity (Iizuka 2002). Although Iizuka et al. (1997) specified the exact source of their cocoons, we are unable to say whether their data pertain to silk of *S. cynthia* or *S. pryeri*. The ultrastructure of silk fibers of *S. cynthia*, *S. canningi*, and *S. ricini* was described, and illustrated with photomicrographs made by scanning electron microscopy, by Ramos and Peigler (1999).

The primary molecular structure of silk of *S. ricini* strongly resembles the dragline silk of spiders, with repeating poly-alanine domains, interleaved with glycine-rich domains. However, its mechanical properties are closer to those of the silk of *Bombyx mori*, which has a different primary structure (van Beek et al. 2000). The amino acid composition of eri silk is reported to include 50.5% glycine, 27.8% alanine, and 10.7% tyrosine, as well as other amino acids (Iizuka 2002). Singh and Benchamin (2001, 2002) described additional properties of eri silk, saying that it had been called "heavenly thread" due to its graceful gloss, large diameter, and higher elongation rate; it has a molecular weight of about $2.3 \times 10^5$ daltons. Textiles made from eri silk show less wrinkles and have great durability, and are ideal for providing warmth in cold weather.

We have little information available pertaining to exploitation of silk from *Samia pryeri* by Japanese society. Again, as in China and India, silk use of the native species in this genus has been supplanted by *S. ricini*. Apparently, during at least one period in the history of Japan, the silk from *Samia pryeri* was highly esteemed, and fabrics made from it could only be worn by the Mikado, and exportation of the eggs of this silkworm was punishable by death (Gómez & Fernández 1976: 78). However, Seitz (1918: 88) was of the opinion that *S. pryeri* has had almost no sericultural use in Japan, despite the fact that *Bombyx mori* has long received much attention. We suppose that if the silk of *S. pryeri* were easily reelable like that of *Antheraea yamamai*, then Japanese people would have valued it more. Rondot (1887: 494; repeated by André 1908: 72) reported that about 250,000 kilograms of combed silk and cocoons of *S. pryeri* were shipped annually from Japan to Europe. If true, that may have included silk from *S. cynthia*, introduced from China to Japan in 1870 (Ando 1960).

### *Samia ricini*

For our outline of eri silk below we have drawn mainly from the works of Indian authors, notably Chowdhury (1982), Sarkar (1988), Baruah et al. (1989), and Mohanty (1998). It takes about 34-41 kilograms of castor leaf to feed enough larvae to produce 0.45 kilograms of silk (Maxwell-Lefroy & Howlett 1909: 488). Other principal foods used are various species of ailanthus, kesseru (*Heteropanax fragrans*), and payam (*Evodia fraxinifolia*) (Watt 1908; Seth 2000; Biwas & Das 2001, and others).

The word "eri" comes from the word *eranda*, an ancient Sanskrit name for the castor plant (*Ricinus communis*) (Fig. 139). Other authors wrote that eri comes from the Assamese word era, meaning castor plant. Thus, the name eri silk means castor silk, because castor is the primary plant used to feed the larvae of *Samia*

*ricini*. The silk was also called Assam silk and palma christi silk by British colonialists. The term "endi silk" has also been used extensively in India, and is the name favored in Bhutan. Other authors have applied the term "poor man's silk" including Patil and Savanurmath (1994), who also cited the local name "ahinsa silk," which apparently refers to the fact that the moths have left the cocoons before the latter are processed. Eri is sometimes written as éri in French (Castiglioni 2001), and some English-writing authors have spelled it eria.

*Samia ricini* is the only wild silkworm to be totally domesticated; like the mulberry silkmoth (*Bombyx mori*) it does not occur anywhere in the wild, and the moths rarely fly. In contrast to the other wild silks of India (tropical tasar, oak tasar, muga), the rearing, spinning and weaving of eri silk is done primarily by women. Rajkhowa (1996) outlined some of the needs for technological improvement in how eri fabric is produced and marketed. Historically, eri silk was the primary textile used to clothe the lower classes of Assam, whereas the middle and upper classes wore muga silk. A century ago some eri was used to make suits for Europeans living in India, but the flood of imports of cotton cloth from Manchester (the textile center of England) into India largely displaced eri clothing, even among the lower classes of Assam (Watt 1908: 1012-1013). Indians themselves have increasingly brought ericulture back to higher levels of production in recent decades. However, all during the twentieth century, success of wild silk production and marketing has been hindered in India by bureaucracy, both by British colonialists and Indian officials (van Schendel 1995). More than ever before, a major obstacle to economic development in India is the burden of regulation imposed by the federal government, stifling the opportunities and efforts of anyone wishing to try something new.

Eri silk has been cultivated for centuries and possibly millennia in the Assam region, and it has been introduced historically to many places, notably Korea, Japan, China, Egypt, and Europe. Even in France, cultivation and processing of eri silk is again going on sporadically on a very small scale (Castiglioni 2001). We summarize the worldwide introductions in a separate section under the text for *S. ricini*, but the cultures in southeastern Asia are discussed here. In India it is grown from lowlands up to altitudes of 1525 meters. The moth is multivoltine, with a life cycle of about 44 days in summer and 85 in winter. The larvae grow rapidly and are disease resistant, and are raised primarily indoors. Larvae reared on leaves that still have petioles and stems attached produce better cocoons (Reddy et al. 1999). Other details on the foodplants and life history of *S. ricini* are given under our treatment of this species. Cocoons lack a peduncle, and are large and puffy like those of *B. mori*, reflecting a long history of artificial selection (see Tazima 1984). Cocoons are of two colors, either brick red or snow white (Fig. 134). Red cocoons yield beige yarn after degumming, so the natural colored fabrics are beige. White cocoons result in cream colored fabrics, which become bright and glossy with increased washing and wearing. The cocoons are generally not reelable. The comment by Watt (1908: 1013) that they had been successfully reeled in Italy is probably an error for *S. cynthia* (see Wallace 1866: 240), although both silkworms were reared in Italy in the late 1850s and 1860s. Choudhuri (1995) was able to reel the silk of *S. ricini* on a very small scale. Using certain strains of cocoons and following careful but unspecified procedures of cooking and degumming, Choudhuri was able to easily obtain more than 50 meters of continuous filaments, and even up to 1000 meters from a single "good reelable cocoon." Normally however, the silk is combed or carded, the resulting floss spun into yarn, much like cotton and wool are spun. This results in a coarse fabric, differing considerably from the shiny and sheer textiles produced from the reeled silks from *B. mori* and species of *Antheraea*. Eri silk has historically had a poor affinity for dyes, requiring bleaching beforehand and twice as much dye as mulberry silk. Modern synthetic dyes yield better results on eri silk. White cocoons command a higher price, and are preferred by weavers, although many believe, probably incorrectly, that yarn made from red cocoons is more durable. All of the procedures and materials used to process eri silk from cocoons to fabric were described in detail by Chowdhury (1982: 64-80) and even more so in the report by Baruah (1989). Maxwell-Lefroy (1917: 131) referred to a machine he called the Coryton Cocoon Reverser that was used to invert eri cocoons so that all larval and pupal remains could be removed, making processing easier and the finished product finer.

Historically, ericulture originated in Assam. According to Hindu legend, the renowned merchant Chand Saudagar of Champanagar exported large quantities of eri silk fabrics to Java, Sumatra, and other islands of southeastern Asia, as well as to Tibet, Bhutan, and Nepal. Production declined considerably during British colonial times in the nineteenth century (Singh & Benchamin 2001). Large quantities of eri silk are again produced each year, mainly in Asia. The production in India grew from about 200 metric tonnes per year in the late 1970s and early 1980s to over 800 metric tonnes in the early 1990s, overtaking and surpassing tasar production during that period (Mohanty 1998: 6, 25). A figure of only 624 tonnes for eri silk in 1990-1991 in India was cited by Agrawal and Seth (2000: 12), but that still exceeded production of tasar and muga silks combined. Most of these wild silks are consumed domestically in India and China, leaving little for export. In India at the present time, most eri silk is produced in the states of Assam, Bihar, Meghalaya, Manipur, southern Arunachal Pradesh, Mizoram, Nagaland, West Bengal, Tripura, and Orissa, i.e., primarily in the Northeast. A

large area of eri production exists in the northern (Himalayan) sector of Bihar, and isolated pockets persist in Orissa to the south and Goa on the West Coast (Mohanty 1998: 30; Fig. 2.3, map). Eri rearing was introduced to Orissa in 1942 in the districts of Cuttack, Puri, and Ganjam, but has since disappeared from those places. Chowdhury (1982: 11) stated that Khurdah was the traditional area for ericulture in Orissa. Recently eri was cultivated in Orissa by about 2000 tribal people in the districts of Phulbani, Keonjhar, Sambalpur, and Koraput, yielding about 2000 kilograms annually for the state, which otherwise favors tropical tasar silk (Mohanty 1998: 28). Currently, about 49.7% of the silk produced in Orissa is tropical tasar, 43% is mulberry, and 7.3% is eri. Ericulture has now been expanded to 11 districts, and during 1993-1994 they produced 2200 kilograms of eri cocoons, which are sold by weight at fixed prices to the Orissa State Co-operative Society, Ltd., in Bhubaneswar (Gochhait & Dikshit 2000).

The Northeast (formerly called the Bengal region) supplies 97% of eri silk in India, and in fact, the majority in the world. This is approximately 950 metric tonnes annually from Assam alone (Singh & Benchamin 2001). The following statistics are taken from Chowdhury (1982: 7-11), the data being at least two decades old. For Arunachal Pradesh, hill people favor ericulture and eri products. About 300 families are involved in ericulture in Manipur, where much of the spinning and weaving are done locally. Only about 70 families practice eri production in Mizoram, whereas about 1600 families do so in Meghalaya, especially in the Bhoi area and Garo Hills; most cocoons from Meghalaya are sold in the weekly markets in adjacent Assam. In Nagaland, about 3000 families grow eri silk, especially the tribal peoples of the plains area of Dimapur. Weaving is traditional in the Naga homes, and ericulture is practiced in all of the seven districts, and the Nagaland government has set up nine eri farms to grow castor (Narain 1995). In Tripura, eri has been produced for a long time by tribal families near Champaknagar. Singh and Benchamin (2001) reported that tribal peoples in the these districts and states practice ericulture: Karbianglong, North Cachar Hills, Kokrajhar, Goalpara, Kamrup, North Lakhimpur, Dhemaji, Morigaon, Nagaon, Golaghat, Jorhat, Sibsagar, etc. in Assam; East and West Garo Hills, East and West Khasi Hills, and Ribhoi districts of Meghalaya; Wokha, Makokchung, Kohima, Tuenchang and Zunheboto of Nagaland; Aizawl and Lungleh of Mizoram; Imphal, Thoubal, and Churachandpur of Manipur; Lohit, Khonsa, Pabuempera and Tirap of Arunachal Pradesh.

Although Andhra Pradesh is a major producer of castor plants, ericulture has not been successful in that state. In Bihar, the main center for eri silk trade today is Bhagalpur, and research on ericulture is carried out in Ranchi. In the past, ericulture in Bihar was common in the Gaya and Shahabad areas, and Bhagalpur District was a major center of eri silk trade (Singh & Benchain 2001). Presently more than 10,000 families are engaged in eri production in 17 districts of Bihar, but the price is lower and quality inferior to the eri silk produced in Assam. In Uttar Pradesh, this industry is confined to Suar (Rampur District), Tamkuta (Deoria District), and Lakhimpur (Khetri District), but little success has been achieved. In West Bengal only the about 1500 tribal families of the Cooch Bihar and Jalpaiguri districts rear, spin, and weave eri silk, most of which is consumed within the state. Chowdhury (1982) added that attempts were being made to introduce ericulture to the Jodhpur area of Rajasthan, and that efforts in Kerala to grow eri silkworms on tapioca leaves had not been successful thus far. There have also recently been attempts to grow eri silk on castor plantations in the dry area of northwestern India, specifically near the village of Devada, Ahmedabad District, in the state of Gujarat. Two primary workers involved with this latter venture are Shashikant Shukla and Ambalal K. Patel (unpublished economic reports from Gujarat).

The state that leads all others in eri yield is, of course, Assam, both historically and today, producing about 90% of all eri silk. Almost all of the tribal peoples of the southern part of the Brahmaputra Valley practice ericulture and the pupae are eaten, this extra source of protein in the human diet providing a major incentive to rear *Samia ricini.* The tribes in the hills and plains include the Kacharis and Meches in the northern part of the Valley, and the Boros, Garos, Syntengs, and Karbis in the southern part. Additional tribes listed by Singh and Benchamin (2001) are the Jugi, Katoni, Abor, Mizo, Miri, and Robha. The districts of North Cachar, Karbi Anglong Hills, Kamrup, Darrang, and Goalpara are the chief eri growing areas, the latter locale being a primary source for red cocoons (Chowdhury 1982: 37). The castor plant abounds in these areas, and it is utilized mainly to feed eri silkworms, rather than to harvest the seeds. Eri cloth has been called “the poor man’s silk” and has traditionally been produced and used by Indic (Indo-Mongoloid) and Tibeto-Burman peoples as winter wear and bed spreads. Lighter mill-produced cloth is suitable for summer wear. Garments made of it were stated by many authors to be extremely durable, sometimes lasting more than the lifetime of the owner, and passed down to a member of the next generation. Most eri silk is converted into chaddars (blankets), shawls, scarves, and similar pieces, and used where they are produced, or exported to neighboring regions (Siddiqui et al. 1993). Bhagalpuri eri chaddars are still famous, measuring about 1.5 m × 2.75 m. Eri fabric is not used to make saris, because it is too thick and heavy.

As already mentioned, the government of India promotes ericulture and other sericulture through its agency the Central Silk Board. Several facilities have been established that carry out research, production, and marketing of eri silk. Some of these include the Regional Tasar Research Station (Imphal, Manipur), the Eri Regional Research Station (Eri RRS) in Titabar established in 1972 and another in Mendipathar (Meghalaya), and Eri Research Extension Centres in Diphu (Assam) and Sille (Arunachal Pradesh) (Agrawal & Seth 2000: 22, 24).

At this writing, use of eri textiles is being extended to the production and marketing of bed spreads, dresses, mufflers, quilts, and there is also potential for production of blankets using Japanese processing technology. There is supposedly a good demand in Germany and the United States. However, in northeastern India itself, sometimes very little of this silk is for sale in the markets because the rearers, spinners, and weavers are only able to produce enough for their own families (Singh & Benchamin 2001). Selk (2000) published an up-to-date review of wild silk culture in India containing many field observations and photographs, and she illustrated some fine eri silk textiles, one being a blend of eri weft and muga warp, and another having bands of white eri and golden muga for the warp, and pure eri for the weft. Eri textiles that are hand made (spun and woven) into cultural garments of the region of origin are the ones that should be targeted by textile collectors and curators for preservation, whereas the mass-produced eri textiles intended for export will have less interest and value.

Researchers at the University of Rajshahi in Bangladesh have conducted studies on ericulture (Joarder 1984, Hoque & Khan 1987). Papaya foliage was found to be an inferior food to that of castor. Castor plantations are rare in Bangladesh, but eri rearers find plenty of castor plants growing naturally near their homes. Cassava has also been used to rear eri silkworms in that country, but again it yields poorer results (i.e., cocoon weight) than castor.

In Nepal, eri silkworms are being cultivated on the terai (the southern plains) on castor plants, where they can produce 4-5 generations per year. The Jhapa Training Centre has promoted ericulture to several locales in Nepal (Dunsmore 1993: 59). Dunsmore reported that some people roast and eat the larvae, but we rather think that the pupae that are eaten, because consumption of larvae would diminish the crop of cocoons, whereas pupae are generally regarded as a byproduct in wild silk culture. Cocoons and fabrics of eri silk have been exported from Assam to Tibet, but the trade link was closed in the 1940s. The Kampa Bhutias transported huge quantities of eri silk from Assam to Lhasa, the capital of Tibet. The heavy fabrics were known as bar kapor. These were favored by the Bhutanese because they provided warmth in their cold climate, according to S. N. Chowdhury (pers. comm. to Peigler, 23 August 1994). In southeastern Nepal, near the border with the Indian state of Bihar, in the districts of Morang (Biratnagar) and Jhapa, the Mechain (Bodo), the Koche from India, and Satar peoples reared eri silkworms and made fabrics from the silk until 1973, but that operation ceased for various reasons. People returning to Nepal from Assam began ericulture again, and it was becoming popular in these same areas on the eastern terai by 1990, and was being tried in the ChitwanValley in the central terai (Neupane et al. 1990).

Assam is the source for Bhutan, a country that has long imported vast amounts of eri silk to provide yarn for the thousands of eri silk weavings that the Bhutanese have made and valued (see Myers & Bean 1994). They prefer fabrics made from red cocoons to those from white cocoons (Chowdhury 1982: 79). People in India and Bhutan have traditionally favored natural colored (beige) fabrics. Textiles are of paramount importance in Bhutanese society, the garments worn representing an individual's social status, and fabrics owned a direct measure of one's personal wealth. Most Bhutanese people do not practice ericulture themselves, because they do not want to risk violating the Buddhist tenet against killing living things, and so need to be one or two steps removed from a process in which moth pupae are killed. There may have been some ericulture in the eighteenth century in Bhutan, and a small amount exists in isolated villages of eastern and southern Bhutan today. The herders of Merak Sakteng and other eastern Bhutanese travel to the Indian border to buy cocoons or yarns. In Dzongkha, the national language of Bhutan, the word for wild silk is "bura," which in fact means eri silk, since other wild silks are rarely imported to Bhutan. The excellent book by Myers and Bean (1994) has color illustrations of numerous eri silk textiles, many of which are preserved in the Peabody Essex Museum (Salem, Massachusetts), as well as in the Victoria and Albert Museum (London). Many of these pieces have exquisite colors and designs, reflecting the high level of dying and weaving achieved by the Bhutanese. In May 1996, Peigler examined some wild silk textiles stored at the Museum Support Center, Suitland, Maryland (a branch of the Smithsonian Institution), and found two rolled pieces of cream-colored eri silk (catalog nos. E406019 and E406020). These were acquired in Assam in November 1966 by Elizabeth B. Willis, measure 136 cm × 32 cm and 136 cm × 37 cm, and are labeled "endi" silk. The lot donated by Mrs. Willis also includes samples of muga and tasar silks that she collected in West Bengal.

We have acquired several textiles from Bhutan, India, and Japan, all composed of silk of *Samia ricini*, and we illustrate some herein. Those shown in Figures 142-144 were all donated to the Anthropology Department of

the Denver Museum of Natural History, now the Denver Museum of Nature & Science.

Figure 142. The white cloth shown in the background is a piece of eri silk sent from Assam in 1990 to Peigler by Dr. S. N. Chowdhury, author of the book *Eri Silk Industry* (1982). The grayish blue crocheted scarf and white dishcloth were purchased by Peigler at the 2nd International Symposium on Wild Silks (Hotaka, Japan, August 1994) from Mr. Nobuaki Yoshida, who said that the eri silkworms were being mass reared in Vietnam, but the unprocessed silk was shipped to Japan where his products were finished. A skein of eri silk yarn from Assam is also shown, received from Carolanne Nuttall (DMNS catalog numbers AN-1996-32.12; AN-1996.32.19; AN-1996.32.20). Duplicates of the dishcloths are in the collections of Naumann and Peigler.

Figure 143. This is a woman's dress from the state of Manipur, India, called a "feege fanek" in Manipuri, and worn during religious and wedding ceremonies. This was obtained in 1996 at a local market by Dr. K. Chaoba Singh, who was then employed at the Regional Tasar Research Station, Imphal, Manipur. It measures 86 cm × 122 cm. The magenta and black striped silk portion has a rep (warp-faced) weave, and across the top and bottom are machine-embroidered cotton bands (DMNS cat. no. AN-1996-32.4).

Figure 144. This is one of two peasant's scarves composed of natural colored eri silk that Peigler bought in Coyote's Paw Gallery, Ltd. (St. Louis, Missouri), a shop specializing in ethnic imports. They are from Bhutan, where such a garment is called a "kabné," a shoulder cloth worn by men. They measure about 50 cm × 314 cm, with fringe on each end that is 19-20 cm long (DMNS cat. nos. AN-1996-32.1 and AN-1996-32.2). These were registered by the International Linen Registry Foundation (Tulsa, Oklahoma). These exemplify that textiles made from the brick red cocoons of *S. ricini* are beige colored as finished products.

Figure 145. This is a "khamar kabné" from Bhutan which, because it contains red lateral panels, we know is the kind worn by a village headman or some lay priests (Myers & Bean 1994: 124). It was imported in 1998 by Himalayan Antiques (Ipswich, Massachusetts), and purchased by Peigler in August 1998. The three panels were all made from white cocoons of *S. ricini,* the central panel being natural in color, the others dyed red. Among the same import lot, Peigler saw another khamar kabné that was composed of a dark brown silk. He interpreted it to represent the color of eri silk in an older garment that had been worn and washed many times, instead of being composed of another type of wild silk. (As mentioned above, tasar silk, which comes from *Antheraea paphia*, is rarely used by the Bhutanese.)

Figure 146. Two strips of eri silk were also imported from Bhutan in 1998 by Himalayan Antiques. One is a further example of natural colored beige silk (Fig. 146), the other is natural colored white silk, both are embroidered with colored threads, and are in the collection of S. Naumann. Two such panels would be sewn together to form a peasant's kabné (Fig. 144), whereas three would compose a khamar kabné (Fig. 145).

Background on back cover. This cream-colored cloth is a sample of pure eri silk sent to Peigler in July 1999 by Mrs. T. Reeta Luikham, Senior Research Assistant at the Regional Tasar Research Station, Imphal, Manipur, India. She wrote that these fabrics are hand-woven in local looms by women. This particular piece has a ghicha spun warp and a ghicha spun weft. In December 2001, Peigler received from Mrs. Luikham another piece of cream-colored pure eri fabric that is 2.5 meters long, made of spun yarns.

**Care and Storage**

Silk artifacts in museum or private collections that have historical, anthropological, or scientific value should be properly handled and stored for permanent preservation. Although many textile collectors enjoy displaying their treasured pieces as wall hangings and table covers, it should be remembered that light deteriorates the protein in silk, eventually resulting in brittle fibers. Heat from ironing is especially damaging. Tight folding, refolding along the same creases, excessive handling, and too high or too low relative humidity are all detrimental. Washing and drying must be done carefully, with distilled water and proper cleaning agents. When wet, silk becomes much heavier, so may become stretched or distorted if handled carelessly. Earlier authors (Milburn 1813: 244; Brady 1868: 3) advocated that silk from *S. ricini* and *S. cynthia* should be washed only in cold water. Prior to washing, or if washing is not feasible, fabrics may be vacuumed if a soft screen is laid over each section as it is being cleaned. Silk textiles are best stored tightly rolled on acid-free cylinders between acid-free white tissue paper, these rolls covered with a tight muslin cloth to keep out dust and dirt, but to allow some air exchange. Rolling eliminates the problem of creases caused by folding. Small samples of wild silk acquired by lepidopterists can be *loosely* folded and placed in plastic bags (polyethylene and Mylar are archival and safe; vinyl is not), these kept in cases alongside of pinned moths, in darkness, and protected from carpet beetles (Coleoptera: Dermestidae) and excessive moisture. In the face of rapid loss of ethnic cultures of Indigenous Peoples due to globalization of the modern world, it is well worth obtaining, documenting, and preserving wild silk objects, especially ones that are hand-made.

# BIOGEOGRAPHY

In the following pages we present our best attempt to provide a natural and workable classification of what we consider to be the species within this genus. Most of the species are allopatric, offering us a distributional pattern that makes the delineation of these putative species fairly straightforward (see Mayr 1999: 151-164). In our discussion below we refer to groupings in the phylogenetic sense, and they are not to be construed as nomenclatural acts in the sense of the Code (1999: 99). The genus *Samia* is comprised of three main species groups, the latter group which may be further subdivided into smaller species groups. The first group is the *watsoni*-group, for which we will discuss the phylogeny under that species, enumerating the characters that give it this unique position. It is the most plesiomorphic in the genus, and must be considered to represent the sister-group to all other taxa within *Samia*. Its relationship to the African *Epiphora* is also obvious, opening the question as to whether *Samia* has an African origin or *Epiphora* has an Asian origin; we favor the former hypothesis, since molecular data and larval morphology suggest *Epiphora* to be the primary candidate for the ancestor of *Samia*, as stated above in our discussion of phylogeny of Attacini. Other more plesiomorphic Attacini are found in Asia, namely *Attacus* and *Archaeoattacus*, as well as *Rhodinia*, which appears to be the sister-group to the other Saturniini, so *Epiphora* itself may have originated in Asia even earlier.

During the Lower Miocene there was considerable interchange between tropical Eurasia and Africa. Several geological events contributed to changes in climate and habitat that separated the two regions, including development of the Red Sea in the Pliocene and expansion of the deserts of the Middle East. In the late Miocene there was an increase in the uplifting of eastern Africa, resulting in drier biomes in that region (Cox & Moore 1993: 227). We believe that the aforementioned changes caused a separation between what is now the African *Epiphora* and the Asian *Samia*.

The second group is the *cynthia*-group. It is a well-defined and compact set of species found on the mainland of eastern Asia and its biogeographic corollary islands (Japan, Taiwan, and Andaman Islands). These include *S. cynthia, S. wangi, S. pryeri, S. canningi*, *S. fulva,* and *S. kohlli*. Since *Samia ricini* is a cultivated derivative of *S. canningi* of human origin, it also belongs to the *cynthia*-group. Within this group, judging from wing pattern, genitalia, chromosome number, larval characters, and geographical locations, we consider *S. cynthia* and *S. wangi* to be closely allied sister species, with *S. pryeri* an offshoot that originated in relative isolation on Japan. The divergence between *S. cynthia* and *S. wangi* can probably be traced to a relatively recent Pleistocene event in China, separating the northern and southern populations. In Yunnan and the northernmost part of Vietnam *S. wangi* and *S. canningi* occur sympatrically. The above hypothetical relationships are somewhat challenged by the similarity of the crescentic markings of *S. cynthia* and some *S. canningi*, both species of which have broad yellow and white (transparent) components, not shared by *S. wangi.*

It is interesting to note that the genus itself, specifically *S. canningi*, has not succeeded in expanding its range down into peninsular India or on Sri Lanka, whereas other saturniid genera have done so quite successfully, such as *Actias, Antheraea, Cricula*, *Loepa*, and *Attacus*. However, like *Samia*, several other saturniid genera including *Saturnia* (=*Eriogyna*), *Neoris, Caligula*, *Archaeoattacus*, and *Rhodinia* range widely to the north, west or east of northern India, but have also failed to extend their ranges down into central and southern India. Some of the latter taxa may have origins far to the north or west of the Himalayas. At any rate, we do not know what ecological factors have prevented *Samia* from extending its range into southern India, but much of peninsular India is dominated by dry tropical (deciduous) forest and thorn forest (Ripley 1969: 18-19), habitats which may not be suitable for *Samia*.

Regarding *S. fulva*, as we will point out under the text for that species, it is simply an insular offshoot that may be characterized as speciation by budding from the edge of the range of *S. canningi* (see Strickberger 2000: 590). *Samia kohlli* is possibly also a member of the *cynthia*-group. However, its narrow and elongated crescentic markings and more falcate wing outline is suggestive of the *insularis*-group (see below). The genitalia and the larval traits lead us to believe that *S. kohlli* is best grouped with its mainland congeners. *Samia peigleri* has no obvious close relatives within the genus, as it is probably a relict species on Sulawesi, an island which was never below sea level during Pleistocene times (de Lattin 1967).

The third main group of species in *Samia* is the *insularis*-group. Not surprisingly, this group contains the highest number of species, given its distribution spanning the many islands of the Philippines and Indonesia. Again, allopatric populations present few taxonomic difficulties. However, there are at least two highly intriguing cases where two species are found to occupy the same islands. These are *S. insularis* and *S. abrerai* on Java and *S. vandenberghi* and *S. peigleri* on Sulawesi, keeping in mind that *S. peigleri* is not a member of the insularis-group. We think that *S. vandenberghi* reached Sulawesi at a later time, probably from the west or south (i.e., Borneo or Java), whereas *S. peigleri* is probably a more ancient inhabitant of that remarkable island. In the

case of the two species on Java, the picture is somewhat different. *Samia insularis* occurs all over Java and also on Sumatra, but not on Bali. *Samia abrerai* is limited to Java and Bali. One plausible hypothesis is that *S. abrerai* evolved in isolation on Bali from an ancestor of Javanese origin, and then re-colonized Java after isolating mechanisms were in force. Wallace's Line is a well-documented biogeographical barrier separating Bali from Lombok (van Oosterzee 1997), but the distance between these two islands is only around 35 kilometers, so the above model of speciation fits the geography. No species of *Samia* can be said to have a strictly Sundanian range, as the area called Sundaland (Greater Sunda Islands) by authors such as Holloway (1983, 1987) and Barlow (1982) is greater than the range of any species in the genus. *Samia insularis* flies on Java and Sumatra but not on Borneo, but vice-versa for *S. tetrica*.

Wing pattern and genitalia of the two Philippine species support placing them in the *insularis*-group. *Samia luzonica* is quite variable, as would be expected as it occurs on numerous islands, in various habitats, and at a wide altitudinal range. This agrees with the variability observed for *Attacus lorquinii*, probably the most variable species in that genus. The island of Palawan is biogeographically isolated from the remainder of the Philippines, so we see endemic species such as *Samia treadawayi* and *Attacus lemairei* (in our Introduction we stated that records of *Attacus caesar* on Palawan are now known to be incorrect), showing affinities to both the taxa on Borneo and Mindanao. *Samia tetrica*, with its small size, dark coloration, and straight postmedian lines may be the closest living relative of *S. treadawayi*.

Distributional patterns for *Samia* in the Lesser Sunda Islands and Moluccas roughly correspond to those found for *Attacus* by Peigler (1989). In these areas, allopatry is the rule for both genera, with no island having more than one congeneric species. *Samia yayukae* occupies Flores and Timor, whereas those large islands have different species of *Attacus*, although the latter two are phylogenetically closely allied. In far eastern Indonesia, *Samia naessigi, S. ceramensis* and *S. naumanni* are clearly sister-species, but they show no close relationship to *S. yayukae*.

A biogeographical link between Sula and Banggai (east of Sulawesi) is substantiated by *Samia*; see map of Townes and Chiu (1970: 17). No *Samia* have been found so far on the islands or island groups of Lombok, Sumbawa, Sumba, Ambon, Buru, Aru, Key (Kepulauan Kai), Tenimber (Kepulauan Tanimbar), Sangihe and Talaud, and considering that most of those islands have been well-collected by entomologists for several decades, cocoons of *Samia* are easily found hanging on trees, and adults of *Samia* readily come to lights, we believe that the genus is probably absent on most of them. Peigler failed to find larvae or cocoons of *Samia* on brief visits to Lombok, Sumbawa, Sumba, Rinca, and Komodo in July 1993, and Naumann visited Lombok in December 1999 and again in April 2000 without finding *Samia*; nevertheless, local collectors in West Lombok knew *Samia* when showing them photos and could clearly separate them from *Attacus inopinatus* which is also known from that island. No Saturniidae at all were found by Naumann on Sangihe and Talaud during an expedition in March 1997, and also no records were obtained during two subsequent expeditions by local people, arranged by Naumann.

As a group, *Samia* is comparatively widely adapted to diverse habitats. Although we tend to associate the temperate species with deciduous forests and the tropical representatives with rain forests, there is considerably more to the picture. *Samia cynthia* and *S. pryeri* probably live equally well in lowlands and foothills, and at least the former is known to adapt well to urban environments. *Samia yayukae* occurs in the Lesser Sunda Islands, each island of which becomes increasingly dry in its habitat as one moves eastward, so that the habitats for *S. yayukae* include dry areas dominated by grasslands at least on the island of Timor. While it is likely that some of the tropical *Samia* prefer or even require primary rainforest, *Samia insularis* and *S. abrerai* live successfully in secondary forests and disturbed areas that have been converted to agriculture, such as tea or coffee plantations. All of the foregoing comments coincide with what we find for the nearest allies of *Samia*. Across Africa, *Epiphora* exist in semi-arid savannas as well as in tropical rainforests. Across eastern North America, *Callosamia promethea* succeeds equally on prairies, in coastal swamps, in mountains, and even urban habitats. *Callosamia angulifera* exists in mountains, coastal plains, and suburban habitats. The various *Hyalophora* occupy almost every habitat across North America, except in deserts they are restricted to mountains and in prairies to riparian zones.

Each known species of *Samia* is treated in detail on the following pages, beginning with the type species of the genus, and arranged in groups of closely related species.

## *Samia cynthia* (Drury)

(Figs. 1-8, 117, 149-153, 199; Map 2)

*Phalaena Attacus Cynthia* Drury 1773: 9 and index, pl. 6, fig. 2 (♂).
*Phalaena Bombyx cynthia*, Schneider 1785: 43.
*Phalaena Cynthia*, Helfer 1837: 45. Royle 1856: 215.
*Bombyx Cynthia*, Olivier 1790: 30. Guérin-Méneville 1860a: 6. de Graaf 1862: 12. Blain 1862: 1 (♀, larvae, pupa, cocoon). Roy 1864: 10. Anonymous 1865: 119. Tegetmeier 1866: 15 (in part). Wallace 1866: 187. Wallace 1867: 485. Clugnet 1877: 33. Keferstein 1880: 18.
*Bombyx cynthia*, Milne-Edwards 1854: 12. Anca 1857: 395. Darwin 1859: 213. Guérin-Méneville 1860b: 10. Stewardson 1861: 525. Blain 1861: 167.
*Bombyx Cynthia vera s. Ailanthi* Weil 1863: 238.
*Bombyx Ailanthi* Weil 1863: 238.
*Bombyx* (*Saturnia*) *cynthia*, Wullschlegel 1863: 171 (in part).
*Saturnia Cynthia*, Westwood 1837, vol. 2: 12, pl. 6, fig. 2 (♂). Duncan 1841: 141, pl. 14, fig. 1 (♂). Chavannes 1855: 327. Chavannes 1856: 147. Snellen van Vollenhoven 1862: 337. Guérin-Méneville 1862a: 341. Guérin-Méneville 1862c: 110. Mulder 1862: 160. van Westmaas & de Graaf 1862: 115, col. pls. 6 (cocoon), 7 (larvae, pupae), 8 (♂♀). van der Hoeven et al. 1866: 91.
*Saturnia aylanti* Motschulsky 1858: 163. Schüßler 1933-1934: 26, 518.
*Saturnia Ailanti,* Fauvel 1895: 22.
*Attacus cynthia vera* Girard 1863: xxxv. Girard 1871: 367. Girard 1875: 300.
*Attacus* [*cynthia*] *vera,* Girard 1868: lxxii.
*Attacus Cynthia vera*, Rondot 1887: 76.
[*Attacus*] *Cynthia vera*, Girard 1875: 313.
*Philosamia cynthia vera*, Bouvier 1927: 921.
*Attacus* (*Bombyx*) *cynthia*, Standfuss 1896: 303.
*Attacus* (*Saturnia*) *Cynthia*, Snellen van Vollenhoven 1862a: 15.
*Attacus* (*Philosamia*) *cynthia*, Silbermann 1897: vol. 1: 317. de Cordemoy 1902: 34.
*Attacus Cynthia*, Walker 1855: 1220. Horsfield & Moore 1860: 407. Morris 1863: 390, pl. 46 (♀), pl. 47 (all immature stages). Hutton 1863: 63. Hutton 1867: 347. Girard 1875: 300. Strecker 1875: 103. Wailly 1879: 9. Wailly 1882: 260. Kirby 1883: xxvii. Weymer & Maassen 1890: 92. Figuier 1892: 245. Huwe 1893: 10. Silbermann 1897: vol. 2: 169. Voelschow 1902: 68, pl. 4 (larva). de Joannis 1910: 214. Moreau 1915: 270. Rougeot 1947: 74. (in part)
*Attacus cynthia*, Gmelin 1784: 914. Moore 1859: 267 (in part). Girard 1868: lxxxiv. Koch 1873: 96. Depuiset 1877: 100. Butler 1878: 388. Wardle 1879: 500. Wardle 1880a: 218. Wardle 1881a: 646. Wardle 1881b: 4. Wailly 1886: 7. Leech 1889: 634 (in part). Ballard 1891: 177. Nolan 1892: 193. Kirby 1897: 99. Clément 1899: 103. Tutt 1902: 291. Tutt 1906: 26. Scherdlin 1906: 77. Froggatt 1907: 257. Osthelder 1926: 219 (footnote).
*Attacus ailanthus* Chowdhury 1982: 6 (as synonym of *cynthia*). [*nomen nudum*]
*Atticus cynthia*, Froggatt 1897: 253. [misspelling]
*Attacus cinthia*, Lacerca 1983: 67. [misspelling]
*Attacus lunula*, Danner 1870: [6]. [misidentification]
*Platysamia cynthia*, Rau & Rau 1929: 84.
*Cynthia Cynthia*, Anonymous 1980: 73.
*Antheraea cynthia*, Hofmann 1887: xviii (in part). [*lapsus*]
*Philosamia Cynthia*, Grote 1874: 258. Rondot 1887: 75. Dusuzeau & Sonthonnax 1897: 89 [29] (in part). Kirby 1903: 135. Côte 1904: 4 (in part). André 1908: 51. Watson 1910a: 24. Watson 1911: 5, pl. 3, figs. E-F (♂, ♀, cocoon). Iches 1933: 26.
*Philosamia cynthia*, Rothschild 1895: 37. Grote 1895: 267. Dickerson 1901: 118, 142. Sonthonnax 1901: 133. Smith 1903: 16 (No. 801). Kostial 1908: 212. Stichel 1908: 194. Davis 1909: 12. Rebel 1910: vol. 2: 132. Hafner 1910: 119. Robertson-Miller 1912: 27. Watson 1912: 45. Watson 1913: 45. Packard 1914: 240 (in part), col. pls. 1-3 (larvae),

pls. 47 (venation), 57 (♂, ♀), 93 (♂, ♀, larva, cocoon, as *P. walkeri*). Hawkes 1916: 51. Holland 1917: 81, pl. 9, fig. 2 (♂). Laurent 1918: 161. Hawkes 1918: 135. Brombacher 1921: 136. Hawkes 1922: 111. Rebel 1924: 111. Rebel 1925a: 1. Clark 1926: 387, 393. Riechmann 1928a: 232. Riechmann 1928b: 285. Bouvier 1928b: 688. Schüßler 1928: 248. Draudt 1929: 715. Anonymous 1930: 6, fig. (♀). Bouvier & Riel 1931: 80. Henke 1933: 15. Medsger 1933: 235, col. pl., fig. 12 (♀). Schüßler 1933-1934: 24, 517. Kuntze 1935: 544. Bryk 1938: 31. Danilevsky 1940: 26. Testout 1941: 137 (footnote). Matschat 1942: 29 (♂). Peinlich 1943: 127. Handschin 1946a: 1920. Handschin 1946b: 2463. Agenjo 1947: appendix. Hick 1948: 9. Forster 1952: 155. Crotch 1953: 281. Carnelutti 1956: 140. Anonymous 1959: 1, fig.♂. Inoue 1961: 659. Howe 1963: 170. Pammer 1965: 1. Pammer 1966: 99. Nopp-Pammer & Nopp 1967: 592. Nopp-Pammer & Nopp 1968: 508. Piek & Engels 1969: 603. Arzone 1970: 205. Arzone 1971a: 75. Arzone 1971b: 87. Staněk 1975: 380. Passarin d'Entrèves & Zunino 1976: 218. Müller 1977: 135. Nijhout 1978: 123. Salzmann 1978: 2. Jolly et al. 1979: 7. Narang & Gupta 1979: 218. Zhu et al. 1979: 21 (in part, not pl. 7, fig. 27). Pruscha & Nopp 1979: 491. Inoue 1982: 316. Zhu & Wang 1983: 410, col. pl. 132, fig. 2960 (♀). Klausnitzer et al. 1988: 69. L.-Y. Wang 1988: 461. L.-Y. Wang 1992: 801. Ye & Hu 1996: 30 (in part). Belyakova & Lukhtanov 1996: 63. Ye & Hu 1996: 30 (in part). Ylla 1997: 154, 180. Ruffo 1998: 168.

*Philosomia cynthia*, Steeg 1939: 50. [misspelling]

*Phylosamia cynthia*, Harz 1973: 150. [misspelling]

*Philisamia cynthia*, Stolyarov & Goderdzishvili 1991: 52. [misspelling]

*Philosamia cynthia cynthia*, Rebel 1925b: 155, pl. 8, fig. 2 (♀). Bouvier 1927: 921.

*Phylosamia cynthia cynthia*, Broszkus & Bodenstein 1950: 99. [misspelling]

*Samia Cynthia*, Hübner 1819 ("1816"): 156 (No. 1629). Grote 1865: 226 (footnote). Wailly 1879: 9.

*Samia*, *Attacus cynthia*, Aue 1933: 125.

*Samia cynthia*, McCook 1891: 52, fig. 18 (cocoons). Packard 1895: 41. Beutenmüller 1898: 434, pl. 21, fig. 2 (♀). Eliot & Soule 1902: 231, unnumbered pl. (♀, cocoons). Soule 1902: 411. Soule 1906: 396. Soule 1907: 116. Jordan 1911a: 130. Jordan 1911b: 212. Eckstein 1915: 78. Seitz 1918: 62, 80. Showalter 1927: 87, 118. Bang-Haas 1929: 34. Bang-Haas 1930: 178. Bollow 1932: 129. Seitz 1928: 503, col. pl. 55Cb (♀). Fazzini 1934: 86. Chen & Wong 1936: 127. Bock 1938: 24. D'Almeida 1943: 129. Dathe 1950: 161. Rupp 1950: 95. Michener 1952: 490, fig. 93 (venation), figs. 401-404 (male genitalia). Rougeot 1955: 87. Werner 1956: 69, col. pl. 9 (♂). Taylor 1957: 102. Remington 1958: 793. Riddiford 1968: 1461. Williams 1968: 344. Swan & Papp 1972: 266. Pyle 1975: 45. Riotte 1975: 87. Gómez & Fernández 1976: 202. Mitchell & Zim 1964: 95 (♂) , 155. Staněk 1977a, b: 272-274, fig. 321 (♀), figs. 320, 322 (larvae). Lemaire 1978: 127, pl. 25, fig. 1 (♂). Peigler 1978: 191. Scriber & Feeny 1979: 831. Gómez & Arroyo 1981: 77. Gardiner 1982: fig. 29 (not 27), pl. 31 (♀). Lemaire & Peigler 1982: 180. Ferguson 1983: 109 (No. 7759). Covell 1984: 50, col. pl. 10, fig. 1 (♂). Baker 1985: 2. Smerdu 1984: 109. Pruscha 1985: 91. de Viedma & Gómez 1985: 6. Frank 1986: 41. Zim & Cottam 1987: 86 (♂), 156. Mitchell & Zim 1987: 95 (♂), 155. Nakajima 1987: 280, pl. 52, figs. 3-6 (larvae, cocoons). McCord 1987: 33. Gómez de Aizpúrua 1988: 27. Dugdale 1988: 140. Mauchamp 1989: 49. Peigler 1989: 2. Weast 1989: 4, 45. Föhst 1991: 295. Carter 1992: 234. Peigler 1992: 165. Johnson 1993: 17. Peigler 1993a: 40. Peigler 1993b: 155. L. Y. Wang 1993: 612 (in part). Zhu & Wang 1993: 257 (in part). Vives 1994: 416. Deschka 1995: 106. Kramer 1995: 117. Naumann 1995: 26. Raineri et al. 1995: 5. Cody 1996: 12, 28. Edwards 1996: 265, 365. Peigler & Wang 1996: 71. Schintlmeister 1996: 199 (No. 6802). Tuskes et al. 1996: 184, col. pl. 5 (larva), col. pl. 25 (♂, ♀). Peigler 1996: 14, 121. Poole 1996: 843. Leraut 1997: 25, 176. Masó & Pijoan 1997: 166. Friedlander et al. 1998: 132. D'Abrera 1998: 78, 79 (♂♂♀♀). Sbordoni & Forestiero 1998: 144, col. pl. 54, fig. 2 (♂). Ramos & Peigler 1999: 18. Peigler 1999: 66. Park & Tshistjakov 1999: 167, col. pl. 13, fig. 89 (♀). Arnett 2000: 770, fig. 27.230 (♀). Passoa & Passoa 2000: 134. Jost et al. 2000: 388-391 (all stages); col. pl. 18, fig. 2a (♂), 2b (♀). Zim & Cottam 2001: 109 (♂), 157. Peigler & Baird 2001: 5. Naumann & Peigler 2001: 75. Deml & Dettner 2002: 82.

*Samia cynthia cynthia*, Bouvier 1936: 316 (in part). Ferguson 1972: 212-218, col. pl. 16, figs. 7-8 (♀♀). Watson & Whalley 1975: 275. Zhu & Wang 1996: 167 (in part), pl. 11, fig. 4 (♂), pl. 4, fig. 7 (cocoon).

*Semia cyntia cyntia*, Kishida 1977a: 3 (in part). [misspellings]
*Samia* (*Philosamia*) *cynthia*, Villiard 1969: 144 (eggs, larva, cocoon) (in part). Dirig 1975: 30.
*Sanira cyntia*, Morral & Segura 1991: 14. [misspellings]
*Samea cynthia*, Dierl 1975: 349. [misspelling]
*Samia cynthya*, Teobaldelli 1994: 70. [misspelling]
*Attacus Walkeri* Felder & Felder 1862: 34. Walker 1865: 525. Fauvel 1895: 77 (in part).
*Attacus walkeri*, Butler 1878: 388. Leech 1889: 634 (in part).
*Philosamia Walkeri*, Kirby 1892a: 748. Fauvel 1895: 78, pl. 4 (larva, cocoons, pupa, ♂). André 1908: 73. Comstock 1936: 727.
*Philosamia walkeri*, Rothschild 1895: 37. Packard 1914: 242, pl. 92, figs. a, b (♂ ♀). Mosher 1916: 155, pl. 6, fig. 14 (pupa). Forbes 1923: 674. Lutz 1935: 153, pl. 30 (larva, cocoon, ♂). Teale 1945: 139, 236. Chowdhury 1982: 6. Tazima 1984: 417.
*Philosamia walkweri*, Chowdhury 1982: 6. [misspelling]
*Philosamia Valkeri*, Dusuzeau & Sonthonnax 1897: 31. [misspelling]
*Philosamia cynthia walkeri*, Rebel 1924: 111. Rebel 1925a: 11. Rebel 1925b: 156. Schüßler 1926: 61 (in part). Crotch 1953: 281. Lének 1958: 68. Forster & Wohlfahrt 1960: 134, col. pl. 18, fig. 1 (♂) Inoue 1961: 659. Wolfsberger 1966: 101. Priesner 1968: 276. Yang 1978: 434 (in part), pl. 25, fig. 2 (♂). Jolly et al. 1979: 7. Witt 1980: 173. Nam 1982: 221, pl. 17, fig. 47. Zhu et al. 1984: 143, col. pl. 55, fig. 656 (♀). Hellmann 1987: 57. Baxter 1992: 55 (in part), fig. 26.
*Philosamia cynthia Walkeri*, Schüßler 1933-1934: 85, 535 (in part). Wu 1962: 371.
*Philosamia cynthia walker*, Belyakova & Lukhtanov 1996: 63. [misspelling]
*Philosamia cynthia* var. *walkeri*, Bouvier & Riel 1931: 81.
*Samia cynthia* var. *walkeri*, Aue 1927: 34.
*Samia cynthia* f. *walkeri*, Döring 1955: 116, pl. 23, fig. 316 (eggs).
*Samia walkeri*, Bock 1938: 24 (in part). Zim & Cottam 1956: 86 (♂) , 156. Tietz 1972: 684. Schwerdtfeger 1977: 178. Gardiner 1982: 212 (in part). Peigler 1989: 2. Peigler 1992: 165. Naumann 1995: 26. Peigler 1996: 16, 121. Peigler & Wang 1996: 77-81 (all stages). Owada & Wang 1997: pl. 45, fig. 15 (♂). D'Abrera 1998: 80, 81 (♂♀) (in part).
*Samia cynthia walkeri*, Jordan 1911b: 213. Closs 1919: 55. Seitz 1928: 504. Lhomme 1923-1935: 622 (No. 1555). Bollow 1932: 130. Bouvier 1936: 316. Collins & Weast 1961: 115. Rougeot 1971: 116. Ferguson 1972: 217. Watson & Whalley 1975: 275. Rougeot & Viette 1978: 122, col. pl. 16 (♂, ♀). Rougeot & Viette 1983: 150, col. pl. 16 (♂, ♀). Scheuringer 1983: 69. de Freina & Witt 1987: 399, pl. 37, fig. 14 (♂ ), fig. 15 (♀). Weast 1989: 4. Bertaccini et al. 1994: 154, col. pl. 11, fig. 4 (♂).
*Samia cynthia walqueri*, Gómez & Fernández 1976: 292. Gómez & Arroyo 1981: 77. [emendation]
*Philosomia walkeri*, Steeg 1939: 50. [misspelling]
*Philosamia cynthia eulouvaina* Watson 1914: 29. Rebel 1924: 111. Rebel 1925b: 156. Seitz 1928: 504.
*Samia cynthia eulouvaina*, Bouvier 1936: 316.
*Philosamia cynthia* form *eulouvaina*, Rebel 1925a: 11.
*Philosamia cynthia* var. *eulouvaina*, Bouvier 1927: 921.
*Philosamia Walkeri* f. *eulouvaina*, Schüßler 1933-1934: 40, 561.
*Philosamia cynthia advena* Watson 1912: 45. Packard 1914: 241. Watson 1914: 30. Hawkes 1918: 135. Hawkes 1922: 123. Rebel 1924: 111. Rebel 1925a: 3, pl. 3, fig. 5 (♂). Rebel 1925b: 162. Bouvier 1927: 923. Draudt 1929: 715. Schüßler 1933-1934: 25, 519. Crotch 1953: 281. Crotch 1956: 130. Lének 1958: 65. Priesner 1968: 276. Jolly et al. 1979: 7. Arnscheid 1981: 150. Baxter 1992: 55.
*Philosamia cynthia* var. *advena*, Bouvier & Riel 1931: 81.
*Philosamia advena*, Chowdhury 1982: 6.
*Samia cynthia advena*, Seitz 1928: 504. Collins & Weast 1961: 34, 115. Gardiner 1982: 212.
*Samia walkeri advena*, Sweadner 1937: 197. McDunnough 1938: 41 (No. 800). Hessel 1955: 142.
*Philosamia cynthia advena* f. *perfracta* Lének 1958: 67.
*Philosamia cynthia advena* f. *fulvescens* Lének 1958: 67.
*Philosamia cynthia advena* f. *obscurata* Lének 1958: 67.

*Philosamia cynthia advena* f. *externata* Lének 1958: 67.
*Philosamia cynthia advena* f. *tristis* Lének 1958: 67.
*Philosamia cynthia advena* f. *amoena* Lének 1958: 67.
*Philosamia cynthia advena* f. *austriaca* Lének 1958: 67.
*Philosamia cynthia advena* f. *analis* Lének 1958: 68.
*Philosamia cynthia advena* f. *riciniformis* Lének 1958: 68.
*Attacus cynthia* var. *Parisiensis* Clément 1899: 103.
*Attacus Cynthia Parisiensis,* Clément 1900: 69.
*Philosamia cynthia* ab. *parisiensis*, Schüßler 1933-1934: 39, 561.
*Philosamia cynthia parisiensis advena*, Bouvier 1927: 925.
*Samia cynthia parisiensis advena*, Bouvier 1936: 316.
*Samia cynthia parisiensis parisiensis*, Bouvier 1936: 316, pl. 12, fig. 5 (♀, not ♂).
*Samia Cynthia Parisiensis*, Collins & Weast 1961: 115.
*Samia cynthia parisiensis*, Weast 1989: 5.
*Samia cynthia* ab. *alboabdominalis* Schüßler 1926: 61. Seitz 1928: 505. Schüßler 1933-1934: 27.
*Samia cynthia pryeri*, Jordan 1911b: 213 (in part), pl. 33a (♂). Lhomme 1923-1935: 623. Nikitin 1936: 1121. Chou 1990: 41. Saito 1994a: 296. Saito 1998b: 2, col. fig. on front cover (♀). [misidentifications]
*Samia Cynthia* var. *Viridis* Mezger 1928a: 60.
*Samia cynthia* ab. *viridis*, Bang-Haas 1929: 34. Bollow 1932: 129.
*Philosamia cynthia* var. *viridis*, Schüßler 1933-1934: 39, 561.
*Samia Cynthia* ab. *Bicolorata* Mezger 1928b: 102.
*Samia cynthia* ab. *bicolorata*, Bang-Haas 1929: 34. Bollow 1932: 129.
*Philosamia cynthia* ab. *bicolorata*, Schüßler 1933-1934: 39, 561.
*Samia Cynthia* ab. *Punctata* Mezger 1928b: 103.
*Samia cynthia* ab. *punctata*, Bang-Haas 1929: 34. Bollow 1932: 129.
*Philosamia cynthia* ab. *punctata*, Schüßler 1933-1934: 39, 561.
*Samia Cynthia* ab. *Fenestrella* Mezger 1928b: 103.
*Samia cynthia* ab. *fenestrella*, Bang-Haas 1929: 34. Bollow 1932: 130.
*Philosamia cynthia* ab. *fenestrella*, Schüßler 1933-1934: 39, 561.
*Hyalophora cecropia*, Grant & Miller 1995: 46. [*lapsus calami*]
*Sine nomen latinum*: Kane 1942: [44]. Swain 1955: 28 (♂). Zulver 1962: 66 (♀).

**Types.** We hereby designate as lectotype of *Phalaena Attacus Cynthia* a male from Drury's collection, with a forewing length of 63 mm (Fig. 1), now in the Macleay Museum, University of Sydney. It bears a green label "Macleay Museum, University of Sydney, 2006, Australia" and a white one "genitalia prep. no. 435/99, 8.10.1999, Samia, China, Stefan Naumann." A red lectotype label was added by us. It came to Australia via the Macleay collection (Marks 1991: 203-204). Drury's collection was auctioned in small lots in London on 23-25 May 1805, and Macleay was one of the main buyers (Westwood 1837: ix-x; Smith 1986: 75). The lectotype is in good condition. Among at least 13 specimens of *Samia cynthia* in the Macleay collection, several are apparently syntypes, but we refrain from designating paralectotypes because it is not certain which ones were in the Drury collection. We are grateful to Margaret Humphrey, Collections Manager at the Macleay Museum, for approving the loan of the lectotype specimen, and to Rolf Oberprieler for facilitating the loan.

*Attacus Walkeri* was based on a pair of specimens from the coastal city of Ningbo, in the collection of Cajetan von Felder and his son Rudolf Felder, and described by them. Their collection was acquired by Walter Rothschild and is now in The Natural History Museum, London. The male was illustrated by Peigler (1992) and both specimens shown in color by D'Abrera (1998). We hereby select the male (Fig. 2) as lectotype and the female as paralectotype. The male bears following labels: A round one with "Ningpo" handwritten (but not by either of the Felders); another round label with "Felder coll."; "Rothschild Bequest B.M.1939.1", "syntype" and "B.M. genitalia slide Sat. 661." The female is labeled: "Felder coll. [round]", "Ningpo", "Felders Type" [handwritten, also not by Felder], "Rothschild Bequest B.M. 1939.1", "syntype", "Walkeri Feld.", and "B.M. genitalia slide B.M. 680." The male genitalia preparation was compared to that of the type of *S. cynthia*, confirming the synonymy of the two names. We illustrate a male from Ningbo (Fig. 4) to show that the population of that locality belongs to the taxon we call *Samia cynthia*.

We examined the female of *Attacus cynthia* var. *Parisiensis* which Clément (1899) labeled as the type. It was figured by Bouvier (1936, pl. 12, fig. 5, mislabeled as a male and the author misspelled as Clemens) who stated that it is the type. According to the Code (1999), Article 74.5, Bouvier's action constitutes a valid lectotype

designation for the name *parisiensis*. The specimen no longer has an abdomen, and is labeled: "Jardin du musée de Cluny à Paris, vers 1879; *A. cynthia* var. *Parisiensis* (Type) Clément; Type ♀ [red ink]; Bull. de la Soc. Nat. d'acclim. p. 103 mars 1899; Saturn. Pl. XII fig. 5; *Samia cynthia* var. *parisiensis* Clément, Jardin du Musée de Cluny, coll. J. A. Poujade 1909, E. L. Bouvier ver." with this latter label in the handwriting of Bouvier. No specimens that could be considered paralectotypes were found by us, but it is clear from the original description that Clément was comparing more than one specimen from the Paris area.

*Philosamia cynthia eulouvaina* was described by Watson (1914) from specimens he reared from stock from Tsingtau, which is now found on maps as Qingdao, on the east coast of the province of Shandong. The description appeared to be based on what Watson believed to be larval characters, but these can vary according to rearing conditions. We found only one female among Watson's material in The Natural History Museum, and we hereby designate it as lectotype. The label data read: "Tsingtau; *P. cynthia Eulouvaina* (Wats.) Type ♀ 1914."

No type material for *Bombyx Ailanthi* Weil, 1863 or for *Philosamia cynthia advena* Watson, 1912 was located by us, and we suppose that none exists. However, there is no question regarding the exact identity of these names. *Samia cynthia* ab. *alboabdominalis* Schüßler and all the names proposed by Lének and Mezger are of infrasubspecific status, which according to the Code (1999), no type specimens can exist because these bear no valid descriptions in the sense of the Code.

**Geographical Distribution** (Map 2). This moth lives in The People's Republic of China, ranging in lowlands in the northeastern portion of that country, and occurs widely on the Korean Peninsula. Korean records are summarized in the discussion below, but are too numerous to show on Map 2. The range probably does not extend into the Far East of Russia. We have seen pinned material from the Chinese provinces and districts of Beijing, Heilongjiang, Liaoning, Shanghai, Shanxi, Shandong, Jiangsu, Jiangxi, and Zhejiang. Specimens labeled as coming from Hong Kong, Xizang, and Nanning in southern Guangxi Province were probably reared in those cities, using northern stock, or may be mislabeled. They are omitted from Map 2 to avoid confusion.

During the past 156 years the species has also been introduced by humans for its silk potential (and secondarily by amateur lepidopterists) to many places around the world. Those populations are discussed in detail in a separate section (p. 84). Locations where introductions have been made and were established, at least temporarily, include northern Japan, southern Australia, northwestern Georgia (on the Black Sea), Slovenia, northern Italy, Germany, northeastern Spain, France, Switzerland, and the northeastern United States.

**Diagnosis.** This species is easily distinguished from other species by the distinctive olive green ground color, shared only by *S. wangi,* which is generally paler or lighter colored. From *S. wangi* it differs consistently by the broader (thicker) yellow and white components of the crescents in the center of each wing. The broad crescent is sometimes shared by *S. canningi*, but the latter has a variable ground color, but never the olive green color of *S. cynthia*. The genitalia of the allied *Samia wangi* differ in the generally weaker characters in the saccus, dorsal valval lobe, aedeagus and sclerites, and as well in a small indentation in the transtilla. *Samia pryeri* differs in the transtilla, saccus, and valves, and has a generally different triangular form of the overall genitalia structure, quite distinctive from those of *S. cynthia*.

**Description.** Adult ♂ (Figs. 1-6). *Head.* Frons and occiput dark olive green. Antennae 12 mm long, 3.5 mm wide. *Thorax.* Tergum dark olive green with thin white collar, sternum mixed patches of white and dark olive green. Legs dark olive green with white bands. *Forewing.* Length 61-72 mm; ground color dark olive green with glossy highlights, fading to golden tan; costal margin same as ground color but paler; antemedian area ground color; antemedian line white, crossing costal margin straight through cell $R_5$, extending onto veins $Cu_{1a}$ and $Cu_{1b}$, extending back to base of forewing, a weak black edge bordering the white distally; median area darkest pure olive green; postmedian line slightly convex above crescent, and again below crescent, with black, white (semitransparent), pinkish purple, and suffused pink and purple components; postmedian area of ground color, peppered with numerous black scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5-7 mm; submarginal line a straight, dark brown line beginning in cell $M_1$, with a slight notch in cell $M_2$; outer margin darker outside submarginal line, dark olive gray, fringe on edges of wings; crescent transparent, bordered by white, broad yellow, broader olive, and on the outer arc, narrow black; apex 10-13 mm long, a large grayish purple patch, a white zigzag line with ochre yellow outer tip; eyespot black with white edge proximally, sprinkled with light scales in center proximally; underside with antemedian line absent, but slightly visible from upperside, crescent lacking olive component. *Hindwing.* Length 45-52 mm. Antemedian area olive green; antemedian line white; median area olive green; postmedian line connecting to antemedian line along subcostal margin, colored same as in forewing, protruding distally, mainly white at tornus tip; postmedian area peppered as in forewing;

submarginal line obsolete; submarginal ornamentation with strong markings in the forms of rods, or B-shaped dark patches surrounded by lighter ochre yellow; outer margin with fringe, slightly scalloped at ends of veins; crescent colored as in forewing but shorter and more bent; tornus tapering to a gentle point. *Abdomen*. Tergum of ground color, with broad white belt on first abdominal segment, broad tufts of white in centers of segments, with smaller white tufts on either side, converging at tip of abdomen giving overall white effect; spiracular ornamentation glossy gold with prominent white tufts; sternum about equally ground color and white, in bands and tufts. *Genitalia* (Figs. 149-153). Uncus bifid; transtilla a single lobe without indentations; saccus rounded, broad, with a broad vinculum; sacculus comparatively small, ventral process of the valve the largest, median one quite short and variable in size, and dorsal reduced to a small point in the dorsal lobe of the valve; aedeagus quite strong, broad, with a large marginal, distal sclerotization, left ventrolaterally; vesica with three sclerites: one dorsal, large and always with clear median ridge, the other two smaller and tending left ventrolateral and right distal and dorsal.

Adult ♀ (Figs. 7-8). Differing from ♂ as follows. *Head*. Antennae 10 mm long, 3.0 mm wide. *Forewing*. Length 65-78 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9-10 mm; crescent with broader transparent component; apex 5-7 mm long. *Hindwing*. Length 48-61 mm; tornus more rounded on outer margin. *Abdomen*. Tergum golden yellow areas widely separating white tufts; spiracular ornamentation large gold ovals up to 2 mm long, surrounded by black and bordered with broad white bands; sternum with two longitudinal white median bands, with gold and black ornamentation. *Genitalia* (Fig. 199). Anal papilles heavily indented, with bases and strong bristles ventrally and laterally; oviporus slightly covered with membranous pellicle; lamella postvaginalis rounded and triangular, strongest sclerotization posteriorly, with two narrow lateral processes; lamella antevaginalis rounded; not absent as stated by Lemaire (1978: 131) where it was probably lost during preparation; anterior apophyses nearly half as long as posterior ones.

**Discussion.** The name Cynthia was apparently chosen by Drury to draw attention to the lunate patches in each wing. Cynthia referred to Mount Cynthus in Delos, birthplace of Artemis (=Diana), goddess of the moon in ancient Greece. The name *walkeri* honored Francis Walker, the well-known entomologist who named hundreds of species of insects (Graham 1979). Watson (1914) proposed the name *eulouvaina* to make a political statement in support of the Belgian town of Eulouvain. The meanings of all other names in the synonymy of this species are either obvious, or in the case of those proposed by Mezger and Lének, of no significance.

It has long been assumed by many lepidopterists that Drury's material had been lost, and Horn and Kahle (1935: 62) indicated that some Lepidoptera types from Drury's collection had gone to the British Museum (Natural History) via G. Milne, but D'Abrera (1995: 98, 110) called our attention to the possible existence of Saturniidae from Drury's collection in the Macleay Museum, where they were located by Rolf Oberprieler. The earliest specimens of *S. cynthia* to reach Europe from China were sent by Pierre d'Incarville to Mortimer in London in 1751 (Fauvel 1895: 71), the same year that he first sent seeds of ailanthus to Paris (see Peigler 1993a). We do not know if any of those original specimens eventually belonged to Dru Drury who named the species 22 years later.

Instead of the lectotype, another male in Drury's collection that we examined appears to have served as the primary model for the original figure. Although it definitely belongs to the taxon from northern China, it is a poorly formed aberration, with the antemedian and postmedian lines fused (but these are not fused in Drury's figure). It has a slight amount of dispersal of the pink scaling into the postmedian areas along the veins, as occasionally occurs in *S. cynthia*. This feature was exaggerated by Moses Harris, the artist who produced Drury's figure, and misled subsequent workers (Jordan 1911b: 212-213; Kirby 1892a: 748; Rothschild, Dyar, and others) into believing that the illustration represented what we now call *S. insularis*. Unfortunately, this compounded the taxonomic confusion among those earlier authors, all of whom wrote that the true *S. cynthia* occurs on Java (see Packard 1914: 241), despite the fact that Drury gave China as the source. It also contributed to the erroneous notion by American taxonomists that the form introduced to the United States had quickly evolved differences from its source population in China. Of all the species Kirby listed under *Philosamia*, none were cited as occurring in China! Seitz (1928) considered true *cynthia* to be from southern China, and figured a female from Hong Kong. The English translation of Seitz (1928) pertaining to the specimen in the figure is unclear, but the French and German editions reveal that Seitz himself collected the cocoon that yielded this female in Hong Kong. We consider Seitz' figure to be an accurate representation of true *S. cynthia*, yet the species does not occur naturally in Hong Kong, it being replaced by *Samia wangi* in tropical China. True *S. cynthia* has probably been commonly reared in urban centers like Hong Kong and possibly also in rural villages south of its original range. Referring to the introduced American moth, Comstock (1936) stated that "the specific identity of this species is in doubt." Ferguson (1972) took a fresh look at the questions of the identity of true *S. cynthia* and the source of the introduced form, and we entirely agree with his conclusion that the American

population is the same taxon as that found in northeastern China.

The hand-colored plates in Duncan (1841) were used again to illustrate Volume 4 of Kirby's (1897) handbook. The figure of *Samia cynthia* is the same in both volumes, and appears to be copied from Drury's original figure. This is logical considering that John O. Westwood (1805-1893) published a revised version (1837 [-1842]) of Drury's books, using the same plates as the 1773 original, and Westwood was one of the artists who signed some hand-colored engravings in the book by Duncan, and may have been a silent co-author of that work (Kirby 1897: xvii-xxii; Fletcher & Nye 1982).

As far as we can determine, the name *vera* was originally published by Guérin-Méneville (1858: 371) within the statement "Introduction d'un nouveau Ver à soie de Chine qui se nourrit des feuilles du vernis du Japon (*aylanthus* [*sic*] *glandulosa*)" but was misinterpreted by Girard (1863, 1868, 1871, 1875) who was probably first to use the name *vera* to indicate a variety of *S. cynthia*, and Bouvier (1927: 921) indicated that it means "vrai." (Ver à soie means silkworm.) However, the work which we attribute to Weil (1863) possibly predates the first one cited by Girard. Weil was probably the editor of the journal *Carinthia* in 1863, but according to Dr. Paul Mildner of the Landesmuseum für Kärnten in Klagenfurt, Austria, it is not possible to determine authorship of the article pertaining to *Samia* from the wrappers or contents of that issue of the journal (pers. comm. to Naumann, 9 February 2000). At any rate, no type specimen for the name *vera* was ever designated. We also believe that no valid type specimen for the name *advena* was designated by any author. Specimens labeled as types representing the names proposed by Oskar Lének (1958) were seen and photographed by Naumann in the Naturhistorisches Museum Wien (Vienna, Austria). As these names were quadrinomials, they are not considered valid according to the Code (1999), and thus the type designations are also invalid. Moreover, we think all names proposed by Lének denote *S. cynthia* and *S. ricini*.

The best overall treatment of this species was published by Ferguson (1972), whose research included the taxonomy, morphology, biology, and history of the introductions of the moth. Additional writings about this moth that are particularly worth consulting are those of Packard (1914), Seitz (1918), Rougeot (1971), Lemaire (1978), Frank (1986), Weast (1989), and Jost et al. (2000). Many authors have considered *Samia cynthia* to be widespread and variable in China, but it is neither. Its original range was only in northeastern China and parts of Korea. There is surprisingly little variation among the Chinese specimens that we have examined, and these agree closely with ones from populations introduced to Japan, the United States, and Europe. The name *walkeri* has been erroneously applied to the American and European populations in much of the literature. Males from Japan (see Fig. 6) do appear to consistently have a more falcate wingspan at the apices and more rounded outer edges of the hindwings, but these trends are subtle and difficult to put into words.

We now proceed in this discussion to cover aspects of the biology and ecology of *S. cynthia*. The resting moths hold their wings flat, with the forewings folded down to partially cover the hindwings (Zulver 1962; Rougeot 1971: 120; Gómez de Aizpúrua 1988: 30; Jost et al. 2000: 391). Some American authors like Covell (1984) stated categorically that this species is a day flier and is not attracted to lights. Clark (1926) said that the moth flies by day in the brightest sunlight, and can be mistaken for a large greenish yellow butterfly. Fazzini (1934) wrote that although it is a night flying moth, it often flies in the daytime on dull, cloudy days when the air is dry and warm. We believe that these reports of the moths flying by day are incorrect, and were perpetuated by later authors who consulted earlier writings. When large saturniid moths are disturbed by an external stimulus during the day, they will sometimes take flight, but usually seek cover within a minute. It is even possible that some of the diurnal reports were based on misidentification of males of *Callosamia promethea*, which is a similar-looking moth. John Cody (pers. comm.) never saw moths of *S. cynthia* flying during the day, and none of the resident correspondents of Weast (1989) reported diurnal activity. Both Naumann and Peigler have observed several times that when adults of *S. cynthia* emerge from cocoons in cages, mating behavior occurs only after dark. Eliot and Soule (1902: 235) and Bertaccini et al. (1994) stated that the moths fly at night. Moreover, Ruffo (1998) reported that the moths are attracted to artificial lights in Italy.

Emergence from the cocoon is usually in the evening. Our recent observations on *S. cynthia* were that mating commenced about midnight to one hour after, and continued until nightfall or nearly so the following evening, lasting about 14 to 18 hours. This pattern is normal for many of the large Saturniinae, in which mating occurs within a few hours after dark and the pair remains *in copula* all during the next day. When darkness comes again, the pair separates, and the female begins searching for appropriate plants on which to oviposit, but the male will wait a few hours and then search for another mate. This aforementioned pattern of reproductive behavior does not apply to all species of the genus *Samia*, as males of some Indonesian species arrive at light in pre-dawn hours, probably indicating that females emit pheromone and mating occurs later in the night. Rau and Rau (1929: 136) carried out numerous release-recapture experiments in St. Louis, and concluded "A summary of the *cynthia* records reveals that for this species there are two periods of activity, a primary period from 9 p.m. until slightly after midnight, and a secondary one which runs from about 3 a.m. until a little after dawn. The peak of

their activity is from 10:30 to 11." Their account apparently does not take in account the fact that the sexes fly at different times, so we interpret that only females fly early in the evening, ovipositing; males then fly later, searching for mates. Mating pairs were shown by Rougeot (1971) and Passarin d'Entrèves and Zunino (1976: 219-221). Matings were achieved in Colorado and Texas using stock from U.S.A. and Japan in a large cylindrical mating cage (made by Marris House Nets, Bournemouth, England), and in South Carolina using stock from Paris and U.S.A. in screen cages. Matings occurred more readily when the cages were placed outdoors, apparently because air circulation is necessary for the males to locate the females via pheromone. Eggs are laid in curved rows of about 9-25, usually all touching the leaf, but sometimes part of them in an upper layer. The egg masses are usually deposited on the undersides of the leaflets on the terminal half of a leaf, but sometimes they are placed on the uppersides of the leaflets. Gómez and Fernández (1976) said females lay 250-400 eggs, and Klausnitzer et al. (1988) stated that there were only 100-250 per female. The latter authors said that eggs hatch after about 20 days in the lab at 18 °C, but we have noted eggs can hatch in only 10 days.

Adults of *S. cynthia* from Matsumoto, Japan, emerged from cocoons in San Antonio, Texas, in late May 2000. One male mated with three different females, one each during three consecutive nights. Fecundity varied considerably; one female deposited 480 eggs, whilst another of the same lot from Matsumoto laid only 334 eggs. Adults again emerged in late May 2001 from the Matsumoto stock reared the previous year; it was univoltine despite the fact that cocoons were spun in July, possibly because of the short daylength in Texas during summer (but see data from Kendall below). Although most larvae ate *Ailanthus altissima*, they readily accepted and grew rapidly on Chinese prickly-ash (*Zanthoxylum simulans*), Chinese cork tree (*Phellodendron chinense*), and Amur cork tree (*P. amurense*), all Rutaceae. Larvae have also been reared in Germany on littleleaf linden (*Tilia cordata,*Tiliaceae) (Huwe 1893, repeated by Steeg 1939), and Tietz (1972: 685) listed three American species of *Tilia* as foods. Although castor (*Ricinus communis*) was reported by several authors as a good food, larvae from Matsumoto reared in San Antonio grew slowly on castor, and did not mature. The hostplant lists given for Lepidoptera by Tietz (1972) are exhaustive, and contain errors, and thus must be viewed cautiously. Interesting records that Tietz listed, and which may be significant, include hoptree (*Ptelea trifoliata*, Rutaceae) and American holly (*Ilex opaca* Aiton), but we have not included his list in our own Hostplant Appendix in hopes of avoiding the perpetuation of many erroneous records. Eliot and Soule (1902: 232) reared larvae of *S. cynthia* on tuliptree (*Liriodendron tulipifera*), lilac (*Syringa vulgaris*), and sassafras (*Sassafras albidum*), presumably because they did not have easy access to ailanthus. Studying Viennese livestock of *S. cynthia* in Leipzig, Klausnitzer et al. (1988) offered larvae English holly (*Ilex aquifolium* Linn.) but observed no feeding behavior. More records of hostplants for the introduced populations of *S. cynthia* are given in the following subsection.

Roy O. Kendall, renowned for maintaining meticulous field and lab notes, reared *S. cynthia* in San Antonio, Texas, on ailanthus in June and July 1965. In March 1965 he received seven cocoons from Jack E. Lipes who lived on Staten Island (Richmond Borough of New York City), which emerged the first half of June. A mating was achieved, the eggs hatched 23-25 June, and 42 cocoons were obtained. Some pupae and freshly emerged adults were destroyed by ants. Adults emerged from 3-12 August 1965. This was a very rapid metamorphosis, with the larval and pupal stages each lasting only three weeks.

For China and Korea, there are numerous records of the larvae feeding on *Ailanthus altissima*, various species of *Zanthoxylum*, and camphor (*Cinnamomum camphora*). The specific hostplants in the particular Chinese provinces were best summarized by Rondot (1887: 75-90, 101-105), although southern and western records generally belong under *S. wangi.* Seitz (1918: 81) wrote that he found larvae in China on various trees, and also often on small bushes, which he did not specify.

We found few statements for the phenology in China from literature. Specimens from several Chinese provinces are labeled mainly with the months of May, June, July, and August, and we believe this insect to be double-brooded in China, as did Rondot (1887: 85). In Korea there are two broods per year, with moths appearing from the beginning of April to the end of September (Park & Tshistjakov 1999). Emergences in the United States are generally in July, where the species was said to have stabilized as single-brooded after its introduction. Watson (*in* Packard 1914: 243) stated that the moths emerged in late June or early July in New York, but two or three weeks earlier in Washington. The species may now be single-brooded (univoltine) in France, but double-brooded in Austria and Italy, where the moths are on the wing May to June and again in September (Klausnitzer et al. 1988; Bertaccini et al. 1994). Pupae sometimes hold over more than one winter. Wullschlegel (1863: 184-185, footnote) received some cocoons in 1857 and some adults emerged in April 1858, but some did not emerge until 1860 and three held over until April 1861. Dr. Austin H. Clark, who was curator of echinoderms at the Smithsonian Institution, and a competent lepidopterist, published the following observations about *S. cynthia* (Clark 1926): "In Washington it is common in late May and June, and again the first week of August; there is a third brood in October; but at this time the moth is much less common than in the spring and summer broods. Of 250 cocoons taken from a tree in Washington last October, 50 had recently

hatched and some of the moths were still about. This would indicate that of this brood about one-fifth of the moths hatch in the autumn while four-fifths sleep till spring. Many, indeed, sleep on till middle of the summer when the children of their brothers and sisters are on the wing. The eggs laid by the moths that fly in autumn are killed by the winter's cold." We found further reports of moths flying in October in France, Germany, etc., as mentioned below. However, regarding the populations in New Jersey, Pennsylvania, and New York, the moth has almost always been univoltine, emerging in July, as substantiated by various American authors, except Beutenmüller (1898) who stated the species to be "partly double-brooded" in the vicinity of New York City. Peigler obtained stock from northeastern United States several different years between the late 1960s and early 1990s, and even cocoons kept indoors as early as March often did not yield adults until June and July. The related genus *Callosamia*, specifically *C. promethea*, is single-brooded in New England south to northern New Jersey, but has double-brooded populations in southern New Jersey and southward (Ferguson 1972: 235-236). The same pattern may exist for *S. cynthia* in the Atlantic States.

Larvae sometimes completely defoliate small ailanthus trees in American cities (Holland 1917, Swan & Papp 1972: 267). In New York City, when abundant, the larvae were considered to be pests of ailanthus trees planted for shade, according to Comstock (1936), and reiterated by Zulver (1962), although she probably based her comment on Comstock instead of new reports. John Cody (pers. comm.) found cocoons hanging on large ailanthus trees, and on smaller ones that had already developed side branches. Cocoons were always hanging; none were found on the ground. He said that cocoons could generally be found every year at the same sites on the same trees, but that in recent years, he has not been able to find cocoons in New York City. Cody never observed the moths being attracted to lights during evening hours. In November 1997 during a visit of the Muséum National d'Histoire naturelle in Paris, Naumann observed a hanging cocoon just opposite the road in a park area, about 5 meters above ground level in an ailanthus tree. Collins and Weast (1961) said that cocoons are found on the ground after the large petioles fall; we have noted that in some cocoons received by us, the silk peduncle did not completely extend the whole length of the long petiole of the compound leaf. Referring to cocoons of *S. cynthia*, Julia Ballard (1891: 177) stated "many fall from the tree." Austrian workers proposed a "summer cocoon" in which the main petiole is not attached by a silk ribbon, and a "winter cocoon" in which it was; diagrams of these were shown by Pammer (1966: 100). Elisabeth Pammer found that shorter photoperiods induce larvae to spin winter cocoons (that would remain attached to the tree) and to enter diapause.

The duration of the larval stages varies according to temperature and food quality, especially water content. Salzmann (1978) recorded the duration in days of each instar using *Ligustrum* (species not indicated) at 23° Celsius to be 3, 3, 5, 5, 12, and 6, resulting in cocoon formation 34 days after eclosion from the eggs. As with many Saturniidae, the number of instars varies; it is normally five for *Samia*, but an additional one was recorded by Salzmann, and we do not question his results. He pointed out that the duration of the larval development is highly variable, and that female larvae generally take longer to mature than male larvae, since the latter are smaller at maturity. We agree, having observed that female larvae require a longer developmental period in many Saturniidae. Larvae of *Attacus* routinely have a sixth larval instar.

Reference to relief maps of China that show plains and mountainous areas reveals that *Samia cynthia* is probably restricted to level bottomlands and low foothills. The statement by de Freina and Witt (1987) that this species occurs at altitudes of 250-400 meters in Spain is erroneous. Much of their text repeats that of Gómez and Fernández (1976), who stated that the females lay 250-400 eggs. Detailed remarks are given below about the urban ecology of *Samia cynthia* in cities of Europe and especially the United States. In short, populations of this moth, like those of many other Saturniidae, especially Attacini, can maintain high population levels in the urban environment. The more relevant questions to this discussion on biology are "What type of population ecology does *S. cynthia* have in the countryside, and what was it like in prehistoric times?" We are aware of no field observations in China and Korea, either anecdotal or quantitative. The insect apparently inhabits forests of foothills and plains, probably in ecotones. We believe that the population ecology of *S. cynthia* in China and Korea mirrors that of related Attacini in North America, about which we know more. These moths maintain dense or sparse populations in the wild, providing propagules for establishment of urban populations that can become quite dense. Scattered data also lead us to believe that the population ecology of *Callosamia securifera*, *C. promethea*, and *Hyalophora cecropia* is characterized by movement and fluctuations. Ferguson (1971: 11; 1972: 247-248) discussed these matters with considerable insight, some of his ideas based on direct field observations. The reader is also referred here to the writings of Collins and Weast (1961) and Jost et al. (2000). Therefore, we propose that *Samia cynthia*, like its American relatives, maintains sparse and low population levels throughout much of its range with periodic and patchy high numbers, and that populations do not occur consistently in the same areas year after year. Selection pressure from key parasitoids can severely impact these higher levels in only two to three years (see Peigler 1996: 37-39). Indeed, remarks by T. Pergande cited in Packard (1914: 247) show that *Samia cynthia* populations were already being decimated by *Enicospilus*

*americanus* and *Conura maria* [cited in Packard as ichneumons and *Spilochalcis mariae*, respectively], the same parasitoids that Peigler has observed to impact *C. promethea* in eastern Texas, *C. securifera* in coastal South Carolina, and *Rothschildia lebeau* in the Lower Rio Grande Valley of Texas. It therefore appears possible that related parasitoids in the genus *Enicospilus* and family Chalcididae keep populations of *S. cynthia* in check in China and Korea.

For the American Attacini, notably *H. cecropia* and the two species of *Callosamia*, field observations by Peigler in the southeastern United States reveal that only a few scattered cocoons can be collected over large fields, along rivers, or along highways, during most winters. Occasionally high numbers of cocoons can be collected where populations are periodically dense, but most of those often contain the above-mentioned parasitoids, and the following year far fewer cocoons can be found at these sites. On the other hand, non-quantitative observations over several years by Peigler suggest that other Attacini such as *Callosamia angulifera* in the Carolinas and *Hyalophora gloveri* in Colorado maintain consistently high populations. Comments by Uberto Nardelli (letter to Naumann dated 5 August 1997) indicate that it is not hard to occasionally find single cocoons in low-lying areas where stands of ailanthus are present. The general impression we get from studying the writings of the Italians and a Slovenian (see sections below on Italy and Slovenia) is that the population ecology of *S. cynthia* in northern Italy and adjacent regions probably approximates that of the moth in China. Certainly, dense populations of *S. cynthia* may occur in large cities like Shanghai and Beijing, but these are artificially enhanced, and differ ecologically from those in the Chinese countryside. It is our hope that Chinese and Korean entomologists will carry out and publish ecological studies on *Samia cynthia* in its native range. In Manchuria, the moth was said to occur on the plain in the southern portion, only near the coast, which has a milder climate, according to Nikitin (1936: 1120), but we found two specimens labeled as coming from Harbin, far inland in Heilongjiang.

Given the paucity of locality data for this insect in its native regions, we summarize below the localities that Park and Tshistjakov (1999) tabulated for Korea. Most records are for the south and east, which may simply reflect a greater amount of collecting by entomologists in those areas. Alternatively, the map of Park and Tshistjakov may provide a clue to the northern limits of the distribution. Support for the latter hypothesis comes from the map of forest types given by Wolfe (1979: plate 1). Localities plotted for *Samia cynthia* by Park and Tshistjakov all fall within the forest types named notophyllous broad-leaved evergreen, mixed mesophytic, and mixed broad-leaved deciduous, with the former type being the most southerly and coastal. No records for the moth are within the zones that Wolfe ascribed to mixed coniferous and mixed northern hardwood. These latter two forest types also occur across most of Hokkaido, Liaoning, Jilin, and Heilongjiang, and we note an absence or at least paucity of records for *S. pryeri* and *S. cynthia* in those areas. For China, Rondot (1887: 77) referred to records for *S. cynthia* from Jilin; in the hills west of the Liao River near Jinzhou, Liaoning; Shanxi; and Nanyang, Henan. Because of its southerly position, the latter might refer to *S. wangi*, instead of to *S. cynthia*.

To complement our attempts to provide as many locality data as possible for China, we now enumerate the ones given for Korea by Park and Tshistjakov (1999: 168), citing the romanizations used by those authors, with some traditional spellings in parentheses. For North Korea, the moth is recorded from Pyungyang (=P'yongyang), Mt. Jeongbang-san, and Mt. Kumgang-san. Witt (1980) reported a male taken 4 August 1971 at a hotel garden in Pyongyan, in South Pyongyan Province. On a visit to Poland in August 1985, Peigler was given an *S. cynthia* by Edward Palik, who worked for Dr. Józef Razowski at the Polish Academy of Sciences in Cracow. Palik caught the specimen in the Kumgang-san Mountains in southeastern North Korea. For South Korea, moving from north to south, *S. cynthia* is noted from Seoul, Mt. Nam-san, and Cheongryang-ri; for province of Gyeonggido (=Kyonggi-do) localities of Gwangleung, Mt. Soyo-san, Mt. Chukryong-san, Mt. Bukhan-san, Cheongpyoung, Mt. Baekun-san, Mt. Unak-san, Mt. Cheonggye-san, Mt. Myungji-san, Suwon, and Asan-bay; for province of Gang'weondo (=Kangwon-do) localities of Mt. Seolak-san, Yangyang, Sangdong-eup, Chuncheon, Gugok-pokpo, Kangwon National University, Dukduwon, Janghak-ri, Hoengseong, Sogumgang, Munmak, Wonju, Donghae, and Mt. Chiak-san; for province of Chungcheongbugdo (=Chungchongbuk-do) localities of Chupungryoung, Mt. Minjuji-san, and Jecheon; for province of Chungcheongnamdo (=Chungchongnam-do) localities of Nonan, Mt. Gyeryong-san, and Cheongyang; for province of Jeonrabugdo (=Chollabuk-do; Chonbuk) locality of Mt. Jiri-san in the southwestern part of that less densely populated province; Daegu (=Taegu City); for province of Gyeongsangbugdo (=Kyongsangbuk-do) localities of Mt. Juwang-san, Mt. Soebaek-san, Mt. Palgong-san, Temp. Sutae-sa, Gunui, Mt. Sudo-san, Gimcheon, Bongwha, island of Ulleung-do, Uiseong, Cheongdo; for province of Gyeongsangnamdo (=Kyongsangnam-do) localities of Mt. Seunghak-san, Pusan, Mt. Baekun-san, Mt. Gibaek-san, Mt. Hwangsuk-san, island of Geoje-do, Pyoungji, Mt. Yeohang-san, Mt. Muhak-san, Milyang, Geochang, Goseong, Namhae, Sacheon, Sancheong, Ulsan, Uiryoung, Jinju, Hadong, Hamyang, and Hapcheon; for province of Jeonranamdo (=Chollanam-do) localities of Temp. Baekyang-sa, Gurye, Haenam, island of Jin-do, Mokpo, and Geumo-do; Gwangju (=Kwangju City); and a

few localities on the large island of Jejudo (=Cheju-do) to the south, namely Seoguipo, Cheju, Ora-dong, and Mokseokwon. The above records were assembled by Dr. Kyu-Tek Park and his colleagues using literature, examining label data on specimens in collections, and from numerous collecting trips throughout the country to sample the moth fauna. It is interesting to note that *S. cynthia* also occurs on Tsushima Island (Japan) to the east, which is closer to Korea than is Cheju Island. This may represent a natural (non-introduced) population of *S. cynthia* within the political boundaries of Japan. Specimens of *S. pryeri* have also been taken on Tsushima; see our text for that species.

**The Introduction of *Samia cynthia* Around the World.** Much attention has been paid in the American and European literature about the introduced populations of this insect during the nineteenth and twentieth centuries, some of which persist today in Europe and the United States. Peigler (1992) presented a review of these introductions, but we now have compiled much more information. It has not been recognized until now by western lepidopterists that *S. cynthia* was introduced from China into Japan in 1870 and has spread in the latter nation, apparently co-existing with the native *S. pryeri* without any evidence of hybridization. Some Japanese lepidopterists (Inoue et al. 1982) have been aware of the fact that two species of *Samia* fly in their country. (*Samia ricini* also is widely cultivated in Japan, but does not exist as feral populations, as far as we know.) Jordan (1911b: 213) was incorrect in stating that *S. cynthia* had been introduced into Europe in 1845, as will be clarified below. The error of 1845 was perpetuated by Esaki (1973: 225), Carnelutti (1956: 141), and probably others.

In our discussions below, we provide historical accounts pertaining to the introductions, and assess the current status of those populations. *Samia cynthia* has apparently gone extinct in Australia, New Zealand, Canada, Germany, and Spain; it apparently never really successfully established itself in Portugal, England, South America, and Algeria; it is nearing extinction in the United States. We noted one casual reference to an attempt to introduce *S. cynthia* into South Africa; Hutton (1872: Appendix: 6) stated, "...and I believe they have it also at the Cape of Good Hope." The ailanthus tree is the primary host of *S. cynthia* both in China as well as in all of the places where the moth has been introduced. The tree was introduced into Europe in the 1750s and the United States in the 1790s (Hu 1979, Peigler 1993a, Kramer 1995), so was already well-established and widely available in those areas several decades prior to the introductions of the moth.

The eventual distribution (northern limit) in Europe where *S. cynthia* appears to have permanently established parallels the natural distribution of *Saturnia pyri* in Europe (see Rougeot 1971), specifically very successful in northern Italy and near the Adriatic and Black seas, ranging to Lower Austria, in northern France approaching the Belgian frontier, and around the southern edge of Switzerland; both species appear to be incapable of surviving most winters of Germany, Benelux, and regions north of the Carpathians, and are absent in the British Isles. A graph showing the ecological profiles of various Saturniidae in Switzerland, reveals that both *Samia cynthia* and *Saturnia pyri* live at lower altitudes than *Aglia tau* (L.) and *Saturnia pavonia* (Jost et al. 2000: 371). Whilst *S. pyri* can exist up to 700 meters in drier habitats, *S. cynthia* appears to be restricted to locales below 500 meters, and cannot live at all in the wettest areas of Switzerland. A bit to the south, some Italian lepidopterists consider 700 meters to the maximum for *S. cynthia* in their area (see text for Italy below). In its native China, *S. cynthia* is likewise restricted to low elevations, as we pointed out earlier. By contrast, *S. wangi* has often been taken at elevations of 1000 to 2000 meters. Of course, *Saturnia pyri* ranges farther to the south in Spain, Italy, and the Middle East, where *S. cynthia* does not.

In early 1992, Peigler sent 50 viable cocoons of United States stock of *S. cynthia* to Dr. S. N. Chowdhury of Assam Agricultural University, Jorhat, Assam, India, at his request. As far as we know, Chowdhury did not attempt to introduce the silkmoth there, where both *Ailanthus excelsa* grows as a native and *A. altissima* as an introduction. In The Natural History Museum in London there is a male of *S. cynthia* that is labeled "Sikkim, I - 4000 ft., Möller/collectio H. J. Elwes/Rothsch. Bequest." Otto Möller was a well known resident collector in Sikkim (Horn & Kahle 1936: 180), and perhaps he received some stock of *S. cynthia* from a correspondent, or the material was confused later in Europe. The identification was verified by genital dissection by Naumann, but we omit this specimen from our section on material examined, because listing Sikkim (now part of India) may confuse some readers. Another specimen of *S. cynthia* in the Deutsches Entomologisches Institut in Eberswalde is labeled as originating on the Nicobar Islands. We also omit it from our material examined, as it is undoubtedly mislabeled.

For perspective, it is worth noting that *Samia cynthia* is one of only a few saturniids that have been successfully introduced and established outside of their original ranges. The others known to us are the Chinese *Antheraea pernyi* on the Balearic Islands (Spain), the Japanese *Antheraea yamamai* in southeastern Europe (Rougeot & Viette 1978, 1983), and the Australian *Opodiphthera eucalypti* (Scott) in New Zealand (Common 1990: 405). There are casual references in older literature to saturniid introductions that did not succeed. For

example, Depuiset (1877: 103) indicated that *Hyalophora cecropia* had been introduced from New Orleans to Paris around 1845. Because of their sericultural value, we suppose that *S. cynthia* and possibly *S. wangi* have been transported in ancient times to regions of China that were not part of their original geographical distributions. If true, this has apparently not complicated our understanding of the taxonomy of these two taxa.

**United States.** *Samia cynthia* was brought to the United States in 1861, and larvae and moths were released later that same year. There has been some confusion pertaining to the exact year of introduction. Stewardson (1861) discussed this project in 1861 at the March 5th and October 1st meetings of the Academy of Natural Sciences of Philadelphia, and his remarks were summarized in the Proceedings published in December 1861. Nolan (1892) considered it worthwhile to publish additional information, because he was a young assistant of Dr. Thomas Stewardson in the early 1860s who had assisted in the rearing of the silkworms, and by 1892 realized that the moth was well established. Nolan's paper is ambiguous as to whether the first rearings were in 1860 or 1861, but it is clear from both publications by Stewardson and Nolan that many larvae were already released into the wild the first year, and the colony was maintained indoors through 1863, with additional releases into the city of Philadelphia in 1862 and 1863. Frank (1986), referring to the papers by Stewardson and Nolan, considered 1860 to be the year that stock was first received from France. However, a report by Dr. John G. Morris (1863) of Baltimore, Maryland, provides definitive dates as follows: eggs were first received from France by Stewardson in June 1861, and many larvae were set out on ailanthus trees in August 1861, but as Ferguson (1972) correctly interpreted, all or most of those were brought back into captivity after their cocoons were spun. Stewardson sent about 20 cocoons to Morris in Baltimore in 1862.

Additional details pertaining to the above include the following. Stewardson had read with interest the articles by Guérin-Méneville in various French journals, such as *Bulletin de la Société de Acclimatation*, and a friend in Philadelphia named G. Roberts Smith brought from Guérin-Méneville to Stewardson some specimens of the moths and small samples of silk (at various stages of preparation from cocoons to woven fabric). In June 1861, Smith also brought eggs from Paris to Philadelphia, the first lot hatching en route and thus failing, but a second lot a few days later arrived alive. Stewardson and a friend Mr. Evans reared some of the larvae, and from the emergences of adults that same August were able to easily increase the colony. Stewardson set out larvae in several areas in the center of Philadelphia, and its suburbs. His office was near the intersection of Broad Street and Sansom Streets. In 1862 Edw. J. Nolan was given the responsibility of maintaining the colony, a task which he gladly accepted, and he set out larvae in the vicinity of 9th Street above Chestnut Street, where a post office now exists. There were two generations per year in the first few years in Philadelphia. Herman Strecker (1875) also released moths in nearby Reading, Pennsylvania, a few years later. The source of Strecker's stock is unknown, and Ferguson (1972) even suggested that it may have been *S. pryeri*. Brozskus and Bodenstein (1950) claimed that the moth occurred in North America from Canada to Florida, which is a greatly exaggerated distribution. They knew that the European stock originated from Shandong, China, but believed that the United States material was from Hong Kong, yet the latter is known to be erroneous based on reliable documentation summarized above.

Stewardson's original wish to create in the United States a new silk industry based on this moth did not materialize. Efforts to develop an ailanthus silk industry in the United States were almost non-existent compared to the expense and labor that sericulturists in France invested in it, strongly supported by the imperial government, as pointed out in the discussion for France below. In the early 1860s the United States was entering a long and bitter civil war, but it is doubtful that the war detracted in any significant way from cultivation and marketing of ailanthus silk, considering the prompt or ultimate failure of every attempt to culture *Bombyx mori* in the United States. In retrospect, it is clear that the article by Morris (1863) in the first volume of the *Report of the Commissioner of Agriculture* was overly optimistic about this new American silk industry.

Although the earliest rearings and releases were mainly in Philadelphia, Reading, and Baltimore, during the next several years they provided abundant stock to establish additional colonies in New York City, Boston, and more cities in Connecticut, New Jersey, and New York State, plus Washington, D.C., and Richmond, Virginia. Specific spots in and near Philadelphia where cocoons have been collected were listed by Frank (1986: 44). There are records of the moth flourishing in all five boroughs of New York City, namely Brooklyn (Robertson-Miller 1912, specifically Prospect Park; Lemaire 1978, pl. 25, fig. 1; Cody 1996), Staten Island (Davis 1909, Forbes 1923), Manhattan (Packard 1914, specifically Central Park), Queens (Weast 1989; John Cody, pers. comm.), and the Bronx (Weast 1989). Brooklyn and Queens occupy the western end of Long Island. Cockerell (*in* Packard 1914), Forbes (1923), Clark (1926), Showalter (1927), Mitchell and Zim (1964, 1987), and Ferguson (1972), some of whom resided in the Washington area, all referred to populations in the capital city, but cocoons could not be found there in the mid 1970s by one resident collector who was a correspondent of Peigler. There is a short series of pinned specimens from Washington, D.C., in the U. S. National Museum of Natural History. A specimen was collected near Washington by Jeff Boettner (pers. comm., February 2000) under a street light

beside Entomology Road on the National Agricultural Research Center near Beltsville, Maryland, on 30 June 1988. (Given the locality, we wonder if that specimen may have escaped from a nearby captive culture). Other specific localities where the species has been collected include Chatham (Ferguson 1972, pl. 16, fig. 8) and Trenton, New Jersey (Packard 1914); Livingston, New York (Forbes 1923); Baltimore, Maryland (Grote 1874: 258); Newark, Elizabeth, and Linden, New Jersey (Weast 1989). Medsger (1933: 236) once found hundreds of cocoons in a thicket of ailanthus near Jersey City, New Jersey, which is just across the Hudson River from Manhattan and Brooklyn. He speculated that the moth would expand its range into the Mississippi Valley, following the spread of the ailanthus tree. Stock cited by Deml and Dettner (2002) from "Oakland/New York" may be an error for Oakland, New Jersey.

Ida Eliot and Caroline Soule (1902) lived in Brookline, a suburb of Boston, but apparently obtained their cocoons from New York. Although the insect was common for many years in New Haven, Connecticut (Remington 1958, Pyle 1975), it apparently went extinct there before 1989 according to Tuskes et al. (1996), who figured a male from that city. We have not been able to verify that the species has existed in Boston with any regularity, and it is probably extinct in Massachusetts. In 1976 Peigler received from a correspondent in Pennsylvania a few viable cocoons stated to be from Boston. According to Dr. Kenneth Frank (1986), *Samia cynthia* had almost entirely disappeared in Philadelphia by 1986, but was rediscovered there by him in 1992 (Tuskes et al. 1996). John Cody (pers. comm.) grew up in Brooklyn, and found cocoons commonly in several spots in Manhattan and Brooklyn, but now says it is no longer possible to find them anywhere in New York City. In a letter to Peigler dated 27 December 1989, Daniel Sblendorio of Middletown, New Jersey, wrote: "During the past month I searched along two 3-mile continuous distributions of ailanthus where *S. cynthia* is known to occur. I managed to find only 12 viable cocoons in very obscure locations. It would once again seem that the common areas are barren due to total collecting." Although the disappearance of the species has often been blamed on over-collecting of cocoons, we reveal another factor below that is probably the real reason for the decline.

We found no records in the literature for the states of Rhode Island and Delaware, although the large cities of Providence and Wilmington, the latter very near Philadelphia, have undoubtedly supported populations of the moth. There are no specimens labeled as coming from Rhode Island or Delaware in the extensive collection of the American Museum of Natural History (F. H. Rindge, pers. comm., 19 January 2000). A specimen in the collection of Boston University is labeled as being collected 1 August 1903 by Howard L. Clark. Clark lived in Bristol, Rhode Island, and the other Saturniidae in his collection are from Bristol, so the specimen of *S. cynthia* probably originated there (P. Z. Goldstein, pers. comm., 7 September 2000).

The limiting factor for the northern spread is one of climate. Weast (1989), following the experiments of Danilevsky (1940), showed that the pupae in exposed cocoons cannot survive freezing temperatures below -15° Celsius (= +5° Fahrenheit). Milder temperatures prevail in urban environments where heat is often trapped below a layer of air pollution, and also coastal areas. Thus New York City and other metropolitan centers near the Atlantic seaboard offer the best habitat for this species in North America. Weast listed the low temperatures for 1983 for St. Louis, Pittsburgh, Toronto, Chicago, Louisville, and Indianapolis, to which can be added the following *average* minimum temperatures in Celsius: Boston -14.9°; New Haven -14.3° ; Philadelphia -10.9°; New York -12.0°; Richmond -9.5°; and Pittsburgh -15.1°. For comparison, Brownsville, Texas, has an average low of 2.5°. Weast reported a batch of cocoons to survive a drop to -29° Celsius in Des Moines, Iowa, but he had covered them with a few inches of dead leaves and placed them on the south-facing side of the house. It is therefore clear that Boston is at or near the northern limit, and that inland cities to the west cannot support populations very long, at the most only a few years, until the coldest winters occur. We do not question that the species has become established in several American cities in the Midwest, apparently via intentional introductions by amateur lepidopterists, but we think that those populations persisted for only a short time. Examples of these include Dayton, Ohio (Pilate 1883, Metzler & Lucas 1990); Dover, Ohio (Metzler & Lucas); Pittsburgh, Pennsylvania (CMNH); St. Louis, Missouri (Weast 1989); and northern Kentucky (Covell 1984).

There are no data to indicate that the species can maintain populations (in North America, at least) in the countryside, and indeed its populations are virtually always restricted to urban and suburban environments. The mass of urbanization from Boston to Washington has offered many pockets of ideal habitat for the species to flourish. However, the moth could not reach *large* cities like Atlanta, Georgia; St. Louis, Missouri; Chicago, Illinois; and Pittsburgh, Pennsylvania, to name just a few, except through separate introductions by humans. In Dayton, Ohio, Pilate (1883) wrote "I turned out some *cynthia* some years ago, and now the species is very common in our city." Many such introductions have clearly occurred, and still do. These considerations, in conjunction with freezing winter temperatures, give us a fair picture of the actual range of the moth in North America. The species must have become established in Washington before 1895 (Packard 1914, pl. 57) and in Pittsburgh before 1937 (Sweadner 1937, pl. 19), probably much earlier. There is a record of cocoons being

found in St. Louis in 1987 and an introduction was attempted in 1948 in Memphis, Tennessee (Weast 1989). For Ohio, Metzler (1980) showed the species as having been recorded from Ashland County (which has no large cities), Cincinnati, and Dayton. A database on Lepidoptera of Illinois, maintained by the Illinois State Museum in Springfield, lists *S. cynthia* from Cook County (Chicago area) and Adams County (western edge near the Iowa/Missouri border). Labels on specimens from Pennsylvania in the Natural History Museum of Los Angeles County that give Adamstown and Blaine may refer to where they were reared instead of collected. Adamstown is a small rual community between Reading and Lancaster; Blaine probably means Blaine Hill, a town southeast of Pittsburgh.

The supposed spread of the range to the South and West has unfortunately been grossly misinterpreted. Collins and Weast (1961) reported the species from Savannah, Georgia, and all over Indiana, especially the southern half of that state, causing later authors (Ferguson 1972, Covell 1984, and others) to embrace the notion that *S. cynthia* was rapidly and progressively spreading southward and westward. The Savannah record was based on a single specimen collected at light in the 1950s, of which the identification was not verified, and Weast (1989) later conceded that the species probably does not occur in Savannah. Peigler has searched in Savannah for cocoons in stands of ailanthus in the 1970s and 1980s on several occasions, but none were found. Earlier editions of Zim and Cottam (1956) showed the range to be roughly between Boston and Washington, but later editions (1987, 2001) showed it to reach Indiana and Savannah. In the same series of pocket-size books, of which thousands of copies have been sold, Mitchell and Zim stated the range to be "Boston to Washington" in 1964, but "Boston to Savannah westward to Indiana" in the 1987 edition. Covell's (1984) widely disseminated field guide also gave the range as south to Georgia and west to Indiana, and Arnett (2000) listed Virginia, North Carolina, South Carolina, and Georgia, as well as northeastern United States. Weast (1989) and Tuskes et al. (1996) pointed out that the records for Indiana were erroneously based on a misidentification for *Hyalophora cecropia* by an entomologist in that state, reporting to Weast prior to the 1961 book. This highly regrettable error will undoubtedly be perpetuated in more literature in the future, despite the fact that recent authors (Opler 1995; Tuskes et al. 1996) showed the range as being mainly from Boston to Washington, a revised distribution with which we concur. However, the range map of Tuskes et al. also included St. Louis, Pittsburgh, all of New Jersey, Maryland and Delaware, and much of eastern Virginia, most of which we do not accept as part of the historical or recent distribution of this species in North America, as interpreted here.

*Samia cynthia* has apparently never established anywhere in the Deep South at any point in time (McCord 1987), even in large metropolitan areas like New Orleans, Houston, and Atlanta. Peigler observed that almost all larvae set out by him that were living exposed in Greenville, South Carolina, and San Antonio, Texas, were killed by paper wasps of the genus *Polistes* (Vespidae), regardless of the hostplant species and the amount of defoliation. Such wasps are very common in urban and suburban areas of the southeastern United States and may be one reason that populations of *S. cynthia* have not been able to persist when introduced by amateur lepidopterists into that region. We do not know if *Polistes* are equally common in the northeastern United States. Wasps have been reported as significant predators of *S. cynthia* caterpillars in Europe (see below). In Greenville, South Carolina, Peigler also observed adults of *S. cynthia* that he released during daylight hours to be captured in flight by Blue Jays (*Cyanocitta cristata*, Corvidae). These birds also captured specimens of *Callosamia promethea* and *Hyalophora cecropia* that were released by day. Another factor that needs to be considered when attempting to understand why *S. cynthia* has not established in the Southeast pertains to the relationship between the short summer days and induction of diapause; see our earlier discussion on diapause.

Seitz (1918: 84, footnote) cited a report by Riley (1887) and implied that *S. cynthia* might have been tried for silk culture in California. Riley's report summarizes sericulture endeavors throughout the United States during that period, but pertains only to *Bombyx mori*. Rebel (1925a: 15) misinterpreted the comments by Seitz and reported that attempts had been made to introduce *S. cynthia* to California. Schüßler (1933-1934: 26, 27), probably following Seitz, also listed Riley's report under *S. cynthia* as anonymous. Specimens from the Neuburger collection in the Muséum d'Histoire naturelle de Lyon (in Lyons, France) that are labeled Arizona, Colorado, and Texas are clearly mislabeled.

Although colonies of this saturniid have been long established in Austria, Italy, and France, it is important to point out that European lepidopterists have been sent thousands of cocoons of this species during the past 125 years from collectors and rearers in the United States. In 1987 Peigler was given some specimens of *S. cynthia* labeled as coming from Bologna, Italy, by an amateur American lepidopterist, but was later told that the stock originated in the United States. These had been reared by Dr. Dario Cappeli in May 1982. Certain European authors like J. Henry Watson (1912), Schüßler (1926) and Mezger (1928a, b) revealed that their livestock was of United States origin. Therefore, some of the historical and recent introductions to localities in Europe probably originated with livestock from the United States.

The first big ecological question is "Why does the moth exist only in cities?" Ferguson (1972) wrote,

"Although seemingly suitable stands of *Ailanthus* may be found here and there in the countryside well removed from the city, *cynthia* is rarely if ever present. The reason for this anomalous habitat has not been investigated, although one is tempted to guess that it has something to do with the absence of natural predators or parasites that do not persist effectively in the disturbed city environment." Weast (1989) reported that some observers believe that stands of ailanthus must be very dense in order to support moth populations, because females will not fly far searching for trees on which to oviposit. We do not agree with that interpretation of why cocoons are found in some areas and not in others where ailanthus occurs. Our basic knowledge of saturniid biology argues against the notion that females will not fly far to find ailanthus trees. Observations in New Haven, Connecticut, indicated that cocoons could be found in stands of ailanthus along railroads where almost no other plant diversity (and thus very few birds or insects) was present, but not along railroads where plant diversity was higher (Pyle 1975). However, such anecdotal reports also do not offer a satisfactory explanation, since the moth was found for many consecutive years in large parks (e.g., Central Park in Manhattan, Prospect Park in Brooklyn) where there is diversity of plants and urban wildlife, both vertebrate and invertebrate. Perhaps the main reason that *S. cynthia* is found in cities more than the countryside is that ailanthus itself shows the same pattern of distribution and density. While the tree is very competitive in cities due to its aggressive root system, it is far less competitive in forests and fields (Peigler 1993a). If that is indeed the main reason, then other factors such as predation and parasitism may be secondary reasons.

The mature white larvae are not well concealed on the green leaves, especially when defoliation has occurred, and they are palatable to birds (Klausnitzer et al. 1988: 70). This urban ecology of dense populations highly susceptible to predation must be very different than a more normal pattern of dispersal and sparser population levels in forests that probably exists for *S. cynthia* in Asia, which more closely approximates what we see in native saturniids in almost any other region of the world. Peigler has observed that attacine saturniids can be very successful in cities, namely *Hyalophora cecropia* in Colorado, *Rothschildia orizaba* and *Eupackardia calleta* in Mexico City, and *Attacus atlas* in Bogor, Java; Naumann observed *Attacus atlas* in central Jakarta in 2000. Collins and Weast (1961) indicated that a population of *Callosamia promethea* lived in the city of Milwaukee, Wisconsin, specializing on lilac (*Syringa vulgaris*). One further example was a population of *Automeris cecrops* (Boisduval), a saturniid in the Hemileucinae, forming clusters of cocoons on the trunks of small *Populus* observed by Peigler in Mexico City (the suburb Ciudad Satélite) in 1976. The existence of all of these populations is possibly precarious and may require repeated replenishment from the surrounding urban or rural zones when local extinctions occur.

"Why is *Samia cynthia* becoming extinct in North America?" is the second major question. Most authors (e.g., Ferguson 1972, Pyle 1975, Weast 1989) did not address this question, because the decline was not widely known or yet apparent until the 1980s or 1990s. Something in the basic ecology of *Samia cynthia* has changed in recent decades. Frank (1986) pointed out that some parasitoids are highly effective controls of *S. cynthia* in Philadelphia, including *Enicospilus americanus* (Christ) and *Conura maria* (Riley) (=*Spilochalcis mariae*); moreover, the bagworm (*Thyridopteryx ephemeraeformis* (Haworth), Psychidae), an abundant pest of trees in eastern cities, serves as an alternate host of *C. maria* (Peigler 1996: 54-55). Frank also suggested that the European Starling (*Sturnus vulgaris* Linnaeus), which was introduced into New York in 1890, may also be a significant predator on the larvae and cocoons in the urban habitats. However, these indigenous parasitoids as well as the introduced bird have all been exerting pressure on urban populations of *S. cynthia* for many decades, so cannot explain the disappearance of the moth. They possibly do account in part for the moth living mainly in urban areas.

The abundance of ailanthus in cities can be volatile. In Japan in July 1994, through train windows Peigler observed the tree commonly in smaller towns between Tokyo and Matsumoto, but saw no ailanthus trees in the center and suburbs of Tokyo itself. There has been a campaign to eradicate ailanthus trees in Paris in recent years (Dominique Adès, pers. comm., March 1995). Frank (1986) reported that urban renewal efforts resulted in the destruction of many stands of ailanthus in Philadelphia. Despite this, ailanthus continues to be widespread and common enough in all eastern American cities, as well as many in the West, and other host plants are available such as privet and lilac. Thus, reduction of ailanthus cannot account for the sharp decline of *S. cynthia* in the United States in the past 30 years. Over-collecting of cocoons by lepidopterists takes a toll on isolated populations (Pyle 1975), but again, this cannot account for a marked decline throughout the range along the Atlantic seaboard. Quite simply, there are hundreds of sites where ailanthus remains abundant yet not accessible to collectors nor subject to urban renewal. Such sites include industrial parks where trespassing is prevented by high fences, entry is unsafe because of electric transformers or chemical pollution, or places along railroad tracks not accessible by roads. Populations of *Samia cynthia* thrive in such places. Under the text for *S. cynthia* in the revised and updated edition of Zim and Cottam (2001), the revisers wrote "Its numbers have declined, and it has disappeared from several cities where it formerly was found." In July 1968 Peigler searched for larvae and

cocoons on ailanthus trees in Central Park and other places in Lower Manhattan (New York City), but found none.

Many parasitoids have been introduced in the twentieth century to control the gypsy moth (*Lymantria dispar* (L.), Lymantriidae), such as *Compsilura concinnata* (Meigen) (Diptera: Tachinidae), and we believe that the introduction of that Eurasian fly has tipped the balance which previously allowed *S. cynthia* to exist in North America. The data of Boettner et al. (2000) strengthens our belief that *C. concinnata* has probably caused the widespread disappearance of populations of *Hyalophora cecropia* and *Callosamia promethea* in the northeastern United States. It is an especially virulent parasitoid with a wide host range (Peigler 1996: 73), and it is logical to assume that its impact on *S. cynthia* parallels that on the related attacines *C. promethea* and *H. cecropia*. We fear that this may be an ecological disaster, in which the introduced parasitoid is having an adverse and widespread effect on other nontarget species of Lepidoptera, most of which are native, and may be irreversible. However, data also indicate that the fly prefers forests and probably succeeds more in the North. Economic entomologists have praised the success of *C. concinnata* as being a highly effective biocontrol agent of the gypsy moth (e.g., Burgess & Crossman 1929).

In any case, *S. cynthia* became firmly established in the northeastern United States from the 1860s until the 1960s, fully a century of flourishing, but has since declined and appears to be almost extinct in North America. The decline must have begun by the 1950s and became noticeable in the 1960s and 1970s (Frank 1986). We wish to note here that this splendid saturniid, which has provided educational enjoyment for thousands of children in classrooms and amateur entomologists, might have remained a permanent part of the fauna of the United States, were it not for the intentional introduction of *Compsilura concinnata*, a parasitic fly that unfortunately has also been introduced to Africa, Australia, and elsewhere. We are aware of no field studies to date that aimed to test the impact of this parasitoid on *S. cynthia* in urban environments, and therefore our belief that it has caused or at least hastened the extinction of the moth in the United States remains speculative. As long as amateur lepidopterists rear this species in captivity and release stock onto ailanthus trees, and as long as other individuals find and report the resulting cocoons and moths, debate will continue about whether the species is really extinct in the United States. For this reason, we have employed terms like "almost extinct" and "nearing extinction," but for all practical purposes, we actually believe that *Samia cynthia* is extinct in the United States.

Taxonomically, earlier literature made much of a supposedly new "race" that evolved rather quickly in the United States, and it was named *advena*. Watson (1912, 1913) and Packard (1914) were among the main persons who advocated this, putting too much faith in erroneous remarks by Strecker (1875), as pointed out by Ferguson (1972). The remarks by Packard (1914: 241) himself reveal that he was comparing the United States material to specimens of *S. canningi* from Assam and Punjab and what we now call *S. wangi* from Canton (=Guangzhou). Probably the most detailed discussion of the form *advena* was published by Bouvier (1927), although we generally discount his remarks on variation. Draudt's (1929: 715) description of *advena* is erroneous and misleading regarding size, coloration, and wing shape. Dr. Harrison G. Dyar of the Smithsonian Institution, one of the foremost authorities on moths during his time, stated that "Evidently ours was introduced from China and there has been *no* 'American race' developed" [italics Dyar's]. It is regrettable that this definitive statement by Dyar, which was published in the explanation of Plate 57 of Packard's (1914) great monograph (edited by T. Cockerell after Packard's death in 1905), seems to have gone unnoticed or rejected by later authors. However, in the same monograph, with annotations by Cockerell, there are passages advocating that a new American race did evolve, such as comments from Hermann Strecker (p. 241), J. H. Watson (p. 243), and even ones written in 1912 by Dyar himself (p. 241). Ferguson (1972) was actually the first author since Dyar to actively dispel the myth of an American race having evolved in North America, although some earlier influential authors did not mention *advena* (e.g., Forbes 1923, Lutz 1935). We have examined historical specimens in The Natural History Museum (London) and Muséum National d'Histoire naturelle (Paris) labeled "Peking" and "Shanghai" (Figs. 3, 5) as well as ones recently collected in China, that are indistinguishable in appearance from specimens from the United States and Europe (Figs. 7-8). Hawkes (1922: 123) reported that wing scales differed microscopically between material from the United States and Ningbo, but that specimens from the two localities were virtually indistinguishable without magnification. There are anecdotal reports of unique phenotypes found to be consistent within the small isolated colonies in American cities (Pyle 1975, Weast 1989), but we disagree that darker ones may be correlated with industrial melanism as Pyle suggested. Recent American authors (Covell 1984, Tuskes et al. 1996) have not accepted *advena* as a valid taxon. Deml and Dettner (2002), on the advice from a personal communication from W. Nässig, called the taxon introduced into the United States *Samia cynthia*, but added that it "possibly will be given another specific name" based on this revision.

**Canada.** We are aware of only one published record for Canada, namely Toronto, Ontario, where the moth reportedly existed from about 1936 to 1958 feeding on ash trees (Riotte 1975). Riotte was a close friend of

Peigler, and he lived about 25 years in Toronto where he worked as a research associate in the Royal Ontario Museum. Two specimens in that collection (exact label data are cited under Material Examined) are labeled as being collected in Toronto in 1936 and 1958, but the first label is not clearly written and could be 1956 (Brad Hubley, pers. comm. to Peigler, 30 April 2001). We question if a population could persist there for more than 20 years, given the harsh winters of the Great Lakes region. The records could be the result of multiple introductions. Lastly, the report of the host plant as ash (*Fraxinus*) could have been a misidentification of ailanthus, for both have compound leaves, although ash is a logical food for *S. cynthia* since it is in the Oleaceae. At any rate, the report of *S. cynthia* living in Toronto from about 1936 to 1958 was possibly based on only two labels on specimens, and thus must be viewed with skepticism.

**New Zealand.** Although the species is now extinct in New Zealand, it was introduced there on at least one occasion. We are indebted to Dr. Richard T. Baker, senior entomologist at the Ministry of Agriculture and Fisheries, Lynfield Plant Protection Centre, Auckland, for unpublished information (pers. comm. to Peigler, 19 February 1992) pertaining to *Samia cynthia* in New Zealand.

Four species of Saturniidae were apparently intentionally introduced in 1982 by an amateur lepidopterist, although the Ministry of Agriculture and Fisheries was never able to secure enough evidence to pursue a prosecution. These species were *Hyalophora cecropia*, *Antheraea pernyi*, *Caligula simla*, and *Samia cynthia*. The first three were deemed to pose a threat to New Zealand's horticulture industry, so an eradication program was undertaken which was successful. *Samia cynthia* was not targeted for eradication. It was established mainly around the university, and on Bowen Street, and in Albert Park in Auckland City, feeding on *Ailanthus altissima* trees and privet bushes (*Ligustrum*). During the winters of 1983 to 1985 many cocoons were found, but the last record was of a first-instar larva on privet on 21 November 1986. Surveys through 1991 yielded no additional specimens, and the species was presumed to have gone extinct (Baker 1985, Dugdale 1988: 140). Weast (1989) searched for cocoons on a row of huge ailanthus trees in Auckland in July 1988 (winter) but saw none.

In addition to the saturniids cited above, *Actias selene* (Hübner) has also been reported as introduced to New Zealand but presumably did not establish since it was not seen for more than two consecutive seasons (Dugdale 1988). *Opodiphthera eucalypti* (Scott), the gum emperor moth, was introduced around 1915 from Australia to New Zealand where it appears to be permanently established in one area on the South Island and several relatively isolated areas on the North Island (Common 1990: 405).

**Australia.** *Samia cynthia* is almost certainly extinct in Australia where it was introduced in 1867 and possibly again in the twentieth century. The ailanthus tree had been introduced and well established there for more than a century by the time that Lady Dorothy Nevill in England, sent livestock to Dr. Antonio Brady in Stratford, England, who then forwarded cocoons to his brother Charles Brady living in Sydney (Nevill 1867-1869). Charles Brady established a plantation of ailanthus trees, which he called an ailantery, and propagated the livestock of *S. cynthia*. He published a lengthy paper describing the procedures for rearing the silkmoth, ending with an advertisement offering eggs to anyone who had established ten acres of ailanthus trees (Brady 1868). He and an associate named Mr. Asselin apparently had high expectations that this introduction would lead to a lucrative silk industry for the British colony. Asselin lived in Brisbane, Queensland, and must have reared *S. cynthia* there, but we do not know if he attempted to introduce it. Brady observed that many larvae reared in the open were taken by birds, and others were destroyed by spiders, beetles, mantises, hornets, frogs, hemipterans, and especially ants. Hutton (1872: Appendix: 6) referring the *S. cynthia*, wrote, "In Australia Mr. C. Brady has produced silk from it."

The silk industry of course, never became a reality, just as was the case in Europe and North America. However, it appears that the moth persisted for several decades in Sydney, where it was reported to be common in the gardens of that city (Froggatt 1897). One report stated that the species had been accidentally introduced (Froggatt 1907: 257), but Edwards (1996: 265, 365) listed it as having been introduced deliberately. Common (1990), in his detailed treatise of Australian moths, cited *S. cynthia* as having been introduced to New Zealand, but not to Australia, apparently because he was aware that the species had already gone extinct in the latter country. There are specimens in the Australian Museum in Sydney labeled as having been reared from cocoons of naturalized stock (Edwards 1996: 365). Two females of *S. cynthia* in the Muséum National d'Histoire naturelle are labeled in Bouvier's handwriting as follows: "var. *parisiensis* form *advena*; Australie: Musée de Melbourne; 3247.82." Bouvier (1927: 926) said that material had been sent to him from Melbourne. We do not know if those specimens were from the United States (since Bouvier considered it to be *advena*), Sydney, or from a population established in Melbourne.

We have not seen any specimens in museum collections labeled as coming from Tasmania. However, Walker (1855: 1221) cited a specimen "presented by Dr. Sinclair from Van Dieman's Land" [Van Diemen's Land], which was the former name for Tasmania. We suppose that the specimen was mislabeled. The citation was repeated by Cotes and Swinhoe (1887: 224) and Rebel (1925a: 15) who said that *S. cynthia* was recorded from

Tasmania.

**Uruguay.** Seitz (1928: 504, pl. 52c) figured a specimen of *Samia ricini* in the Senckenberg-Museum that originated from a culture in Montevideo, Uruguay. Peigler (1992) cited this record as *S. ricini*, but Tuskes et al. (1996: 184) referred to it as *S. cynthia*, and Ferguson (1972) also mentioned Uruguay but considered *ricini* to be a subspecies of *S. cynthia*. Naumann has in fact found a female of *S. cynthia* in the Zoologisches Museum der Humboldt-Universität Berlin labeled as having come from the Burmeister collection, Montevideo. Bouvier (1927: 926-927, footnote) wrote that Guérin-Méneville sent *cynthia* × *ricini* hybrid stock to Montevideo around 1860. Hermann Carl Conrad Burmeister (1807-1892) made many contributions to the early knowledge of Lepidoptera of Uruguay, Brazil, and Argentina (Horn & Kahle 1935: 34-35), through his publications and by sending specimens to European workers.

We were not able to obtain recent information directly from Uruguay, but we believe that *S. cynthia* never became established there, and that *S. ricini* has not been cultivated there since the nineteenth century.

**Brazil.** There is evidence, albeit minimal, that attempts were made to introduce *S. cynthia* to Brazil. Bouvier (1927) stated that the Muséum National d'Histoire naturelle had a specimen collected by Émile R. Wagner in the Orgues Mountains, near Rio de Janeiro. Bouvier believed that this specimen showed hybrid characteristics with parentage of *S. ricini*, and that it was descended from the Uruguay material mentioned above. In that museum there is a male, which is probably that specimen, reared in 1902 by E. R. Wagner from the environs of La Tijuca, massif du Pico de Papagayo [mountain]. Wagner was a resident entomologist whose collection from Brazil and the Argentine Chaco is now in the museum in Paris (Horn & Kahle 1937: 387).

Two French naturalists named Isidore Geoffroy Saint-Hilaire and Louis Jacques Brunet attempted to acclimatize *S. cynthia* in 1857 in Pernambuco, a state in northeastern Brazil (Marcos Filgueira, pers. comm., March 2000). That record possibly refers to *S. ricini*.

**Argentina; Paraguay; Venezuela.** Guérin-Méneville (1862c: 113) stated that a man named Meyer had introduced ailanthiculture to La Plata, hoping to develop that silk industry with the help of the government. Handschin (1946a, b) indicated that stock may have been sent to Argentina in the 1860s. Stock of *Samia cynthia* was again sent from France to Argentina in 1898 by agents of the Société Nationale d'Acclimatation (Iches 1933). Rebel (1925a: 15) listed Paraguay as another site for introduction. *Ailanthus altissima* grows in the Argentine cities of Buenos Aires and Tucumán (Hu 1979). There is a pair labeled Valencia, Venezuela, collected by "F. Kummerow" in the Zoological Museum at Humboldt University in Berlin. According to Horn and Kahle (1935: 145) the Lepidoptera collection from Venezuela of Frederico Kumarov went to that museum. He probably received those specimens from Europe, or possibly reared them in Venezuela from cocoons. We do not believe that the ailanthus silkmoth established itself in Argentina, Paraguay, or Venezuela, even temporarily.

**Japan.** Zhu and Wang (1996) cited Japan as part of the range of *Samia cynthia*, which they treated as a separate taxon from *S. pryeri*. Handschin (1946a, b) stated that *S. cynthia* had been introduced to Japan in the nineteenth century. A photograph of a living female from Nagano Prefecture was shown in color by Saito (1998b) on the front cover of *Wild Silkworm News*, a Japanese publication, where it was cited as "*S. cynthia pryeri*." According to Ando (1960: 61), *S. cynthia* was introduced from China to Japan in 1870. We believe that it has become widespread throughout Honshu, but as we are not able to access and read historical literature in Japanese, we do not know if it is mainly an urban dweller in Japan. It is hoped that this revision will clearly demonstrate the differences between *S. cynthia* and *S. pryeri*, allowing Japanese entomologists to sort out the many reports and records that have been confounded, pertaining to geographical distribution, parasitism, hostplants, and flight times of the two species in Japan.

Jordan (1911b, pl. 33a) figured a male of *S. cynthia* under the name *pryeri*. It was an unfortunate error that has enhanced the confusion of these two taxa in Japan, and unnecessary since Jordan had ready access to Butler's type specimens of *pryeri*. Shortly after Jordan's publication, Watson (1913) pointed out the error, but all later authors appear to have accepted the figure as correct.

Through the kindness of Yasunori Kishida, who sent specimens and color photographs of material collected on the Tsushima Islands (a group of small islands halfway between Japan and Korea), we know that both *S. cynthia* and *S. pryeri* occur on them. Considering that *S. cynthia* is indigenous and common on mainland Korea and probably also indigenous on the Korean island of Cheju-do, it is possible that the population of *S. cynthia* on Tsushima may also be indigenous. However, the occurrence of *S. pryeri* on Tsushima would seem more likely to represent an indigenous population, arguing against the same for *S. cynthia*. Molecular genetic comparisons of relevant populations would probably help to answer these questions as to whether *S. cynthia*, *S. pryeri*, neither, or both are originally native to Tsushima.

In the National Science Museum in Tokyo, there are also specimens of *S. cynthia* from Sapporo and Isakarifutomi (Tobetsucho), both on the big island of Hokkaido, collected in June 1996 at the latter locale. Peigler visited the city of Matsumoto briefly in July 1994 and observed that trees of the Chinese ailanthus are

common there, but did not find any larvae or cocoons of *Samia*. In recent years, Peigler received cocoons of *S. cynthia* from two colleagues in Japan: Dr. Toshimasa Mitamura sent material from Date-gun, Yanagawa-machi, in Fukushima Prefecture; and Dr. Hitoshi Saito sent material from Azamukaiyama, Okada-machi, Matsumoto, in Nagano Prefecture. Both localities are on Honshu, Japan's main island. Thus, we now have valid records of *S. cynthia* from several places that are no longer confused with *S. pryeri*, although we believe that the two species may be broadly sympatric in Japan.

**Russia; Georgia; Ukraine.** In his comprehensive book on insects of the former USSR, Gornostaev (1970) did not mention *Samia,* nor did Izersky (1999 a, b) in his work on the bombycoids of the Far East. We do not believe that any populations of *S. cynthia* exist in far eastern Russia, a region that has been fairly well surveyed biologically. However, the moth has been reared and released in areas of the former Soviet Union that are around the northern and eastern coasts of the Black Sea. According to Dr. V. V. Dubatolov, Siberian Branch, Russian Academy of Sciences, Novosibirsk, *Samia cynthia* occurs as an introduced species in Georgia (Transcaucasia) for certain, where it feeds on ailanthus. Dubatolov thinks there is a record for Ukraine also (pers. comm. to Peigler, May 1992). Rebel (1925a: 15) said that *S. cynthia* was introduced to Tiflis [T'bilisi] in the Transcaucasus somewhat later than the ones to England, United States, etc., in the 1860s.

A rather lengthy paper by A. S. Danilevsky of the Entomological Laboratory, State University of Leningrad [now St. Petersburg], in cooperation with a sericultural institute (Srednieaziatskij Institut Shelkovodstva) in Tashkent, which is now in the republic of Uzbekistan, dealt with *Samia cynthia* in the area of the Black Sea. Both Danilevsky (1940) and Stolyarov and Goderdzishvili (1991) referred to the well-established population of the moth in Abkhazia, which is the region of northwestern Georgia. These latter authors worked at the Georgia Institute of Science in T'bilisi, the capital of Georgia. Danilevsky also cited the Talysh District. The two Georgian authors saw many moths and cocoons on ailanthus trees in the summer of 1987 in the Galsk area. In September of that same year they found many mature larvae. They speculated that the species had been introduced into the region by an unknown amateur entomologist, instead of by a government sponsored program. We are grateful to Jacek Marzec of Gdynia, Poland, for an English translation of the paper by Stolyarov and Goderdzishvili, received by us via Ulrich Paukstadt.

**Spain.** According to Gómez and Fernández (1976), *Samia cynthia* was introduced to Spain within a few years after it was brought to Italy in 1856. A man named Cazes of Barcelona may have been the first one to release stock in that city, since he was cited by Guérin-Méneville (1862c: 114) as being interested in ailanthiculture in Spain. It is not known to us whether the species persisted for a century in Barcelona, or if subsequent introductions account for the more recent records. There is a female specimen labeled Barcelona in the Muséum National d'Histoire naturelle, Paris, dated February 1968, and another female labeled March 1968 in The Natural History Museum, London. According to Dr. Víctor Sarto i Monteys (pers. comm. to Peigler, 19 July 1998), an entomologist at the Departament d'Agricultura, Ramaderia i Pesca Fundació CReSA, Universitat Autònoma de Barcelona, local lepidopterists in the 1970s considered the extinction to be caused mainly by over-collecting of cocoons on ailanthus trees. This corroborates published accounts by American entomologists that urban populations were vulnerable to over-collecting by humans in United States cities. Humans can be thorough, persistent, and systematic at removing individuals of *Samia cynthia* from breeding populations. Sarto believes that the species went extinct in the 1960s. Most other Spanish lepidopterists now acknowledge that the species is extinct in Spain (de Viedma & Gómez 1985: 6), although Gómez de Aizpúrua (1988) treated it as part of Spain's saturniid fauna. The presumed decimation of *S. cynthia* by the tachinid *Compsilura concinnata* in United States cities (see above) opens the question if urban populations of *S. cynthia* in Spain might have been more vulnerable to this parasitoid in Europe, where the parasitoid is native. This seems doubtful, however, since the moth has flourished in Paris and Vienna for many decades, presumably in the presence of native populations of *Compsilura concinnata*. Moreover, the tachinid reportedly prefers forested habitats (Boettner et al. 2000).

**Portugal.** The moth was supposedly introduced into Portugal in the 1860s, but we have very little information on this (Rebel 1925a: 15). Guérin-Méneville (1862c: 115, 117) referred to José Augusto de Souza as making progress toward establishment of ailanthus and *S. cynthia* while working at the Royal Museum in Lisbon, with the support of Luiz I, King of Portugal. Since we are aware of no records for the moth in Portugal during the twentieth century, it is doubtful that it successfully established in that country.

**United Kingdom.** We have not seen specimens labeled as having been reared from a population established in England. We are indebted to Dr. Alexander Wallace (1866) of Colchester for documenting and publishing a very detailed treatise on the early attempts to culture *S. cynthia* in England. The most ambitious attempt to rear and establish the ailanthus silkmoth in Great Britain was in Colchester (Kirby 1903: 136). Indeed there was considerably more effort expended in the 1860s in England than the United States to establish a silk industry based on *S. cynthia*. Several factors came together in Great Britain during that time, including the easy availability of ailanthus, epidemics of disease of mulberry silkworms in Europe, the notion that the labor of

women and children was insufficiently exploited, the decline of cotton imports because of the Civil War in the United States, and the concern that France was surpassing England by rapidly developing this and other wild silk industries (Wallace 1866: 244-245). Although many of the cultures of *S. cynthia* were kept outdoors on ailanthus trees, the species did not establish feral populations like it did in the United States, because the sites in England were in the countryside instead of large cities, so the larvae and cocoons received less protection from natural enemies and freezing temperatures.

Wallace (1866: 190) and Wardle (1881b: 51) thought that Frederic Moore was the first to rear *S. cynthia* in England, having received eggs from Guérin-Méneville in October 1859, but those larvae were reared on castor, so were more likely to have been *S. ricini*. Wardle's text comments and misidentifications (e.g., his pl. 8) reveal that he did not understand the differences between *S. cynthia*, *S. canningi*, and *S. ricini*. Therefore, the first person to rear *Samia cynthia* in England was probably Lady Dorothy Nevill, of Dangstein near Petersfield, Hampshire. Dorothy Nevill (1826-1913) was a well known writer and horticulturist, and corresponded with Charles Darwin. She sent stock to Antonio Brady in Stratford (see our earlier discussion for Australia) (Nevill 1867-1869), and in 1863 to Alexander Wallace of Colchester (Anonymous 1865: 119-121). Wallace first saw these silkworms in 1862 at the town house of Mrs. Nevill (Wallace 1866: 191). She reared her stock under nets and canvas covers in 1861 (Guérin-Méneville 1862c: 114), from eggs sent by Guérin-Méneville in summer 1861 (Wallace 1866: 189). Wallace experimented with a number of silk moths and kept meticulous records. He had some large ailanthus trees in his garden where he could watch the development closely, and moreover in the spring of 1863 he had established about 1340 two-year-old trees along a branch of the main line of the Great Eastern Railway that led to Colchester, a town that is northeast of London, in Essex County near the coast. These made good growth in 1865. With moths from cocoons received from Dorothy Nevill he obtained many pairings, and set out 18,678 eggs in his garden. When half grown the larvae were transferred to the larger plantation near the railroad. Natural enemies that he noted included spiders, ladybird beetles (Coccinellidae), earwigs (Dermaptera), ground beetles (Carabidae), wasps (Vespidae), ants (Formicidae), disease (virus or bacteria), a species of parasitic fly (Tachinidae), and especially tom-tits (Paridae). Still, he harvested 5318 cocoons, of which very few contained ichneumonids.

Several other people in England established plantations of ailanthus and attempted to rear *S. cynthia*. Besides Dorothy Nevill, Wallace (1866) also mentioned Mr. Calvert of East Bergholt, Suffolk, who found robins and ants to be the primary problems; Lady Heathcote of Hursley Park, near Winchester (west of Petersfield); and Mr. Mongredien at Bratton Clovelly, North Devon, who Wallace considered to have been the first person to rear these silkworms in England in the open without nets. Tegetmeier (1866) also cited Lady Mary Thompson as someone who worked to establish ailanthus silk culture. J. Henry Watson, who experimented with and published prolifically on saturniids early in the twentieth century, lived in Withington, near Manchester, where he reared *S. cynthia* on many occasions, but his publications give no hint that he ever tried to establish the moth in that city. Eventually, enthusiasm for establishing an ailanthus silk industry in England faded, for as Hutton (1872: Appendix: 6) indicated a few years later, "In England, it is not quite so highly thought of as it once was."

**The Netherlands.** Rebel (1925a: 15) cited "Holland" in a list of countries to where *S. cynthia* had been brought in the 1860s. The lengthy paper by van Westmaas and de Graaf (1862) documents that the species was reared in some quantity in The Netherlands, but it probably never became established in that country. Those Dutch authors provided detailed descriptions of all of the life stages, accompanied by color plates.

**Italy.** This is the country that was the primary gateway for the insect to be introduced directly from China and then on to numerous other countries in Australia, Europe, and America. On 4 November 1856 freshly spun cocoons from the second annual brood were sent from east-central China by Father Annibale Fantoni, a Roman Catholic priest from Piedmont (Italian: Piemonte) working as a missionary in Shandong Province (formerly romanized as Shantung), to his friends named Comba and Griseri living in Turin (Italian: Torino) (Figuier 1892: 245). Griseri and Comba were told the Chinese name of the hostplant by Fantoni, but they were better able to determine it to be ailanthus by the leaves attached to the cocoons. Moths emerged in Turin in May and June 1857, and the first matings resulted in many eggs, and larvae were reared successfully on ailanthus; Griseri also reared some on castor, which he suspected would be suitable since *S. ricini* had already been cultured on it in Italy for a few years. A second brood was reared in late summer of 1857 in Turin, and the next year stock was sent to Guérin-Méneville; see our comments for France below. The generous sharing of the original stock from Turin to Paris, and from Paris to Petersfield and Philadelphia, etc., showed that there was a spirit of cooperation instead of competition, when *S. cynthia* was still considered to hold much financial potential for profit in the sericultural field. In the research collections of Lepidoptera in the Muséum National d'Histoire naturelle in Paris, there is a case containing a piece of cynthia silk fabric and other processed samples of silk sent by Father Fantoni to Guérin-Méneville (Fig. 147).

It is noteworthy that *Samia cynthia* does not appear to be restricted to large urban centers in northern Italy,

whereas it is in most other countries where it was introduced. We speculated earlier that the climate and topography of that region might approximate the natural range in China, where we know that the moth exists in the countryside. Ailanthus trees are common throughout southern Europe, in both urban and rural habitats. *Samia cynthia* offers intriguing opportunities for ecologists to make field studies and comparisons pertaining to these questions. Ailanthus was introduced to Italy in 1760 (Bertaccini et al. 1994).

There is a thorough compilation of the current and historical distribution of *Samia cynthia* in northern Italy in the excellent book by Bertaccini et al. (1994). Although of some sections of northern Italy are German-speaking, we cite all of the geographical names in the remainder of this subsection by their Italian spellings, giving English equivalents for a few of the main ones. There are records from the northeastern half of Emilia-Romagna, including Piacenza and Boara, and throughout much of Veneto, including the Lessini Mountains, Bassano del Grappa, Brenta, and especially Venezia (English: Venice). In Romagna the moth is recorded from sites in the provinces of Forlì and Ravenna, San Pietro in Vincoli, and Barisano, a male from the latter figured by Bertaccini et al. (1994: pl. 11). From there the range continues down into northern Marche on the Adriatic Coast. In Piemonte it has been collected at Caselette, Chieri, and Verbania. In Lombardia (English: Lombardy) records are all around Lago d'Iseo, Lago di Garda (English: Lake Garda; German: Garda See), and parks in Milano (English: Milan). A pair now in the Natural History Museum of Los Angeles County from the Peigler collection is labeled as being collected by U. Nardelli at Etschtal, Mattarello, 250 meters, in Trentino. In Trentino-Alto Adige, the records include Val Senales, Bolzano, Ponte Gardena, Merano, Madonna di Campiglio, and Ponte Pià. Bertaccini et al. considered the region around Fiorenzuola (a small village halfway between Milan and Bologna) to be at the current southern limit. This is in the Pesaro District of the province of Pesaro-Urbino, in the northern part of the Marche region. It is not yet recorded from the southern part of the Marche region, in the province of Macerata (Teobaldelli 1994). However, even farther south, a specimen of *Samia cynthia* was reported in a local newspaper in the early 1990s in Genova (English: Genoa), a town on the coast (A. Zilli, pers. comm. to Peigler, 7 October 2002). There are as yet no valid records from Rome or Firenze (English: Florence), but we have no reason to doubt the locality data on a specimen in Thomas Witt's collection labeled as coming from a cocoon collected in Bologna which emerged 11 June 1961. In 1994, Dr. Alberto Zilli (pers. comm. to Peigler, 18 July 2001) and his associates set out hundreds of young larvae onto ailanthus trees in Rome, but severe winds dislodged them soon afterwards, preventing the new colony from establishing.

Uberto Nardelli (pers. comm. to Naumann, 5 August 1997) has collected *S. cynthia* in Italy in several localities: between Cles and Bozzana at the start of the Sonnental in the Non Valley; near Pinzolo in the Rendena Valley; between Storo and Lodrone in the Chiese Valley; between Borgo and Grigno in the Sugana Valley in the larger Ledro Valley; the localities of Preore (650 m), Stenico (600 m), and Andogno (550 m), all in the Giudicarie Valley. In areas where there are persistent stands of ailanthus growing between 0 and 300 meters, or in other places up to 700 meters where no intensive fruit or wine culture is carried out, especially in level areas that are not too dry or too disturbed, single cocoons can be found fairly commonly. (However, Jost et al. (2000) suggest that *S. cynthia* prefers dry habitats, and the species is well-known to tolerate highly disturbed habitats, namely large urban centers.) Also, according to Nardelli, *Bombyx mori* and to a lesser extent *S. cynthia* were widely reared by farmers in Trentino and Veneto until about 1945, where women and children collected leaves of mulberry and ailanthus daily. Recently, insecticides have decimated possibly up to 90% of the populations of *S. cynthia* in Italy, and also adversely affected many other non-target Lepidoptera. These insecticides are primarily contact poisons such as diflubenzuron (Dimilin), teflubenzuron (Nomolt), triflumeron (Alystin), but also ones that interfere with development (prolonging larval stages or inhibiting pupation) such as an ethylcarbamate named fenoxycarb, sold under the names Insegar, Logic, and Torus, all listed by Nardelli in his letter of 5 August 1997. Our German colleague Helmut Probst sent Peigler eggs of *S. cynthia* in August 1993 of stock from Torbole, at the northern end of Lake Garda, but the larvae hatched and died en route.

Several faunal surveys of moths for regions in northern Italy have been published, and the following ones included specific data for *S. cynthia*. Föhst (1991) noted that there are two generations per year around the southern area of Lake Iseo in the province of Bergamo in Lombardy, with flights from early May to early June, and again in August and September. Localities near the lake that he listed for *S. cynthia* were Sárnico Quarry, Predore Pass, Eurovil, Provàglio, Iseo, Poláveno, and Tavérnola. Föhst further stated that the moths are normally olive colored, but that about 10% of them are color variants. Around Lake Garda, Wolfsberger (1966) also reported two generations per year, as mid May to late July, and late August to mid September, saying that the second brood moths were normally smaller in size. If these latter larvae must hasten their development toward the end of the season, we wonder why the first brood moths which result from them the following year should not be smaller. Like Nardelli (see above), Wolfsberger considered 700 meters to be the maximum altitude that the species could live in this region. Bertaccini et al. (1994) indicated that *S. cynthia* does not occur in Italy at altitudes above 400 meters. Specific collection sites for the moth around the lake cited by Wolfsberger included

Lazise, Bardolino, Garda, Torri, Albisano, Pai, Malcesine, Navene, Manerba, and Riva; sites in the nearby Sarca Valley were Dro, Pietramurata, and Cavedinesee. Arnscheid (1981) surveyed the Macrolepidoptera in the Sole Valley and Non Valley, and although he collected no specimens, he stated that this moth should be present in that area. Hellmann (1987: 57) sampled the nearby Brenta Mountains, a small group north of Lake Garda and to the northwest of Trento. He recorded a specimen taken in early September at Ponte Pià. Dathe (1950) captured two males in Venice in late August 1947, and reported that others were taken in August 1946 near Padua at a village named Casenova. Pupae in some of the cocoons he kept during the next winter were eaten by mice. Bostjan Dvorak (pers. comm. to Naumann, November 2001) found *S. cynthia* near the village of Opicina, close to Trieste, in September 1991 or 1992, and he also observed a lot of defoliation of ailanthus trees on the coastal side of a railroad between Trieste and Monfalcone in the late summers of 1999, 2000, and 2001.

Alessandrina Arzone (1970, 1971a, b) made detailed observations on the biology of *S. cynthia* along the western bank of Lake Maggiore in Piedmont, paying particular attention to the complex of parasitoids and hyperparasitoids that attack the species in its various life stages. She worked at the Istituto di Entomologia, Università di Torino. Her papers have English summaries, and some of the data are cited in the section on parasitoids in this revision. Eggs of *S. cynthia* are attacked by the tiny chalcid wasp *Anastatus bifasciatus* (Eupelmidae). The caterpillars of *S. cynthia* are heavily parasitized by the fly *Pales pavida* (Tachinidae), which in turn is attacked by the hyperparasitoid *Eupteromalus arzoneae* (Pteromalidae). *Pales pavida* ranges from Scotland to Japan, and has a broad host range within the Lepidoptera, attacking caterpillars of various Sphingidae, Lasiocampidae, Arctiidae, Geometridae, Noctuidae, Nymphalidae, Pyralidae, and several other families. We assume that *P. pavida* attacks *Samia* species in their native regions in China and Japan.

To the above Italian locality records of *S. cynthia* extracted from literature and reports from our correspondents, we can add the following additional ones that we took from data labels on specimens in collections: the villages or towns of Pordemone, Sirmione, Lopia near Torbole, Alfonsine in Ravenna, Marco near Rovereto, Rovereto itself (Fig. 7), Marting in the southern Tirol, and Lake Loppio (Lago di Loppio) in Trentino.

**Switzerland.** Rougeot and Viette (1978, 1983) cited southern Switzerland (German: Schweiz; French: Suisse; Italian: Svizzera) among their European locality records for *Samia cynthia*. Two cantons along the southern border appear to be where most of the records are centered, for which the Italian names are Ticino and Grigioni (German: Tessin and Graubünden). The moth may have been introduced into Geneva (French: Genève), based on a citation by Brozskus and Bodenstein (1950). Handschin (1946 a, b) stated that the moth had become well established around the lakes in Ticino, especially in the neighborhood of Ascona, which is a village on the north end of Lake Maggiore. There the moth was reported by Handshin to be single-brooded.

A more up-to-date and detailed account for known colonies of the moth in Switzerland is available from Jost et al. (2000: 388-391), in a splendid, multi-volume series containing copiously illustrated and comprehensive treatments of the Lepidoptera of that country, compiled by a large team of authors. Jost et al. gave a map (p. 390) showing three records prior to 1960 in central Switzerland: Flüenen and Vitznau (on the lake Vierwaldstätter See) and Gunten on Lake Thuner (Thuner See, Berner Oberland), plus one to the east from Poschiavo (German: Puschlav) on the Italian border. On the same map are eight records since 1960 in Ticino, especially around Lake Lugano (German: Luganer See) and in spots between Lake Maggiore and Lake Como. This area in Ticino also has eight locality records prior to 1960. Jost et al. did not cite any records for the southern canton of Valesse (French: Valais; German: Wallis). An old specimen in the collection of Otto Staudinger & Otto Bang-Haas in the Museum für Tierkunde, Staatliche Naturhistorische Sammlungen [zoological museum, state natural history collections] in Dresden there is a female labeled Zürich, but clearly that city is too far north and too high in elevation to support a permanent colony of this species. Naumann also saw specimens from Mamete (in Ticino) collected in early July of 1981, now in the collection of Thomas Witt.

Natural enemies were listed by Wullschlegel (1863: 191-193) at St. Gallen who wrote that ants and spiders can be kept off the trees by placing glue on the trunks, and that solitary wasps (*Sphex*; Sphecidae) drag the caterpillars into holes they have dug in the ground. Wullschlegel considered ichneumons and tachinids to be the most detrimental. His reference to “Inquilinen” apparently refers to microgastrine braconids (such as *Apanteles*, *Cotesia*, and *Protapanteles*), in which large numbers of wasp larvae emerge from the caterpillar and spin cocoons on the integument. Birds were also listed by him as natural enemies of *S. cynthia*.

**Slovenia; Croatia.** Schintlmeister (1996) gave Yugoslavia, and Bertaccini et al. (1994) cited Slovenia, but no specific data were given. Hafner (1910) reported that *S. cynthia* occurred in the wild in Kranj (German: Krainburg), but did not know how the species got there. Rebel (1925a: 17) reported the moth from Kranj and nearby Ljubljana (German: Laibach), the capital city of Slovenia.

We are grateful to Bostjan Dvorak (pers. comm. to Naumann, November 2001) of Tübingen, Germany, for his up-to-date observations in Slovenia, a summary of which follows. Over several years, he found larvae on the

Istrian Peninsula in western Slovenia on ailanthus, lilac (*Syringa vulgaris*), and two kinds of privet (*Ligustrum lucidum* and *L. vulgare*). In December 1994 west of Lucija (=Liminjan) he found two cocoons in the bottom of a bush with some defoliation. The plant was wig-tree (*Cotinus coggygria*), and two males emerged from the cocoons in June 1995. However, later attempts to rear *S. cynthia* (Slovenian livestock) on wig-tree in Germany were not successful. (*Cotinus coggygria* is also known as smoke tree and Venetian sumach.) In the town of Portoroz, Dvorak collected larvae in June 1981, June 1986, and moths at light in May or June 1995, but saw no *Samia* in the area in 1996 and 1997. Along the road from Lucija to Koper, he saw single larvae on ailanthus every year in June or July from 1990 to 1995. On a road from Portoroz to Strunjan, Dvorak observed defoliated trees and cocoons every year in July and August of 1990 to 1995. In September of 1998, he took at least 30 cocoons along that same stretch of road, and collected one more cocoon in October of that same year in the town of Strunjan itself. These long-term observations in the same small area suggest that *S. cynthia* undergoes population fluctuations, evident even from casual collecting. Dvorak observed tachinid larvae exiting captive cocoons in 1981 and 1989. He summarized that the moth flies from the end of April through June, and also sometimes in September, and larvae are found from May to July, and rarely in August. Other authors from this region who wrote in Serbo-Croatian about *S. cynthia* and other European saturniids include Carnelutti (1956) and Smerdu (1984).

Portoroz is no more than a few kilometers from the Croatian border, so *Samia cynthia* undoubtedly ranges farther south on the Istrian Peninsula into Croatia.

**Germany.** There have been numerous attempts to acclimatize *Samia cynthia* in Germany, but apparently none of the populations have persisted, probably because the pupae cannot withstand the colder winters. Introductions have focused in two main regions, Berlin in the Northeast and cities in the Ruhr Valley in the West. Additionally, Strasbourg was formerly in German territory, but it is discussed below with France.

Closs (1919) listed the species as part of the moth fauna of the Berlin region. He gave several hostplants, most taken from earlier literature, of particular interest which are sloe (*Prunus spinosus*) and millet. This latter is an error; it is a grass. We include sloe, also called blackthorn, in the Hostplant Appendix as a food used in capitivity, based on our assumption that it was. The species was reportedly established in suburbs on the western side of Berlin, notably Charlottenburg, where a collector found about 32 cocoons. Earlier, van der Hoeven (1866) reported rearing of the species in that area. Other German localities where the moth was introduced included Jena and Heilbronn (Rebel 1925a: 16-17).

In his book on wild silkmoths, Dr. Adalbert Seitz (1918) discussed his efforts to establish this moth in Frankfurt, Mainz, and vicinity, and many of his remarks were repeated by Rebel (1925a). Seitz attempted to introduce the moth in the area of Frankfurt am Main, where he was raising them in captivity for several consecutive years. Probably most of his livestock was received from the United States. Over several years, thousands of eggs were set out in Mainz, a sizable town southwest of Frankfurt, these eggs given by Seitz to Wilhelm von Reichenau, who was a curator at the museum. Seitz also released mated females in Darmstadt onto ailanthus and lilac. The flight time in that region of Germany was from May till July, with most emerging in June. A second generation in early September had problems maturing due to the onset of cold weather. Ailanthus was the preferred hostplant. Seitz was not certain that the species ever actually established itself in that region and he lamented that the high hopes for a German silk industry based on *S. cynthia* were eventually dashed. He discussed the advantages and disadvantages between this species and *Bombyx mori*. There are two specimens in the Senckenberg-Museum collected in 1938 in Frankfurt, but the species has not been seen there since World War II (Kramer 1995). We doubt that the latter specimens were descended from any of the original cultures that Seitz attempted to establish.

According to Rupp (1950), a resident of the city of Cologne (German: Köln), the ailanthus silkmoth was introduced into the Zoological Garden in Cologne around 1910. He observed that the moths in captive cultures became increasingly smaller, whereas the wild ones remained large. In 1921 an unseasonably warm October caused all of the pupae to emerge instead of entering diapause, so the colony died out. A specimen from near Cologne is in the Museum Alexander Koenig, Bonn, which is labeled as being collected at Swisttal-Buschhoven, west of Bonn, but since it was taken in 1983, it is surely the product of a more recent introduction that did not become established.

There are a few reports pertaining to avian predation in Germany. Seitz (1928: 498) observed that the large moths of *S. cynthia* that he released in his yard were *not* attacked by flycatchers (*Muscicapa* sp., Muscicapidae), whereas the same birds aggressively pursued all Noctuidae and Notodontidae. In the same work (Seitz 1928: 505), there is a report by K. Dietze, living in Jugenheim, that a large number of larvae being reared outdoors were eaten by titmice (*Parus* sp., Paridae).

**Austria.** The moth has become established at both ends of that country. There are urban populations in Vienna, Lower Austria (German: Wien, Niederösterreich), and the species has spread into the Tyrol (German:

Tirol) area of far western Austria from the populations in northern Italy. One locality for Lower Austria is Atzgersdorf, cited by Rebel (1925a: 15). Osthelder (1926) reported a male from Kufstein collected on 11 September 1905 that he speculated arrived there on a train from southern Tyrol. We have seen a female in the collection of Thomas Witt reared from a larva in 1958 from Knittelfeld, Steiermark (English: Styria), a village in south-central Austria, southwest of Vienna, closer to the Slovenian border. The first records for Vienna were in 1905. In July 1907, three specimens were found in Vienna (Stichel 1908). Rebel (1925a: 17) noted several sections of Vienna where the moth existed, including Wieden to the south, Mariahilf on the southwestern side, Prater (2nd Precinct), Land Street (3rd Precinct), Ring Street, Alser Street, and in 1924, the village of Rodaun near Vienna. Other spots listed by Rebel were a park near Reichsbrücke (Neustetter Park) and Rathauspark.

As we have reported the over-collecting of cocoons by lepidopterists in several other places in this revision, Rebel (1925a: 17) said the same problem existed in Vienna. As a resident of Vienna, he observed flight times from early July until mid September, and moths selected ailanthus trees as their primary ovipositional sites. Deschka (1995: 107) wrote that in Vienna, *S. cynthia* is found primarily in highly disturbed ecosystems, such as backyards, along streets, vacant lots, along railroads and their embankments, waste areas, and abandoned gravel pits, all of which are habitats that closely match those routinely given for the moth in the United States. Pupae of *S. cynthia* have been reported to survive freezing temperatures of -25° Celsius in Vienna (Peinlich 1943), which supports some of the data cited above for the United States.

Studies on diapause, ethology, and ecology of *S. cynthia* in Vienna have been conducted by entomologists working in that city (Pammer 1965, 1966; Nopp-Pammer & Nopp 1967, 1968; Nopp & Pruscha 1978; Pruscha & Nopp 1979). Key findings in their work are cited elsewhere in this revision. They reported that *Syringa* was not accepted as a food by larvae of this population.

Helmut Pruscha sent cocoons from Vienna to Klausnitzer et al. (1988) who carried out some rearing experiments in Leipzig. The latter authors offered some interesting comments on the urban ecology of *S. cynthia,* saying that it has a free ecological license [freie ökologische Lizenz]. They opined that no indigenous species were displaced by *S. cynthia*, because it occupies an empty ecological niche, adapts to a newly created ecosystem, and does not disturb an already existing one.

**France.** Actually *Samia ricini* was introduced into France in 1854 by Professor H. Milne-Edwards (Lucas 1854), in whose honor *Archaeoattacus edwardsii* was named, whereas stock of *S. cynthia* was not received in France until 1858 by Guérin-Méneville (Iches 1933); see above remarks for Italy. Félix-Édouard Guérin-Méneville (1799-1874) worked with the importation and acclimatization of moths that were potential wild silk sources, was active in several agricultural and scientific societies, and was apparently particularly interested in collecting and studying beetles (Coleoptera) (Horn & Kahle 1935: 99). In 1860 he published a 100-page report (Guérin-Méneville 1860b) on the introduction and culture of the ailanthus silkmoth to the emperor, as well as a 60-page booklet (1860a) dealing with that, as well as *S. ricini*, and the cultivation of ailanthus and castor. In these works he outlined the sequence of introductions, naming most of the participants, from China to Italy, Italy to France, France to Algeria, etc. Guérin-Méneville sent samples of some saturniid moths, cocoons, and the silk "spun and manufactured" to England in 1861, this material now contained in the Hope Entomological Collections, University Museum, Oxford (Smith 1986: 122). Hutton (1872: Appendix: 6) wrote, "There are difficulties attending to the reeling of the silk as there is with all the *Attaci*, but nevertheless the French have succeeded in turning out some very good silk pieces."

Brief summaries of this earliest history were repeated in Dutch by van Westmaas and de Graaf (1862), de Graaf (1862), and later in German by Weil (1863) and Rebel (1925a: 13-17), but no such details have been published in English until now. In a footnote on page 1 of his 1860a booklet, Guérin-Méneville wrote, "At my suggestion, the Imperial Society of Zoological Acclimatization, recognizing the great importance of the introduction of this species, has given to Father Fantoni the highest honor that it can bestow, by naming him an honorary member." (transl. by Peigler).

The ailanthus silk industry reached its peak in France and northern Italy in 1861, when more than 40 ailanthus tree farms were established in France, and intense efforts were made to develop technology for processing the silk (Rebel 1925a: 15). A large-scale attempt was made by Henri Givelet to rear the ailanthus silkworms in the 1860s at the Château of Flamboin, where he planted ailanthus trees in 1860. By 1865 he claimed to have collected 20,000 cocoons, and about three times that number were still on his trees (Anonymous 1865: 119). Numerous rearing enterprises in France had resulted in extensive plantations of ailanthus near the end of the Second Empire, but these all ultimately failed to support the new silk industry, despite strong support of the imperial government. The Emperor Louis Napoleon himself was committed to development of economic opportunity for the general populace of France. Besides Guérin-Méneville, other individuals involved at the onset included Édouard Drouyn de Lhuys and someone named Vallée (Rougeot 1971: 122). A plantation of six hectares of ailanthus was planted by Ernest Rousseau at Rabuntinière in Sologne (Wallace 1866: 197). French

regions where the moth became established are primarily Alsace, Seine, and Gironde (Rougeot & Viette 1978: 122; 1983: 150).

Moreau (1915) discussed the Parisian populations, and listed four main things that he believed would cause their decline or eventual extinction. These were a parasitoid in the Tachinidae; the wind, which dislodges many molting larvae from the trees; crows [probably the Jackdaw, *Corvus monedula*, but possibly the Carrion Crow, *C. corone*, or the Rook, *C. frugilegus*], which he said destroy a large number of the cocoons; and the workmen of maintenance crews (French: les cantonniers) for the city. He considered the latter to be the most destructive. Mr. Dominique Adès (pers. comm., March 1995), a resident lepidopterist of the Paris area, told Peigler that grubbing of ailanthus trees by the city's work crews had caused a decline in populations of *S. cynthia* in Paris in recent years. In October of 1865, hundreds of caterpillars from a third generation of that year could be seen on ailanthus trees at the Jardin d'Acclimatation (the zoo) in the Bois de Boulogne, a large wooded park on the west side of Paris (Anonymous 1865). Rougeot (1971) believed that the species could not spread its range beyond the city habitats because of parasites and other natural enemies, citing Hymenoptera, Coleoptera (specifically the ladybird *Coccinella septempunctata* L.), spiders, birds, and rodents, among others. Rougeot's list appears to be lifted from a nearly identical one given above by Wallace in England (Anonymous 1865), rather than based on new data. *Samia cynthia* is generally single-brooded in Paris, but occasionally a second brood develops in the fall, which Mauchamp (1989) believed was caused by additional lighting in the city (simulating longer days), higher temperatures than in the countryside, and changes in the chemistry of ailanthus leaves later in the season.

Alsace is a region in northeastern France, where the moths have mainly been reported from the city of Strasbourg. The region was for several decades in German territory, the names being spelled Strassburg, Elsass (=Straßburg, Elsaß). Introduction was also attempted at Mulhouse, in southern Alsace (Rebel 1925a: 17). The moth was reported to be single-brooded in Alsace (Handshin 1946a, b). The first reported breeding in Strasbourg was by a man named Schmitter in 1867, and it was bred there again in 1875, with the first moths being released in 1878. Cocoons survived a very cold winter in 1879 because more adults were seen in 1880, and another harsh winter in 1900. It was so common in the summer of 1897 that residents feared that it would become a pest, so they burned the cocoons in villages around Strasbourg. It was found to be common in 1901 in University Square, and was common in City Park and other places in the city from 1881 till at least 1906 (Scherdlin 1906). A specimen collected in Strasbourg in 1920 is in the Zoologisches Museum der Humboldt Universität Berlin.

As stated above, Rougeot and Viette (1978, 1983) cited Gironde, Alsace, and Seine as the main centers of distribution in France. The Gironde area is in southwestern France, surrounding the city of Bordeaux. Lhomme (1923-1935: 623) reported "*S. cynthia pryeri*" at Arcachon, in Gironde south of Bordeaux. We do not know if those introductions in southwestern France resulted in permanently established colonies, but doubt the stock was true *S. pryeri* (which Lhomme distinguished from the Parisian form which he called *S. c. walkeri*), because we examined specimens from 1926 from southwestern France in The Natural History Museum, London, and consider them to be true *S. cynthia*. Lhomme cited *Sorbus*, *Prunus*, *Juglans*, and *Pinus* as hostplants, but of course pine is incorrect. The Seine is a primary river in France that flows through Paris. Weast (1989), quoting details received from Robert Vuattoux, a resident lepidopterist and well-known specialist of Saturniidae, wrote the following, edited herein: One can find *S. cynthia* everywhere in Paris, especially at the ports of Paris. They are particularly concentrated in the industrial suburbs of St. Denis, Nanterre, Montreuil, Clamart, Pantin and Mont Rouge. There are few in the wooded areas of Boulogne and Vincennes. There are isolated populations at St. Germain Pontoise, Versailles, Neuilly, and Plaisance. Farther out the spread of the species becomes impossible. Its principal natural enemies are wasps, parasitoids, and birds. The primary host is ailanthus, but smaller cocoons can be found on plum (*Prunus*) and lilac (*Syringa vulgaris*). When ailanthus is planted as an ornamental along a highway, the trees will have many cocoons the first year. Noise and pollution deter predators but not *S. cynthia*. Vuattoux also reported that there is a cycle of abundance every five to seven years. Many factors contribute to abundance and decline in these urban environments, and no such cycles have been suggested for populations in American cities, but they have been noted in Slovenia (see above). In any case, we can verify that populations still exist, because in recent years specimens were found in the city of Paris by Naumann.

Weast (1989) himself collected cocoons in the 15th District (Arrondissement 15) of Paris in the winter of 1966-1967 on ailanthus, plum, and lilac. He also cited records from Nice and Marseilles, cities in southern France on the Mediterranean Coast. Possibly populations became established in those two places, but we do not know if they are still extant. Additional locality records include Val de Marne, Arcueil (specimens in Peigler and Naumann collections from 1975), and Villeneuve-le-Roi (Iches 1933). In the 1930s *Samia cynthia* occurred every year in the garden of the country home of Dr. Claude Lemaire (pers. comm. to Peigler, 26 January 2002) at Champigny-sur-Marne near Paris. Lemaire added that mature larvae and hatched eggs of *S. cynthia* had been found on a small tree labeled "*Zanthoxylum japonicum*" beside the Muséum National d'Histoire naturelle in

Paris in the summer of 2001. (The name *Z. japonicum* is not cited in botanical lists, so is probably a *nomen nudum,* and we assume a synonym of *Z. piperitum*.) Another report for the moth in France was given by Brozskus and Bodenstein (1950), saying that the moth occurs in the Rhone Valley up to Geneva (Switzerland). If true, that population might have resulted by spreading from northern Italy, instead of a separate introduction in France.

Some early workers wrote about a new form that had supposedly evolved in Paris after the introduction from Italy. It was named *Attacus cynthia* var. *parisiensis* by Clément (1899, 1900), and discussed in detail by Bouvier (1927, 1936), who figured the type female (1936, pl.12, fig. 5). We examined the type specimen and numerous historical and recent specimens from the environs of Paris, and concluded that no new form or race ever really evolved. These do not differ in any measurable way from material collected in China or in Italy, the latter being the direct source of the parental stock for the French population. J. H. Watson and A. Seitz apparently did not consider *parisiensis* to be a distinctive entity, since they did not cite it in their publications. More recent French authors (Rougeot 1971, Lemaire 1978, Rougeot & Viette 1978, 1983) also did not consider *parisiensis* to be a valid taxon.

**Bulgaria.** Although we found no mention in literature of *S. cynthia* existing as established populations in Bulgaria, Peter Kautt reported that a man named Schülke found the species over several years in Bulgaria on the coast of the Black Sea, in the locality of Michurin [=Micurin, formerly found on maps as Tsarevo], near the Turkish border. We examined two undersized males from Kautt, reared by Schülke in May 1981 and on 30 June 1993. Additional material from Michurin was reared in Cottbus, Germany, by Kautt.

Michurin is so far from the other known localities for *S. cynthia* in southeastern Europe, namely Georgia at the opposite end of the Black Sea and Austria and Slovenia to the northwest, that we assume the Bulgarian populations resulted from an isolated introduction by humans. We expect that the moth still exists in that region.

**Algeria; Greece.** Because Algeria was under colonial rule by France, it was natural for attempts to be made to establish ailanthus silk culture in that country. The species was introduced to Algiers (Guérin-Méneville 1860a), but we do not know if it became established, even temporarily. Gómez de Aizpúrua (1988: 27) showed Algeria as part of the range of *S. cynthia*, which we have assumed to be erroneous, possibly resulting from confusion with *S. ricini* being cultured in the Middle East. The same map shows the range correctly for the moth being established in Barcelona, three regions in France (Paris, Alsace, Bordeaux), northern Italy, southern Switzerland, southern Austria, and Slovenia, but we do not know the source for Gómez de Aizpúrua also showing a large area of Greece as part of this European and Mediterranean distribution. As far as we know, *S. cynthia* has not been introduced in Greece.

**Tunisia.** A male simply labeled "Tunisia" was found by Naumann in the Muséum d'Histoire naturelle de Genève (Geneva, Switzerland).

**Material Examined (Indigenous Populations). CHINA**: Zhejiang Province, 3♂2♀ Ningbo, 1912 & 1922, leg. A. Buch, genitalia no. 224/97 Naumann (MNHN); 1♀ "Ning-po, Checkiang," coll. J. Fallou, Chambre de Commerce de Lyon, Laboratoire d'Étude de la Soie (MNHN); 14♂3♀ Ningbo, *ex* cocoon May 1914 (BMNH); 3♂2♀ Yushan, 1992 via J.-M. Cadiou (SMFL); 1♀ Chusan Island [Zhoushan Dao], 1948, leg. Father A. Buch (FMNH); 3♂5♀ West Tien Mu Shan, 1600 m, 4-26 May 1932, leg. H. Höne, genitalia no. 50/96 Naumann (ZFMK); 1♀ East Tien Mu Shan, Lingan, 1500 m, 18 Aug. 1931, leg. H. Höne (ZFMK); 12♂7♀ Mokanshan [720 m, 30˚36'N 119˚52'E], 10-31 May, 2 & 13 Aug. 1931, leg. H. Höne, genitalia no. 51 & 52/97 Naumann (ZFMK); 1♀ "Tschekiang", *ex* larva 12 May 1932, coll. Staudinger & Bang-Haas (MTD); 1♂1♀ "Tschekiang" (MTD). Shanghai Shi District. 1♂1♀ Shanghai, coll. J. M. A. van Groenendael (ZMA); 1♂3♀ H. Watson (MNHN); 1♂ *ex ovo* July 1918 (MNHN); 1♂ Shanghai, *ex* cocoon June 1918, leg. G. M. Franck (BMNH); 28♂34♀ 29 April-30 June 1941 & 1942, leg. H. Höne, genitalia 92 & 93/97 Naumann (ZFMK); 1♂4♀ *ex* cocoon 2 - 7 May 1939 in Berlin, leg. Alin (DEI). 1♂1♀ Jiangxi Province, Kiukiang [Jiujiang, 29˚44'N/115˚49'E], July 1887, leg. A. E. Pratt, coll. Staudinger (ZMHB); 4♂7♀ same data, Rothschild Bequest (BMNH); 1♂ Kuling [S. Jiujiang, 29˚31'N 115˚59'E], 11 June 1932 (ZFMK). Jiangsu Province. 4♀ Kong-tcheau, Kong-yang [Kongyangcun, near Chao Hu Lake], 1906, leg. R. P. Cavalière & Fortunat (MNHN); 1♂ Nanking [Nanjing], coll. Borgert (DEI); 1♀ Lungtan [Longtan, 32˚11'N 110˚04'E], 7 June 1933, leg. H. Höne (ZFMK). Shandong Province, 1♂1♀ Tsingtau [Qingdao] without further data (ZMA); 1♂ Tsingtau [Qingdao], coll. Franke (ZMHB); 7♂4♀ Tsingtau [Qingdao], May, Aug., & Sept., coll. Hoffmann (DEI); 9♂3♀ Tsingtau [Qingdao], May, August, & without data, via Steyler Mission, genitalia no. 94/97 Naumann (ZFMK); 2♀ Tai-Shan, 1550 m, 22 & 28 July 1934, leg. H. Höne (ZFMK); 10♂11♀ Shandong, July 1913, leg. Steyler Mission (ZFMK); 1♂2♀ Shandong, 2nd generation, *ex ovo* 26-30 April 1992 on ailanthus in Czech Republic (Naumann). 1♀ Shandong, stock via Czech Republic, reared in Colorado on ailanthus in 1993 by Peigler, emerged 6 May 1994 (LACM); 1♂1♀ "Shantung Province," Kiantschou, 20 June 1921 & 6 July 1926, coll. F. Daniel (Witt). Beijing District, 3♂2♀ Pekin, *ex*

pupa 6 March & 12 May 1863, leg. Simon, coll. Guérin-Méneville, genitalia no. 225/97 Naumann (MNHN). 3♂5♀ Shanxi Province, Kiantschou [Wenxi], leg. v. Stegmann & Stein (ZMHB); 2♂2♀ Liaoning Province, Dairen [Lüda, 38˚53'N/121˚35'E], Aug. 1929, leg. v. Tolmachov, ♂genitalia no. 48/97 Naumann (ZFMK); "Manchuria" May 1928 (ZFMK). 3♂ Yundao, Manchuria [probably Liaoning Province], July-Aug., leg. v. Tolmachov (ZFMK). 1♂ Heilongjiang Province, Harbin, June 1925, leg. v. Tolmachov (ZFMK); 1♂ Kharbin [Harbin], *ex* pupa in Nice, France, May 1939 (MHNG); 2♂ China without exact data (MNHN); 2♀ *ex ovo* 1993 (Naumann); 3♂ "Frontière orientale du Thibet" [probably somewhere in West Sichuan], leg. P. Dejean, Levick Bequest (BMNH); 1♂ "Thibet, Oua-Se, Yu-tong, Kitchang-kou" [probably somewhere in Sichuan or North Yunnan], May - June 1892, Levick Bequest, genitalia no. 175/97 Naumann (BMNH); 1♂ Nanning, coll. Oberthür (ZFMK). **NORTH KOREA**: 1♂ North Pyongan Province [Pyongan Bukto], Mount Myohyang-san, 17 July 1982, no. 821, leg. L. Forró & L. Ronkay, genitalia no. 72/97 Naumann (Witt). 1♀ South Pyongan Province [Pyongan Namdo], Pyongan, hotel garden, 4 Aug. 1971, leg. S. Horvatovich & J. Popp (Witt); 1♀ Pyongyang Province, Pyöngyang (DEI). 1♂ Kangwon Province, Mount Kumgang-san, Ontsong, 9-11 July 1977 at light, leg. Li & Ashkovits (Witt); 2♂2♀ Mount Kumgang-san, 22- 24 July 1982, leg. L Forró & L. Ronkay (Witt). 1♂, southeastern N. Korea, Kumgang-san Mountains, 16-19 July 1985, leg. Edward Palik, given to Peigler by J. Razowski (LACM). **SOUTH KOREA**: 3♂ South Kyongsan Province, Masan, 150 m, 11-20 Aug. 1988, leg. Bogner, genitalia no. 154/97 Naumann (SMFL); 1♂ Namhae, 13 June 1982, leg. Bogner (SMFL).

**Material Examined (Introduced Populations). JAPAN**: 1♀ Honshu Island, Okayama Prefecture, "*Samia pryeri*", Okayama, July 1908, coll. Staudinger & Bang-Haas (MTD); 1♂, Nagano Prefecture, Matsumoto, *ex* pupa 1 July 1987, received via Far East Biological Supplies, genitalia no. 153/97 Naumann (SMFL); 2♂3♀ same locality, *ex ovo* May 1989, reared by U. Paukstadt, genitalia no. 222 Paukstadt (Paukstadt); 2♂ 5♀ Matsumoto, Okada-machi, Azamukaiyama, cocoons emerged in Texas late May 2000, Hitoshi Saito (Peigler), 1♂ same data, but reared *ex-ovo* in Texas by Peigler on ailanthus, em. May 2001 (LACM). 3♂ 2♀, Fukushima Prefecture, Date-gun, Yanagawa-machi, reared June 1996 in Denver, Colorado, from cocoons sent by Dr. Toshimasa Mitamura (Peigler, LACM); 3♂2♀ same data (Naumann); 1♂2♀ Hokkaido Island, Hokkaido Prefecture, Toubetsucho, *ex* pupa July 1996, via Y. Kishida (Naumann); 1♂ Tsushima Island, Nagasaki Prefecture, Sasuna, 10 Aug. 1977, leg. Y. Kishida (Naumann); without exact data: 1♂ Japan, *ex* pupa 1990 (MHNL); 1♂1♀ *ex ovo* June 1998, reared by H. Schulz, received from M. Beeke (Naumann). **AUSTRALIA**: 2♀ "Australie: Musée de Melbourne, 3247.82" (MNHN). **CANADA**: Ontario. 1, Toronto, 1936 [or 1956?], R. B. Johnston (ROM); 1, Toronto, Park Plaza Hotel, 26 June 1958, John Treadea (ROM); 1, London, June 1903 (ROM). [The sexes of these Canadian specimens were not noted.] **AUSTRIA**: 1♂ Wien [Vienna], *ex* larva, em. 7 Aug. 1973, leg. Walter Dittrich, sent to Peigler by Dittrich (LACM); 1♀ Wien, em. 18 May 1973, leg. W. Dittrich, *ex* Peigler coll. (LACM); 1♂ Wien, *ex* larva 23 Feb. 1920, reared by F. Daniel [specimen figured in Forster & Wohlfahrt 1960, pl. 18, fig. 1] (Witt); 1♂1♀ *ex ovo* June 1944, coll. Bilek (MHNG); 2♂ *ex ovo* 22 June 1963, reared by O. Lének (Witt); 1♂, May 1974, leg. Friedel (Witt); 3♂8♀ bred, without further data (Witt); 1♀ Styria, Knittelfeld, *ex* larva 30 June 1958, reared by F. Fröhlich (Witt). **FRANCE**: 1♀ Val de Marne, Arcueil, *ex* wild cocoon 12 June 1975, sent to Peigler by C. Lemaire, collected by Lucien Jean (LACM); 1♂ same locality, 7 June 1975, received from Peigler, genitalia no. 131/97 Naumann (Naumann); 1♀ Arcueil-Cachan sur Seine, cocoon collected Jan. 1925, *ex* pupa May 1925, leg. A. Neuilly (MNHN); 1♀ Paris, 15 May 1975, reared on ailanthus by Claude Lemaire, sent to Peigler (LACM); 2♀ Paris, emerged April 1995 from cocoons given to Peigler and reared by Robert Lemaître (LACM); 1♀ Paris, stock from C. Lemaire, reared in South Carolina on *Liriodendron tulipifera* by R. Peigler, em. April 1976, mated to ♂ *Callosamia securifera* (LACM); 1♂ same data, em. 2 May 1976 (LACM); 1♀ same data but reared on ailanthus, em. 18 May 1975 (LACM); 13♂12♀ Paris, 1860, reared by M. Dupuiset (UMO); 1♀ Paris, 29 June 1915, leg. Berthe (Witt); 2♂1♀ *ex* larva July 1925 (MHNG); 6♂6♀ *ex ovo* or larva 1946, 1980, 1985 (Witt); 2♀ gardens of Paris, 10 July (ZFMK); 1♂ Paris, *ex ovo* Aug. 1995, reared by R. Strauß (Beeke); 1♂1♀ Paris-Midi, *ex ovo* 16 & 23 June 1992, reared by F. Kelac (Naumann); 2♂2♀ East Paris, gardens, ca. 100 m, 3rd generation *ex ovo* May 1992 on *Ligustrum*, leg. G. Fiebig (Naumann); 2♂3♀ 8 km W of Paris, Seine, June 1896 & *ex ovo* June 1898, coll. L. Viard, in collection of René Oberthür 1922 (ZFMK); 2♀ Medoc, Arcachon, 14 June 1933 & 28 June 1954 (MHNG); 1♂ St. Arnaud, *ex* larva 28 May 1948, coll. Monard (MHNL); 2♂1♀ Basses Pyrénées, Le Lac Saint-Jean-de-Luz, *ex* larva, 19 June 1928 and *ex* pupa June 1926, V. Muspratt (BMNH); 1♂ Strasbourg, April 1920, acclimatized (ZMHB); 1♂ France, without further data (ZFMK). **SWITZERLAND**: 2♂2♀ Lugano, *ex* larva 6-13 June 1930 (Witt); 1♂1♀ *ex* pupa 17 May & 10 June 1937, reared by E. Möbius (DEI); 2♂3♀ *ex* larva 16-28 May 1937, reared by E. Möbius, coll. Staudinger & Bang-Haas (MTD); 4♂3♀ Tessin [Ticino], Mamete, 1-3 July 1981, coll. Eberhart (Witt); series from Tessin without further data, coll. Claudius Côte (MHNL); 1♀ Zürich, coll. Staudinger & Bang-Haas (MTD). **ITALY**: 2♂ 1♀ Alfonsine, Ravenna, em. 2, 3, & 4 May 1988 from wild cocoons collected on ailanthus, sent to Peigler by Naumann (LACM); 2♂2♀ Alfonsine, *ex* wild coll. cocoon 2-5 May 1988 on *Ailanthus altissima*, genitalia no.

10/96 Naumann (Naumann); 1♂1♀ Ravenna, *ex* pupa 17 & 21 March 1970, coll. Aussem (Witt); 1♂2♀ Lago di Garda, *ex* pupa 13 April 1964, 7 & 18 May 1964 (Witt); 1♂1♀ Garda, 1 May 1964 & 4 Aug. 1967, leg. W. Pavlas (Witt); 4♂1♀ Garda, 1-15, 15, 28-30 May 1964, 17-19 June 1964, leg. B. Koch (Witt); 1♂ Lago di Garda, *ex* pupa 16 May 1988, leg. U. Peters, *ex* coll. Nässig, received from R. S. Peigler, genitalia no. 141/97 Naumann (Naumann); 3♂2♀ Lago di Garda, reared *ex ovo* June 1998 on *Ligustrum* by M. Beeke, ♂ genitalia no. 328/98 Naumann ( Naumann); 1♂1♀ Lago di Garda, second generation, eggs from U. Nardelli, reared in Berlin *ex ovo* 14 & 31 Aug. 1998 on *Ailanthus altissima* by S. Naumann (Naumann); Lago di Garda, 16 May 1988, U. Peters (Peigler); 1♂ Lago di Garda, 16 May 1988, U. Peters (LACM); 1♂ 1♀ Etschtal Mattarello, 250 m, Trient [Trentino], *ex* cocoon 17 May 1988, leg. U. Nardelli, sent by W. Nässig to Peigler (LACM). 1♂ Bardolino, June 1977, leg. Pavlas (Witt); 3♂ Sirmione, *ex* pupa 18 March, 2 & 3 May 1964, coll. W. Zeller (Witt); 2♂ Torbole, 29 May 1956, leg. G. Friedel (Witt); 2♂6♀, Navene, *ex* pupa May & June 1964 [1♂ figured in de Freina & Witt 1987], reared by B. Koch (Witt); 2♀ Etschtal, Lopia, near Torbole, *ex* pupa 19 & 20 Feb. 1962, leg. B. Koch (Witt); 1♂3♀ Etschtal, env. of Rovereto, *ex* wild cocoon 22-29 May 1997 on *Ailanthus altissima*, leg. U. Nardelli (Naumann); 1♂2♀ Trentino, Marco, near Rovereto, 190 m, *ex* wild cocoon 21 April, 4 & 8 June 1997 on *Ailanthus altissima*, leg. U. Nardelli (Naumann); 1♂1♀ S. Trentino, Mattarello, 200 m, *ex* pupa May-June 1995, leg. U. Nardelli (Naumann); 1♀ Albisano, 350 m, end of May 1963, leg. Daniel (Witt); 1♂ Bologna, *ex* pupa 11 June 1961 (Witt); 1♀ Pordemone, 18-24 Aug. 1961, leg. Sielmann (ZFMK); 1♂2♀ Südtirol, Sarca Valley, Pietramurata, 250 m, 8-15 Sept. 1959, leg. Daniel (Witt); 1♂ Südtirol, Marting, *ex* pupa 26 April 1988, coll. A. Mayr (Beeke); 1♂1♀, Val d'Isarco, Waidbruck, 1-13 July 1959, leg. B. Koch; "Population nicht bodenständig, die Falter stammen aus Kokons von Trient, von denen Forchermeyer etwa 1000 Stück bei Waidbruck ausgesetzt hat, pers. Com. Daniel 1972" [population not native; cocoons from Trentino] (Witt); 1♂1♀ Trentino, Lago di Loppio, 220 m, 16-22 June 1961, leg. Daniel (Witt); 1♂ Lado di Loppio, 200 m, June 1980, leg. Behounek (Witt); 1♀ Milano [Milan], 10 May 1976, leg. Ferruti (USNM). **SPAIN**: 1♀ Barcelona, 60 m, March 1968 (BMNH); 1♀ Barcelona, 50 m, Feb. 1968 (MNHN). **GERMANY**: 1♂3♀ Berlin, gardens of Berlin-Dahlem, on plum, reared by Walther Horn (DEI); 1♀ Nordrhein-Westfalen, Swisttal-Buschhoven, west of Bonn, 23 May 1983, collected alive, leg. Graff (ZFMK). **BULGARIA**: 1♂ Micurin [Michurin], *ex ovo* May 1981, reared by Schülke, received from Peter Kautt in 2002 (Naumann); 1♂ Micurin, 30 June 1993, leg. Schülke, received from Peter Kautt (SMFL). **EUROPE**: 3♀ "European stock," emerged May 1975, cocoons from Worldwide Butterflies Ltd., Sherborne, Dorset; imported with U.S.D.A. permit issued to R. Peigler (LACM). **UNITED STATES**: 1♀ Connecticut, New Haven, *ex* cocoon May 1976, R. S. Peigler [mated to ♂ *C. angulifera* and resulting hybrids reared; see Peigler (1978)] (DMNS); 4♂2♀ New Haven, 12, 14, 19, 20, 20 & 22 July 1949, C. W. Kirkwood (LACM); 1♂1♀, New Haven, emerged in Los Angeles on 16 and 19 May 1965, George Crouchet (LACM). District of Columbia, 3♂3♀ Washington (USNM). 1♀ Massachusetts, Boston, emerged indoors 21 May 1976, cocoon received by Peigler from William H. Houtz (LACM). 1♀ New Jersey, Newark (LACM); 3♂ Oakland, May 1990, leg. T. Temesvary (Beeke); series from New Jersey, without further data (MTD). New York, 1♀ Brooklyn, 8 July 1978, W. D. Winter; illustrated by William H. Howe (LACM); 1♂ Kings Co., environs of Brooklyn, 6 June 1990 (Löffler); 1♂ New York City, Bronx, emerged 16 July 1975 *ex* wild cocoon, Paul J. Russell (LACM); 2♀ New York City, Brooklyn, *ex* cocoon June 1971, cocoons bought by Peigler from Melvin Goliger (LACM); 1♀, emerged 26 June 1969, cocoon bought by Peigler from Butterfly Art Jewelry, Inc., Brooklyn (Peigler); 1♀ Brooklyn, *ex*-wild cocoon em. 13 July 1975, Sandra Russell [mated in South Carolina to ♂ of *C. angulifera*, but eggs did not hatch] (LACM); 1♀ same data, em. 26 June 1975 (LACM); 1♀ em. in Colorado 13 July 1991 from cocoon bought by Peigler from The Butterfly Company, Far Rockaway [formerly Butterfly Art Jewelry] (LACM); 7♂8♀ Richmond, Staten Island, reared on ailanthus *ex-ovo* in San Antonio, emerged 3-12 Aug. 1965, Roy O. Kendall collection (TAMU); 1♂1♀ New York State, Carl F. Krueger collection (LACM); series from New York without further data (MTD). Pennsylvania, 1♂ Adamstown, 2 July 1934, Lloyd M. Martin collection (LACM); 1♂ Blaine, collection of Munroe L. Walton (LACM); 1♀ emerged in Glendale, California, 7-8-1932, Munroe L. Walton (LACM);♀ Philadelphia, 1889, J. Bunn (LACM); 1♀ Philadelphia, Frankford, em. July 1972 *ex* wild cocoon, Dale F. Schweitzer (LACM); 1♂ same data, received from Peigler (Naumann); 1♂ Philadelphia, reared from cocoon 18 May 1889 by H. G. Dyar, [figured in Packard 1914: pl. 56] (USNM); 1♀ Philadelphia, leg. Joseph Steiger, institutional exchange with Academy of Natural Sciences, Philadelphia [a dark brown aberration resembling *Epiphora*] (CMNH); 1♀ Pittsburgh, 30 June 1955, leg. L. F. Dippold (CMNH); 1♂ Wilmerding, coll. Staudinger & Bang-Haas (MTD); 1♂ southwestern Pennsylvania (MTD); 1♀ Pennsylvania, *ex* wild cocoon on ailanthus 7 June 1993 (Naumann). "United States stock", cocoons reared by Jeff Frey in Pennsylvania, 1♂ emerged 14 June 1994 in Colorado (LACM); 1♀ same data, em. 31 May 1994 (Peigler); 1♀ same data, em. 18 June 1992 (LACM); 1♀ emerged June 1969 from cocoon bought by Peigler from John Staples of Rochester, New York (LACM); 1♂ same data, received from R. S. Peigler, genitalia no. 129/97 Naumann (Naumann); 1♀ reared in Rochester, N.Y., by John

Staples, emerged 29 July 1979 (LACM); 1♂ Glenn A. Gorelick collection, 1982 (LACM); 1♂ 19 June 1934, collection of John W. Johnson, donated 1982 (LACM); 1♂2♀ cocoons from American Entomological Company, 1905, Harold M. Bower (LACM); 1♂ raised in Scranton, Pennsylvania, 1905, Harold M. Bower (LACM); 2♂ 1♀ reared in Flint, Michigan, from cocoons 7, 10 & 14 July 1944, Elwyn C. Lewis, John W. Johnson collection (LACM); 1♂ "eastern U.S.," 24 May 1953, M. Osborne (LACM); 1♀ reared at Long Beach, California 5 July 1975 (LACM). Unknown origin, but erroneously labeled (next 14 specimens), 1♂1♀ Herdale [?], 10 & 25 June 1973 (MHNL); 2♂1♀ Arizona, coll. Neuburger (MNHL); 1♂ Colorado, coll. Neuburger (MHNL); 1♂1♀ Texas, coll. Neuburger (MHNL); 1♀ North Dakota, Missouri-Valley, 500 m, June-July, coll. Staudinger & Bang-Haas (MTD); 2♂ Ohio, reared by S. Naumann *ex ovo* 16 May 1980 on *Ligustrum* in Germany, genitalia no. 11/96 Naumann (Naumann); 1♂ Illinois, Chicago, *ex* pupa 24 June 1960, coll. K. Andres (Witt); 1♀ Illinois, without additional data, coll. Neuburger (MHNL); 1♂ Wisconsin, Milwaukee (RMNH). **TUNISIA**: 1♂ without further data (MHNG). **VENEZUELA**: 1♂1♀, Valencia, leg. F. Kummerow (ZMHB). **URUGUAY**: 1♀ Montevideo, no. 74916, reared by E. Urbahn, coll. P. Maassen (ZMHB). **BRAZIL**: 1♂ Montagnes des Orgues, env. de la Tijuca, Massif du Pico do Papagayo [near Rio de Janeiro], 1902, leg. E. R. Wagner (MNHN). **Without locality**: 1♂ collection of Guérin-Méneville (MNHN).

## *Samia wangi* Naumann & Peigler

(Figs. 9-16, 154-158, 200-201, 225-228; Map 3)

*Saturnia piperata* Motschulsky 1858: 163. [*nomen nudum*]
*Saturnia piperita*, Fauvel 1895: 22. [*nomen nudum*] [misspelling]
*Attacus Walkeri* Felder & Felder 1862: 34. Walker 1865: 525. Fauvel 1895: 77.
*Attacus walkeri*, Butler 1878: 388. Leech 1889: 634 (in part).
*Attacus Cynthia*, Horsfield & Moore 1860: 407 (in part).
*Attacus cynthia*, Candèze 1927: 120.
*Philosamia Walkeri*, Kirby 1892a: 748. Fauvel 1895: 78, pl. 4 (larva, cocoons, pupa, ♂). André 1908: 73.
*Philosamia walkeri*, Rothschild 1895: 37. Packard 1914: 242, pl. 92 (♂ ♀). Chowdhury 1982: 6.
*Philosamia walkweri*, Chowdhury 1982: 6. [misspelling]
*Philosamia Valkeri*, Dusuzeau & Sonthonnax 1897: 31 [misspelling]
*Philosamia cynthia walkeri*, Rebel 1924: 111. Rebel 1925a: 11. Rebel 1925b: 156. Lének 1958: 68. Inoue1961: 659. Priesner 1968: 276. Yang 1978: 434 [in part], pl. 25, fig. 2 (♂). Jolly et al. 1979: 7. Lee 1982: 221, pl. 17, fig. 47.
*Philosamia cynthia* var. *Walkeri*, Bouvier 1927: 921.
*Philosamia cynthia* var. *Walkeri*, Sonthonnax 1901: 133.
*Philosamia cynthia Walkeri*, Schüßler 1933-1934: 85, 535.
*Philosamia cynthia walker*, Belyakova & Lukhtanov 1996: 63. [misspelling]
*Philosamia cynthia* var. *walkeri*, Bouvier & Riel 1931: 81.
*Philosamia Cynthia*, Dusuzeau & Sonthonnax 1897: 29 (in part).
*Philosamia cynthia*, de Joannis 1929: 523. Mell 1939: 143 Hill & Cheung 1978: 73. Zhu et al. 1979: 21, col. pl. 7, fig. 27 (larva, ♂) (in part). Zhang 1986: 24, pl. 7, fig. 58. Guo 1989: 548. L. Y. Wang 1992: 801. Huang 1993: 423. Ye & Hu 1996: 30 (in part).
*Philosamia cynthia cynthia*, Rebel 1925b: pl. 8, fig. 2 (♀).
*Samia walkeri*, Bock 1938: 24. Gardiner 1982: 212. Peigler 1989: 2. Peigler 1992: 165. Naumann 1995: 26. Peigler 1996: 16, 121. Peigler & Wang 1996: 77-81 (all stages). Owada & Wang 1997: pl. 45, fig. 15 (♂). Wang & Lee 1998: 83.
*Samia cynthia walkeri*, Jordan 1911b: 213. Seitz 1928: 504. Bollow 1932: 130. Bouvier 1936: 316. H. Y. Wang 1988: 46-48 (♂, eggs, larvae). Weast 1989: 4. Owada & Wang 1992: 156 (Number 117.15a). H. Y. Wang 1994: 80. Song et al. 1996: 11.
*Semia* [*sic*] *cyntia* [*sic*] *walkeri*, Kishida 1977a: 3. Kishida 1977b: fig. 2 (♂). [misspellings]
*Samia cynthia walqueri*, Gómez & Fernández 1976: 292. Gómez & Arroyo 1981: 77. [emendation]

*Samia cynthia cynthia*, Allen 1981: 112 (in part). Zhu & Wang 1996: 167 (in part).
*Samia cynthia*, Chen & Wong 1936: 127. Allen 1981: 112, pl. 4, lower (♂). Gardiner 1982: pl. 31 (♀). Hill et al. 1982: 248-249, pls. 247 (♀), 248 (larva). L. Y. Wang 1993: 612 (in part). Zhu & Wang 1993: 257 (in part). Allen 1993: 55. Morishita & Kishida 2000: 16.
*Samia insularis*, Lemée 1950: 39. [*incertae sedis*]
*Philosamia cynthia insularis*, Zhu & Wang 1983: 410, pl. 132, fig. 2955 (♂). [misidentification]
*Samia cynthia insularis*, Zhu & Wang 1993: 255. Zhu & Wang 1996: 163, pl. 11, fig. 3 (♂). [misidentification]
*Platysamia cynthia*, Mell 1935: 363.
*Samia wangi* Naumann & Peigler 2001: 79.

**Types.** Holotype ♂ (Fig. 9): China, Guangdong Province, Huiji, Duang Mountain, ca. 112˚10'E 23˚54'N, 1500 m, July 1998, leg. Yin. A red holotype label was affixed to the specimen, which was deposited in the Natural History Museum of Los Angeles County, Los Angeles, California, in March 2002.

Allotype ♀ (Fig. 10): China, Guangdong Province, Huiji, Duang Mountain, ca. 112˚10'E 23˚54'N, 1500 m, July 1998, leg. Yin. The specimen bears a red allotype label and was also deposited in the Natural History Museum of Los Angeles County in March 2002.

Paratypes. A large number of paratypes were designated from Guangdong, Hong Kong, Macao, Hunan, Jiangxi, Fujian, and seven counties in Taiwan. The data for all these are cited in the section below of material examined. Paratypes are in the following institutional collections: Academia Sinica, Beijing; Shaanxi Academy of Forestry, Yangling; Taiwan Provincial Museum, Taipei; National Museum of Natural Science, Taichung; Natural History Museum of Los Angeles County; Zoologisches Museum der Humboldt-Universität Berlin; Macleay Museum, University of Sydney; Muséum National d'Histoire naturelle, Paris; and The Natural History Museum, London. Our color figures show paratypes from Taiwan (Figs. 14, 16) and Jiangxi (Fig. 11).

Additional material available to us from Vietnam, Zhejiang, Sichuan, and other inland Chinese provinces was excluded from the type series. The type locality in west-central Guangdong is also found on maps as Huaiji and Huaicheng, and does not correspond exactly with the coordinates sent by the original Chinese collector.

**Geographical Distribution** (Map 3). In general, this moth flies throughout southeastern China. It occurs from the provinces of southern Shaanxi to southern Zhejiang, including Anhui, throughout most of Sichuan and thence south into Yunnan and Xizang. The range encompasses all or most of the provinces of Guangdong, Fujian, Zhejiang, Jiangxi, Hunan, Guizhou, Guangxi, and probably Hubei. It also flies on Taiwan and Hainan, the latter island now a province, but formerly part of Guangdong. There is a record from eastern Xizang that needs verification, which if valid, would currently represent the western known limit of the range. There are also records from Vietnam, primarily the northern part of that country.

**Diagnosis.** The species is readily separated from *S. cynthia* by its visibly narrower crescents in each wing, and from *S. pryeri* and *S. canningi* by the narrower crescents and olive green ground color.

**Description.** Adult ♂ (Figs. 9, 11-15). *Head.* Frons and occiput brown. Antennae (Fig. 225) 11-12 mm long, 4.0-4.8 mm wide. *Thorax.* Tergum and sternum brown; legs (Fig. 227). *Forewing.* Length 59-70 mm. Ground color olive green, fading to golden brown; costal margin visibly lighter brown; antemedian area lighter brown than ground color; antemedian line variable, with strong white and black components; median area of ground color; postmedian line black, white, rose, and lavender, curving proximally above and below crescent; postmedian area strongly sprinkled with black scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5-9 mm; submarginal line usually broken below apex, weakly defined; outer margin ; crescent with very narrow white, and usually narrow yellow components, almost straight or weakly curved; apex variously rounded or pointed; eyespot black with white proximal edge, white dusting within, and large; underside with rose of postemedian line less intense. *Hindwing.* Length 45-54 mm. Antemedian area loghter than ground color; antemedian line prominent; median area of ground color, lighter near inner margin; postmedian line curving, with sharp indentation at crescent; postmedian area as in forewing; submarginal line obsolete; submarginal ornamentation weakly contrasting, in three rows, the inner row sometimes strongly developed within each cell; outer margin straight or rounded; crescent short, contacting postmedian line, narrow, sharply curved; tornus pointed. *Abdomen.* Tergum with many prominent yet tiny white tufts; spiracular ornamentation white and dark, along a gold bar; sternum brown. *Genitalia* (Figs. 154-158). Uncus bifid; transtilla with small central indentation, in some southwestern specimens also two further small lateral impressions; generally there is a tendency toward increased indentations of transtilla from eastern to western populations; saccus relatively small;

vinculum somewhat triangular; sacculus of valves relatively large compared to *S. cynthia*, ending with curved outer margin of ventral part of valves, continued dorsally; ventral process compared with other species relatively short and arising very far dorsally, almost half way to dorsal tip; central process short and blunt, similar to *S. cynthia*; dorsal process only slightly defined on the lobe; aedeagus longer and thicker than in *S. cynthia*, with a smaller left ventrolateral sclerite; vesica with three bulbs as usual in most *Samia* species: a large one dorsally with sclerite medially, and two bulbs right and left laterally, which are smaller; sclerite always present, but much smaller than in *S. cynthia*; the genitalia cannot be confused with sympatric species like *S. kohlli* or *S. canningi*.

Adult ♀ (Figs. 10, 16). Differing from ♂ as follows. *Head.* Antennae (Fig. 226) 10-11 mm long, 3.6 mm wide. Legs (Fig. 228). *Forewing.* Length 70-82 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9-12 mm; crescent gently curved, 15-20 mm long; apex very short and rounded. *Hindwing.* Length 54-61 mm; crescent variable, generally narrow; tornus rounded. *Abdomen.* Tergum with large white tufts, three per segment, separated by areas of golden ochre; spiracular ornamentation prominent, large golden ochre circles surrounded by dark brown, alongside white patches; sternum an even mixture of white, brown, and golden ochre. *Genitalia* (Figs. 200-201). Anal papilles small, compact, and not widely separated; tergite of A8 strongly sclerotized; oviporus covered by two lateral lobes; lamella postvaginalis broad, heavily sclerotized, with long lateral lobe; apophyses not connected to latter lobe; lamella antevaginalis straight, without much sclerotization; posterior apophyses only slightly longer than anterior ones.

**Discussion.** We named this species in honor of our colleague Hsiau Yue Wang of the Taiwan Provincial Museum. Mr. Wang has published several books on Taiwanese insects, especially Lepidoptera, which are embellished by his beautiful photography of living insects in the field and laboratory. He has consistently and cheerfully responded to our questions and requests during this study. Mr. Wang has also developed scientific collaboration with entomologists in mainland China. The Chinese word Wang means emperor or king, and the name emperor is also commonly applied to saturniid moths in both English and Chinese.

This species is widespread and well known, but has been misidentified as *S. walkeri* in much of the literature, including our own earlier publications. It occurs throughout most of eastern China, particularly in the Southeast, and on Taiwan and Hainan. It is the species that flies in Hong Kong, notwithstanding the fact that Seitz (1928) showed a female of *S. cynthia* reportedly from Hong Kong. The latter probably originated from adventive stock from further north, if it was indeed from Hong Kong. Prior to our original description of *S. wangi*, we concluded that all available names for populations in China pertained to *S. cynthia*, leaving this species without a name. Although earlier we had both examined the pair of syntypes of *S. walkeri*, it was not immediately clear that these are true *S. cynthia*. More recently, with the definitive color photographs of the syntypes of *S. walkeri* published by D'Abrera (1998), the examination of the genitalia of the male syntype, and the location of the original material of *S. cynthia* in Drury's collection, we have been able to definitively establish that the name *Attacus Walkeri* is a subjective synonym of *Phalaena Attacus Cynthia*. We gratefully acknowledge Bernard D'Abrera for facilitating our efforts to locate Drury's type material and to obtain a photograph of the genitalia preparation of the male syntype of *S. walkeri*. That genitalia preparation was of utmost importance to this revision, and was made by David Goodger, curator of the Saturniidae at The Natural History Museum. Lemaire (1978) considered the two names to be synonymous after examining the syntypes of *S. walkeri*. Holland (1917) and other authors also correctly synonymized the names *cynthia* and *walkeri*. More comments were given previously under our treatment of *Samia cynthia*, in the subsection on Type Material. To conclude this point, the name *walkeri* is not the correct one for the *Samia* in southern China, nor for any of the introduced populations in Europe and North America.

Hsiau Yue Wang has called our attention to some recent records for this taxon on very small islands, including Kinmen Island (Jinmen Dao) and Matsu Island (Matsu Tao), both near the coast of Fujian Province. He has also found the species on Guisandao Islet (I-Lan County), a tiny island near northeastern Taiwan, as reported in his lepidopterological survey of that island (Wang & Lee 1998: 83), in which a male of *S. wangi* collected 15 April 1998 is shown in color. The record of Kinmen Island, better known to westerners as Quemoy, was found by Fan and Yang (2000), who also collected *Saturnia pyretorum* Westwood there. A male was cited as collected at 1100 meters in the Nanling Mountains [Nanling Shan], near the northern edge of Guangdong Province, on 2 June 2000, by Morishita and Kishida (2000). It may have three generations annually in Hong Kong (Hill & Cheung 1978). On the island of Taiwan, specimens have been collected at various localities at different altitudes in the months of March, April, May, June, July, September, October, and November; with most captures for March and April and September, suggesting a bivoltine life cycle (Wang 1994). *Samia wangi* is broadly sympatric with other large, well-known saturniids such as *Samia canningi, Attacus atlas*, *Actias selene*, *Actias sinensis* (Walker), *Saturnia pyretorum*, and some species of *Antheraea, Loepa*, and *Cricula*. It is also sympatric with *Samia watsoni* in several mountain ranges, as well as with *Actias angulocaudata* Naumann &

Bouyer (1998), a fine yellow moth resembling *A. sinensis*.

Zhang (1986) listed and figured a moth from Yigang, at 2250 meters, in extreme southeastern Xizang (Tibet), where it is sympatric with *Loepa anthera* Jordan [misidentified by Zhang as *Loepa oberthuri* (Leech)], another species of *Loepa*, and two species of *Caligula*. The latter locality is found on some maps as Zayu and Gyigang. That site is so close to the border with India and Myanmar, that *Samia wangi* may eventually be found to be a part of the entomo-fauna of those countries. However, we were not able to identify that specimen with certainty by the poor figure in the book; it might be a male of *S. kohlli*. Although we have no records from Guangxi, *Samia wangi* undoubtedly occurs in most of that province, since specimens have been collected in all of the surrounding areas. Most specimens of *S. wangi* have been taken between 500 and 2000 meters in altitude. The series that we cite below from the Danba District in western Sichuan labeled as coming from 4000 meters is possibly mislabeled regarding the altitudinal data.

Specimens (Fig. 12) received by Naumann from Huai Hua in Hunan Province are attractively marked with dark, broad postmedian lines having conspicuous rose components. Although we did not include them as part of the type series, the genitalia agree with those of other populations and we simply consider this to be a distinct population of *S. wangi.* The holotype, allotype, and other specimens from the type locality have these rose components less developed. There is some geographical variation that is consistent throughout the range of *S. wangi*, but we hope that splitters will not apply a series of names for what they claim to be subspecies. Variation of this sort is to be expected in a taxon that has such a wide distribution, occurring in numerous mountain ranges. It is certainly possible that our concept of *Samia wangi* represents two or more species (but not conspecific with *S. cynthia* to the northeast), but our study limited to preserved adult specimens leads us to conclude that this is one wide-ranging species. Despite the occasional populations that show consistent differences, *S. wangi* is actually quite uniform in its appearance throughout its range.

The habitat for this species is primarily found in two major types of forests, according to Wolfe's (1979: pl. 1) map showing the distribution of humid to mesic forests in eastern Asia. The regions in northern Vietnam, along the southeastern coast of China, and the outer portions of Taiwan and Hainan, are covered by paratropical rainforests, whereas the vast region of southern and eastern China from Jiangsu to Sichuan and Fujian toYunnan, is mainly notophyllous broad-leaved evergreen forests, at least where those natural habitats still remain. These contrast with the deciduous forest types found to the north, where *S. cynthia* occurs. Another difference between the two distributions is that *S. cynthia* lives in lowlands, but *S. wangi* is more often found in mountains and foothills, as suggested by the frequent appearance of the word shan in the Material Examined. Maps of China showing the altitudinal differences indicate a clear line separating the ranges of the two moths. Moreover, although *S. wangi* occurs throughout much of Taiwan, no records exist for the lowland belt all along the western coast. Since *S. wangi* and *S. cynthia* appear to be mutually exclusive regarding their habitats (i.e., altitude), it is not surprising that the two have not been found to be sympatric at any locale. Their ranges may meet in Zhejiang and Jiangxi.

According to Chen and Wong (1936) this species attacks citrus trees in eastern China. Some of the hostplants cited by Zhu and Wang (1983, 1993, 1996) require verification, since they are a mixture of ones for *S. cynthia* in northern China and *S. wangi* in southern China. However, parasol tree (*Firmiana platanifolia*) and bananashrub (*Michelia figo*) grow only in milder climates, so those records probably belong under *S. wangi.* In Hong Kong, caterpillars have been found feeding on camphor (*Cinnamomum camphora*), Chinese tallow (*Triadica sebifera* Small [=*Sapium sebiferum*]) (Hill & Cheung 1978), white jade orchid tree (*Michelia alba*), and lantana (*Lantana*) (Hill et al. 1982: 249). On Taiwan, Hsiau Yue Wang (1988: 47) recorded castor bean, *Lindera megaphylla*, *Triadica cochinchinensis*, camphor, *Euscaphis japonica*, and *Glochidion hongkongense*. To that list he added *Rhamnus formosana* (Wang 1994: 81). Some of the aforementioned hostplants are utilized by *Attacus atlas* in the same regions (Peigler 1989). Naumann received a specimen reared from a larva collected in Hong Kong on *Ilex asprella*, a small deciduous holly tree native to Taiwan. For Sichuan, there are recent and historic records of cocoons being collected on camphor trees, and another in the Naturhistorisches Museum in Vienna reared in 1926 on soapberry (*Sapindus mukorossii*); it is from the collection of an Austrian named Robert Gschwandner (1875-1927), who specialized in Saturniidae (Horn & Kahle 1935: 98). Soapberry is an evergreen tree that ranges from India to Japan, and is grown in Florida. Not surprisingly, *Ailanthus altissima* proved to be an excellent food for this species in rearings conducted in Germany and Texas, and we believe that it is selected by ovipositing females of *S. wangi* in nature in many regions of China. Reports by Motschulsky (1858) and Fauvel (1895: 22) indicate that *Samia wangi* feeds on Szechwan pepper (*Zanthoxylum piperitum*; cited by Motschulsky as *Fagara piperata*) in China.

Eggs were received in May 2001 by Peigler in Texas from Eric van Schayck; the stock was from Wuanyuan in the Daba Mountains of southern Shaanxi. Larvae grew well on *Ailanthus altissima*, and spinning occurred 25-29 days later. Leaves of hoptree (*Ptelea trifoliata* L., Rutaceae), cockspur coral tree (*Erythrina crista-galli* L.), and

camphor were *not* accepted, the latter unexpected because cocoons of the parental stock were spun in camphor leaves, as noted earlier. Most larvae were lost very early, and only three adults were obtained from the rearing, which emerged 18-22 June 2001 in Texas. A mature larvae was also preserved in alcohol.

Cocoons of *S. wangi* are indistinguishable from those of *S. cynthia*. If the larvae have any differences, we were not able to find them, and we would expect those to be weak, and probably variable. If there are any differences between the wing venation of the two species, they might be figured by Packard (1919: pl. 48) who showed a complete set of veins for a female (labeled as a male) from Brooklyn, New York, and the radial veins for *S. wangi* from Canton [Guangzhou], saying that "only III-2 [R2] is a little longer and better developed." We suspect that this supposed difference is inconsistent and insignificant. Our figures 225-228 show photographs of the antennae and de-scaled legs of moths of both sexes of *S. wangi*.

**Material Examined. CHINA**: Guangdong Province, 5♂ paratypes, Dianbai, ca. 111˚20'E/21˚30'N, Sept. 1997, leg. Li, genitalia no. 212-214/97 Naumann (Naumann); ♂ holotype,♀ allotype, 7♂ paratypes, Huiji, Duang Shan, ca. 112˚10'E/23˚54'N, 1500 m, July 1998, leg. Yin, ♂genitalia no. 366 & 367/99 Naumann (LACM, Naumann); 1♂ paratype, Shixin, Danxia Shan, ca. 114˚04'E/25˚00'N, 1300 m, May 1997, leg. Li, genitalia no. 267/98 Naumann (Naumann); 4♂3♀ paratypes, Canton [Guangzhou], *ex* pupa March & April 1912, April & May 1914, coll. R. Mell (ZMHB); 3♀ North Guangdong, Lianshan, Jinzhi Shan, ca. 24˚50'N 112˚20'E, 1600 m, June 1998, leg. Wang (Naumann). Hong Kong, 1♀ paratype, Tai Mo Shan, 450 m, *ex* larva on *Ilex asprella*. 24 May 1992, leg. K. H. K. Li (Naumann); 4♂ paratypes, New Territories, Uk Tan, Sai Sung, sea level, 25-28 April 1998, coll. C. G. Treadaway, genitalia no. 320 & 321/98 Naumann (SMFL); 1♂ paratype, *ex* pupa 1 March 1908, coll. Staudinger, genitalia no. 182/97 Naumann (ZMHB); 1♀ paratype, 4 April, coll. Staudinger (ZMHB); 1♂ paratype, "*Saturnia cynthia* type sauvage", "*Saturnia cynthia* var. *walkeri*, det. Bouvier", 1925, coll. Ch. Oberthür, genitalia no. 226/97 Naumann (MNHN); several ♂♀ Kowloon, June & July 1911 & 1912, leg. E. Wahr, Rothschild Bequest (BMNH). Macao, 1♀ paratype, 1909, coll. Poujade (MNHN). Fujian Province, 14♂1♀ paratypes, southern Fujian, northern Yongding County, Chitonyian Shan, ca.116˚42'E 24˚42'N, 1540 m, April 1998, leg. Wang & Li, ♂genitalia no. 296/98, 368 & 369/99 Naumann (Naumann); 7♂3♀ paratypes, Yongan, Baiyian Shan, 117˚20'E/25˚58'N, 1500 m, July 1997, leg. Li (Naumann); 3♂ Foochow [Fuzhou, 26˚06'N/119˚17'E], 1935/36, leg. M. S. Yang (BMNH); 1♂ Fuzhou, Aug. 1984, sent by Naumann to Peigler (LACM); 1♂♀ Shaowu, Liantang Shan, 1200 m, April 1998, leg. Li (Naumann); 1♂ Shanmin, Aug. 1990 (Naumann); 1♂ same data (LACM); 1♂ Shangang, July 1989 (Naumann); 1♂1♀ Sha County, May 1975 & July 1988 (Naumann); 1♂ Sha County, July 1988, sent by Naumann to Peigler (LACM). Jiangxi Province, 22♂ 4♀ paratypes western Jiangxi, Jingang Shan, 400-500 m, July 1994, leg. Wang, ♂genitalia no. 16-18/96, 95 - 97/97, 100/97 Naumann (Naumann), 1♂ paratype, same data (Peigler); 3♂ paratypes, same data (LACM); 1♂ same data, not a paratype (Peigler); 8♂ same data, not paratypes (LACM); 1♂ western Jiangxi, Wugong Shan, environs of Anfu, 1300 m, Oct. 1998, leg. Li & Ying (Naumann); 2♂2♀ southeastern Jiangxi, Pingh-Siang, leg. M. Kreyenberg, Rothschild Bequest (BMNH); 2♂ eastern Jiangxi, Wuyi Shan, Yangjialing, 1500 m, Aug. 2000, leg. Yin (Naumann); 1♀ Nanchang, July 1992 (Naumann); 1♂ Nanchang, Meilin, Aug. 1993 (Naumann). Hunan Province, 2♂ paratypes, eastern Hunan, Guidong, Bamia Shan, ca. 113˚56'E/26˚04'N, 1600 m, June 1998, leg. Wang (Naumann); 4♂ paratypes, Zhengzhou, ca. 113˚00'E/25˚48'N, Sept. 1997, leg. Z. (Naumann); 26♂9♀ western Hunan, Huai Hua, Luyang, 2-13 May 1996, leg. Wu Y., ♂genitalia no. 144 & 145/97 Naumann (Naumann); 1♂ same data (Peigler); 6♂ same data, sent by Naumann to Peigler (LACM); 3♂2♀ southern Hunan, Yinzhang, Qitianlin, 1500 m, Aug. 1997, leg. Li, ♂genitalia no. 268/98 Naumann (Naumann); 1♂ without data, leg. A. E. Pratt (BMNH). Hainan Province, 27♂15♀ Weng-Shang [Wenchang], April 1904, Rothschild Bequest (BMNH); 13♂2♀ Bunsho, March 1905, Rothschild Bequest (BMNH); 1♂ Ling Sui, 18 June 1907, coll. A. Seitz, genitalia no 152/97 Naumann (SMFL); 2♂1♀ Hainan Island, Wuzhi Shan, 1600 m, June 1998, leg. Wang (Naumann); 2♂1♀ same locality, received from S. Naumann (Brosch); 4♂ Tongza, 1600 m, Wuzhi Shan, June 2002, leg. Ying et al., genitalia no. 736/02 Naumann (Naumann). Guizhou Province, 43♂31♀ Leishan, Leigong Shan, 1540 m, Aug. 1996, ♂genitalia no. 44-46/97, 85/97, & 147/97 Naumann (Naumann); 2♂2♀ same data, *ex* coll. Naumann (Brosch); 1♀ same data (Peigler); 3♂ 2♀ same data, sent by Naumann to Peigler (LACM). Yunnan Province, 15♂7♀ south of Lijiang [=Dayan], May 1997, leg. Chui, ♂genitalia no. 263, 264, & 266/98 Naumann (Naumann). Sichuan Province, 1♂ Moupin, June 1890, leg. Franz Kricheldorff, coll. Leech (BMNH); 7♂9♀ western Sichuan, Baoxin [=Baoxing] to Moupin, Yanjin, ca 102˚05'E/30˚02'N, 20-29 June 1996, leg. Wang, ♂genitalia no. 23-25/96, 241/98 Naumann (Naumann); 1♀ same data, *ex* coll. Naumann (Beeke); 3♂ 2♀ same data, sent by Naumann to Peigler (LACM); 13♂7♀ western Sichuan, Mount Emei [formerly Mt. Omei], 1600 m, 2-15 May 1996, leg. Wu (Naumann); 9♂6♀ same locality, Aug. 1996, genitalia no. 86 & 87/97, 276/98 Naumann (Naumann); 1♂1♀ same data (Peigler); 3♂ 2♀ same data, sent by Naumann to Peigler (LACM); 1♂ 1♀ Cheng-tu [Chengdu], reared *ex* larvae by Rev. G. M. Franck, coll. J. H. Watson, figured in Packard 1914: pl. 92

(BMNH); 1♀ Tâ-tsien-lou [Kangding, 30˚03'N/102˚02'E], 1910, Levick Bequest (BMNH); 1♀ Siao Lou [ca. 30˚06'N/102˚04'E], 1900, Levick Bequest (BMNH); 3♂1♀ western Sichuan, Danba District, Maiduoershan grassland, environs of Danba, 4000 m, July 1999, leg. Wang & Li (Naumann); 1♂ Chungking [Chongqing], 27 Aug. 1911, leg. G.M. Franck (USNM); 1♀ Chungking, leg. G. M. Franck (RMNH); 2♂ 5♀ Suifu [Yibin] (USNM); 2♂2♀ Szetschswan [Sichuan], *ex* larva 27 & 30 May, 14 June, 5 July 1926, plus two cocoons, one on *Cinnamonum camphora*, one on *Sapindus mukorossii*, coll. R. Gschwandner (NHMW). Shaanxi Province, 1♂ Tsinlingshan, Tapaishan [Taibai Shan], 1700 m, 9 July 1936, leg. H. Höne, genitalia no. 180/97 Naumann (ZMHB); 1♂ Tsinlingshan, southern Taibai Shan, Houzhenzi village, 33˚53'N/107˚49'E, 1500 m, 5-10 May 2000, leg. V. Sinjaev & V. Plutenko, received from A. Schintlmeister (Naumann); 7♂ southern Shaanxi, environs of Ankang, July 1997, leg. Ma, genitalia no. 310/98 Naumann (Naumann); 1♂ southern Shaanxi, 30 km south of Hanyin, 1100 m, Aug. 1999, leg. Jing (Naumann); 1♂ Daba Shan, Shou-Man village, 32˚14'N/108˚34'E, 1000 m, 25 May-14 June 2000, leg. V. Sinjaev & V. Plutenko, received from A. Schintlmeister (Naumann); 5♂1♀ southern Shaanxi, near border with Sichuan, Daba Shan, Wuanyuan, July 1998, leg. Long (Naumann); several ♂♀ Daba Shan, Huayueshan, Wuanyuan, 1500 m, from wild collected cocoons, Aug. 2000, on *Cinnamonum camphora*, leg. Long, 1st generation emerged in Germany April 2001, 2nd and 3rd generation reared *ex ovo* in Germany and Texas on ailanthus, emerged June, July, Aug. & Dec. 2001 [some labeled Sichuan] (Naumann, Peigler, LACM). Hubei Province, 8♂1♀ Changyang, Wushangling, July 1998, leg. Li (Naumann); 3♂1♀ Fanxian [=Fangxian], Hei Shan, 1700 m, Aug 1998, leg. Li & Yang (Naumann); 10♂6♀ S. Ankang, 500 m, May 1997, leg. Ma, ♂genitalia no. 236/98, 260 - 262/98, & 277/98 Naumann (Naumann); 6♂4♀ East Hubei, Tiantangzhai, Yinshan, 1600 m, June 1997, leg. Li (Naumann). Anhui Province, 5♂7♀ southern Anhui, Quinyang, Hua Shan, 1400 m, July 1997, leg. Li, ♂genitalia no. 265/98 Naumann (Naumann). Zhejiang Province, 3♂1♀ eastern Zhejiang, Yueqin [=Yueqing], Beimyantang Shan, July 1997, leg. Li, ♂genitalia no. 618/01 Naumann (Naumann). **Taiwan:** 2♂ paratypes, Taitung County, 2 km north of Tupan, 120˚52'E/22˚29'N, 500 m, 16 Oct. 1995, leg. T. Csovary & P. Steger (Witt); 5♂ paratypes, 4 km N Tupan, 120˚52'E/22˚28'N, 390 m, 13-14 Aug. 1996, leg. T. Csovary & L. Mikus (Witt); 1♂ paratype, same locality, 1 July 1997 (Witt); 1♂ paratype, same locality, 3 July 1997 (Witt); 3♂ paratypes, 3 km west of Hungyeh, 120˚52'E/23˚28N, 350 m, 15-16 Aug. 1996, leg. T. Csovary & L. Mikus (Witt); 3♂1♀ paratypes, same data (Brechlin); 2♂ paratypes, 2 km south of Liyusan, 1760 m, 21 Oct. 1996, leg. G. Fábián & F. Nemes (Witt); 2♂1♀ paratypes, 3 km west of Hungyeh, 120˚52'E/22˚28'N, 350 m, 5 Nov. 1996, leg. T. Csovary & C. Szaboky (Witt); 1♂2♀ paratypes, same locality, 30 June 1997 (Witt); 1♂ paratype, same locality, 5 July 1997, leg. T. Csovary & L. Mikus (Witt); 1♂ paratype, same locality, 12 July 1997 (Witt); 1♀ paratype, same locality, 1 Jan. 1997, leg. C. Szaboky & I. Soos (Witt); 1♀ paratype, 7 km east of Taimali, 120˚56'E/22˚41'N, 710 m, 30 May 1997, leg. C. Szaboky & I. Soos (Witt); 2♂ paratypes, same locality, 13 July 1997, leg. T. Csovary & L. Mikus (Witt); 1♂ paratype, Nantou County, 3♂ Sun Moon Lake [Jihyuetan], 760 m, forested area, 20-25 June 1980, Donald R. Davis (USNM); Lushan Spa, 1200 m, 29 April-1 May 1984, leg. H. Yoshimoto (Naumann); 2♀ paratypes, Wushe, at light, 8 July 1981 and 31 March 1987, leg. Hsiau Yue Wang (TM); 1♂ paratype, 3 km east of Tili, 120˚58'E/23˚47'N, 555 m, 31 March 1996, leg. T. Csovary & P. Steger (Witt); 3♂ paratypes, Ursun F., 16 km east of Kuohsing, 121˚00'E/24˚05'N, 560 m, 20-21 July 1996, leg. T. Csovary & L. Mikus (Witt); 1♀ paratype, Tayuling, 2750 m, 19 April 1997, leg. G. Fábián & S. T. Kovács (Witt); 4♂1♀ paratypes, Tungpu, Yu-Shan National Park, 1400 m, 24-25 April 1997, leg. G. Fábián & S. T. Kovacs (Witt); 2♂2♀ paratypes, 3 km SW Tsuifeng, 121˚10'E/24˚06'N, 2100 m, 7 Aug. 1996, leg. T. Csovary & L. Mikus (Witt); 6♂ Pu Li, 23 April-23 May 1957, leg. S. K. Ong, coll. H. Eckerlein (MHNG); 1♂ paratype, Taoyuan County, 14 km east of Fushing, 121˚23'E/24˚50'N, 800 m, 18 May 1995, leg. M. Hreblay & P. Steger (Witt); 2♂ paratypes, same locality, 24-25 May 1995, genitalia no. 28/96 Naumann (Witt); 1♂ paratype, 16 km east of Fushing, 121˚24'E/24˚50'N, 870 m, 5 Oct. 1997, leg. T. Csovary & P. Steger (Witt); 2♂ paratypes, same locality, 21 May 1997, leg. C. Szaboky & I. Soos (Witt); 3♂1♀ paratypes, same locality, 22 Aug. 1996, leg. T. Csovary & L. Mikus (Brechlin); 1♂ paratype, Taipei County, Wulai, 16 July 1968, leg. S. Suzuki, *ex* coll. Y. Arita, genitalia no. 440/99 Naumann (Naumann); 1♀ paratype, Wulai, 12 Sept. 1986 (TM); 2♂ paratypes, Pi Hu, 121˚45'27"E/24˚54'02"N, 450 m, 4-5 April 1997, leg. L. Peregovits & A. Kun (Witt); 1♂ paratype, 10 km southeast of Pinglin, Pihou, 450 m, 16 April 1997, leg. G. Fábián & S. T. Kovács (Witt); 4♂1♀ paratypes, I-Lan County, Guisandao Islet, 16 April 1998, H. Y. Wang (TM); 1♂ paratype, Fushan, 700 m, 121˚34'E 24˚45'N, 9 Sept. 1999, leg. G. Csorba & B. Herczig (Löffler); 1♂ paratype, Kaohsiung County, Lukuei, 4-5 Sept. 1989, leg. C. S. Lin, GP 274/98 Naumann (TNM); 1♀ paratype, Pingtung County, Kentine, 7-10 Jan. 1991, leg. C. S. Lin (NMN); 1♀ paratype, 1 km south of Shinen, 120˚45'E/22˚08'N, 250 m, 14 Oct. 1995, leg. T. Csovary & P. Steger (Witt); 1♂1♀ paratypes, 10 km northwest of Saulin, 120˚46'E/22˚05'N, 350 m, 21 March 1996, leg. T. Csovary & P. Steger (Witt); 1♂1♀ paratypes, same locality, 12 Aug. 1996, leg. T. Csovary & L. Mikus (Brechlin); 1♀ paratype, road no. 199, 120˚51'E/22˚14'N, 500 m, 19 April 1997, leg. L. Peregovits & A. Kun (Witt); 1♂ paratype, 5 km west of Chipen, 470 m, 27-28 April 1997, leg. G. Fábián & S. Kovács (Witt);

Han County, 1♂ Mingchyh Forest Recreation Area, 1180 m, 6 April 2002, leg. G. Fábián (Naumann); uncertain localities, 1♂ paratype, Koamania, July 1907, coll. A. E. Wileman (BMNH); 2♂ paratypes, Kanshirei, 1000 ft., 19 April 1908, coll. A. E. Wileman (BMNH); 1♂1♀ paratypes, Taiwan, bought by R. S. Peigler in 1974 from Mrs. Chang Pi-Tzu (Peigler), 1♂ paratype, same data, received from Peigler, genitalia no 127/97 Naumann (Naumann); 1♀ paratype, same data (LACM); 1♂ "Taiwan," without further data (CMNH). **VIETNAM**: 1♂ "*Samia cynthia* var. *cynthia* Drury, det. Bouvier," " Cochinchine" [Cochin China= southern Vietnam], 1903, leg. de Claybrooke, genitalia no. 233/97 Naumann (MNHN); 1♂ Cho-Ganh, Chu Ga, 1920-1922, coll. L. & J. de Joannis, genitalia no. 222/97 Naumann (MNHN); 1♂ northern Vietnam, Mount Fan Si Pan, northern slopes, Chapa [=Cha Pai], 1600 m, 22˚17'N/103˚44'E, primary forest, April 1995, received from R. Brechlin, genitalia no. 947/96 Nässig (SMFL); 1♂ North Vietnam, Mount Fan Si Pan, Chapa, 1600-1800 m, 22˚20'N/103˚40'E, secondary forest/cultivated land, April 1995, leg. Viktor Sinjaev & local people (SMFL); 1♂ Hoa Binh, 29 May 1990, leg. Edward Palik, sent to R. S. Peigler by Józef Razowski (Peigler).

## *Samia pryeri* (Butler)

(Figs. 17-20, 159-161, 202; Map 1)

*Attacus pryeri* Butler 1878: 388. Butler 1881: 11, col. pl. 43, fig. 5 (♂). Leech 1889: 634 (in part).
*Attacus Pryeri*, Fauvel 1895: 77.
*Attacus Cynthia*, Fukai 1911: 103. [misidentification]
*Philosamia Pryeri*, Kirby 1892a: 749. André 1908: 69. Watson 1911: 5.
*Philosamia walkeri pryeri*, Rothschild 1895: 37.
*Philosamia Cynthia*, Dusuzeau & Sonthonnax 1897: 29 (in part).
*Philosamia cynthia*, Collins 1987: Annex 2: 12 (in part). Ye & Hu 1996: 30 (in part).
*Philosamia cynthia* var. *pryeri*, Kaiser 1919: 64. Bouvier & Riel 1931: 81.
*Philosamia cynthia* var. *Pryeri*, Hick 1948: 9.
*Samia, Attacus cynthia* var. *pryeri*, Aue 1933: 155.
*Philosamia pryeri*, Watson 1913: 46. Packard 1914: 247, pl. 77 (♂). Hawkes 1918: 146. Chowdhury 1982: 4, 6. Tazima 1984: 417.
*Philosamia cynthia pryeri*, Rebel 1924: 111. Rebel 1925a: 11. Rebel 1925b: 156. Bouvier 1927: 921. Broszkus & Bodenheimer 1950: 100. Lének 1958: 68. Inoue 1961: 659. Priesner 1968: 276. Mutuura et al. 1970: 32, pl. 11, fig. 26 (♂, larva). Jolly et al. 1979: 7. Hayakawa & Chino 1981: 43. Nam 1982: 222. Zhu & Wang 1983: 410, pl. 132, fig. 2959 (♂). Belyakova & Lukhtanov 1996: 63. Iizuka et al. 1997: 43.
*Philosomia* [*sic*] *pryeri*, Steeg 1939: 50. [misspelling]
*Samia cynthia*, Matsumura 1931: 730. Miyata 1974: 74. Baxter 1992: 55. Saito 1993: 163. [misidentifications]
*Samia cynthia pryeri*, Jordan 1911b: 213 (in part), *not* pl. 33a [misidentification]. Seitz 1928: 504. Bouvier 1936: 316. Sonan 1937: 203. Ishinoda 1954: 28. Ishinoda 1955: 24. Ando 1960: 61. Collins & Weast 1961: 115. Kojima et al. 1963: 5. Ferguson 1972: 218. Esaki 1973: 225, fig. 2621 (♂). Gómez & Fernández 1976: 292. Gómez & Arroyo 1981: 77. Gardiner 1982: 212. Weast 1989: 4. Zhu & Wang 1993: 257. Shimada et al. 1995: 224. Yamada 1995: 26 (♂). Zhu & Wang 1996: 165, pl. 11, fig. 6 (♂). Song et al. 1996: 11. Park & Tshistjakov 1999: 168. Miyata et al. 2003: 55, figs. 30-32 (♂♀).
*Samia pryeri*, Bock 1938: 24. Peigler 1989: 13. Peigler 1992: 167. Peigler 1996: 14, 121. D'Abrera 1998: 90, 91 (♂).
*Samia* (*Philosamia*) *cynthia*, Villiard 1969: 144 (♀). [misidentification]
*Sine nomen latinum*: D'Aubenton *in* Martinet 1765: pl. 42 (♀). Fukaya 1994: 28-29 (all stages), 31 (♂). Kuzukawa 1999: 1 (♀).

**Types.** We examined the pair of syntypes in The Natural History Museum (London). The male is labeled "*Attacus pryeri* Butler Type." The female is labeled "77.9 Japan." We hereby designate the male (Fig. 17) as lectotype (figured by Butler 1881: col. pl. 43, fig. 5) and the female (Fig. 18) as paralectotype of *Attacus pryeri*. The pair is in good condition. The original description indicates that these two type specimens were collected by F. M. Jonas in Yokohama. Horn and Kahle (1937: 358) indicated that the British Museum (Natural History)

received a shipment of specimens from Jonas in 1877 from Japan. Specimens from the Pryer collection are not syntypes, because they came to The Natural History Museum via the Leech collection in 1900 (accession number 1900-64) (see Horn & Kahle 1935: 151).

**Geographical Distribution** (Map 1). *Samia pryeri* ranges throughout much of Japan, reportedly on all four of the main islands: Hokkaido, Honshu, Shikoku, and Kyushu, although we have not seen material from Shikoku and Hokkaido (see Discussion below). Fukai (1911) said that it is found in southern and central Japan, implying that it is not found in northern Japan [Hokkaido]. We have seen historical and recently collected specimens from the Ryukyu Islands, far south of Japan's main islands. It also lives on Tsushima, a small archipelago halfway between Japan and Korea. Its occurrence at Osaka and on Kyushu strongly indicates its presence on Shikoku, which lies between the two. Zhu and Wang (1983: 410; 1996: 166) cited this taxon from the Chinese province of Heilongjiang. However, the historical specimens labeled as originating from northern China and far eastern Russia must be viewed with skepticism until verified by further collecting. The questions pertaining to its occurrence in Shikoku, Hokkaido, Russia, and China all pertain to possible confusion with *S. cynthia*.

**Diagnosis.** This species has smaller black eyespot markings on the apices of the forewings than other species. The postmedian line forms an S-shaped curve between the crescent and the anal margin. The ground color is ashy gray or greenish gray, fading to dark brown, instead of olive green or cinnamon, fading to tans, in related species. There is a lot more contrast within the postmedian line, strongly marked in white and dull purplish gray, instead of pinkish rose and the more subdued white component seen in *S. wangi* and *S. cynthia*. The male forewing is more falcate in *S. pryeri* than in the allied species. The male genitalia of *S. pryeri* appear taller than those of *S. cynthia*, with a longer and nearly triangular saccus, a longer and more dorsally-directed ventral process of the valve, a very short tip for the dorsal process itself, and always a large sclerite on the dorsal part of the vesica.

**Description.** Adult ♂ (Fig. 17). *Head.* Frons and occiput dark olive brown. Antennae stramineous, 12 mm long, 3 mm wide. *Thorax.* Tergum dark olive brown with thin white collar, sternum mixed patches of white and dark olive green. Legs dark olive brown with white bands. *Forewing.* Length 60-70 mm; ground color dark olive brown, fading to darker brown; costal margin same as ground color but paler; antemedian area ground color; antemedian line white, crossing costal margin straight through cell $R_5$, barely extending onto veins $Cu_{1a}$ and $Cu_{1b}$, extending back to base of forewing, a smoky black edge bordering the white distally; median area darkest pure olive brown; postmedian line strongly convex above crescent, and again below crescent, forming a gentle S-shape, with black, white, pinkish purple, and suffused pink and purple components, curving inward at anal margin; postmedian area of ground color, finely peppered with numerous black scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5-6 mm; submarginal line a straight, dark brown line beginning in cell $M_1$, with a prominent notch in cell $M_2$; outer margin darker outside submarginal line, dark olive gray, fringe on edges of wings; crescent transparent, bordered by white, broad yellow, broad olive, and on the outer arc, narrow black; apex 6-9 mm long, a large grayish purple patch, a white zigzag line with ochre yellow outer tip; eyespot small (2-3 mm), black with white edge proximally, sprinkled with light scales in center proximally, usually with a tiny black speck touching it above; underside with antemedian line absent, postmedian area more suffused with pink; crescent lacking black component. *Hindwing.* Length 45-52 mm. Antemedian area olive brown; antemedian line white; median area olive brown; postmedian line connecting to antemedian line along subcostal margin, colored same as in forewing, protruding distally, curving inward before reaching tornus tip; postmedian area peppered as in forewing; submarginal line obsolete; submarginal ornamentation consisting of double or triple parallel rows of markings; outer margin with fringe, slightly scalloped at ends of veins; crescent colored as in forewing but shorter and more bent; tornus tapering to a gentle point; underside as in forewing. *Abdomen.* Tergum golden yellow, with broad white belt on first two abdominal segments, three longitudinal rows of white tufts, converging at tip of abdomen giving overall white effect; spiracular ornamentation glossy gold with prominent white tufts; sternum about equally ground color and white, in bands and tufts. *Genitalia* (Figs. 159-161). Uncus with two short processes, transtilla with a central lobe, indented a little laterally, vinculum quite broad basally, but the saccus forming a tip, terminating nearly triangular; valve with a long sacculus, ventral process beginning far up dorsally, central process quite short, and dorsal one reduced to a small tip at the costal margin; overall aspect quite tall, compared with other species; sclerotized part of aedeagus slightly longer than in *S. cynthia*, distally ending with a broad ventrolateral sclerite which is bent outward at its top, and a second right lateral process, weakly sclerotized; vesica with three cornuti, the largest always dorsal with broad sclerite medially, small cornutus right lateral, and medium sized cornutus left lateral distally.

Adult ♀ (Figs. 18-20). Differing from ♂ as follows. *Head.* Antennae 10 mm long, 3 mm wide. *Forewing.*

Length 65-78 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9-10 mm; crescent with broader transparent component; apex 5-7 mm long. *Hindwing*. Length 48-55 mm; tornus more rounded on outer margin. *Abdomen*. Tergum golden yellow areas widely separating white tufts; spiracular ornamentation large gold ovals up to 2 mm long, bordered with broad white bands; sternum with two longitudinal white median bands, with gold band between, and dark patches along outer edges of white bands. *Genitalia* (Fig. 202). Anal papillaes long and bifurcated, and a bifid lobe on the oviporus; lamella postvaginalis quite long, almost semi-circular, lateral sternite separated a little from anterior apophysis; lamella antevaginalis triangular, ventral side longest; anterior and posterior apophyses approximately equal in length.

**Discussion.** This insect was named in honor of Henri James Stovin Pryer (1850-1888), who lived in Yokohama (Butler 1878; Horn & Kahle 1936: 216). The taxon was originally described as a full species and was considered as such by some of the earlier authors, but unfortunately has been treated as a subspecies of *S. cynthia* for most of its taxonomic history, including by many current authors. We reinstate *S. pryeri* to its original species status. *Samia pryeri* not only differs from *S. cynthia* in characters of the wings, genitalia, and probably the larvae, but the two have different chromosome numbers, namely *n*=14 for *S. pryeri* and *n*=13 for *S. cynthia* from Korea and northeastern China (Yosida 1953).

Zhu and Wang (1996: 165) cited the following as a synonym under *pryeri*: *Philosamia mitsougui kaiko* Ouékaki Morikonni, 1848, Yo-Sam-Fi-Rok: 44. Although we have not seen the literature cited, we disagree that this is a synonym. It is a Japanese vernacular name in the Roman alphabet, which Zhu and Wang apparently extracted from Schüßler (1933: 30), who took it from Rondot (1887: 494). Mitsugi refers to *Ilex rotunda*, one of the primary foodplants (Anonymous 1886: 37; André 1908: 73). Mitsougui is a French spelling of mitsugi.

A female of this species is depicted on plate 42 of the famous color plates by D'Aubenton, commissioned by Georges Buffon himself (Martinet 1765), and is labeled "Phalêne à croissant de la Chine." A female of *Antheraea pernyi* is shown on the same plate. An excellent color photograph of a female of *S. pryeri* hanging from its cocoon was published by Yoshihiro Kuzukawa (1999) on the front cover of *Yadoriga*, the news magazine of the Lepidopterological Society of Japan. That specimen was stated to be from Maeda, Gouda-cho, Anpachi-gun, Gifu Prefecture. Esaki (1973) figured a large male with a forewing length of 70 mm.

Inoue et al. (1982) did not consider true *S. pryeri* to be on Hokkaido, and we have not seen material from that island. Inoue et al. considered the populations of *Samia* that are found on Hokkaido and the small island of Tsushima (off the west coast of Kyushu) to be the mainland (Chinese and Korean) form, which they called *S. cynthia walkeri*. We now know those populations to be the introduced Chinese *S. cynthia,* but *S. pryeri* also occurs on Tsushima. We are grateful toYasunori Kishida (pers. comm. to Naumann, June 1998) for his comments pertaining to the various taxa of this genus in Japan. Kishida sent a specimen of *S. cynthia* from Tsushima to Naumann, and then in January 2002, he sent color photographs of specimens of *S. pryeri* from Tsushima that are in the National Science Museum in Tokyo. There are dozens of references to *S. pryeri* or *S. cynthia pryeri* in papers authored by Japanese workers. Except when a figure is given, it is impossible to sort out which ones belong under *S. cynthia* and which under *S. pryeri*, even when the source locality of the stock is cited. The stock with which Saito (1994a) worked was probably *S. cynthia*, since it came from Sapporo. Villiard (1969), whose book is widely used in the United States by amateur lepidoptersists (including the 1975 Dover reprint edition) and who received and reared stock of several moth species from Japan, gave a photograph of an obvious *S. pryeri* labeled as *S. cynthia*, but it is unclear if the immature stages shown on the same page are *S. pryeri*. As stated in our treatment of *S. cynthia* in Japan, a male of that species figured by Jordan (1911b: pl. 33) under the name *pryeri* has exacerbated the confusion between these two taxa in Japan, by workers in all countries. Some of the specimens cited below were collected by Alfred Ernest Wileman (1860-1929) who collected insects extensively in eastern Asia (Horn et al. 1990: 423).

Dr. Hitoshi Saito of the National Institute of Agrobiological Sciences, Tsukuba, Ibaraki Prefecture (formerly the National Institute of Sericultural and Entomological Science), reported (pers. comm. to Peigler, Nov. 1999) that *S. pryeri* feeds on *Ailanthus altissima* in most areas of Japan, including the major islands of Honshu, Shikoku, and Kyushu. However, in Kanto (Saitama, Tokyo, and Kanagawa prefectures) the larvae are found on karasu-zansyo (*Zanthoxylum ailanthoides*). Zansyo (=sansyo) means Japanese pepper, and karasu means crow. Other hostplants commonly reported in the literature as being used in Japan are *Ilex rotunda* and corktree (*Phellodendron amurense*) (Jordan 1911b, Rebel 1925a: 11; Aue 1933: 155). Trees of *Ilex rotunda* may exceed 12 meters in height, and are called round-leaf holly and Lord's holly in the West. Plants cited by Fukai (1911), in addition to the four cited above, include *Celtis sinensis*, *Clerodendrum trichotomum*, *Ligustrum japonicum*, *Osmanthus fragrans*, *Paulownia tomentosa*, *Firmiana platanifolia*, *Cinnamomum camphora*, and *Styrax japonica*. We consider all of these to be reliable, and doubt that any are false hostplants, i.e., based on cocoon finds where larvae strayed from the true hostplant before spinning. Japanese snowbell (*Styrax japonica*) is worth

noting, because Peigler collected cocoons of *Callosamia promethea* on snowbell tree (*Halesia carolina* Linnaeus) in western North Carolina, a plant also in the small family Styracaceae. Fukai additionally cited *Zanthoxylum alatum*, *Ailanthus excelsa*, and *Coriaria nepalensis*, all presumably taken from European authors citing foods of *Samia* in the Himalayas. Therefore, some trees cited above from his list may refer to *S. cynthia* or *S. wangi* in China or Japan and *S. canningi* in India, instead of to *S. pryeri*, although we have listed them in the hostplant appendix under *S. pryeri*. To the known Japanese hostplants, Nakajima (1987: 280) added *Picrasma* and *Sapium*. We assume the latter refers to Chinese tallow (*Triadica* (=*Sapium*) *sebifera*) and/or *T. japonicum*. In Germany, the larvae have been reared on ailanthus and littleleaf linden (*Tilia cordata*) (Steeg 1939). Rondot (1887: 76) stated that *Ailanthus altissima* is not native to Japan, but was introduced from China. In his book on sericulture, Seitz (1918: 81) said he sometimes found larvae of *Samia* when searching on *Phellodendron* for larvae of *Papilio maackii* Ménétriés.

There are five larval instars, and larvae sometimes completely defoliate ailanthus trees, paralleling reports of defoliation by larvae of *S. cynthia* in New York. There are two generations per year, with adults on the wing in May and June and again in August and September. However the second generation is partial according to some authors, and many pupae resulting from the May-June brood do not yield moths for a full year. The species has a sporadic emergence pattern, so moths can be found continually from late May to early October (Ishinoda 1954, Ando 1960, Kojima et al. 1963, Esaki 1973, Fukaya 1994). Compared to other *Samia*, the moths were reported to be hard to pair in captivity, and the males very active and easily excited (Watson 1912: 47).

Parasitoids include several ichneumon wasps which locate and oviposit into exposed cocoons, including *Apechthis capulifera* (=*Pimpla japonica*; *Ephialtes capulifera*) (Aue 1933), *Acropimpla persimilis*, *Iseropus himalayensis*, *Pimpla luctuosus*, and *Pimpla parnarae* (original reports cited by Peigler 1996). Apparently cocoons that hang in the open like those of *Samia* are especially vulnerable to attack by this group of pimpline ichneumonids. Additionally, the tachinid fly *Blepharipa sericariae* (=*Sturmia sericaria*) (Kojima et al. 1963) is a larval-pupal parasitoid. Larvae are also attacked by a bacterial disease and the Little Cuckoo (*Cuculus poliocephalus* Latham, Cuculidae) (Kojima et al. 1963). As has been reported for *S. cynthia* in the United States, Austria, and Spain, cocoons are very subject to over-collecting. Fukai (1911) wrote that collectors searched in the vicinity of Tokyo and found many cocoons every winter for exportation. Although we have sorted out the foodplant preferences as far as possible, some of the aforementioned comments pertaining to defoliation, phenology, natural enemies, and over-collecting may refer to introduced populations of *S. cynthia* instead of to the indigenous *S. pryeri*.

Hokkaido is composed mainly of mixed coniferous forests and mixed northern hardwood forests. Honshu has the same two forest types at its northern tip, but otherwise contains mainly mixed mesophytic forests in the north and central parts, and notophyllous broad-leaved evergreen forests in its central coastal areas and southern sector. Shikoku and Kyushu are mainly composed of notophyllous broad-leaved evergreen forests, with patches of mixed mesophytic forests in the highest elevations (Wolfe 1979: pl. 1). The moth is not found on the Kanto Plain, although ailanthus grows there. *Samia pryeri* is especially found in mountainous areas, particularly at elevations above 500 meters (H. Saito, pers. comm. 1999), unlike *S. cynthia* which appears to prefer lowlands in China, and therefore perhaps also in Japan.

*Samia pryeri* certainly ranges on Honshu as far north as Fukushima on the east side and Niigata on the west side. A male was collected at an altitude of 140 meters on Mount Awaga-dake in Niigata Prefecture on 10 August 1991, and figured by Yamada (1995). In the spring of 1996 Peigler was sent cocoons by Dr. Toshimasa Mitamura, and the cocoons yielded adults of both *S. cynthia* and *S. pryeri* in Colorado. These stocks were from Date-gun, Yanagawa-machi, in Fukushima Prefecture. In January 2002, Yasunori Kishida kindly sent Naumann color photographs of several specimens in the National Science Museum in Tokyo. The specimens which were definitively identified by Naumann as *S. pryeri* have the following data: Yakushima Island [Yaku Jima]: Onoaida (5-8 July 1972, T. Watanabe), Mizuta (13 August 1972, T. Watanabe), Atagodake (4 Sept. 1972, T. Watanabe), Miyanoura, Shiratani (18-20 June 1993, M. Owada); Shizuoka, Oohito (12 Aug. 1977, Y. Kishida); Saga, Taku (14 Aug. 1977, Y. Kishida); Okinawa Islands: Kunigami (8 Sept. 1991, H. Kobayashi), Mount Katsuudake (25 March 1980, K. Yasuda); Yaeyama Islands: Isigaki Island, Bannaake (30 March 1973, Y. Imamura); Iriomote Island, Shirahama (27 May 1973, Y. Kurosawa), Shirahama (1 June 1975, S. Kawahara), Omoto (30 July 1981, M. Owada), Otomirindo (15 March 1993, M. Owada). The latter localities are in the Ryukyu Archipelago which extends between Japan and Taiwan. The range of *S. pryeri* is seen to reach almost to Taiwan, and collection dates suggest that there are probably two generations per year at these southernmost localities. Some of the Saturniidae that are endemic to Taiwan are closely allied to species on Japan (see H. Y. Wang 1988, 1994). Specimens of *S. wangi* on Taiwan appear to have a similar brownish ground color (also fading to darker brown) to that of *S. pryeri*, but their genitalia structure argues in favor of our belief that they are conspecific with populations on mainland China. The chromosome number of *S. wangi* on Taiwan is $n$=13, whereas, as

mentioned above, it is *n*=14 for *S. pryeri*. The occurrence of *S. pryeri* on the Ryukyus and its possible absence on Hokkado, coupled with the aforementioned relationship to Taiwanese *S. wangi*, indicate that *S. pryeri* reached Japan via a southern dispersal route, instead of from Korea or northern China. D'Abrera (1998) also noted the similarity in the facies of Taiwanese and Japanese material.

We doubt that *S. pryeri* lives on the Asian mainland. There has been a lot of historical and recent collecting of Lepidoptera around Vladivostok, and in the Primor'ye Maritime Territory, and near the Amur River. Between 1977 and 1995, Peigler received several lots of papered Saturniidae collected in those regions from entomological correspondents in Estonia, Poland, and Russia, but no *Samia* were ever among the material. Izersky (1999a, b) did not list *Samia* in his survey of the Far East, nor did Gornostaev (1970) cite the genus in his comprehensive field guide to Russian insects. Regarding the pair labeled as coming from the Ussuri in the Amur Region, collected by Arnold Moltrecht in 1909, we note that he collected *S. pryeri* in 1908 in Japan, so it seems possible that the supposed Ussuri material may have been mislabeled. Moltrecht also collected in southwestern China and Taiwan in 1908-1909 (Horn & Kahle 1937: 372). The occurrence of *Samia pryeri* or *S. cynthia* on Sakhalin Island also appears unlikely. The map of Korea in Park and Tshistjakov (1999: 168) shows no records for *Samia* in the northern portions of the Korean Peninsula, not even along the coast, an area only 200 kilometers to the south of Vladivostok. (However, there has been far less collecting activity in the northern part of the Korean Peninsula in recent decades.) The three historical specimens cited below at the end of our "Material Examined" as coming from Amur, Shandong, and Heilongjiang are probably erroneously labeled, or otherwise might represent Japanese material transported by humans in connection with the sericulture trade.

Lhomme (1923-1935: 623) cited "*Samia cynthia pryeri*" from the Gironde area (Bordeaux), contrasting it with "*Samia cynthia walkeri*" in Paris. The specimens we have seen from southwestern France (in The Natural History Museum, London) are true *S. cynthia*, but we concede it is possible that true *S. pryeri* was introduced and established in southwestern France. On the other hand, the introduction may also have resulted from stock of *S. cynthia* imported from Japan, misleading French entomologists into thinking that they had introduced *S. pryeri*.

**Material Examined. JAPAN**: 1♂1♀ syntypes, Honshu Island, Yokohama, leg. F. M. Jonas (BMNH); 1♀ Yokohama, 1 July [18]98 (BMNH); 1♂1♀ "*Attacus pryeri*", Yokohama, ♀ 11 Aug. 1910, ♂ 21 Aug. 1914 (ZFMK); 1♂1♀ Yokohama, 25 & 26 Aug. 1911, leg. Höne, coll. Aussem (Witt); 1♀ Yokohama, *ex* larva 1911, reared by Franz Daniel (Witt); 1♂ Yokohama, 21 July 1911 at light, leg. Höne, coll. R. Gleichauf, genitalia no. 22/96 Naumann (Witt); 1♂1♀ Yokohama, without further data (BMNH); 1♀ Yokohama, leg. Ruegg (MNHN); 1♂1♀ coll. A. J. Buis (ZMA); 1♀ Tokyo, May 1914, coll. L. Ditgens (Witt); 1♂1♀ Saitama Prefecture, Torozawa, 29 July & 1 Aug. 1933, leg. C. Watanabe (USNM); 1♂ Tokyo, July 1914, coll. Robert Gschwandner (NHMW); 1♂ Tokyo, 15 July 1926, leg. M. Aigner (BMNH); 1♀ 6 July 1955 (ZFMK); 2♂10♀, 3 cocoons, environs of Tokyo, Sept. 1958, leg. Tomita (MHNG); 1♀ same data, coll. G. Terral (MHNL); 3♀ Tokyo without data (NHMW); 1♂ Tokyo, *ex* coll. Neuburger, coll. Côte (MHNL); 1♂ Hachiôji, 45 km northwest of Tokyo (MTD); 1♂ environs of Nagoya, Nagashima-sho, 8 June 1967, leg. Isao Imamura, genitalia no. 74/97 Naumann (Witt); 1♂ Osaka, Sakai, 20 May 1952, coll. Franz Daniel (Witt); 2♂2♀ Fukushima Prefecture, Date-gun, Yanagawa-machi, em. June 1996 in Colorado, from cocoons sent by Dr. Toshimasa Mitamura (LACM; Peigler); Osaka Prefecture, 5♂ Osaka, Sakai, em. 26 May 1981, cocoons collected by Dr. Hiroshi Kuroko on *Ilex rotunda*, and specimens sent to Peigler (LACM); 2♀ Kyoto, 20 Aug. 1910, coll. E. A. Cockayne (BMNH); 2♂ 3 June 1956 & 31 May 1957, leg. K. Nishimura (MHNG); 1♂ Kyoto area, R. Lenczy coll. via Arizona-Sonora Desert Museum 1985 (LACM). 1♂ Kobe, 1908, leg. Dr. Moltrecht (BMNH); 1♂ Kobe, end of Aug. 1913 leg. H. Höne (MHNL); 2♂ Kobe, June 1914, leg. H. Höne (ZFMK); 1♀ Kobe, June 1916, leg. H. Höne (MHNL); 3 ♀ end of Aug. 1918, leg. H. Höne (ZFMK); 1♀ June 1926, leg. H. Höne (ZFMK); 1♂ Shoji, 1914, coll. Kaiser, *ex* coll. F. Daniel (Witt); 1♀ Kyushu Island, Nagasaki, *ex* Missions-Museum Steyl, March 1957 (ZFMK); 1♀ Kagoshima, Satsuma Pref. [now in Kagoshima Pref.], 15 July 1895, leg. A. E. Wileman, coll. Wileman , B.M. 1929-261 (BMNH); 1♀ N. Kyushu, 11 May 1954, leg. H. Inoue, Franz Daniel coll. (Witt); 1♂ Ryukyu Islands [Yaeyama Retto], Okinawa Island, May 1904, Rothschild Bequest, genitalia no. B.M. 674 (BMNH); 2♀, Okinawa Island, Yona, 4 Sept. 1970, leg. M. Chujo, *ex* coll. Y. Arita, ♀genitalia no. 624/01 Naumann (Naumann); 1♂ Ishigaki-Jima Island, Nagura, 5 Nov. 1983 at light, leg. K. Fukuzumi, *ex* coll. Y. Arita, genitalia no. 441/99 Naumann (Naumann); 2♂ Iriomote-Jima Island, Shirahama, April 1975, *ex* coll. Y. Kishida, genitalia no. 477& 478/00 Naumann (Naumann); 1♂ Iriomote-Jima Island, Mariudonotaki, 9 Aug. 2001, 20:50 h, leg. K. Fukinuki, genitalia no. 1474/01 Nässig (SMFL); Japan, without further locality data: 2♂2♀ (USNM); 1♂ Japan, leg. Mitsukuri, figured by Packard 1914: pl. 77 (USNM); 1♀ "Mts. Interior", 25 July 1918 (BMNH); 5♂1♀, "Mts. Interior", leg. Höne (BMNH); 2♀, "cocoon ex Mts. Interior" (BMNH); 1♂, "Interieur du Japon", 1925, coll. Ch. Oberthür (MNHN); 4♂3♀ coll. H. Pryer, *ex* coll. Leech 1900-64 (BMNH); 1♂ 8 Aug. 1894, coll. Wileman, B.M. 1929-261 (BMNH); 1♀ 1915 (ZMHB); 3♂1♀ bred (BMNH); 1♂1♀ coll. Staudinger & Bang-Haas (MTD); 1♀ coll. E.

Möbius (MTD); 1♂ 468., "*Philosamia* var." (MHNL). **CHINA**: 1♂, Heilongjiang Province, "*Samia cynthia* var. *walkeri* Feld. ♂", Mandschurei, May 1928, genitalia no. 49/96 Naumann (ZFMK); 1♂ [Shandong Province]: Shantung, *ex* coll. of Missionshaus SVD Steyl (Eing. Nr. 3/59), genitalia no. 91/97 Naumann (ZFMK). **RUSSIA**: 1♂1♀, Amur, "Oussouri," Ussuri District [Ussurijsk], "zwischen Korea und Amur Gebiet" [between Korea and Amur region], 1909, leg. Dr. Moltrecht, Levick Bequest 1941-83 (BMNH).

## *Samia canningi* (Hutton)

(Figs. 21-29, 135, 162-166, 168, 203; Map 4)

*Sat*[*urnia*] *Canningi* Hutton 1859a: 28.
*Sat*[*urnia*] *Canningii*, Guérin-Méneville 1862a: 343 (footnote). [misspelling]
*Attacus Canningi*, Hutton 1859b: 242. Hutton 1863: 63, pl. 2 (cocoon). Hutton 1867: 347. Wardle 1879: 500. Wardle 1881b: 5.
*Attacus canningi*, Wardle 1880a: 218.
*Attacus canningii*, Cotes & Swinhoe 1887: 224. [misspelling]
*Attacus Canningii*, Walker 1865: 525. [misspelling]
*Attacus Canninghii*, Simmonds 1869: 599. Schüßler 1934: 522. [misspelling]
*Philosamia Cumingii*, Grote 1874: 258. [misspelling]
*Attacus cumingii*, Kirby 1892b: 267. [misspelling]
*Attacus baningi*, Lacerca 1983: 64. [misspelling]
*Attacus* (*Philosamia*) *cynthia*, Silbermann 1987: vol. 1: 318 (in part).
*Philosamia canningii*, Butler 1889: 6. [misspelling]
*Philosamia Canningi*, André 1908: 74. Watson 1911: 5.
*Ph*[*ilosamia*] *c*[*ynthia*] *cannigii*, Broszkus & Bodenstein 1950: 100. [misspelling]
*Philosamia cynthia canningi*, Watson 1912: 45. Rebel 1924: 111. Rebel 1925a: 11, pl. 3, fig. 6 (♂). Rebel 1925b: 156, pl. 10, fig. 7 (♂). Crotch 1953: 281. Crotch 1956: 129. Lének 1958: 68. Baxter 1992: 55, fig. 17.
*Philosamia Cynthia canningi*, Bouvier 1927: 920.
*Philosamia cynthia canningii*, Bryk 1944: 3 (in part). Priesner 1968: 276. Jolly et al. 1979: 7. Zhu & Wang 1983: 410, pl. 132, fig. 2956 (♂). Belyakova & Lukhtanov 1996: 63. [misspelling]
*Philosamia cynthia* var. *Canningi*, Sonthonnax 1901: 133. Hick 1948: 9.
*Philosamia cynthia* f. *Canningii*, Schüßler 1933-1934: 28, 522. [misspelling]
*Philosamia canningi*, Watson 1913: 45. Packard 1914: pl. 88, fig. b (larva). Hawkes 1916: 52. Hawkes 1918: 136. Bouvier & Riel 1931: 80.
*Samia cynthia canningii*, Seitz 1928: 504, pl. 52c (♀, as *walkeri*). Zhu & Wang 1993: 256.
*Samia cynthia canningi*, Bouvier 1936: 316. Collins & Weast 1961: 115. Weast 1989: 4. Zhu & Wang 1996: 164.
*Samia canningii*, Lemaire & Peigler 1982: 180. Peigler 1989: 13. Pinratana & Lampe 1990: 6, pl. 1 (larva), pl. 10 (♂, ♀). Peigler 1992: 164, 167. Allen 1993: 55. Saito 1993: 166. Naumann 1995: 26. Peigler & Wang 1996: 65. Peigler 1996: 15, 121. Ramos & Peigler 1999: 18. [misspelling]
*Philosomia canningii*, Steeg 1939: 50. [misspellings]
*Samia canningi*, Gardiner 1982: 212. Mohanraj et al., 1998: 61. D'Abrera 1998: 80, 81 (♀). Brosch et al., 1999: 39. Naumann & Peigler 2001: 79.
*Phalaena Attacus Cynthia*, Cramer 1775: pl. 39, fig. A (♀). [misidentification]
*Bombyx Cynthia*, Tegetmeier 1866: 15, pl. 1 (larva, ♂, ♀) (in part). Clugnet 1877: 53. [misidentifications]
*Attacus cynthia* (in part), Moore 1859: 267. Cotes & Swinhoe 1887: 224. Anonymous 1891: 201. Cotes 1891-1892: 73, pl. 3 (♂, ♀, cocoon). Hampson 1892: 16. Swinhoe 1894: 152. Maxwell-Lefroy & Howlett 1909: 477. [misidentifications]
*Attacus Cynthia*, Walker 1855: 1220 (in part). Horsfield & Moore 1860: 407 (in part). Hutton 1867: 347 (in part). [misidentification]
*Philosamia Cynthia*, Dusuzeau & Sonthonnax 1897: 29 (in part).

*Philosamia cynthia*, Wood-Mason 1886: 20. Swinhoe 1892: 245. Joutel 1907: 101. Pant & Chatterjee 1951: 329. Chowdhury 1962: 7. Linsenmaier 1972: 211 (♂). Jolly et al. 1975: 86. Jolly et al. 1979: 152. Chowdhury 1982: 4. Collins 1987: Annex 2: 12 (in part). Sarkar 1988: 10. Ye & Hu 1996: 30 (in part). Sahay et al. 1997: 25. Seth 2000: 880. [misidentifications]
*Philosamia* (*Attacus*) *cynthia*, Misra et al. 1991: 48. [misidentification]
*Samia cynthia*, Sevastopulo 1946: 414. Watson & Whalley 1975: col. pl. 333, fig. b (♂). Arora & Gupta 1979: 49, fig. 17 (venation, genitalia), pl. 11, figs. 43-44 (♂), 45-46 (♀). Hansen 1988: 5 (larva,♂). Haruta 1994: 159. Gupta 1997: 419 (in part). [misidentifications]
*Samia cynthia cynthia*, Haruta 1992: 93, pl. 26, fig. 9 (♂). [misidentification]
*Samia cynthia walkeri*, Seitz 1928: pl. 52c (♀). [misidentification]
*Samia cynthia* ab. (or var.?) *Andrewesi* Debauche 1929: 65. Schüßler 1933: 39. [infrasubspecific]
*Samia cynthia* ab. (var.?) *andrewesi*, Bang-Haas 1929: 178.
*Samia cynthia* ab. *andrewesi*, Bollow 1932: 130.
*Samia lunula*, Jordan 1911a: 130.
*Philosamia cynthia lunula*, Rebel 1924: 110. [misidentification]
*Attacus ricini*, Wardle 1881b: pl. 8, fig. 1 (♂), fig. 2 (♀). Silbermann 1987: vol. 1: 315, fig. 169 (♂). [misidentifications]
*Samia ricini*, Myers & Bean 1994: 189, fig. 8.3 (♀) (reproduction of fig. 2 in Wardle 1881b: pl. 8). [misidentification]
*Philosamia ricini*, Rondot 1887: 90, fig. on p. 93 (♂), p. 94 (♀). [misidentification]
*Philosamia cynthia* var. *manillensis* Bouvier 1927: 933. [misidentification]
*Philosamia cynthia* var. *insularis* form *manillensis* Bouvier 1932: 44. [misidentification]
*Samia cynthia insularis manillensis*, Bouvier 1936: 316. [misidentification]
*Philosamia cynthia insularis manillensis*, Nässig & Treadaway 1998: 250 [misinterpretation]

**Types.** We examined a pair of syntypes from Hutton's original material in The Natural History Museum. They bear identical labels which read: "Mussoorie; Masuri, Hutton; Moore Coll., 94-106; *Attacus canningii* ♂ [or ♀] cotype) Hutton. We hereby designate the female as lectotype and the male as paralectotype of *Saturnia Canningi*. Both specimens were probably reared from larvae or cocoons and are in good condition including relatively unfaded coloration. The male has a forewing length of 65 mm and hindwing length of 50 mm. The female is smaller, with wing lengths of 61 mm and 47 mm. The lectotype female was figured by D'Abrera (1998: 81).

Bouvier's type of *P. c.* var. *manillensis* we found in the Museum National d'Histoire naturelle, Paris. It is a male in good condition, but mislabeled "*cynthia* Manille." It is a male in good condition, but missing its abdomen, and has a forewing length of 62 mm and hindwing length of 45 mm. There is also a red label that says "TYPE" and the usual large label of Bouvier written by him in pencil: "*Samia cynthia* var. *manillensis* Bouv. ♂ Type Manille / Coll. Ch. Oberthür 1925 (de la coll. Boisduval)." The origin of the name was based on the erroneous belief that the specimen came from Manila, Philippines [French: Manille].

No material labeled as the type of *andrewesi* was located. Moreover, we interprete this name to have been described with an infrasubspecific status (an aberration or variety in the concept by Debauche), and therefore this name is unavailable in the sense of the Code, and as such, no valid type material can exist. This name was misinterpreted by Nässig and Treadaway (1998) as being a synonym of *S. luzonica*.

**Geographical Distribution** (Map 4). *Samia canningi* ranges over much of the southeastern Asian mainland, mostly in northern and eastern India and southern China. The distribution is typically what would be termed sub-Himalayan, with the moth found all along the Himalayan Range from Pakistan and Himachal Pradesh, all through Nepal and Bhutan, and into tropical areas of Myanmar, Cambodia, Laos, northern Vietnam, and down the Bilauk Taung Range of Thailand. In China it is recorded from southern Yunnan and eastern Xizang (Tibet). There are questionable records from northeastern China and Peninsular India that we discuss below. All known records are on the mainland of Asia.

**Diagnosis.** *Samia canningi* is one of the most brightly colored species in the genus, although variable. On the forewing there is always a broad white and black antemedian line connected to the basal part of the crescent, which has a strong, thick yellow component, and always touches or pushes through the curved postmedian line. The male genitalia can be distinguished by the elongated ventral process and large dorsal lobe of the valves.

**Description.** Adult ♂ (Figs. 21-25). *Head.* Frons and occiput brown. Antennae 10-11 mm long, 3.5-4 mm wide. *Thorax.* Tergum golden to rusty brown with thin white collar, sternum mixed patches of white and brown. Legs light brown with major white portions. *Forewing.* Length 65-86 mm; ground color highly variable ranging from dark smoky gray to dark brown to cinnamon rust to brilliant golden orange; costal margin same as ground color but usually paler; antemedian area ground color; antemedian line black, white, and black crossing costal margin straight through cell $R_5$, extending onto veins $Cu_{1a}$ and $Cu_{1b}$ to postmedian line, extending back to base of forewing; median area pure ground color; postmedian line slightly convex above crescent, and again below crescent, with black, white, pinkish purple, and suffused pink and purple bands; postmedian area of ground color, peppered with numerous dark scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5-6 mm; submarginal line a straight, dark brown line beginning in cell $M_1$, with a slight notch in cell $M_2$ and darker where crossed by veins; outer margin darker outside submarginal line, dark olive gray, fringe on edges of wings; crescent transparent, bordered by white, broad yellow fading to pale olive, and on the outer arc, narrow black with a trace of yellow; apex 10-13 mm long, a large grayish purple patch, a white zigzag line with ochre yellow outer tip; eyespot black with white edge proximally, sprinkled with light scales in center proximally; underside with antemedian line absent, but slightly visible from upperside, crescent as above. *Hindwing.* Length 50-64 mm. Antemedian area ground color; antemedian line black, white, and black; median area ground color; postmedian line connecting to antemedian line along subcostal margin, colored same as in forewing, pushed distally by crescent; postmedian area peppered as in forewing, with rose patches sometimes extending from postmedian line out along veins; submarginal ornamentation with strong markings in the forms of rods, or B-shaped dark patches surrounded by lighter ochre yellow; outer margin with fringe, outer margin evenly curved; crescent colored as in forewing but shorter and more bent; tornus tapering to a gentle point. *Abdomen.* Tergum of ground color, with broad white belt on first abdominal segment, weak tufts of white in centers of segments, with larger white tufts on either side, converging at tip of abdomen giving overall white effect; spiracular ornamentation glossy gold with prominent white tufts; sternum about equally ground color and white, in bands and tufts. *Genitalia* (Figs. 162-166, 168). Uncus bifid; transtilla with a central rounded lobe, laterally less broad; vinculum as broad as the saccus is long, thus appearing somewhat rectangular; valves typical over the wide range of this species and very similar to *S. ricini* and *S. fulva*; ventral process medium-sized; central and dorsal processes totally fused into a single large lobe, which lacks defined processes, here very different than in *S. kohlli*; base of vinculum is relatively broad; proximal process of aedeagus very tall and long, bent ventrally, distal part with a sclerotization on left lateral and ventral end and bent outside into a spine; vesica with three bulbs, a large one dorsally, a medium-sized left lateral, and a small right distal-lateral one; dorsal oneusually with a sclerite of varying size medially; the existence and size of this sclerite varies within single populations, but there is a greater tendency to have a more prominent sclerite in western than in southeastern populations.

Adult ♀ (Figs. 26-29). Differing from ♂ as follows. *Head.* Antennae 12-13 mm long, 4 mm wide. *Forewing.* Length 70-81 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 8 mm; crescents and postmedian lines more strongly marked; apex 7-10 mm long. *Hindwing.* Length 63-70 mm; outer margin and tornus more rounded. *Abdomen.* Tergum reddish brown areas widely separating white tufts, central row of tufts very prominent; spiracular ornamentation large gold lanceolate patches up to 3 mm long, bordered with broad white bands; sternum with two longitudinal rows of brown ovals, surrounded by white. *Genitalia* (Fig. 203). Anal papilles broad and short, covered with short and thin bristles; a heavily bifurcate lobe covering the oviporus; lamella postvaginalis nearly triangular, with one side ventral and distal; lamella antevaginalis straight and thin; apophyses, as in *S. fulva*, very short, the anterior ones shorter, the posterior ones 1.5 times as long.

**Discussion.** Unfortunately, there was no formal description of the name *canningi*, but we have determined that Hutton's (1859a) paper leaves no doubt that this taxon was the one he was referring to, and he made some descriptive remarks, i.e., "wild races such as...the sub-Himalayan Eria," so we consider it to represent the first valid description of the name *canningi*. Kirby (1892b) was aware of this problem, stating that there had never been a description, and therefore considered that the name should not be used. This is probably why Jordan (1911a) used the name *lunula*. It should not be surprising that the name *canningi* has been consistently misspelled as *canningii*, because that misspelling was used by several early authors such as Guérin-Méneville (1862a), Cotes and Swinhoe (1887), Walker (1865), and Butler (1889), and in more recent major taxonomic references like Seitz (1928) and Schüßler (1933-1934). The name was proposed by Captain Thomas Hutton to honor Charles John Canning (1812-1862), governor-general and first viceroy of India, serving from 1856 till 1862. Canning promoted many agendas in the British colony, of which sericulture was only one. There is a town bearing his name southeast of Calcutta. A book detailing the life and career of Canning was written by MacLagan (1962).

*Samia canningi* is a large and attractive species that ranges over much of the southeastern Asian mainland, but

only on the mainland. It is found primarily in mountains and foothills, with virtually no records for coastal or very low lying areas. We have examined specimens or seen literature reports from altitudes of 150 to 2500 meters, but we are a bit skeptical of the record from southwestern Yunnan for 3500 meters (over 11,480 feet). The distribution is typically what would be termed sub-Himalayan, mainly on the southern slopes of the range. The few records for Cambodia and Laos were made by the collecting efforts of Sabine Steinke and her brother, thelate Michael Steinke, former residents of Thailand. Specimens were collected in Thailand by Brother Amnuay Pinratana (pers. comm. to Peigler, 15 October 1998) at Kanchanaburi on 12 October 1998. For Thailand (Figs 24-25), it also has been collected at Chiang Mai in August, September and October, and at Nakhon Nayok in September (Pinratana & Lampe 1990). Butler (1889: 6) listed it from the Kangra District, in western Himachal Pradesh. On the northern side of the high mountains, the species occurs in the southern Chinese provinces of Xizang (Fig. 23) and Yunnan. The specimen we cite from Charles Oberthür's collection labeled "Thibet" may have come from Sichuan, as is the case of the lectotype of *S. watsoni* and many other "Tibetan" Lepidoptera that Oberthür received. However, north of the Himalayas, the species is generally displaced by *S. wangi*. To the east (Guangdong, Vietnam, etc.), the montane barrier becomes less defined and less effective, and the species becomes sympatric with or even displaced by *S. kohlli* and *S. wangi*. Its relationship to *S. kohlli* is further discussed under our treatment for that species.

Several records require additional discussion. Specimens for these records have been examined, and verified by genitalia dissection where necessary, so their identity is not in question, but their labeling may be. The Western Ghats extend up into Orissa, so that record is logical. The presence of *S. canningi* in the Eastern Ghats is also plausible, but material labeled as coming from Bombay may have originated further inland, in those mountains. Those from the Isthmus of Kra on the Peninsula of Tenasserim (southwestern Thailand and southeastern Myanmar) (Fig. 28) are farther south than one would expect for this species, but the species has been taken on several mountains of the Dawna Range and Bilauk Taung Range. The species is to be expected also in south-central Xizang, northern Bihar, more locales in Yunnan, and perhaps also southern Guangxi and even southern Sichuan. However, the Khorat Plateau covering most of eastern Thailand is probably not suitable, and Cambodia has very few mountain ranges, primarily in the southwestern portion of that country. Although the occurrence of this Himalayan species would seem highly unlikely in far northern China, four specimens with apparently valid locality data have come into our hands, as cited among our material examined under the province of Heilongjiang. These represent three independent sources, and the female (Fig. 27 and on back cover) received by Naumann from Tieli was in a mailing containing saturniids typical for that region, i.e., *Actias artemis*, *Caligula japonica* Moore, and *Antheraea yamamai*, received directly from China. Moreover, these specimens have the most brilliant golden orange coloration of any we have seen, further suggesting that they represent a distinct population. The genitalia and wing pattern verify that they are true *S. canningi*. Perhaps a population has been introduced by humans to Heilongjiang, possibly even resulting from escapes from a culture of *S. ricini* that phenotypically reverted back to the "wild form" (i.e., *S. canningi*). *Actias selene*, another saturniid of the Himalayas and tropical Asia, was cited from the Far East of Russia by Izersky (1999a, b), and Naumann has received material of *A. selene* from the Heilongjiang. Unfortunately, on the other hand, Izersky is known to mix material; Izersky's (1999c) book on Peruvian moths depicts several saturniids indigenous to southeastern Brazil but stated to be from Peru, as well as the Asian *Antheraea paukstadtorum* Naumann, Holloway & Nässig, misidentified as *Copaxa rufinans* Schaus. To return to *Samia*, the presence of *S. canningi* in Heilongjiang is more plausible by its occurrence in Pakistan (Fig. 22), a region that is also not tropical. We omitted Heilongjiang from Map 4 only because including it would reduce the scale considerably.

One noteworthy feature of the distribution of *S. canningi* is the absence, as far as is known, in southern India and Sri Lanka. Some widely ranging saturniid genera (*Actias, Cricula, Attacus*) have extended their ranges into the Western Ghats along the western coast of India and also on Sri Lanka, and *Loepa* is known from the Nilgiris, but other saturniid genera (*Neoris, Saturnia, Caligula, Salassa, Archaeoattacus*) do not range in India south of the Himalayas. The rainforests of the Western Ghats are separated from those of the Himalayas by about 1000 kilometers of thorn forest and dry tropical deciduous forest (Ripley 1964: 18), but there was a recent mesic connection during the last Pleistocene pluvial period (Mayr 1999: 231, map). We do not believe that *Samia* could have been exterminated in southern India by persistent and systematic collecting of the conspicuous cocoons for silk, given that human populations in that region were not so dense historically, and cocoons of *Antheraea paphia* have apparently been heavily collected for centuries without being exterminated (but are in fact now approaching extermination in some areas of India due to overcollecting).

The caterpillars are undoubtedly found on many different trees and shrubs, given the wide range of distribution of this species, covering mountains and foothills, both temperate and tropical, and a range in altitudes. In Assam, a primary food is the *Ailanthus excelsa*, a sub-Himalayan species similar to *A. altissima*. The Chinese *A. altissima* has also become established in that area according to Dr. S. N. Chowdhury (pers.

comm. to Peigler 11 April 1990), and both species of *Ailanthus* are used by the moth. Extracts from *Ailanthus excelsa* are commonly being used today in herbal medicines. A mature larva was depicted in color on *A. excelsa* by Tegetmeier (1866). *Samia canningi* is well documented to thrive well on *A. altissima* in captivity in England, to where its cocoons were imported from India by the thousands during much of the twentieth century.

An error in the literature citing hostplants of *S. canningi* pertains to the name *Zanthoxylum hostile*. Hutton (1863: 63) said that the larvae feed at Mussoorie on a local plant named "tez-buhl, or *Xanthophyllum hostile*." The spelling of the generic name became corrected by most subsequent authors, but not the specific name, and has been perpetuated by several including Rebel (1925a: 12), Arora and Gupta (1979), and Stone (1991). However, although *Xanthophyllum* (Polygalaceae) is a genus of hardwood trees found in the Indo-Australian region, the name *Xanthoxylon hostile* is a synonym of *Zanthoxylum alatum* Roxburgh, a tree variously called timur, fagara, and in Himachal Pradesh (where Hutton worked) it is called tejphul, a variant spelling of Hutton's tez-buhl above. Thus here is an example where a common name was used to verify the correct identity of a plant whose botanical name was in question. Larvae have also been collected on *Zanthoxylum alatum* (Rutaceae) in Nepal, as cited in our material examined below.

The reference by Chowdhury (1982: 23) to "wild eriworms" being frequently found on the trees of *Evodia fraxinifolia*, Rutaceae (=*Tetradium trichotonum*), suggests that this plant is used by *S. canningi* in the Assam region. Hutton (1863: 63) also reported the shrub *Coriaria nepalensis* to be a food in northern India for *Samia canningi*. The local name for it is mansuri, for which the mountain station Mussoorie was named. Hutton said he reared *Samia* easily on Cape Woodbine, but we found no botanical name for that plant. He indicated that larvae of *S. canningi* did not live well when fed on castor in his area. Incidentally, Hutton also discovered that larvae of the Indian moon moth (*Actias selene*) commonly fed on *Coriaria nepalensis* at Mussoorie (Moore 1859: 263). *Samia canningi* was reported to feed on barberry (*Berberis asiatica*) along with *Attacus atlas* in the province of Kumeon [Kurseong, Sikkim] in northern India (Voelschow 1904: 72). Some of these Himalayan trees and shrubs are listed with their English and Nepali names and their habitats in a useful book by Shrestha (1989). Copies of the periodicals containing the verbose writings of Captain Hutton are apparently now very rare, and we gratefully acknowledge Matthew Kettle for assistance in obtaining photocopies for us of Hutton's papers. These were obtained in the British Library and the library of the Royal Horticultural Society in London, because no copies of the periodicals could be located by us among the holdings of libraries in The Natural History Museum (London), nor any in North America and on the mainland of Europe.

The preimaginal stages of *S. canningi* were described by Sevastopulo (1946). He reared the caterpillars on crepemyrtle (*Lagerstroemia indica*), "bred from ova found at Tudkah (5,000 ft. Darjeeling District)." Larvae were reared in Germany by Steeg (1939) on ailanthus and littleleaf linden (*Tilia cordata*). Misra et al. (1991) also described the immature stages of *S. canningi*, and treated it as a serious defoliator of *Ailanthus excelsa*. These latter authors reported that larvae in the field died of disease caused by the fungal pathogen *Beauveria bassiana* (Balsamo) Vuillemin, and they believed that the pathogen may have practical application in controlling this species when it reaches pest status on *A. excelsa*. In the field, Hutton (1863: 70) wrote that many larvae were destroyed by wasps and hornets (Hymenoptera: Vespidae) at Oudh, where a man named Dr. Bonavia attempted to introduce the species in 1861 for sericultural reasons. Hutton, who confounded this Indian species with the Chinese *S. cynthia*, speculated that *Ailanthus excelsa* used by Bonavia was less suitable than *Ailanthus altissima*, but we disagree. Hutton was unaware that *A. excelsa* is a preferred natural host of *S. canningi* further down the Himalayas to the Southeast. In the larvae, there exists a weak trend toward the pink or reddish scoli that are seen in *S. kohlli* and other species, such scoli containing β-carotene. Sevastopulo (1946) stated that a few of his larvae entered a 6$^{th}$ instar, "similar to the 5$^{th}$ except that the subdorsal tubercles on the 2$^{nd}$ to 10$^{th}$ and the dorsal one on the 11$^{th}$ somite were pale pink instead of blue." Cocoons are basically indistinguishable from those of *S. pryeri*, *S. wangi* and *S. cynthia*, but tend to be larger and more often have a reddish hue. However, some cocoons are gray or beige like those of the aforementioned related species. In 1980 Peigler received three empty cocoons of *S. canningi* from Ramesh C. Narang labeled "*Philosamia cynthia obscura*; Nov. 1979; Labang, Assam; *Ricinus communis*." Pupae from these were used for cytogenetic studies (Narang & Gupta 1979a). These cocoons were deposited in the Natural History Museum of Los Angeles County, with updated identification labeling. They are gray and slender, with peduncles, so are definitely not cocoons of *S. ricini*.

Some specimens of *S. canningi* are truly gigantic, exceeding those of *S. watsoni*, *S. peigleri*, *S. kohlli, S. naumanni* and *S. naessigi*, the species that we consider to be the largest *Samia* on average. One female from Shillong from the Hermann Strecker collection in the Field Museum of Natural History has a forewing length of 85 mm. Generally recognizable by orange tints, appropriately referred to as cinnamon by some authors, the ground color of the wings varies from golden yellow, dark sepia, to grayish brown, but never the greenish tints that characterize *S. cynthia* and its allies to the North. Although specimens have been illustrated in color by many authors, a hand-colored plate by Tegetmeier (1866), a painting of a live male in flight by Linsenmaier

(1972), and a female in Seitz (1928, pl. 52c), all do particular justice to the rich cinnamon coloration. However, the antennae in the figure of Seitz were greatly exaggerated by the artist. Pakistani specimens have short crescents, whereas those from southern Myanmar and southern Thailand are usually dark brown, approaching the coloration of *S. fulva*; ones from northern Vietnam lack the pink outer component of the postmedian line; specimens we have seen from Xizang and Yunnan are often quite colorful. All of these geographical forms have the same genitalia structure. In places like southern Yunnan and northern Myanmar where specimens of *S. canningi* and *S. kohlli* may appear so similar that individual specimens cannot be identified by wing color and pattern, dissection of the genitalia always provides a reliable determination.

The dark sepia form of *S. canningi* can be considered to be semi-melanic. Among *Samia*, we know of melanism only in the *cynthia* species-group, where it has been seen in *S. cynthia* (Pyle 1975), *S. canningi*, (Fig. 26), and some forms of *S. ricini* (i.e., *obscura*). Based on this fact plus their geographical position, the *cynthia* species-group may be closest to the ancestral form that gave rise to the genera *Hyalophora* and *Callosamia*, both of which have genes for melanism well established in their genomes, as seen in *Hyalophora columbia* and *Callosamia promethea*. The wings of semi-melanic specimens of *S. canningi* superficially resemble artificial hybrids between *Callosamia* and *Samia*.

*Samia canningi* varies in its ground color more than any other species in the genus. This polymorphism must be polygenic (Mayr 1999: 72), since it is continuous with intermediates. Several possible explanations are available, but larger samples of specimens from single localities, as well as field observations, may be needed to decide which of these explanations, if any, might be valid. We do not believe that these are seasonal color forms, as is known in *Actias* (Ferguson 1972, Veenakumari et al. 1996), *Callosamia* (Ferguson 1972), and *Rothschildia*. The polymorphism could be a defensive adaptation in some regions to counter against search images formed by avian predators (see Evans 1984: 308). However, the hypothesis that we favor is that this insect occurs in a wide range of habitats in the foothills, mountains, and lowlands, and that many of the populations are sufficiently isolated so that genes which code for wing color expression become fixed or lost quickly. In Nepal, there are at least two forms, a smaller pale form flying in the terai (lowlands) and foothills of eastern Nepal, and a larger, more intensely marked form flying in the mid-hills of central Nepal (Allen 1993). Despite its geographical variation, the synonymy of *Samia canningi* consists entirely of misspellings and misidentifications, except for Bouvier's *manillensis*.

**Material Examined. INDIA**: Assam, 1♂ Almna, western Assam (ZMHB); 3♀ Jorhat, received June 1991 from S. N. Chowdhury, Assam Agricultural University, by Peigler (LACM); 1♂ Dibruhgarh, 1943, leg. W. L. Jellison (USNM); 1♂ Assam (ZMHB); 1 ♀ Assam, *ex ovo* 1 Dec. 1962, reared by P. Battenfeld (Naumann); 2♀ Assam, *ex* pupa 30 June 1982 (Naumann); 1♀ Himalaya, 28 Aug. 1860 (MNHN); 2 mature caterpillars, Assam (NMHW); 2♂1♀ Assam, 3 July 1953, 25 & 28 Aug. 1953, D. H. Schroeter (LACM). Manipur, 1♂ Imphal, coll. H. C. Tytler (BMNH); 2♂1♀ Manipur (NMHW); 2♂ Karen Hill Tracts, PTHG, Sept.-Oct. 1924 (BMNH). 3♀ Nagaland, Naga Hills, Aug. 1923, leg. C. B. Antram (UMO); 6♂2♀ Naga Hills, *ex* larva July 1938 in Coburg, coll. H. Eckerlein (MHNG). Meghalaya, 1♂ Khasia [Khasi] Hills, 1890, leg. Hamilton (ZMHB); 1♂ Khasia Hills, 1893, leg. Rev. W. A. Hamilton (BMNH); 1♂ Khasia Hills, Rothschild Bequest, genitalia no. 174/97 Naumann (BMNH); 2♂ Khasia Hills, 1893, coll. Ch. Oberthür (MNHN); 1♂ Khasia Hills, coll. R. Gschwandner (NMHW); 2♂ Khasia Hills, 3 & 10 May 1935 (DEI); 1♂1♀ Khasi Hills, 1935, coll. J. M. A. van Groenendael (ZMA); 10♀ Khasia Hills, 7 July 1948 (USNM); 6♂ 4♀ Khasi Hills (USNM); 1♂ Khasi Hills, Mawphlang, *ex* pupa 16 June 1920 (ZMA); 5♂3♀ Khasi Hills, Shillong to Mawphlang, 600-1000 m (Naumann); 4♂ Khasi Hills, *ex* pupa 9 & 16 June 1970, 18 & 21 April 1972 (Witt); 1♂2♀ Shillong, 1936, leg. Morendro Doonai (RMNH); 1♂ Shillong, Khasi Hills, Carl F. Krueger collection 1980 (LACM); 3♂2♀ Umran, 33 km north of Shillong, 800 m, 14-23 July 1997, leg. J. Afonin & V. Sinjaev, ♀genitalia no. 631/01 Naumann (Naumann); 2♂ same data, reared on *Ligustrum* in Germany, *ex ovo* May 1998, reared by A. Schintlmeister (Naumann); 1♂1♀ western Meghalaya, Garo Hills, Nokrek National Park, 1150 m, 10 July 1997 (Brosch); 4♂8♀ Khasi Hills, coll. Doncaster (UMO); 2♂2♀ Shillong, coll. Hermann Strecker (FMNH). West Bengal, 1♂ Darjeeling (DEI); 1♂2♀ Darjeeling, *ex ovo* 21 July 1916, adults Sept.-Oct. 1916, reared J. H. Watson (MNHN); 1♂ Darjeeling, Sept.-Oct. 1916 (MNHN); 1♂1♀ Darjeeling (USNM); 1♂ Pedong near Darjeeling, coll. Ch. Oberthür (ZFMK); 13♂ Darjeeling, 1891, leg. Möwis (BMNH); 3♂ Darjeeling, 1891, leg. Möwis (MNHN); 1♂ Calcutta (MHNL). Sikkim, 1♂ "*Ph. lunula*" (RMNH); 1♂ Sikkim, 63/4 (RMNH); 1♂ Sikkim, 1916, coll. Staudinger (NMHW); 1♀ Sikkim, Kurseong (RMNH); 1♂ Sikkim (USNM); 1♂ Sikkim, Mirik, Gopaldhara, leg. H. Stevens (BMNH); 2♂2♀ Sikkim, Darjeeling, Gopaldhara, 745-1160 m, leg. H. Stevens (BMNH); 1♂ southern Sikkim, Gangtok, 1830 m, coll. F. M. Bailey, genitalia no. 176/97 Naumann (BMNH); 1♂ Sikkim, Darjeeling, coll. A. Heyne (ZFMK); 1♀ Sikkim, Mand., coll. Felder (BMNH); 4♂ Sikkim, 1894, leg. local collectors, coll. R. P. Bretandeau (BMNH); 4♂1♀ Sikkim, 2000 m, Aug. 1895, coll. J. G. Pilcher (BMNH); 11♂2♀ same data (UMO); 2♂

Sikkim, coll. J. de Joannis (MNHN). Uttar Pradesh, 2♂ Mussoorie [near Dehra Dūn, 30˚27'N/78˚05'E], coll. J. Davidson (BMNH); 1♂ "*Philosamia ricini*", Dehra Doon [Dehra Dūn] (MHNL); 1♀ District Naini-Tal, north of Bhim-Tal, 1525 m, *ex* larva 28 April 1936, reared by J. A. Graham (BMNH); 2♀ Kumaon-Himalaya, District Naini-Tal, Bhim-Tal, 1500 m, 10 & 20 June 1971, leg. J. de Freina (Witt); 4♂2♀ same locality, 16 July 1977, 3, 13, & 17 July 1978, 7 & 20 July 1979, leg. F. Smetaček (Witt); 1♀ Almora, Garyola, *ex* cocoon July 1913 (BMNH); 2♂1♀ Almora (BMNH); 3♂ Randakeit, leg. Mansfield (BMNH). Himachal Pradesh, 1♂ Kangra [32˚06'N/76˚16'E], 86.69(43) (BMNH); 1♂ Solan near Simla, 1896, leg. Lakhat (BMNH); 3♂ Simla, July 1914, coll. Brodie (UMO); 4♂1♀ Simla, 2135 m, leg. A. E. Jones (BMNH); 2♂1♀ Simla, Punjab [*sic*], 2500 m, July, no. 878 & 879, coll. H. Eckerlein (MHNG); 1♀ Mount Kufri, Simla, Punjab [*sic*], July, 2300 m, coll. Côte (MHNL). Maharashtra, 2♂ Bombay, 1937, coll. M. Steeg (Witt); 2♂ Bombay (NMHW). Orissa, 1♂1♀ Eastern Ghats, Ganjam [north of Brahmapur, ca. 19˚20'N 85˚E], coll. H. J. Elwes (BMNH). Kerala, 1♀ Shembaganur, coll. A. Heyne (DEI). [India], without exact locality, 4♀, *ex* pupa May 1975, cocoons bought by Peigler from Worldwide Butterflies Ltd., Sherborne, Dorset; imported with U.S.D.A. permit (Peigler, LACM); 3♂3♀ John T. Mason collection, donated 1918 (DMNS). India, without additional locality data, 1♀ May 1921, R. W. Dawson (University of Nebraska Museum, Lincoln). 1♂ 1 inflated larva, no data, Karl H. Christian collection, donated Dec. 1954 (LACM). **PAKISTAN**: 1♂ Punjab, Lahore, Soula, June 1878 (NMHW); 11♂2 ♀ Margalla Hills, 20 km north of Islamabad, Pir Sowaha, 600 m, 30˚50'N 75˚55'E, 29-31 July 1994, genitalia no. 21/96 Naumann, leg. B. Herczig, G. M. László & G. Ronkay (Witt). **BHUTAN**: 1♂ Aug.-Sept. 1894, leg. local collectors, coll. R. P. Bretandeau (BMNH); 5♂ Bhutan, Rothschild Bequest (BMNH). **NEPAL**: 1♂ Bagmati, Kathmandu Valley, Nagarkot [32 km east of Kathmandu], 1525 m, 30 Aug. 1934, leg. F. M. Bailey (BMNH); 1♀ Kathmandu Valley, Kakoni, 2070 m, 25 June 1991, leg. M. G. Allen (Paukstadt); 1♂ Kakoni, 2070 m, 1 Sept. 1994, leg. M. G. Allen (Naumann); 1♂ Godavari [25 km south of Kathmandu], 1550 m, 1 July 1991, leg. M. G. Allen (Paukstadt); 3♂2♀ Ganesh Himal Mountains, 3 km northeast of Sumpati [ca. 75 km north of Kathmandu], 2330 m, 13 June 1993, leg. M. Hreblay & G. Csorba, genitalia no. 27/96 Naumann (Witt); 1♂ Kathmandu, 2000 m, 11 July 1996, leg. W. Fickler (Naumann); 1♂ Gandaki, Tanakoun District, Bimalnagar Village, 500 m, 12 Oct. 1994, leg. G. Csorba & G. Ronkay (Witt); 1♂1♀ Janakpur, Jiri, 2200 m, June 2000, leg. O. Ammosov (Naumann); 1♂ same data, received from S. Naumann (Brosch); 1♂ Nagarkak, 30 July 1937, *ex*- larva on *Zanthoxylum alatum* (BMNH). **BANGLADESH**: 1♂ Chittagong State, Silhet (MNHN); 1♀ "Sylhet" (UMO). **MYANMAR**: northern Myanmar, Kachin State, 1♂ Nan Sa Bon, 25 km east of Putao, 27˚21'N/97˚40'E, 800 m, 6-9 May 1998, leg. S. Murzin & V. Sinjaev, genitalia no. 311/98 Naumann (Naumann); 1♂ Nan Thi, 50 km east of Putao, 27˚21'N/ 97˚55'E, 950 m, 11-16 May 1998, leg. S. Murzin & V. Sinjaev (Naumann). Tanin-Thayi State, 4♀ Tenasserim, July 1996, leg. Steinke & Lehmann (Naumann); 1♀ Tenasserim, 18 Sept. 1996, leg. S. Steinke (Naumann); 1♂ Tenasserim, July 1996, genitalia no. 190/97 Naumann (Meister). Kayin State, 2♂ Dawna, northeast of Moulmein, 1300 m, 18 April 1994 & 20 May 1995, genitalia no. 77/97 & 106/97 Naumann, leg. S. Steinke (SMFL); 1♀ Dawna Range, 20 May 1995 (Brosch). Chin State, 1♀ western Myanmar, environs of Thaing-gnin, ca. 2160 m, 23˚11'N/93˚48'E, July-Aug. 2001, primary forest, leg. local collector (Naumann); 1♀ Myanmar, Tingkawk, 29 May 1944, Capt. Kuitert (Snow Entomological Museum, University of Kansas, Lawrence). Without exact locality, 1♂ Upper Burma, Htawgaw, 1830 m [probably Shan State, Loi Tawngyaw, ca. 23˚N/97˚10'E], leg. Capt. A. E. Swann (BMNH). **THAILAND**: northern Thailand, Lampang Province, 1♂ Doi Mae Yen, Wang Tai, Wang Nena Lampang, 6 June 1989, leg. A. M. Cotton (BMNH). 2♂ Chiang Rai Province, Mae Kajan, 6 Nov. 1986, genitalia no. 16/96 Naumann (Naumann); 1♂ Chiang Rai, 27 Sept. 1988, genitalia no. 218 Paukstadt (Paukstadt); 1♀ same data (Beeke); 1♂ same locality, 4 Oct. 1988 (Peigler). Chiangmai Province, 4♂ Maetaeng, 6 Oct. 1998, leg. Sabine Steinke, 1♂ figured by Peigler & Wang 1996 (LACM); 1♂ Maetaeng, 23 Sept. 1988, leg. M. G. Allen (LACM); 1♂ Maetaeng, 6 Oct. 1988, leg. S. Steinke (Beeke); 1♂ Chiang Mai, Aug. 1990, leg. S. Steinke genitalia 468 Paukstadt (Paukstadt); 1♂ Chiang Mai, 1 Sept. 1996, genitalia no. 108/97 Naumann (SMFL); 2♂ Chiangmai, 10 km south of Chiang Dao, 14/15 Aug. 1980, leg. D. Burckhardt (MHNG); 3♂ Doi Kan, 500 m, July 2000, leg. local people (Löffler); 1♂ same locality, Aug. 2000, leg. S. Löffler (Löffler); 3♂3♀ same locality, end of Sept. 2000, leg. local people (Löffler). Central Thailand, Nakhon Ratchasima Province, 2♀ environs of Pak-Chong, Khao-Yai National Park, 4-22 Sept. 1998, leg. S. Löffler (Löffler); 1♂ same locality, *ex ovo* June 1999 in Germany on *Ligustrum*, reared by S. Löffler (Löffler); 1♀ same locality, 6-12 Aug. 2000, leg. S. Löffler (Löffler). Peninsular Thailand, Ranong Province, 1♀ environs of Ranong, March-April 1999, leg. Steinke & Lehmann (Beeke); 4♂ same data, genitalia no. 364 & 365/99 Naumann (Naumann); 4♂ same data (Brosch). **LAOS**: Louang Prabang Province, 2♀ 100 km east of Louang Prabang, Military Camp, 1400-1800 m, July 1997, leg. M. Steinke (Naumann); 1 ♂ same locality, 20 Aug.-10 Sept. 1997, genitalia no. 413/99 Naumann, leg. M. Steinke (Beeke); 1 ♀ same locality, 20 Sept.-10 Oct. 1997, leg. M. Steinke (Brosch); 1♂2♀ Ban Hin Ngon, 15 km southwest of Xam Nua, ca. 20˚17'N/103˚58'E, 1000 m, 11-20 Sept. 2002, leg. Ihle (Löffler). **CAMBODIA**: southwestern Cambodia, Batdambang Province, 2♀

Pailin, 300 m, 5-8 June 1999, leg. S. Steinke & H. Lehmann (Naumann); 2♀ same data (Brosch). **VIETNAM**: 1♀ northern Vietnam, Hoa Binh Province, environs of Hoa Binh, 1935, leg. A. de Cooman (MNHN). Vinh Phu Province, 15♂ Tam Dao, 60 km northwest of Hanoi, 950 m, 21˚34'N/105˚20'E, secondary forest, April 1995, genitalia no. 20/96 Naumann, leg. V. Sinjaev (Witt); 2♂ same data, but 1200 m (Witt). Lai Chau Province, 5♂2♀ Mount Fan-Si-Pan, western slopes, 1600-1800 m, May 1994, 30 June-12 July 1994, July 1994, Sept. 1994 (Brechlin); 2♂ same locality, 2000 m, July 1994 (Brechlin); 1♂ Mount Fan-Si-Pan, northern slopes, 1525 m, July 1994 (Brechlin). Lao Cai Province, 4♂ Mount Fan-Si-Pan, western slopes, Chapa, 1600-1800 m, 22˚20'N/103˚40'E, April 1995, leg. V. Sinjaev & local collector, genitalia no. 216/97 Naumann (SMFL); 2♂ Mount Fan-Si-Pan, 2000 m (Vinciguerra). So'n La Province, 10♂1♀ Mai Chau, 1400 m, 20˚50'N/ 104˚50'E, 25 km southeast of Moc Chau, 7-22 April 1995 (Brechlin); 2♂ same data, genitalia no. 949/96 & 973/96 Nässig (SMFL). Cao Bang Province, 6♂ environs of Cao Tri, Be Be Lake National Park, 500 m, 6-8 Nov. 2000, leg. S. Löffler (Löffler). **CHINA**: Yunnan Province, 2♂1♀ southern Yunnan, 30 km north of Lanchang, east of Simao City, Hei Shan, 2400 m, 20-30 Aug. 1999, leg. Wang & Li, ♂genitalia no. 473 & 474/00 Naumann (Naumann); 1♂ same locality, 2200-2400 m, Sept. 1999 (Naumann); 1♂ same data, received from S. Naumann (LACM); 1♂ same locality, 2300 m, Aug. 1999, leg. Zhi, genitalia no. 616/01 Naumann (Löffler); 1♀ western Yunnan, Yunling County northern border, north of Baoshan, Daoren Shan, 2800-3200 m, Sept. 1999, leg. Wang & Li (Naumann); 1♂1♀ southwestern Yunnan, Juangjiang, Daxue Shan, 3500 m, 22-28 May 1999, leg. Wang & Li (Naumann); 2♂ southern Yunnan, Wongding forest area, 20 km west of Changyuan, 2500 m, Sept. 1999, leg. Wang & Li, genitalia no. 455/00 Naumann (Naumann); 4♂ southeastern Yunnan, Maguan, Suiyuanqing, 2500 m, July 2000, leg. Li & Tu (Naumann). Heilongjiang Province, 1♂♀ Mandchuria, May 1928, coll. Aussem, ♂genitalia no. 26/96 Naumann (Witt); 1♂ "*S. cynthia walkeri*" [*sic*], Mandchuria, genitalia no. 49/96 Naumann (ZFMK); 1♀ Tieli, Xiaoxinganling, 1300 m, 46˚59'N/128˚4'E, Aug. 1999, leg. Zhu (Naumann). Xizang [=Tibet]: 1♀ "Thibet, *Phil. cynthia* [*sic*], coll. Ch. Oberthür" (MNHN); 3♂1♀ southeastern Xizang, Metok, Beibeng, 29˚29'N/95˚20'E, 850 m, 27 Aug.-4 Sept. 1995, leg. H. Hao, ♂genitalia no. 115/97 Naumann (Naumann); 1♂ Yigong, ca. 30˚30'N/94˚80'E, 2300-2400 m, collected May-Sept. 1996, bought Sept.-Oct. 1996, leg. Wang, genitalia no. 294/98 Naumann (Naumann).

## *Samia ricini* (Anonymous)

(Figs. 30-32, 118-119, 133-134, 167, 169, 204)

*Phalaena Ricini*, Donovan 1798: 82. Roxburgh 1804: 43.
*Phalaena Cynthia*, Roxburgh 1804: 42, pl. 2 (eggs, larvae cocoons). [misidentification]
*Bombyx Cynthia*, Anonymous 1854: 29. Newman 1854: 29. Royle 1856: 216. [misidentifications]
*Saturnia Cynthia*, Duncan 1841: pl. 15 (larva). Costa 1854: 3, pl. 1 (all stages). Hutton 1855: 169 (in part). Kirby & Spence 1856: 190. Rössler 1859: 420. [misidentifications]
*Philosamia cynthia*, Henke 1936: 7, pls. 5-7. [misidentifications]
*Bombyx* (*Saturnia*) *cynthia*, Wullschlegel 1863: 171. [misidentification]
*Samia cynthia*, Collins 1987: Annex 2: 12. Masó & Pijoan 1997: 233, 292 (♀). Gupta 1997: 419 (in part). [misidentifications]
*Phalaena Penelope* Buchanan 1833: 214. Junior primary homonym of *Phalaena Attacus Penelope* Cramer 1775. [See International Commission on Zoological Nomenclature 1987: 145; and Lemaire 1988: 46]
*Philosamia penelope*, Schüßler 1933-1934: 32, 733.
*Saturnia Ricini*, Boisduval 1854: 755. Wullschlegel 1863: 171.
*Bombyx Ricini*, Roxburgh 1804: 43. Wallace 1866: 187. Wallace 1867: 490.
*Bombyx Ricinus*, Tegetmeier 1866: 15. [emendation]
*Attacus Ricini*, Hutton 1863: 71. Hutton 1872: Appendix: 6. Wardle 1879: 500. Wailly 1882: 260. Wailly 1886: 15. Pagenstecher 1890b: 14. Weymer & Maassen 1890: 92.
*Attacus* (*Bombyx*) *ricini*, Figuier 1892: 247.
*Attacus* (*Saturnia*) *Ricini*, Snellen van Vollenhoven 1862a: 15.
*Attacus ricini*, Moore 1859: 267. Walker 1865: 525. Wardle 1880a: 218. Wardle 1881a: 646. Wardle 1881b: 4 (in part). Stack 1885: 214. Cotes & Swinhoe 1887: 225. Cotes 1890: 163. Anonymous 1891: 199. Hampson 1892: 17. Swinhoe 1894: 152. Silbermann 1897:

vol. 1: 314 (not fig. 169); vol. 2: 170. Tutt 1902: 291. Haly et al. 1903: 1. Watt 1908: 1011. Maxwell-Lefroy & Howlett 1909: 479, pl. 44, fig. 1 (♀), fig. 2 (♂). Candèze 1927: 120. Leefmans 1930: 98. Pant & Chatterjee 1951: 329. Kalyanam 1967: 53. Quo & Pan 1964: 20. Bhargava & Narian 1972: 237. El-Shaarawy et al. 1975: 82. Dunsmore 1993: 59. He et al. 1998: 153.

*Attacus racinii*, Saxena & Srivastava 2001: 249. [misspelling]

*Philosamia Ricini*, Dusuzeau & Sonthonnax 1897: 91 [31]. Côte 1904: 4 (in part). Watson 1910a: 24. Watson 1911: 5, pl. 3 figs. A-B (♂ ♀ cocoon).

*Philosamia ricini*, Wood-Mason 1886: 20. Rondot 1887: 90 (in part). Swinhoe 1892: 245. Watson 1913: 47. Packard 1914: pl. 88, fig. a (larva), pl. 93 (♂, ♀, larva, cocoon). Hawkes 1916: 51. Hawkes 1918:135. Léon 1925: 123 (♀, eggs). Bouvier & Riel 1931: 81. Teissier 1936: 340. Koidsumi & Shibata 1938: 212. Lének 1958: 68. Chowdhury 1962: 7. Jolly et al. 1975: 77. Jolly et al. 1979: 5, 139-162. Narang & Gupta 1979: 217. Chowdhury 1982: 4, figs. 1-2 (♂, ♀, cocoons). Joarder 1984: 1. Sarkar 1988: 10. Andriamahenina 1996: 11. Sahay et al. 1997: 25. Mohanty 1998: 30. R. K. Goel *in* Agrawal & Seth 2000: 61. S. S. Misra *in* Agrawal & Seth 2000: 218.

*Philosamia ricinii*, Watson 1910b: 255 (footnote). [misspelling]

*Philosamia cynthia ricini*, Rebel 1924: 112. Rebel 1925a: 13, pl. 3, fig. 8 (♂). Rebel 1925b: 158. Bouvier 1927: 920. Takeda 1950: 143. Crotch 1953: 281. Crotch 1956: 130. Inoue 1961: 659. Wu 1962: 371. Priesner 1968: 276. Tomida & Ishii 1968:103. Jolly et al. 1979: 7. Hayakawa & Chino 1981: 43. Tazima 1984: 416. Baxter 1992: 54. Tomida & Fuse 1993: 1760. Belyakova & Lukhtanov 1996: 63. Ye & Hu 1996: 30. Iizuka & Itoh 1997: 37.

*Philosamia cynthia* form *Ricini*, Hick 1948: 9.

*Philosamia cynthia ricina* [*sic*], Zhu et al. 1979: 22, col. pl. 8, fig. 28 (larva, ♂). Zhu et al. 1984: 143, col. pl. 55, fig. 657 (♂). Guo 1989: 548. L. Y. Wang 1992: 801. Huang 1993: 423. X.-Y. Wang et al. 2000: 57. [misspelling]

*Philosoma* [*sic*] *cynthia ricini*, Yang 1978: 436, pl. 25, fig. 1 (♂). [misspelling]

*Philosomia* [*sic*] *ricini*, Steeg 1939: 50. Rajkhowa 1996: 37. [misspelling]

*Philosemia* [*sic*] *ricini*, de Zayas 1989: 62. [misspelling]

*philosamia ricinia*, Baruah 1989: 1. [misspellings]

*Philosamia racini*, Baruah 1989: 81. [misspelling]

*Philosamia Bacini*, Baruah 1989: pl. [10] (larvae). [misspelling]

*Samia cynthia ricini*, Seitz 1928: 504, pl. 52c (♂). Bouvier 1936: 317. Collins & Weast 1961: 115. Bowers & Thompson 1965: 1003. Ferguson 1972: 217. Esaki 1973: 225, fig. 2620 (♂). Fujishita & Ishizaki 1981: 121. Hoque & Khan 1987: 397. Takahashi & Enomoto 1987: 249. Weast 1989: 4. Bestmann et al. 1989: 2911. Neupane et al. 1990: 113. Tomida & Mayesawa 1992: 1962. Saito 1993: 163. Saito 1994b: 213. Takahasi & Enomoto 1995: 303. Shimada et al. 1995: 224. Sauman & Reppert 1996: 418. Saito 1998a: 141. Reddy et al. 1999b: 42. van Beek et al. 2000: 1077. Iizuka 2002: 32 (Table 1).

*Samia cynthia vicini*, Ishinoda 1954: 28. [misspelling]

*Samia cynthia* f. *ricini*, Arora & Gupta 1979: 53.

*Samia, Attacus cynthia* var. *ricini*, Aue 1933: 157.

*Samia* "*ricini*", Naumann 1995: 26.

*Samia cynthia ricina* [*sic*], Zhu & Wang 1993: 257. Zhu & Wang 1996: 166, pl. 12, fig. 1 (♂). Park & Tshistjakov 1999: 168. [misspelling]

*Philosamia cynthia ricina* [*sic*], Wu & Lin 1995: 351. [misspelling]

*Semia* [*sic*] *cyntia* [*sic*] *ricini*, Kishida 1977a: 3. [misspellings]

*Cynthia Ricini*, Anonymous 1980: 73. [*lapsus calami*]

*Samia ricini*, Bock 1938: 24. Gardiner 1982: 212. Lemaire & Peigler 1982: 180. Peigler 1992: 164, 168. Myers & Bean 1994: 213. Peigler 1996: 62, 121. Peigler & Wang 1996: 94-102. Friedlander et al. 1998: 132. Naumann 1998: 455. D'Abrera 1998: 82, 83 (♂♀). Ramos & Peigler 1999: 18. Peigler 1999: 66. Selk 2000: 71 (♂, larvae, cocoons). Seth 2000: 879. Reddy et al. 2001: 75. Peigler & Baird 2001: 5. Singh and Benchamin 2002: 20.

*attacus* [*sic*] *arrindia* Milne-Edwards 1854: 13.

*Attacus* (*Philosamia*) *arrindia*, de Cordemoy 1902: 33.

*Attacus Arrindia*, Koch 1873: 96.

*Attacus arrindia*, Girard 1868: lxxii. Clément 1899: 104. Tutt 1902: 291. Tutt 1906: 26.
*Attacus arrindis*, Lacerca 1983: 67. [misspelling]
*Saturnia Arrindia*, Snellen van Vollenhoven 1862b: 337. Guérin-Méneville 1862a: 341. van Westmaas & de Graaf 1862: 117.
*Saturnia arrindia*, Mulder 1862: 163.
*Saturnia Arrundi*, Royle 1856: 216. [misspelling]
*Saturnia arrundi*, Moore 1859: 267. [misspelling]
*Bombyx arrindia*, Darwin 1859: 213.
*Bombyx Arrindia*, Guérin-Méneville 1860a: 6. Roy 1864: 6. Clugnet 1877: 53.
*Philosamia arrindia*, André 1908: 78, fig. 46 (♀), fig. 47 (cocoon).
*Philosamia cynthia* f. *arrindia*, Schüßler 1933-1934: 34, 532.
*Saturnia Dupuiseti* Boisduval 1854: 755.
*Attacus guerini* Moore 1859: 269, Annulosa pl. 65, fig. 3 (♂). Cotes & Swinhoe 1887: 225.
*Attacus Guerini*, Moore *in* Horsfield & Moore 1858 [1860]: 409. Walker 1865: 525. Wardle 1879: 500. Silbermann 1897: vol. 1: 322. [junior homonym and objective synonym of *Attacus guerini* Moore, 1859]
*Attacus Guérini*, Wardle 1881b: 5. [emendation]
*Attacus* (*Saturnia*) *Guerini*, Snellen van Vollenhoven 1862a: 15.
*Bombyx Guerinii*, Wallace 1867: 490. [emendation]
*Philosamia Guerini*, Grote 1874: 258. Kirby 1892a: 748.
*Philosamia lunula* ab. *guerini*, Rothschild 1895: 37.
*Philosamia cynthia canningi* ab. *guerini*, Rebel 1925a: 4.
*Samia cynthia* ab. *guerini*, Bouvier 1936: 317.
*Philosamia Ricini* Var. *Guerini*, Sonthonnax 1901: 133.
*Attacus obscurus* Butler 1879a: 5. Wardle 1879: 500. Wardle 1881b: 5. Cotes & Swinhoe 1887: 225. Silbermann 1897: vol. 1: 322.
*Philosamia lunula* ab. *obscura*, Rothschild 1895: 37.
*Philosamia Obscura*, Kirby 1892a: 748.
*Philosamia cynthia obscura*, Rebel 1924: 110. Rebel 1925a: 13. Rebel 1925b: 158. Crotch 1953: 281. Crotch 1956: 130. Jolly et al. 1979: 7.
*Philosamia cynthia* var. *obscura*, Bouvier 1927: 920.
*Samia cynthia obscura*, Seitz 1928: 504. Bouvier 1936: 317.
*Philosamia cynthia ricini* ab. *Guerini*, Bouvier 1927: 935.
*Saturnia iole* Westwood 1881: 144, pl. 12, fig. 1 (♂). Cotes & Swinhoe 1887: 226.
*Philosamia iole*, Packard 1914: 248.
*Philosamia Iole*, Kirby 1892a: 749.
*Philosamia walkeri* ab. *iole*, Rothschild 1895: 37.
*Philosamia cynthia* ab. *jole*, Rebel 1925a: 4. [emendation]
*Samia cynthia* ab. *jole*, Seitz 1928: 504. [emendation]
*Samia Cynthia Iole*, Collins & Weast 1961: 115.
*Attacus lunula* Walker 1855: 1221. Wardle 1879: 500. Wardle 1881b: 5. Silbermann 1987: vol. 2: 170.
*Attacus Lunula*, Weymer & Maassen 1890: 92.
*Attacus ricini* var. *lunula*, Silbermann 1897: vol. 1: 322.
*Philosamia lunula,* Kirby 1892a: 748. Kirby 1897: 89, pl. 115, fig. 1 (♂), pl. 118 (larva). Packard 1914: 248, pl. 77, fig. 2 (♂). Fauvel 1895: 71, 77.
*Samia Cynthia Lunula*, Collins & Weast 1961: 115 (in part).
*Philosamia Ricini* Var. *Lunula*, Sonthonnax 1901: 133.
*Philosamia cynthia lunuloides* Rebel 1924: 110. Rebel 1925a: 13. Rebel 1925b: 159. Bouvier 1927: 934. Jolly et al. 1979: 7.
*Samia cynthia lunuloides*, Seitz 1928: 504. Bouvier 1936: 317.
*Philosamia cynthia* var. *fusco-fasciatus* Bouvier 1927: 931. [incorrect original spelling]
*Samia cynthia fusco-fasciatus*, Bouvier 1936: 316.
*Sine nomen latinum*: Milburn 1813: 244. Kehimkar 1997: 3 (♀). Reddy et al. 1999a: 91. Castiglioni 2001: 64.

**Types.** No original material on which the name *Phalaena Ricini* was based is extant, nor did we locate any specimens that could be identified as potential types of Moore's *Attacus Guerini.* There are several reasons that we do not wish to select and designate a neotype for the name *ricini.* We do not know the original generic combination, because we do not know which publication contains the first validly published description for the name; it is probably one we have not seen. Furthermore, stability of nomenclature would not be enhanced by designation of a neotype. Lastly, since this species does not exist as wild populations, fixing a type locality by selecting a neotype would not be logical.

In the Muséum National d'Histoire naturelle in Paris, Naumann located at least two specimens to which Milne-Edwards may have referred when describing *Attacus Arrindia*. One male bears the label "*Bombyx cynthia* et *arrindia*, Ann. Soc. Ent. Bull. 1858, pl. CLXXXIII," and a second male has following label: "*B. Arrindia*, Soc. Agr. France Bull. 1854, t. 10, p. 13." It is at least certain that the second one is an original syntype since its label refers to the original description, so we hereby designate it as the lectotype of *attacus* [*sic*] *arrindia*. As we were not able to view the original description, we gratefully acknowledge the help of Claude Lemaire who kindly located and transcribed it plus its full citation for us. As pointed out already in our discussion of hostplants, the name arrindi is a local name for the castorbean plant.

Also in the Muséum National d'Histoire naturelle, there are four males with identical labels "*Sat. arrindia* var. *Dupuiseti* Bd.V. [Boisduval], Inde Anglaise, Becker, Silhet; *Philosamia cynthia* var. *ricini* Jones (Bdv.), passant à la var. *obscura* Butl., coll. G. Méneville, E. L. Bouvier det." [handwritten by Bouvier]. Although unclear to which among this series Boisduval (1854) intended in his description, we select the largest one of those four specimens and designate it as lectotype of *Saturnia arrindia* var. *Dupuiseti*.

We examined one male and three female syntypes of *Attacus obscurus* in The Natural History Museum. All of them are labeled: "*Attacus obscurus* ♀ Butler; Cachar 78.70" with the male erroneously labeled as a female. One female, the darkest of the four specimens, is further labeled "Type" and we hereby designate that specimen as lectotype of *Attacus obscurus*, and the other two females and male as paralectotypes. All four are uniformly chocolate brown in color. The type locality of Cachar is a district in southern Assam, bordering Manipur and Mizoram.

In the Hope Entomological Collections, University Museum, Oxford, Naumann located the male holotype of *Saturnia iole* described by Westwood (1881). It bears following labels: "type Lep. No. 1982 *Saturnia iole* Westwood, Hope Dept. Oxford; Westwood's type of *Saturnia iole* [handwritten]; *lunula*, n. s. [blue, handwritten by Walker]; Assam" plus a piece of blue paper with nothing written on it. The specimen has a forewing length of 51 mm and shows, as in the figure in the original description, somewhat deformed wings, probably caused by problems during emergence from its cocoon.

Also in the Hope Entomological Collections, University Museum, Oxford, Naumann examined a male syntype of *Attacus lunula* with following labels: "type Lep. No. 1983 *Attacus lunula* Walker, Hope Dept. Oxford; F. Walker's type of *Attacus lunula*, 5-1221 [handwritten]; Sylhet [handwritten]." The specimen is well preserved and has a forewing length of 57 mm. We examined a second male in The Natural History Museum labeled as being a type of *Attacus lunula*. It bears the following labels: "type ♂ *Philosamia* (Grote) *lunula* Walk.; Type; Silhet 43.58." This dwarfed specimen is in fair condition, with a forewing length of 50 mm and a hindwing length of 40 mm. It also bears a circular blue syntype label. Swinhoe (1892: 246) already mentioned that the type of *Attacus lunula* was in the museum at Oxford. We hereby designate the specimen at Oxford as lectotype of *Attacus lunula*, and the one in The Natural History Museum as a paralectotype. The type locality of Silhet, also spelled Sylhet, is now in Bangladesh.

Two male syntypes of *Philosamia cynthia lunuloides* with nearly identical labels were located by Naumann in the Naturhistorisches Museum Wien. Those read: "*Philosamia lunuloides* Rbl ♂ Type [red]; Don '19 Gschwandner [handwritten, not in Gschwandner's handwriting]; Assam [printed]" and one bears an additional label "6." The specimen without that number has a forewing length of 53 mm and is hereby designated as lectotype, the paralectotype hereby designated has a forewing length of 52 mm.

In the Muséum National d'Histoire naturelle in Paris, we found a female singleton labeled as "*Samia cynthia* var. *fuscofasciata* Bouvier, ♀ type, Java, coll. De Beaulieu, E. L. Bouvier det. [handwritten by Bouvier]; *Saturnia cynthia*, Java; MUS. PARIS, de Beaulieu, 1507-92; TYPE [red letters] ♀". Bouvier evidently added a label giving a corrected version of the incorrect original spelling used in his published works, both regarding the hyphen and the gender ending. Since the original description does not state categorically that Bouvier based the name on a single specimen, it must be considered a syntype, and we accordingly designate it now as lectotype.

**Geographical Distribution.** The existence of this moth is virtually dependent on its being maintained in captive cultures, and therefore its distribution is contingent on where it is reared. However, some remarks can be given here pertaining to the climatic conditions that are most suitable for it. It does not live well in areas where

there is dry heat, such as the Deccan, the high plateau of central India, which is probably why ericulture did not spread to that area historically. The pupae do not survive freezing temperatures, which also limits its northward and altitudinal range in the Himalayas. The preferred climate is warm and humid, and this is ideally met with in the East Gangetic Plain, which includes Bangladesh, Assam, and adjacent sections (Maxwell-Lefroy 1909: frontispiece [map], 20-27).

**Diagnosis.** *Samia ricini* is variable, but always has a solidly white dorsal surface of the abdomen. This is derived from the white tufts seen in related species being expanded, flattened, and fused. The ground color is usually gray or grayish brown, rarely reddish, but occasionally olive gray. The wing pattern is heavily marked by white in the antemedian and postmedian lines. The postmedian area is often very darkened, which is probably the easiest and quickest way to recognize this species.

**Description.** Adult ♂ (Figs. 31-32). *Head.* Frons and occiput dark brown, with lighter edges. Antennae 12 mm long, 4 mm wide. *Thorax.* Tergum and sternum brown to dark gray. *Forewing.* Length 55-75 mm. Ground color dark gray or brown; costal margin of ground color; antemedian area ground color, sometimes darker along veins; antemedian line prominent with more white than black; median area brown or gray; postmedian line black, white, rose, and lavender, sometimes grayish purple instead of rose, drawn inward above and below crescents; postmedian area strongly blackened; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 4 mm; submarginal line prominent, often separating darker area on outside from lighter area inside; outer margin ochre brown; crescent short, thick, with more white than yellow; apex very shortened; eyespot black, outer edge flattened distally; underside paler overall, but with very dark postmedian area. *Hindwing.* Length 44-52 mm. Antemedian area lighter brown or gray; antemedian line prominent and white; median area of ground color; postmedian line colored as in forewing, with white at tornus of hindwing; postmedian area blackened; submarginal line obsolete; submarginal ornamentation contrasting; outer margin rounded; crescent shorter and thicker than in forewing; tornus weakly pointed. *Abdomen.* Tergum suffused with white scales, tufts flattened; spiracular ornamentation well developed, with white, dark brown, and golden ochre; sternum with mainly white tufts, but dark medially. *Genitalia* (Figs. 167, 169). Very similar to those of *S. canningi*, uncus and transtilla similar; saccus a bit shorter and narrower basally, compared to *S. canningi*; valves almost with the same form with ventral process and dorsal main lobe, but medial process weakly defined in about half of the specimens examined; aedeagus little shorter than in *S. canningi*, with the typical ventrolateral sclerite which is less developed than in latter species; vesica with three bulbs, the dorsal large one having sometimes a median sclerite. An interesting variation was found in genitalia of a hybrid between *S. ricini* and *S. cynthia* where the medial processus of the valve was little more outwardly curved, and the sclerites both on the dorsal end of the aedeagus and the dorsal bulb of the vesica were much more pronounced than in typical *S. ricini* genitalia, and show a mixture of those of the latter and *S. cynthia*.

Adult ♀ (Fig. 30). Differing from ♂ as follows. *Head.* Antennae 12 mm long, 3 mm wide. *Forewing.* Length 60-70 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 3-4 mm; crescent short; apex very shortened and rounded. *Hindwing.* Length 42-55 mm; crescent short and thick; tornus rounded. *Abdomen.* Tergum white; spiracular ornamentation white and dark brown; sternum mainly golden ochre. *Genitalia* (Fig. 204). Anal papilles very short, indented medially; oviporus slightly covered by membranous lobe; lamella postvaginalis almost triangular, as in *S. canningi*, but with small median indention on ventral posterior margin; lamella antevaginalis short, thin, lobed; anterior apophyses not connected laterally to lobe arising from lamella postvaginalis, short, and only two-fifths the length of posterior ones.

**Discussion.** There has been considerable confusion pertaining to the author of the original description of the name *ricini.* David Goodger (pers. comm. to Peigler, March 1995), curator of Saturniidae at The Natural History Museum, remarked "When one tries to find the original description for the name *ricini*, it is a dead end." We have likewise been unable to satisfactorily settle the issue, and we hope that a future researcher can resolve it. Some authors have attributed the name to Boisduval (1854), but his paper does not contain a valid description, and the name *ricini* was already in wide usage several decades earlier. Moore (1859: 267) wrote, "The late Sir William Jones mentions this insect in a letter to Dr. Anderson, dated 17 May, 1791, under the name *Phalaena ricini*:---". Donovan (1798: [82], footnote) wrote, "A Gentleman resident in the East Indies, speaks of a large Phalaena, producing silk in that country. 'We have a beautiful silk worm north-east of Bengal, that feeds on the Ricinus, whence I call it Phalaena Ricini: it is sea green, with soft spines, very large, and voracious, and spins a coarse, but strong and useful silk. The moth is of great size, with elegant dark plumage.---Is it known to European Naturalists?'---*In a collection of papers published by* Dr. Anderson, *in* Madras, 1788, 1789." Dr. James Anderson was a Scotsman who lived much of his life in India and attempted to establish a silk industry in

Madras in the 1780s and 1790s (Charsley 1995). Various authors have consequently attributed the name *ricini* to either Jones, Anderson, or Donovan, in addition to Boisduval. Therefore, following Articles 14 and 50.1 of the Code (1999), we can only cite the authorship as "Anonymous," since we have not been able determine the earliest author to have validated the name.

We attempted to locate published citations of the name *ricini* prior to that of Donovan in 1798, without success. Fabricius (1775: 583) applied the name *Bombyx Ricini* to a moth in the Arctiidae from India, and we believe it was not the saturniid but that arctiid to which Schneider (1785: 43) referred in his list, because Schaller is cited in the bibliography of Schneider. The arctiid was also cited as *Bombyx Ricini* by Forster (1795: 28, no. 38) who referred to Fabricius' earlier publication. Turning to the later publication by Schaller (1788, pl. 1, fig. 13, not 12) we find that he described and pictured what he considered to be the Fabrician taxon, and Rothschild (1916: 258, pl. 25b) showed the same moth, by then known as *Pericallia ricini*. Although the saturniid and the arctiid were both named *ricini*, they are probably not primary homonyms, since the saturniid was almost certainly first cited in the genus *Phalaena*, whereas the arctiid was first cited in *Bombyx*. Whenever and whatever the original authorship, year, and generic combination for the name *ricini* used for the saturniid are eventually determined to be, that name should be conserved in the interest of stability in nomenclature, considering the voluminous amount of entomological and sericultural literature that exists on the eri silkmoth.

The specific epithet follows the tradition of naming insects for their hostplants, so the name *ricini* comes from *Ricinus*, the generic name for the castor plant. Some readers may object to treating this taxon as a full species, and others may question if it is even a valid taxon. It is our opinion that this moth should be afforded the rank of a species, because taxonomy and nomenclature are foremost required to provide a useful and usable classification. It is thus a matter of necessity beyond convenience and effective communication to allow this moth to carry a binomial name. The insect is not simply a little-known entity, familiar only to a handful of lepidopterists. On the contrary, it ranks as the second most important producer of wild silk, providing income for thousands of people in India, China, Bhutan, and a few other countries. Much research is conducted in the field and the laboratory on *S. ricini*, so this study animal needs a valid name to be used in the resulting publications. To satisfy those who would argue that a classification and the corresponding nomenclature should reflect the true phylogeny of a group, we provide information to show that this moth is indeed an artificial derivative of another species, i.e., no attempt is being made to disguise or distort the facts. Our action has precedence: it is now accepted that the mulberry silkmoth *Bombyx mori* (Linnaeus) is the domesticated form of the wild *Bombyx mandarina* Moore, yet there is no movement to synonymize these two names which clearly refer to a single species. Some authors even placed them in two different genera, while acknowledging that *Bombyx mori* is the domesticated form of *Theophila mandarina*! The numerous breeds of dogs throughout the world are generally assigned the scientific name *Canis familiaris* Linnaeus, but they are actually domesticated forms of the wolf (*Canis lupus* Linnaeus). There are many other examples among cultivated plants (fruits, vegetables, grains) in which hybrids or cultivars are given a specific-epithet, so we must disagree with the statement by Nässig and Treadaway (1998: 255, footnote) that "Usually such anthropogenic taxa are treated as forms or, rarely, subspecies of the wild species from which they were artificially selected."

Jordan (1911a, b) considered the correct name for *Samia canningi* to be *S. lunula*, but the lectotype of *Attacus lunula* is a specimen of *S. ricini*, as pointed out above. The names *iole*, *guerini*, *arrindia*, *obscurus*, and *obscura* were all widely used in the literature of the nineteenth century to apply to the taxon we now call *Samia ricini*, details of which can be extracted from the synonymy. Early on, Hutton (1872: Appendix: 6) made clear his opinion about Moore's *guerini*, saying it "is known only from a few specimens of the moth in some museum in England, and I am induced to regard it as no more than an ill-fed specimen of *Attacus Ricini*," and he went on to say that he had not been able to obtain it anywhere in India. There has also been widespread confusion between the domesticated *S. ricini* with the wild *S. canningi* and *S. cynthia*. The name *S. ricini* has been used more consistently for the introduced cultures in the Middle East, Latin America, Japan, and Europe, as discussed in the following section. Early in the twentieth century, the name *S. ricini* became the generally accepted one for the eri silkmoth, and fortunately it has been used by almost all Indian authors. Listing of the names *iole* and *lunula* by Collins and Weast (1961: 115) was based on their trust in the work of Packard (1914).

Most of what is known about the biology of this moth is embodied in the voluminous literature published about it by sericulturists and insect physiologists. An excellent review article is one written by Singh and Benchamin (2002) that outlines and details many facts pertaining to the culture and biology of this domesticated silkworm. Reports by earlier authors (e.g., Hugon 1837) that "the white caterpillars invariably spin red silk, the green ones white" was not verified by rearings in Colorado by Peigler, who reared broods of *S. ricini* from Assam that contained white (yellowish) and green (bluish) larvae (Fig. 119), but all cocoons produced by those larvae were white. In our larval description for the genus *Samia*, we indicated that traits such as the amount and presence of black spots and mottles are controlled by single pairs of alleles, as is the case of the blue, yellow, or

white integument. Peigler and Wang (1996: 97) showed mottled and unmarked larvae from Assam. They implied that stock of *S. ricini* from the Philippines always lacks such mottles, but it is possible for cultures in any location to become highly homozygous for any of these traits. Peigler reared *S. ricini* on choke cherry (*Prunus virginiana*) in Colorado in the spring before leaves of ailanthus were available. Lilac (*Syringa vulgaris*), common in Denver, was also found to be an excellent food for the larvae. Our final paragraph in the earlier section entitled Ecology and Rearing pertains to characteristics of *S. ricini* that are attributable to centuries of domestication, such as larval disease resistence, adults readily mating but rarely flying, and large pure white cocoons with ample silk. Although some of the Asian *Antheraea* are semi-domesticated and frequently captive reared, they also exist as wild populations. By contrast, *Samia ricini* is the only species of Saturniidae that has become fully domesticated.

**Cultures of *Samia ricini* in various countries around the world.** We offer here a summary of some of the historical and current reports of captive cultures of this taxon. Some of these have been frequently cited in the literature. The moth has been reared widely in India for many centuries, and perhaps for several centuries in China. In an earlier section on sericulture of eri silk, we provided details of the locales where this type of silk is or has been cultivated in the twentieth century across India, and in the neighboring countries Bangladesh, Bhutan and Nepal. Eri silkworms have reportedly been introduced in recent years to New Guinea (Jolly et al. 1979: 139) and Laos (Baruah 1981: 7) but we found no further published reports on those projects.

Stock of *Samia ricini* was taken to other countries around the world in the middle of the nineteenth century and all through the twentieth century. Frederic Moore may have been the first person to rear *Samia ricini* in England (Wallace 1866: 190; Wardle 1881b: 51), who received eggs in October 1859 from F.-E. Guérin-Méneville. Cultures in Europe, particularly England and France, have been common all during the twentieth century, and replenishment of the stock has routinely been possible by importation of fresh material from India. Dealers such as Worldwide Butterflies Ltd. in England offered eggs for many years, and the eri silkworms and silkmoths have been reared and displayed in some butterfly houses (insect zoos) in Europe and North America in recent years. Livestock is also widely used in laboratories in Japan, China, Europe, and North America for experimental studies in physiology, genetics, behavior, pathology, and diapause. Since the moths rarely fly, and the species does not exist in a feral state (German: in Freiland), introductions expire unless the cultures are maintained indoors continually by human care. Although there are occasional reports of specimens of *S. ricini* being taken at light, we consider these to be insignificant, and probably always pertain to escapes from nearby cultures. A supposed wild collected female of *S. ricini* from Chiang Mai, Thailand, reported by Pinratana and Lampe (1990), was from a captive culture, and the actual specimen was not figured, despite what was stated in their text. Watson (1912: 46) believed that *S. ricini* existed in the wild in Assam, but pointed out that the Assamese often cross *S. ricini* with the wild *S. canningi*. Below are some of the reports we found for attempts to rear *S. ricini* for its silk around the world.

**Sri Lanka.** Rondot (1887: 91, footnote 2) gave the following account of *S. ricini* in Sri Lanka, noting that it was not indigenous to that island. "Le *Philosamia ricini* mange, à Ceylan, les feuilles du *Ricinus communis*, du *Terminalia catappa*, du *Ficus religiosa* et d'un amandier (A general description of the island of Ceylon, 1876).--- L'érié est élevé à Dimbula; on récolte de beaux cocons de coleur brun clair, dont on obtient une soie blonde ou grise." The almond tree (amandier) he referred to was probably Indian almond (*T. catappa*). The culture apparently was homozygous for producing cocoons of the red form, yielding beige silk. Dimbulla is a district in the central highlands, famous for its black tea plantations. The mention of Ceylon by Silbermann (1897: vol. 1: 314) was likely based on Rondot. Haly et al. (1903) indicated that this moth had been imported recently to the island and was consequently found (in cultivation, we assume) in and around Kandy.

Braine (1904: 37) considered that he was the first person to introduce *S. ricini* to the island. We doubt that however, considering the writings of Rondot who quoted a source from 1876. In his small book on silkworms of Sri Lanka, Braine devoted all of Chapter 8 to ericulture. He reported that at lower elevations (600-1500 feet) [183-457 meters] the life cycle was 10 days in the eggs, 17 days as larvae, and 17 more as pupae, for a total of 44 days, producing 8 crops per year; at higher elevations there would be only 3-4 crops annually. He included detailed accounts of how to cultivate castor, and how to properly harvest leaves from the plants to feed the eri silkworms.

There are surprisingly few specimens in western museums for which their labels state that they came from Sri Lanka. We found only two such males in The Natural History Museum in London, and none in the Muséum National d'Histoire naturelle in Paris. There are four very dark specimens of *S. ricini* labeled "Ceylon" and as *lunula* in the National Museum of Natural History in Washington. As indicated among our material examined, two more are in Vienna and one in Berlin.

**Thailand.** In a letter to Peigler dated 29 November 1993, Surindr Supasvasdebhandu, President of the Thai

Silk Association, said that a few years earlier in Thailand, Chinese sericulturists had investigated the possibility of growing eri silk on tapioca leaves. The experiment showed that this would not be economically feasible because of the high cost of machinery to process and spin eri silk yarn and the low price of waste silk for spun silk manufacturing. Studies on growing eri silk were made in the early 1980s in the highlands of northern Thailand (Singh & Benchamin 2001). Paukstadt and Paukstadt (1991) figured a male specimen of *S. ricini* they received from Sabine Steinke, with the data "N. Thailand, Chiang Mai, 19 April 1984, leg. A. M. Cotton." As indicated among our material examined, there were several cultures throughout Thailand in the 1980s, and some of these are probably still maintained.

**Vietnam.** There is an active and developing program to develop an eri silk industry in Vietnam, in cooperation with Japanese manufacturers. One example is the Tajima Silk Company working with VISERI (Union of Sericulture Enterprises of Vietnam). The cocoons are raised in Vietnam and then shipped to Japan for processing. Eri silk linens, shawls, and undergarments are now available to Japanese consumers, and a French designer of apparel is making scarves and neckties of eri silk, all of this according to a United Nations report (UNISTAR) from July 1997. Peigler bought several finished pieces of eri silk textiles at the 2nd International Symposium on Wild Silks in Japan in 1994, where he was told that the silk was grown in Vietnam, but the finished products made in Japan. A blue scarf, one of several colors available at the symposium, and a white dishcloth are shown in Figure 142.

**Japan.** Eri silkworms are widely reared in Japan, but less for their silk than for the fact that they provide an easy-to-rear study animal that can be conveniently handled and investigated in laboratories. Peigler (1992: 168) pointed out that Japanese specimens of *S. ricini* appear to be more gray in color than material from India, suggesting that Japanese stock probably has been crossed occasionally with *S. pryeri*. Genitalia preparations examined during this study disprove Peigler's speculation that *S. ricini* may have even originated in Japan from *S. pryeri*; we are now convinced that *S. ricini* originated in Assam from *S. canningi.* We note here that the Chinese *Antheraea pernyi* occurs mainly in cultivation in Japan, rarely if ever in a feral state, and the existence of *S. ricini* in Japan is even more dependent on the maintenance of captive cultures. By contrast, the Chinese *S. cynthia* has become established as wild populations in many parts of Japan.

**China.** Jolly (1979: 139) reported a recent introduction to Taiwan, but this form was earlier listed by Sonan (1937: 203-204). On the mainland, introduction of the easily managed *S. ricini* has probably helped to displace exploitation of cocoons of the native species, *S. wangi* and *S. cynthia*. Eri silkworms have been introduced in recent decades to several places in China. They were brought to the Chengde Research Institute in Hebei Province to take advantage of available castor and abundant ailanthus, where the silk has been used especially for insulation in coats. Attempts were first made to bring the eri silkmoth to China in 1940 but this failed. A second attempt in 1952 was more successful, and cultures are currently reared in Guangdong Province. At the Guangzhou Research Institute, castor and cassava have both been used as foods. Attempts were also made in China to develop a diapausing strain of *S. ricini*, by crossing it with *S. cynthia*, the breeding trials taking 18 years (Anonymous 1980: 73). Occasional reports of *S. ricini* being cultivated in Shandong and Zhejiang provinces (Jolly et al. 1979: 139; Baruah 1981: 7) probably refer to historical sericulture of *S. cynthia.* We reared stock of *S. ricini* in 1999 from cocoons received directly from Sichuan.

**Malta; Algeria; Grenada.** Apparently the first introduction of *S. ricini* to the West was in 1854 when Mr. Piddington, a museum curator in Calcutta, sent stock to Sir William Reid, the governor of Malta (Royle 1856: 216). It increased rapidly that first year, but there was an almost total failure in the summer of 1855 on Malta. Reid sent stock from Malta to Italy, Algeria, and the island of Grenada in the West Indies. A man named Wells reported good success in rearing them in 1855 in Grenada. Reid sent stock to a man named Hardy in Algeria, who reported optimism in September 1854. The drier climate of the Mediterranean countries, as compared to humid Bengal, was considered to be a major limitation on successful acclimatization, for although it was stated that Malta was well suited for the cultivation of castor, the silkworms were adversely affected there by cold winds (Newman 1854: 30-31). A letter from Governor Reid to the Duke of Newcastle dated 17 May 1854 gave some background and intentions of the introduction, and was published by Newman (1854: 29).

**Italy.** Again, drawing from notes given by Royle (1856: 216, footnote), stock was sent from Governor William Reid to some gentlemen named Bellini in the town of Rivoli, very near Turin (=Torino). Apparently these were successful the first year, but the results were not considered by the Bellinis to be worth their efforts after that. We should point out that Turin is the site where *S. cynthia* was first introduced to the West from China, just a few years later. Watt (1908) reported that an attempt to reel the silk of *S. ricini* had been successful in Italy.

A different early report of *S. ricini* in Italy suggests that others may have been involved early on. Koch (1873: 96) wrote "Die Zucht der Ricinusraupe wurde durch Baruffi und Borgonzi [*sic*] zuerst in Italien, dann in Berlin und Coblenz eingeführt." But then he added "Die ersten Raupeneier stammen aus Tsiao-Kien in Nord-China."

This suggests that *S. cynthia* instead of *S. ricini* may have been the subject of that introduction. Baruffi, president of the Royal University in Turin, and Bergonzi evidently imported additional material. Wullschlagel (1863: 171) stated that stock originating in the interior of India went to Calcultta, and was then sent via Egypt to Malta, and then on to Turin. From there is was redistributed to France, Germany and other countries. Kock and Wullschlagel probably confused the two species of *Samia*, even reporting that *S. ricini* had been introduced to Germany, but we have found no reliable reports of that. Problems in the rearing the first year included obtaining eggs too late in the season, but after some experimentation, it was found that the pupae were able to hibernate, and the first successful rearings took place in 1861 and 1862.

**Slovakia.** A pair of moths in the Natural History Museum of Los Angeles County (California) was examined in March 2002 by Peigler with the following data, without dates: Slovakia; *ex-ovo*; leg. M. Zubrik; Ken Davenport collection. We have no further information about culturing of *S. ricini* in this region.

**France.** There are numerous reports in the literature for rearings of *S. ricini* in France, especially during the latter half of the nineteenth century. Guérin-Méneville (1854, 1860a) was probably the first person to maintain colonies of this silkworm in France (Lucas 1854). The genus *Samia* was quite unknown to most French lepidopterists prior to the 1850s; for example it was not mentioned by Lucas (1838) in his book on rearing Lepidoptera. In March 1995, Peigler was given live cocoons of *S. ricini* by lepidopterists Dominique Adès and Robert Lemaître, who came to meet him at the Muséum National d'Histoire naturelle. These began to yield adults a few days later in Barcelona, and thus one specimen was illustrated by Masó and Pijoan (1997: 292). We also found a report of *S. ricini* presently being cultivated for its silk in France (Castiglioni 2001).

**Egypt.** Eri sericulture was introduced into Egypt prior to 1931 and continued at least until the 1970s, where the cultures generally produced five generations annually (El-Shaarawy et al. 1975, and references cited therein). Bodenheimer (1931) and Adair and Adair (1931) published accounts of these early trials, followed by Bouvier (1936). In June 1999 Naumann visited Egypt and attempted to find evidence of past or current cultivation of *S. ricini*. No specimens were found in the insect collection of the Entomological Society of Egypt (14 Ramses Street, P. O. Box 430) in Cairo. We are not aware of any current sericulture programmes for this silkworm in Egypt. We examined a pair in the Muséum National d'Histoire naturelle in Paris labeled as having been reared in Cairo.

**Israel; Palestine; Lebanon.** A report by Léon (1925) stated that *S. ricini* was first reared in Palestine by him in September 1921. He was the director of the Sericulture Station at Nahlath-Ychouda [Nahlat Ishuda]. There were generally four crops per year, but as many as six. Castor grew well and was widely available in the area. The report gave tables of costs and profits of how many kilograms of cocoons could be produced on a hectare of castor plants. We know that the silkworm has been cultivated in Lebanon in recent decades. We examined several pinned specimens labeled as being reared in Beirut in 1974, as indicated in the section of material examined.

**Madagascar.** Jolly et al. (1979: 139) reported that steps were being taken to establish ericulture in Madagascar. We have no details on that, except that Andriamahenina (1996: 11) said that the climate was suitable for eri silk culture, and that it should be tried in all areas of Madagascar.

**Bolivia.** In a letter to Peigler dated 25 August 1994, S. N. Chowdhury, of Assam Agricultural University, wrote, "One scientist went to Bolivia last year and produced beautiful eri cloth and yarn with Japanese technology collaboration." We have no further information about that project.

**Brazil.** We found the following reference (Newman 1854: 31) to an early attempt to introduce *S. ricini* into Brazil from Italy: "His Excellency Sir James Hudson, the English minister in Turin, assures us that when at Rio [de] Janeiro, two years ago, he had heard that a Lombard had come there for the purpose of attempting, on a large scale, the rearing of the Palma-Christi worm, as both this insect and the Palma-Christi [castor] thrive well in Brazil." *Samia ricini* was cultivated off and on in the 1860s in southeastern Brazil. The Naturhistoriches Museum Wien has a pair of moths reared by Burmeister in 1868. See also our discussion of Brazil under *S. cynthia*. According to Weymer and Maassen (1890), Stübel purchased a specimen of what he considered to be *S. ricini* in Rio de Janeiro or Santa Catarina.

Eggs of *S. ricini* were obtained in 1982 from Japan by Dr. Julio Rosado in the state of Rio Grande do Norte, but the rearings only proceeded through the fourth generation. In the mid-1980s more eggs were received from Japan, China, and India, and the rearings were carried out in Rio Grande do Norte at the Graduate School of Agriculture in Mossoró. Sericulture for this Castor Oil Silkworm Project is being directed by Professor Marcos Filgueira. There were initially some problems with inbreeding among the stocks. Currently in Brazil there is great optimism for cultivating eri silkworms, because they are well suited to the tropical, humid climate. Brazil is a major producer of mulberry silk on the world market, so a serious interest in ericulture by Brazilians is to be expected.

**Uruguay.** As stated under Uruguay in our treatment of *S. cynthia*, both taxa were sent there, but authors have

generally not distinguished between the two. The specimen of *S. ricini* that Seitz (1928: 504, pl. 52c) cited and figured, was stated to be from Montevideo. About 1860 hybrid stock between *S. ricini* and *S. cynthia* was also sent by Guérin-Méneville in France to Burmeister in Montevideo (Bouvier 1927: 926-927, footnote). We doubt that these cultures of *S. ricini* were maintained very long. They were probably long extinct before Bouvier and Seitz cited on them almost 70 years later, based on a few specimens from Uruguay that were preserved in museums in France and Germany. We found a specimen bearing Burmeister's label in the Zoologisches Museum der Humboldt-Universität Berlin. Letters that Peigler sent to two institutions in Uruguay asking about historical and current ericulture received no response.

**West Indies.** Records of *S. ricini* being grown in Cuba date back at least to Seitz (1928), and were reiterated by de Zayas (1989: 62). In 1976 Claude Lemaire gave Peigler a pair of *S. ricini* from the collection of Eugène Le Moult with typeset labels that read "Cuba, Guantanamo, coll. E. Le Moult." Another male with the identical appearance and labeling is in The Natural History Museum (London). Le Moult had labeled the latter male as a paratype of a manuscript name, which fortunately was never published. We have no further information pertaining to the cultivation of *S. ricini* in Cuba, but it was apparently a brief and limited venture, and it is doubtful that any significant amount of silk was processed. As stated above, Royle (1856) reported that the silkmoth was sent by Reid from "Malta to the West Indies," so stock may have found its way to Cuba as well as Grenada at that very early date. Rebel (1925a: 15) cited Puerto Rico as another site for introduction.

There is a specimen of *S. ricini* in the Institute of Jamaica, probably indicating that this silkmoth was also cultivated there at one time. It is in the Gowdey Collections, and its labels bear the data "Hope Gardens, 16 October 1923" according to Dionne Newell (pers. comm. to Naumann, February 2002), an entomologist at the Natural History Division, Institute of Jamaica, who provided us with a color image of the specimen. Hope Gardens are in Kingston.

**Material Examined.** **INDIA**: 1♂ "*ricini*, Bsd. An S. E. III Ser. II p. 755, *lunula* Wlk., *arrindia* Miln.Edw., Ind. Or., hosp. In Eur.; 8729"[*sic*] (ZMHB); 1♂, "Felder, *ex* Ind. Or. nota Austr." (RMNH). Assam, 2♂ Golaghat, Sept. 1945, native bred, coll. J. E. Knight (BMNH); 1♂1♀ Assam, *ex ovo* 1957 (Witt); 4♂ Assam (NHMW); 2♀ Assam, *ex ovo* 1994 in Czech Republic, genitalia 627/01 Naumann (Naumann); 3♂3♀ Cachar (NMHW); 4♂5♀ between Jorhat and Gauhati, stock from Nancy Simpson, reared *ex-ovo* in 1994 in Colorado by R. S. Peigler on *Ailanthus altissima* (LACM, BMNH, Peigler, Naumann). Manipur, 1♂ Manipur (NHMW). Mizoram, 1♂ Chin Hills [The source locality is probably actually in Myanmar], leg. Crowley, figured by Packard 1914: pl. 77 (USNM). Sikkim 1♂ (NHMW); 1♀ (ZMA). Uttar Pradesh, 2♂ Mussoorie [Masuri, near Dehra Dun, 30˚27'N/78˚05'E] (NMHW). West Bengal, 1♂1♀ Manbhoom [near Puruliya, ca. 23˚20'N 86˚25'E], 1893, Rothschild Bequest (BMNH); 2♂1♀ Darjeeling, *ex ovo* 17, 22 & 31 Oct. 1994, 2nd generation bred in Czech Republic (Naumann). Himachal Pradesh, 1♂ Simla, "Punjab" M. Occ., July, 2500 m, coll. Côte (MHNL). Tamil Nadu 1♂1♀ ova & cocoons, Trichinopoly [Tiruchchirapalli], from silk production (DEI); 2♂1♀ Madras, *ex ovo* 4-5 Sept. 1973, reared by R. Gleichauf (Witt). Kerala, 2♂ Shembaganur, "*Philosamia lunula* Wlk.", coll. A. Heyne (ZMFK); 1♂ Shembaganur (NMHW). **SRI LANKA**: 1♀ Mineriya Tank, 16 Feb. 1906, coll. H. Schoede (ZMHB); 1♂ Colombo, 7.05, coll. Mackwood, BM 1927-341 (BMNH); 1♂ Sri Lanka, with no further locality data, coll. E. E. Green (BMNH); 2♂ (NHMW); 2♂2♀ Ceylon (USNM). **BANGLADESH**: Chittagong State, 1♂ Silhet [Sylhet], "*arrindia*" (NMHW); Dhaka State, 1♀, cocoons, Tangail District, Ialchatra, Moghipur jungle, from silk production, 27 March 1983, leg. D. Kock (SMFL). **THAILAND**: Chiangmai Province, 1♂1♀ northern Thailand, 17 Aug 1989, ♂ genitalia no. 9/96 Naumann (Naumann). Chiangrai Province,1♂1♀ Wiang Pa Pao, 6 April & 10 May 1988 (Naumann); 1♂ Phrae, Wang Chin, 28 July 1988 (Naumann). 1♂ eastern Thailand, Mukdaharn, Phu Pahn, 12 June 1987 (Naumann); 1♂ same locality, 22 July 1987, received from S. Naumann (Brosch). Chantaburi Province, 1♂ southern Thailand,, Khao Soi Dao, 16 Jan 1983 (Naumann). 1♂1♀ without locality, *ex ovo* Aug. 1999, reared by M. Beeke (Naumann). **VIETNAM**: Hoang Lien Son Province, 1♂ northern Vietnam, Yen Bai, 200 m, 10 May 1990, leg. Z. Skuta, genitalia no. 162/97 Naumann (Naumann). **INDONESIA**: 1♂, Borneo (ZMHB); 2♂, Borneo, coll. A. J. Buis (ZMA) [These specimens might instead be from East Malaysia or Brunei.]. **PHILIPPINES**: 2♂1♀ reared by Peigler in spring 1994 on choke cherry and castor in Colorado (LACM). **CHINA**: 3♂3♀ Sichuan Province, reared from eggs in April 1999 on *Ricinus communis* and *Fraxinus velutina* in San Antonio, Texas, by R. S. Peigler (LACM, Peigler, Naumann); 1♂1♀ Fujian Province, Shanmin, Aug. 1990 (Naumann). **JAPAN**: 1♂ Japan, coll. A. Heyne (ZMHB); 1♂ Japan (Naumann); 1♂ Fukuoka, sent to Peigler by Dale E. Pforr in 1971 (LACM). **LEBANON**: 2♂2♀ Beirut, 2nd generation, *ex ovo* 25 July & 30 Aug. 1974, coll. Lének, *ex* coll. Vartian (Witt); 1♂1♀ Beirut, "*ex* wild collected pupa 26 Nov. 1974" (Naumann); 1♂1♀ same data, sent by Naumann to Peigler (LACM). **EGYPT**: 1♂1♀ Cairo, *ex* larva (MNHN). **KENYA**: 1♀ Nairobi, 1919, "bred same July as Queen Moth[er]," Rothschild (BMNH). **SLOVAKIA**: 1♂1♀ *ex-ovo*, leg. M. Zubrik, Ken Davenport collection (LACM). **CUBA**: 2♂1♀, Guantamano,

coll. Le Moult. (Peigler, MNHN); 1♂1♀ Cuba, coll. Côte (MHNL). **URUGUAY**: 1♂ Montevideo, "Burme., hosp. ?", no. 17877, leg. C. H. C. Burmeister (ZMHB). **BRAZIL**: 1♂1♀, Rio de Janeiro, *ex* larva 1868, leg. C. H. C. Burmeister (NMHW). **Without locality**: 1♂ "*Saturnia guerini* Moore", coll. Riethe (ZMHB).

## *Samia fulva* Jordan

(Figs. 33-35, 170, 205; Map 4)

*Samia lunula fulva* Jordan 1911a: 130.
*Samia cynthia fulva*, Seitz 1928: 504. Bouvier 1936: 316. Peigler 1989: 78.
*Philosamia cynthia fulva*, Rebel 1924: 111. Rebel 1925b: 157.
*Philosamia cynthia fluva*, Jolly et al. 1979: 7. [misspelling]
*Philosamia cynthia Canningi* var. *fulva*, Bouvier 1927: 920.
*Philosamia cynthia* f. *fulva*, Schüßler 1933-1934: 29, 523.
*Philosamia fulva*, Chowdhury 1982: 6.
*Samia cynthia*, Chandra & Kumar 1992: 141. [misidentification]
*Samia fulva*, Mohanraj et al. 1998: 51, col. pls. 1 (all stages), 2 (♀). Nässig & Treadaway 1998: 255. D'Abrera 1998: 84, 85 (♂♀).
*Philosamia ricini fusca*, Watson 1912: 46. Rebel 1925b: 157. Schüßler 1933-1934: 29, 523. [*lapsus*]

**Types.** We examined a series of one male and four female syntypes in The Natural History Museum. The male (Fig. 33) was designated as lectotype by Mohanraj et al. (1998: 53), and was figured by D'Abrera (1998: 85). It bears the following labels: "♂ *Samia guerini fulva* Type; Nov. Zool. 1911 Jordan; Port Blair, Andaman Is." All four females, which were designated as paralectotypes by Mohanraj et al. have labels that read "Port Blair, Andaman Is.," and one (Fig. 34) bears a label that reads "*Samia lunula fulva* ♀." One of these paralectotypes was also figured by D'Abrera.

**Geographical Distribution** (Map 4). This species is known only from the Andaman Islands in the Bay of Bengal. It is also to be expected in the nearby Nicobar Islands, but no *Samia* have been collected on those islands thus far.

**Diagnosis.** *Samia fulva* is readily recognized by the intense cinnamon brown ground color, which is sometimes a lighter chocolate brown. There is minimal variation in the pattern and color. Specimens of the allied *S. canningi* may be dark, but never in the deep shades of rust seen in *S. fulva*. Even historical specimens that have undergone a certain amount of fading remain recognizable by the dark ground color. In the male genitalia, it shares the bilobed valves and broad saccus with *S. canningi*, but the aedeagus is longer in *S. fulva*. There is no possibility to confuse this species with Sumatran specimens of *S. insularis*, which differ in the size and wing shape (more elongated and falcate wings), lighter color, and several features of the genitalia.

**Description.** Adult ♂ (Figs. 33, 35). *Head*. Frons and occiput brown. Antennae 10 mm long, 3 mm wide. *Thorax*. Tergum rusty brown, with thin white collar not always visible, sternum mixed patches of white and brown. Legs light brown with major white portions. *Forewing*. Length 64-74 mm; ground color rusty brown; costal margin same as ground color; antemedian area ground color; antemedian line black, trace of white, and black not crossing costal margin through cell $R_5$, extending onto veins $Cu_{1a}$ and $Cu_{1b}$ to postmedian line, extending back to base of forewing; median area pure ground color; postmedian line almost straight above crescent, weakly curved inward below crescent, with narrow black, white, and broader pinkish purple bands; postmedian area of ground color, densely suffused with dark scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5 mm; submarginal line a straight, dark brown line beginning in cell $R_5$, deeply notched or totally disrupted and restarted in cell $M_1$; outer margin darker outside submarginal line, ochre yellow inside it, fringe on edges of wings; crescent transparent, bordered by white, broad yellow fading to pale olive, and on the outer arc, narrow black with a trace of yellow; apex 10 mm long, a large orangish brown patch, a white zigzag line with orangish brown outer tip; eyespot black with white edge proximally, sprinkled with light scales in center proximally; underside with antemedian line absent, but slightly visible from upperside, crescent as above. *Hindwing*. Length 45-49 mm. Antemedian area ground color; antemedian line black, white, and

black; median area ground color; postmedian line connecting to antemedian line along subcostal margin, colored same as in forewing, pushed distally by crescent; postmedian area peppered as in forewing; submarginal ornamentation with strong markings in the forms of rods surrounded by lighter ochre yellow; outer margin with fringe, outer margin evenly curved; crescent colored as in forewing but shorter and more bent; tornus tapering to a gentle point. *Abdomen*. Tergum of ground color, with broad white belt on first abdominal segment, otherwise too greasy and damaged in available material to describe in detail. *Genitalia* (Fig. 170). Generally very similar to those of *S. canningi*, but with some differences. Uncus and transtilla similar to *S. canningi*; saccus a little broader; valves also with the ventral process and dorsal lobe, but in *S. fulva* longer and more rounded, making the genitalia appear more compact; aedeagus somewhat longer than in *S. canningi*,with a hooked sclerotized area ventrolaterally at distal end; a medium-sized sclerite on dorsal process always present and located dorsomedially.

Adult ♀ (Fig. 34). Differing from ♂ as follows. *Head.* Antennae 10-11 mm long, 3 mm wide. *Forewing.* Length ca. 70 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5 mm; antemedian lines with more white between broad black components; crescents and postmedian lines more strongly marked, crescents may or may not penetrate postmedian line; apex 6-7 mm long. *Hindwing*. Length ca. 55 mm; outer margin and tornus more rounded. *Abdomen*. Tergum reddish brown areas widely separating white tufts, central row of tufts more prominent, outer tufts few and small. *Genitalia* (Fig. 205). Anal papilles broad, short, covered with rounded, wartlike tubercles; lamella postvaginalis composed of two lateral portions, forming a nearly rectangular structure, with a sclerotized lobe connecting it laterally with the apophyses; lamella antevaginalis relatively small, straight, rounded; anterior apophyses very short for the genus; posterior apophyses almost twice as long as anterior ones.

**Discussion.** The name *fulva* refers to the fulvous coloration of the wings. Bouvier (1927) recognized the close relationship between *canningi* and *fulva*, when he referred to the latter as a special variety of the former. We agree with Mohanraj et al. (1998) that *Samia fulva* is a full species that has originated by peripatric speciation (see Strickberger 2000: 590) from *S. canningi.* When a population becomes established on a small island by propagules from the mainland, the new insular population does not have all of the genetic variability of the parental (mainland) population, and therefore mutations can become fixed more rapidly in the reduced genome. This has been termed the “founder principle” by those who study island biogeography, and the phenomenon and name may be attributed to Ernst Mayr (1976; 1999: 237). If *S. fulva* has reached full species status, it should not be surprising, since most of the other saturniids endemic to the Andamans have also been found to differ significantly from their mainland relatives. *Attacus mcmulleni* J. H. Watson was formerly considered to be a subspecies of *Attacus atlas* (Peigler 1989, Veenakumari et al. 1995) and *Actias callandra* Jordan was formerly considered to be a subspecies of *Actias selene* (Mohanraj et al. 1996). We acknowledge that a certain amount of circular reasoning is invoked when we say that an Andaman endemic is a full species because the other ones are also. Comments on the historical adherence to trinomials were given in our introduction and are applicable here. Jordan himself was a strong proponent of this taxonomic philosophy (Munroe 1955). For those lepidopterists who insist on using the subspecies concept, this taxon might be considered a subspecies of *S. canningi*, but that name combination has not been published (see synonymy above).

A nice pair was beautifully illustrated in color by D’Abrera (1998), and photographs of two living females were shown by Mohanraj et al. (1998). As far as we know, there is very little variation in this species, as would be expected from the restricted range. However, certain characters do vary conspicuously, such as how far the crescents push through the postmedian lines, and how prominent are the outer purplish rose bands of the postmedian lines. A dissection of a wild-collected specimen from the Andaman Islands in the collection of R. Brechlin was done by Naumann, but unfortunately the exact data were not given to us (genitalia no. 503/01). An old specimen of *S. cynthia* in the Deutsches Entomologisches Institut in Eberswalde is labeled as coming from the Nicobars, but we are certain that the locality label is erroneous. The presence of *Samia fulva* itself on the Nicobar Islands is possible, but at this writing no *Samia* are known from the latter island group.

Details on the life history of *Samia fulva* were presented by Mohanraj et al. (1998). Their article contains color figures of the immature stages. We are grateful to Prashanth Mohanraj and his wife Dr. Kamalanathan Veenakumari, who have sent us material of this species and other Saturniidae, invited us to co-author with them, and hosted Naumann on his visit to the Andamans in March 1996. By their intensive and persistent field work, our Indian colleagues are making excellent discoveries about the lepidopterous fauna of the Andamans, where many species are endemic. The larval stages, summarized below, were shown in color by Mohanraj et al. (1998). A striking similarity exists between the appearance of the mature larvae of *Samia fulva*, and the mature larvae from the hybrid cross *Callosamia angulifera*♂ × *Samia cynthia*♀ (Fig. 130). Both larvae have a lime green integument lacking white wax, slender dark orange scoli, and lateral blue scoli. Larvae of *S. fulva* have a series of black spots on the integument, not noted in the hybrids.

The habitats on South Andaman where this species has been found include lowland forests; at Mount Harriet National Park (only up to 365 meters) the site is covered with evergreen primary forests, and at Chiriyatapu it is a mixture of primary and secondary forests, which are considered to be mixed deciduous. Larvae of *Samia fulva* were found at Mount Harriet feeding on leaves of *Zanthoxylum rhetsa* (Rutaceae) and *Heteropanax fragrans* (Araliaceae). At Chiriyatapu, more than 20 cocoons of *S. fulva* and two eggs and one cocoon of *Attacus mcmulleni* were found on *Picrasma javanica* (Simaroubaceae), so it is obviously also a natural hostplant for both moths. On the mainland of tropical Asia, larvae of *Samia canningi* are recorded to feed on *Zanthoxylum alatum*, and those of *S. ricini* are sometimes reared on *Z. alatum* and *Heteropanax fragrans* (Watt 1908, Kumar et al. 1993). The latter eri foodplant is called keseru in Assam. In Japan, *S. pryeri* is recorded to eat *Picrasma*. In the Andamans, when attempting to rear *S. fulva* in captivity, Mohanraj and Veenakumari (Mohanraj et al. 1998) offered several seemingly suitable plants, but newly hatched larvae rejected all of them and died. One other possible foodplant is nutmeg (*Myristica* sp., Myristicaceae) because Mohanraj found one cocoon on Mt. Harriet on that tree at a height of 6 meters above ground. However, this needs to be verified as a foodplant, because larvae sometimes spin cocoons on plants near the ones on which they fed. Thus far, the only parasitoids known from *S. fulva* are the scelionid *Telenomus* (*Aholcus*) sp. from the eggs, and the ichneumonid *Xanthopimpla* sp. from the cocoons.

Newly hatched larvae are quite black, with traces of yellow showing through the spiny scoli. In the second instar they are yellow with a glossy black head, but the mouthparts are yellow; there are tiny black spots on the integument, the scoli, anal plate, and spiracles are all black. In the third instar they are completely yellow, but the head, anal plate, spiracles, and legs are black; scoli yellow with black setae. In the fourth instar the head, legs, and prolegs are yellow; crochets brown; mouthparts bluish green; spiracles black; scoli ashy white with a few black setae, and secretions of wax; anal plate with blue ornamentation. The final instar is pale green, with a yellow head and blue mouthparts; the head and prolegs are yellow, with turquoise on the prolegs; spiracles black; anal plate pale yellow with turquoise edges; black spots near spiracles on integument; dorsal scoli reddish orange with blue bases; subdorsal scoli pale orange; lateral scoli blue with orange at tips; reddish orange median scolus on 8$^{th}$ abdominal segment, with blue base.

**Material Examined. INDIA**: 1♂ lectotype, 4♀ paralectotypes, Andamans & Nicobars (state), South Andaman Island, Port Blair (BMNH); 1♂ Port Blair, Garacharma, 20 Aug. 1992, leg. K. Veenakumari (LACM); 1♂ Port Blair, Oct. 1992, leg. Rautenstrauch, coll. Terral (MHNL); 1♂ Mount Harriet, reared 25 Aug. 1995 by Prashanth Mohanraj (LACM); 4♂ same data, received from R. S. Peigler, genitalia no. 123-126/97 Naumann (Naumann); 1♂ Andaman Islands, donated 1919, coll. Robert Gschwandner (NHMW); 1♂ Andaman Islands, *"P. lunula ricini* Sikkim" [*sic*], 1916, coll. Otto Staudinger (NHMW).

## *Samia kohlli* Naumann & Peigler

(Figs. 36-41, 97-101, 171-177, 206; Map 7)

*Samia cynthia*, Barlow 1982: 49 (in part), pl. 9, fig. 1 (♀). Holloway *in* Barlow 1982: 192. Lampe 1984: 5, pl. 1, fig. 2 (♂), fig. 3 (♀). Lampe 1985: 7, pl. 1, fig. 2 (♂), fig. 3 (♀). Holloway 1987: 113. Nässig et al. 1996a: 27, pl. 2, fig. 6 (genitalia). [misidentifications]
*Samia canningii* [*sic*], Pinratana & Lampe 1990: pl. 10 (♀). [misidentification]
*Philosamia cynthia canningii* [*sic*], Bryk 1944: 3 (in part). [misidentification]
*Samia (Philosamia) insularis*, Lemée 1950: 39. [misidentification]
*Samia insularis tetrica*, Paukstadt & Paukstadt 1991: 89, figs. 1 (♂), 2 (♀), 5 (genitalia). [misidentification]
*Samia walkeri,* Peigler 1992: 167 (in part). [misidentification]
*Samia* n. sp., Brosch et al. 1999: 39.
*Samia kohlli* Naumann & Peigler 2001: 78.

**Types.** Holotype ♂ (Fig. 36): West Malaysia, Pahang State, Cameron Highlands, Tanah Rata, 18 January 1998, leg. local collector, sent by Steve Kohll, *ex* collection of S. Naumann. A red holotype label was affixed to the specimen, which was deposited in the Zoologisches Museum der Humboldt-Universität Berlin.

Allotype ♀ (Fig. 37): West Malaysia, Pahang State, Cameron Highlands, 3 kilometers north of Brinchang, 1350 m, *ex* wild female collected by Steve Kohll, reared *ex ovo* in Germany by S. Naumann on *Ligustrum*

*ovalifolium*, emerged 14 July 1998, at ca. 19:00 hours. The specimen bears a red allotype label and was deposited in the Zoologisches Museum der Humboldt-Universität Berlin.

Paratypes (79♂♂, 28♀♀), all from West Malaysia. These specimens were given blue paratype labels, and their data are cited below among "Material Examined." Some of the paratypes from the collections of Naumann and Peigler were deposited in institutional collections: Muséum d'Histoire naturelle de Lyon; Zoologisches Museum der Humboldt-Universität Berlin; Natural History Museum of Los Angeles County; and The Natural History Museum.

**Geographical Distribution** (Map 7). *Samia kohlli* is a montane moth, widespread in southeastern Asia. Records are known from West Malaysia, Myanmar, Thailand, Laos, Vietnam, the southern Chinese provinces of Guangxi, Yunnan, Guangdong, and Xizang. All known localities are on the Southeast Asian mainland, and none are coastal. The species generally lives at altitudes between 200 and 2500 meters.

**Diagnosis**. Distinguishing characteristics generally include large size, especially in females, bright intensive coloration, crescents with prominent (long and wide) yellow and hyaline components, and violet forewing apex, which is tall and falcate in males. When specimens are difficult to distinguish from those of *S. canningi* and *S. wangi*, the male genitalia provide definitive identifications. This includes a triangular saccus, prominent and long ventral process of the valve, short but visible median one and rounded dorsal one, and a prominent cornutus on the dorsal portion of the vesica.

**Description.** Adult ♂ (Figs. 36, 38-40). *Head.* Frons and occiput brown. Antennae 12-12.8 mm long, 4.8-5.2 mm wide. *Thorax.* Tergum golden to rusty brown with thin white collar, sternum mixed patches of white and brown. Legs light brown with small white sections. *Forewing.* Length 75-84 mm; very elongated; ground color light brownish orange; costal margin same as ground color; antemedian area ground color; antemedian line white and black crossing costal margin straight through cell $R_5$, extending onto veins $Cu_{1a}$ and $Cu_{1b}$ to postmedian line, extending back to base of forewing; median area pure ground color; postmedian line slightly convex above crescent, and again below crescent, with black, white, pinkish purple, and suffused pink and purple bands; postmedian area of ground color, peppered with numerous dark scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 7-8 mm; submarginal line a straight, dark brown line beginning in cell $M_1$, with a slight notch in cell $M_2$; outer margin hardly darker outside submarginal line, dark olive gray, fringe on edges of wings; crescent transparent, bordered by white, broad yellow, and on the outer arc, narrow black with a trace of yellow, a bit of yellow extending beyond postmedian line; apex prominently falcate, 12-14 mm long, a large grayish purple patch, vein below marked with black, a white zigzag line with ochre yellow outer tip; eyespot black with white edge proximally, sprinkled with light scales in center proximally; underside with antemedian line absent, but slightly visible from upperside, crescent with much less black component. *Hindwing.* Length 52-67 mm. Antemedian area ground color; antemedian line white and black; median area ground color; postmedian line connecting to antemedian line along subcostal margin, colored same as in forewing, pushed distally by crescent; postmedian area peppered as in forewing; submarginal ornamentation with strong markings in the forms of rods, or B-shaped dark patches surrounded by lighter ochre yellow; outer margin with fringe, outer margin rounded; crescent colored as in forewing but shorter and more bent; tornus tapering to a gentle point. *Abdomen.* Tergum of ground color, with broad white belt on first abdominal segment, white tufts obsolete or minimal, but tip of abdomen whitish; spiracular ornamentation golden brown and white; sternum about equally ground color and white, in bands and tufts. *Genitalia* (Figs. 171-177). Uncus bifid, process bent distally; transtilla with a small central ventral indention; valves with typical form and minimal variation; sacculus small, the ventral process most prominent and longest, situated very low ventrally so that there is hardly a ventral edge on the margin; central process less developed and blunt, variable in size, but always present; dorsal process highly reduced to a rectangular lobe; juxta long, with two dorsal lateral peaks; saccus long and narrow, slightly triangular; aedeagus with left ventrolateral thornlike process; vesica with three bulbs: large dorsal one with a sclerite, smaller left lateral one and right one more distal, sometimes reduced to a small curved structure.

Adult ♀ (Figs. 37, 41). Differing from ♂ as follows. *Head.* Antennae 12-13 mm long, 2.8-4.2 mm wide. *Forewing.* Length 70-81 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 8 mm; crescents and postmedian lines more strongly marked; apex 7-10 mm long. *Hindwing.* Length 63-70 mm; outer margin and tornus more rounded. *Abdomen.* Tergum golden brown areas widely separating white tufts, central row of tufts very prominent; spiracular ornamentation large gold blocks up to 3 mm long, bordered with broad white bands; sternum with two longitudinal rows of brown ovals. *Genitalia* (Fig. 206). Anal papilles medium sized, with short bristles, and their bases far medially lateral; papillaes slightly indented, but with prominent ventrolateral lobes distal to the oviporus; lamella postvaginalis nearly straight, with small invagination medially;

lamella antevaginalis straight; both anapophyses and postapophyses very shortened, and bursa copulatrix elongated and slender.

**Discussion.** The patronym for this species credits Steve Kohll of Kayl, Luxembourg. As a result of his successful collecting trip to West Malaysia, he made the first breeding of this species possible, and kindly sent eggs to Naumann in early 1998. This is one of the largest and most beautifully colored species in the genus; the forewings are elongated and falcate, and the ground color is usually a combination of bright orange and reddish pink. Nicely colored figures were published by Barlow (1982) and especially Lampe (1984, 1985), but our color figure in the original description does not do justice to this attractive moth. Thanks to commercial collectors operating during the past 30 years in West Malaysia, this species is fairly common in collections. *Samia kohlli* is sympatric with many famous or lesser known tropical Asian saturniids such as *Actias maenas* Doubleday, *Actias selene*, *Archaeoattacus staudingeri*, *Archaeoattacus edwardsii*, *Saturnia cameronensis* Lemaire, *Lemaireia loepoides* (Butler), *Cricula trifenestrata*, *Attacus atlas*, *Samia canningi, Samia tetrica, Samia wangi*, at least two species of *Loepa*, and several species of *Antheraea* (Seitz 1928; Lampe 1984, 1985; Peigler & Wang 1996).

Nässig et al. (1996a: 27-29) referred to this taxon as "*S. cynthia, sensu* Holloway" and Peigler (1992) considered that it was probably *S. wangi*, which he called *S. walkeri*. Those authors realized that the West Malaysian taxon was not conspecific with true *S. cynthia* from China, but were unsure of which name to apply. Some historical citations (e.g., Candèze 1927) in the synonymy of *S. canningi* probably belong under this taxon, but it would not be possible to sort these out without examining original specimens. One of the three specimens cited by Bryk (1944) was verified by Naumann by genitalia dissection to be *S. kohlli*, but the other two were in fact *S. canningi*; those three specimens were located in The Natural History Museum in London. The specimen cited by Lemée (1950) belongs to *S. kohlli* based on his description and the source locality of Saigon, now Ho Chi Minh City. In their book on Thai saturniids, Pinratana and Lampe (1990) did not distinguish this species from *S. canningi*, but both occur sympatrically in northern Thailand.

Although specimens have been taken in all 12 months of the year, a main flight period appears to be in March and April. There are probably at least two generations per year. The emergence times for the adults undoubtedly depends on the altitude and latitude of the location where a population exists. Available data lead us to conclude that *Samia kohlli* inhabits low to moderately high altitudes with elevations from 200 to 2500 meters, preferring undisturbed (primary) forests. Label data on specimens that say altitudes greater than 2500 meters we suspect to be erroneous, but in any case, most populations apparently exist between 1000 and 2000 meters. Although this moth is common in Peninsular Malaysia, its montane habitat requirements have probably prevented its dispersal to nearby Sumatra. According to Corbet and Pendlebury (1956: 34), the highland or montane zone in West Malaysia is above 760 meters. The trees become smaller than those of the rainforests of the lowlands, and bear some resemblance to deciduous forests of Europe and North America. The absence of *S. kohlli* on Sumatra may provide an important clue to its origin and relationships. About 85% of the butterflies found on Peninsular Malaysia also occur on Sumatra, and those which do not, are generally montane ones. These were considered to be more recent arrivals by Corbet and Pendlebury (1956: 26), because geologically, Peninsular Malaysia was connected to Sumatra more recently than to Burma. Therefore, *Samia kohlli* may be derived from populations in the Himalayas or other low mountains to the northeast.

We opted to restrict the type series to specimens from West Malaysia, which is the southernmost area of dissemination of this species. Much of the material that we have examined is from that region, and the phenotypic variation is less pronounced than in populations farther north. While specimens from the type locality always show a uniformous brownish orange color, there is much variation in populations from other areas. Those from southern and central Thailand, southern Myanmar and Laos are more brownish olive and have a broader white component of the postmedian band. The northern Thai populations share those characters, but they sometimes are even larger and have more white scales in their pattern. Material from northern Myanmar as well as certain specimens from western Yunnan share a lot of characters with typical *Samia canningi*, such as the larger portion of pink to rosy scales in the postmedian area of the wings, a large subapical eyespot, a somewhat rounder forewing apex in some specimens, and a somewhat lighter or ochreous yellow portion anterior to the outer margin; generally those specimens resemble much more closely the West Malaysian specimens than those from populations originating between. In Xizang Zizhiqu *Samia kohlli* appears a little different with a broader pink zone distal to the postmedian band, and in the northwestern end of its occurence also more olive. Specimens from southern, central and sometimes northern Vietnam are quite large and almost uniformously brownish olive in their ground color; the more northerly in origin, the more there is a tendency to be more colorful. In northern Vietnam, syntopic and synchronous occurring specimens in that morph described above and as well some smaller, paler and less colorful are found which very much resemble *Samia wangi*, which occurs nearby. In the southeastern highland parts of Yunnan, plus the populations of Guangdong and Guangxi, *Samia*

*kohlli* becomes somewhat smaller, has less pink and more olive coloration, sometimes similar to the smaller specimens from northern Vietnam. In all these populations we always found single specimens which did not agree with the general overall pattern, size, or color, but after genitalia examination, identification was always certain. It is interesting to note that in some areas in northern Myanmar or northern Vietnam, *Samia kohlli* looks very similar to the co- occurring *S. canningi* and *S. wangi*, respectively; obviously in those areas species identification must rely mainly on genitalia structures, and the parallel pattern and color probably has an ecological basis. It is fortunate, therefore, that the male genitalia are very consistent and diagnostic.

We considered the hypothesis that *S. kohlli* may represent an extreme end of a cline within the widespread and variable *S. canningi*, but the genitalia and larvae do not support this, and the two species are sympatric in some places. Paukstadt and Paukstadt (1991: figs. 1, 3) showed males of *S. kohlli* and *S. canningi* from the same locality in northern Thailand, and the differences in wing pattern and male genitalia (their figs. 5, 6) are obvious. However, the greater variation and less diagnostic phenotypes of *S. kohlli* in the northern and western portions of its range make it difficult to recognize and to characterize taxonomically. In the Introduction to this revision, when we pointed out that taxonomic confusion remains for *Samia* in mainland Southeast Asia, we were referring to *S. kohlli* and *S. wangi*. The various populations that we consider to be *S. kohlli* may in fact represent more than one species, which again, is why we restricted the type series to West Malaysia. We hope that careful field studies by future workers at sites where two or more of these *Samia* fly will provide a clearer understanding. Documenting the immature stages of populations from widely separated locales would also be helpful.

In Peninsular Malaysia (=West Malaysia), *Samia kohlli* is sympatric with *S. tetrica*, from which it is easily separated, the latter being a smaller and darkly colored moth. In that country, *S. kohlli* is known thus far only from the states of Perak and Pahang, but it undoubtedly flies in others. The vast majority of available material originated from the resort areas of Cameron Highlands and Genting Highlands in the Wangsa Mountains (Banjaran Titiwangsa), including the nearby village of Tanah Rata, which is the type locality. (*Samia tetrica* has also been taken at Tanah Rata.) The distribution of the insect extends up the Malay Peninsula through the Isthmus of Kra via the Tenasserim into the Dawna Range of southeastern Myanmar, a country formerly known in the West as Burma. There are also scattered records for northern Myanmar, northern Thailand, Laos, Vietnam, and the southern Chinese provinces of Yunnan, Guangxi, and even Xizang (Figs. 38-41). Naumann recently received a series of four males and one female from Shikangkong Mt. near Luyuan in the Chinese province of Guangdong, collected at 1500 meters in September 2001. This is the easternmost record we have for *S. kohlli*. Its presence in Cambodia should be assumed, at least in the mountainous regions of the Southwest.

Steve Kohll collected caterpillars of this moth on trees of camphor (*Cinnamomum camphora*) in the wild, 6 kilometers south of Tanah Rata in the Cameron Highlands, but no other hosts in nature are known to us. *Samia kohlli* has been reared in Europe on privet (*Ligustrum ovalifolium*) and ailanthus (*Ailanthus altissima*). There are tea plantations in the highlands of West Malaysia, and although those are disturbed habitats, collectors may wish to search for larvae and cocoons on tea plants (*Thea sinensis*), since they are known to be fed upon by *S. insularis* and suspected to be used by *S. abrerai*. Undoubtedly, *Samia kohlli* feeds on many kinds of native and introduced trees throughout its range. Preliminary circadian data recorded in the field and in captivity by Steve Kohll in West Malaysia and by Sven Löffler in Thailand, and by Naumann during his rearing, were that emergences from cocoons were from 19:00 to 23:00 hours; arrivals at lights were from 22:15 to 00:45 hours.

The larval stages are shown in our figures 97 to 101. The mature larva is impressively colored, arguably the most beautiful caterpillar in the genus, so we decided to present a larger photograph of it on the back cover of this book. Based on captive reared material, the cocoons are large and pinkish tan, probably indistinguishable from those of *S. canningi*. Four voucher specimens of cocoons from a lot reared in 1998 by Naumann (one yielded the allotype) were deposited in the Natural History Museum of Los Angeles County.

A few remarks pertaining to the genitalia are needed for clarification. In one dissection (453/00 Naumann) of a Yunnan male Naumann found a third, dorsal process on the uncus, the only one observed in the genus *Samia*, but which sometimes occurs in *Archaeoattacus staudingeri* (genitalia prep. no. 383/99 Naumann; also Peigler 1989: 114). Although the central process of the valve is less developed and blunt, it is variable in size, especially in specimens from northern Vietnam and southern China, and in this character *S. kohlli* can always be easily separated from sympatric and similar-looking specimens of *Samia canningi*. The dorsal sclerite is found in all populations of *Samia kohlli*, with a tendency to be more prominent in northern (northern Vietnamese and Chinese) than in southern (West Malaysian, southern Thai, and southern Myanmarese) specimens. The juxta is longer than in other species. Our figures 171 to 177 are photographs of genitalia of males from West Malaysia, Thailand, Myanmar, Yunnan, Laos, and Vietnam. Regarding the female genitalia, the apophyses are quite short compared to other *Samia*, but the bursa copulatrix is longer.

**Material Examined**. **MALAYSIA**: WEST MALAYSIA, Perak State: 2♂ environs of Taiping, 24 Jan.1983

& April 1988 (Beeke); 1♂ Taiping, 20 March 1992 (Brosch). Pahang State: 4♂1♀ Genting Highlands, 1500 m, 1♂ Feb. 1981, 3♂1♀ March 1981 (Lampe); 1♂1♀ Genting Highlands, ca. 1800 m, bought March 1986 from L. K. Tong by W. A. Nässig, sent to Peigler (LACM); 3♂2♀ Cameron Highlands, 900 & 950 m, 2♂2♀ Nov. 1982, 1♂ Feb. 1984 (Lampe); 30♂6♀ Cameron Highlands, Kampong Raja, ca. 1600 m, 1♂ 9 Oct. 1994, 7♂1♀ 15 Feb. 1995, 3♂2♀ 17 Feb. 1995, 2♂ 20-25 March 1995, 1♂ 1♀ 25 March 1995, 16♂ 2♀♀ 15 Feb.-10 March 1996, leg R. Chong, genitalia 1029-1034 Paukstadt (Paukstadt); 1♂1♀ same data, 14 Feb. 1995, from Paukstadt (Brechlin); 5♂ Cameron Highlands, Tanah Rata, ca. 1400 m, 1♂ March-May 1995, 1♂ Sept.-Dec. 1995, 1♂ Dec. 1995, 2♂ Dec. 1995-March 1996, leg. local people, from Fatt Seng, genitalia 1035 & 1036 Paukstadt (Paukstadt); 1♂ same data, March-May 1995 (Brechlin); 1♂ Cameron Highlands, Tanah Rata, 1400 m, May-July 1995 (Peigler); 1♂ Kampung Raja, 1600 m, 15 Feb. 1996, leg. R. Chong, from Paukstadt (Beeke), 1♂ same data (Brosch); 1♂ Cameron Highlands, Tanah Rata, Robinson Waterfalls, 29 Oct. 1994, 23:00 h, leg. S. Kohll (Kohll); 4♂ 2♀ Pahang, probably Genting Highlands, Hotelareal, ca. 1800 m, leg. local collector via L. K. Tong, genitalia 370 & 470/86 Nässig (SMFL); 2♂♂ Pahang, Genting or Cameron Highlands, 4500-5500 ft. [1371-1676 m], leg. local collector 1978-1985, bought March 1986 from L. K. Tong (SMFL); 1♂ Cameron Highlands, Tanah Rata, 21 March 1984, leg. M. Lüttgen (SMFL); 1♂ Kampong Sahom, ca. 1982, leg. H. F. Wong, genitalia 32/96 Naumann (Naumann); 1♂ Cameron Highlands, Tanah Rata, ca. 1500 m, Dec. 1993-Feb. 1994, leg. W. T. Fatt (Naumann); 4♂ Cameron Highlands, Tanah Rata, 18 Jan. 1998, leg. local collector, from S. Kohll, genitalia 297/89 Naumann (Naumann); 2♂1♀ Cameron Highlands, 6 kilometers south of Tanah Rata, 1250 m, *ex* larva 4 & 8 April 1998, larvae collected on *Cinnamonum camphora* by S. Kohll (Kohll); 2♂ Cameron Highlands, 6 kilometers south of Brinchang, 1250 m, 26 Feb. 1998, leg. S. Kohll (Kohll); 1♀ Cameron Highlands, 3 kilometers north of Brinchang, 1350 m, 21 Feb. 1998, leg. S. Kohll (Kohll); 4♂10♀ same locality, *ex* wild collected female, *ex ovo* in Germany on *Ligustrum ovalifolium*, 1♂ 31 May, 2♂ 4♀ June, 1♀ 3 June, 1♀ 5 June, 1♀ 6 June, 1♀ 28 June, 1♂ 13 July, 23:00 h, 2♀ 14 July, 19:00 & 22:00 h, genitalia 327/98 Naumann (Naumann); 1♀ same data 23 July 1998 (Peigler); 1♂1♀ Cameron Highlands, 1500 m, early March 1999, leg. R. Zenker (MTD); 3♂2♀ Cameron Highlands, 1-10 March 1999, leg. P. Spona (Löffler); 3♂ Fraser's Hill, 1-14 March 1999, leg. P. Spona (Naumann). **MYANMAR**: 1♂1♀ southeastern Myanmar, Dawna, Oct. 1990, leg. S. Steinke, ♂ genitalia 467 Paukstadt (Paukstadt); 2♂ southeastern Myanmar, Dawna, northeast of Moulmein, ca. 1300 m, 1♂ 18 April 1994, 1♂ 21 July 1995, from S. Steinke 1994, genitalia 75 & 76 /97 Naumann (Nässig); 1♂ southeastern Myanmar, Dawna, 25 April 1997, leg. Lehmann (Löffler); 2♂ same data, genitalia 362 & 363/99 Naumann (Beeke); 3♂ same locality, 20, 25 & 28 April 1997, genitalia 215/97 Naumann (Naumann); 2♂ 1♀ northern Myanmar, Zi Yar Dam, 65 km northwest of Putao, 1250 m, 27˚50'N/97˚01'E, 18-21 May 1998, leg. S. Murzin & V. Siniaev (Naumann); 10♂ 1♀ northern Myanmar, Nan Sa Bon, 25 kilometers east of Putao, 800 m, 27˚21'N/97˚40'E, 6-9 May 1998, leg. S. Murzin & V. Siniaev, genitalia 318/98 Naumann (Naumann); 2♂ northern Myanmar, Putao, 500 m, 27˚21'N/97˚24'E, 27 April 1998, leg. S. Murzin & V. Siniaev (Naumann); 2♂ northern Myanmar, Nan Thi, 50 kilometers east of Putao, 950 m, 27˚21'N/97˚55'E, 11-16 May 1998, leg. S. Murzin & V. Siniaev (Naumann). Kachin State, 1♂ Pan-wa, 2200-2350 m, 13 June 2002, leg. Y. Watanabe (Naumann). **THAILAND**: northern Thailand, Chiangmai Province, 1♂ Hang Dong, 19 Oct. 1988, leg. S. Steinke, genitalia 217 Paukstadt (Paukstadt); 1♂1♀ Chiangmai Prov., Mount Inthanon National Park, Stichstraße zum Gipfel [dead end road to summit], ca. 1989, leg. A. Pinratana et al., ♂genitalia 156/97 Naumann (Nässig); 6♂ northern Thailand, Chiangmai 1♂ June 1994, 2♂ 9 April 1995, 3♂ 1 Sept. 1996, via S. Steinke, genitalia 42/97, 107/97, 109-111/97 Naumann (Nässig); 1♂ northern Thailand, Chiangmai, 1 July 1983, genitalia 157/97 Naumann (Nässig); 2♂ northern Thailand, Fang, ca. 1800 m, June 1997, via S. Steinke, genitalia 361/99 Naumann (Beeke). Chiangrai Province, 1♂ 27 Sept. 1988, leg. S. Steinke, genitalia 218 Paukstadt (Paukstadt); 3♂ northern Thailand, Doi Pui, Chao Mong village, 1300 m, 21-23 Aug. 2000, 22:15-00:45 h, leg. S. Löffler (Löffler); 1♂ central Thailand, Kanchanaburi, Sept. 1988; genitalia 155/97 Naumann (Nässig); 1♂ Siam, coll. Fruhstorfer, via R. Caillois, genitalia 228/97 Naumann (MNHN). **LAOS**: 1♂ Mine de Phontiou, 23 May 1963, leg. P. Sciama, genitalia 221/97 Naumann (MNHN); 2♂ 100 kilometers east of Luang Prabang, near Vietnamese border, military camp, 1400-1600 m, 20 Aug.-10 Sept. 1997, leg. M. Steinke, genitalia 360 & 413/99 Naumann (Beeke); 5♂1♀, same data, genitalia 235/97 & 259/98 Naumann (Naumann); 2♂ Ban Hin Ngon, 15 km southwest of Xam Nua, ca. 20˚17'N/103˚58'E, 1000 m, 11-20 Sept. 2002, leg. Ihle (Löffler); 6♂ Dan Sawan, Ban Thalat, 90 km northwest of Viangchan [=Vientienne], 500 m, 5-9 Sept. 2002 leg. Ihle (Löffler). **VIETNAM**: 1♂ Hanoi, 11 May 1910, coll. V. Laboissière, genitalia 232/97 Naumann (MNHN); 3♂ northern Vietnam, Lai Chau Province, Mount Fan Si Pan, western slopes, Sa Pa, 1600-1900 m, 22˚20'N/103˚40'E, secondary forest, 1♂ Sept. 1994, 1♂ June-Aug. 1995, 1♂ Sept. 1995, leg. Mong, genitalia 946/96 Nässig (Nässig); 4♂ same data, 30 June-12 July 1994, leg. R. Brechlin & A. Schintlmeister (Brechlin); 2♂, same data (Lampe); 1♂ Mount Fan Si Pan, western slopes, Sa Pa, 2000 m, 22˚15'N/103˚45'E, primary cloud forest, 5 July 1994, leg. R. Brechlin & A. Schintlmeister (Brechlin); 3♂1♀ Mount Fan Si Pan, western slopes, Sa Pa, 1525 m, 22˚17'N/103˚44'E, primary

forest, 7-10 July 1994, leg. R. Brechlin & A. Schintlmeister; 6♂1♀ Lao Cai Province, Mount Fan Si Pan, northern slopes, Sa Pa, 1600 m, 22˚17'N 103˚44'E, primary forest, April 1995, leg. local people (Brechlin); 1♂ same locality, 20-30 April 1995, leg. V. Siniaev & local people, genitalia 972/96 Nässig (Nässig); 1♂ Mount Fan Si Pan, July 2000 (Löffler); 5♂ Thanh Hoa Province, Cuc Phuong, 120 kilometers southwest of Hanoi, National Park, 400 m, 20˚15'N/105˚20'E, 1 & 2 April 1995, leg. V. Siniaev & A. Schintlmeister; genitalia 948 & 955/96 Nässig (Brechlin); 4♂ northern Vietnam, Vinh Phu Province, Tam Dao, 60 kilometers northwest of Hanoi, 900 m, 21˚34'N/105˚20'E, 20-30 April 1995, leg. local people (Brechlin); 3♂ same locality, April 1995, leg. V. Sinjaev, genitalia 101 & 105/97 Naumann (Naumann); 1♂ same data, 1200 m, genitalia 73/97 Naumann (Witt); 1♂ Tam Dao, ca. 1000 m, 24-26 June 1999, leg. A. Kallies, Y. Arita et al. (Naumann); 2♂ northern Vietnam, Nghe An Province, Ben En National Park, 40 kilometers southwest of Than Hoa, 200 m, 19˚40'N/105˚40'E, 22-30 Nov. 1994, leg. V. Sinjaev & M. Simonov (Brechlin); 4♂1♀ northern Vietnam, Hoang Lien Son Province, Yen Bai, 200 m, 16 May 1990, leg. Z. Skuta, genitalia 102 & 103/97 Naumann (Naumann). Cao Bang Province, northern Vietnam, 1♂ Ba Be Lake National Park, Cao Chi, environs of Bau Pieng, 1450 m, 13 Oct. 1999, leg. S. Löffler (Löffler); 3♂ southern Vietnam, Lam Dong Province, vicinity of Bao Loc, Rung Cat Tien, ca. 1500 m, 11˚32'N/107˚48'E, secondary forest, 20-27 April 1993, leg. V. Sinjaev & M. Simonov, from A. Schintlmeister, genitalia 217/97 Naumann (Nässig); 6♂ southern Vietnam, Kon Tum Province, Plato Tay Nguyen, Mt. Ngoe [Ngoc] Linh, 900-1400 m, 15˚02'N/107˚59'E, 10-25 Aug. 1996, leg. V. Siniaev & Afonin, genitalia 308 & 309/98 Naumann (Brechlin); 1♂ Ninh Bin Province, Cho Ganh, Dec. 1869, collection of L. & J. de Joannis, genitalia 234/97 Naumann (MNHN); 1♂ northern Vietnam near Haiphong, Hai Phong Province, Bach Mai, 10 April 1937, collection of P. Acheray, genitalia 231/97 Naumann (MNHN); 1♂ Phu Lang Thuong [probably near Hanoi, Thai Binh Province ?], collection of L. & J. de Joannis, genitalia 230/97 Naumann (MNHN). **CHINA**: Guangxi Province, 4♂ western Guangxi, Laogong Shan, Xiling, 1800 m, June 2002, leg. Li et al., genitalia no. 762/02 Naumann (Naumann); 1♂ Guangxi, environs of Cua-bung, 1927, leg. Labouille, genitalia 220/97 Naumann (MNHN). Yunnan Province, 1♂ *ex* pupa 27 May 1915, R. Mell collection, genitalia 181/97 Naumann (ZMHB); 4♂ southern Yunnan, Wongding Forest area, ca. 20 kilometers northwest of Changyüan, 2500 m, Sept. 1999, leg. Wang & Li, genitalia 453-455/00, 475/00 Naumann (Naumann); 12♂2♀ northwestern Yunnan, Baimaxue Shan [=Baimaxue Mountains], environs of Dexin, ca. 4500 m, June 1999, leg. Wang & Li, genitalia 384-387/99, 438/99 Naumann (Naumann); 11♂1♀ Deying, Baimaxue Shan, ca. 4000 m, 2 July 2002, leg. Ying et al. (Naumann); 2♂ northwestern Yunnan, Dali Bai Autonomous Pref., Fengshuining Mts., 13 kilometers north of Caojian, 2460 m, 25˚46'N/99˚06'E, 10-23 June 1999, leg. local people, genitalia 471 & 472/00 Naumann (Naumann); 1♂ northern Yunnan, Likiang, 16 July 1934, leg. H. Höne, genitalia 47/97 Naumann (ZFMK); 1♂ southern Yunnan, Jin Ping County, Watershed Nature Preserve, near Vietnamese border, ca. 1000 m, 22˚50'N/103˚00'E, May 1997, leg. local people, genitalia 295/98 Naumann (Naumann); 3♂ Central-western Yunnan, Juangjiang, Daxue Mountain, 3500 m, 22-28 May 1999, leg. Wang & Li, genitalia 436 & 437/99 Naumann (Naumann); 1♂ southern Yunnan, 30 kilometers north of Lanchang, Hei Mountain, 2400 m, 20-30 Aug. 1999, leg. Wang & Li, genitalia 476/00 Naumann (Naumann); 1♂ Yunnan, Yunlong County, northern Baoshan, Daoren Mountain, 2800-3200 m, Sept. 1999, leg. Wang & Li (Naumann).
Guangdong Province, 4♂1♀ Luyuan, Shikangkong Mt., 1500 m, Sept. 2001, leg. Ying (Naumann). Xizang, 1♂ environs of Yargang, April 1901, leg. R. P. Soulié, genitalia 227/97 Naumann (MNHN); 2♂ eastern Xizang, Meilixue Mountain, environs of Yanging, 6000 m [*sic*], July 1999, leg. Wang & Li, genitalia 439/99 Naumann (Naumann); 1♀ eastern Xizang, Tangmai, 2060 m, 20˚10'N/95˚10'E, 5 July 1997, leg. W. Pfitzmeyer (Naumann); 1♂ eastern Xizang, road from Tongme to Peleng, 2000 m, 24 June 1996, leg. W. Fickler (Lampe).

## *Samia peigleri* Naumann & Nässig

(Figs. 42-46, 178, 207; Map 6)

*Samia peigleri* Naumann & Nässig 1995: 13. Paukstadt et al. 1995: 485. Naumann 1995: 27, pl. 6, figs. 6-7 (♂), fig. 8 (♀). Peigler & Wang 1996: 88 (♂, underside), 89 (♀, underside). Paukstadt et al. 1996: 354. Paukstadt et al. 1998: 114. Nässig & Treadaway 1998: 256. D'Abrera 1998: 90-91 (♂♂).

**Types.** Holotype male: Mount Sampuraga, 2˚10'S/120˚45'E, 1400 m, province of Sulawesi Selatan, island of Sulawesi, Indonesia, collected 1-6 February 1995, by Viktor Sinjaev & Evgeni Tarasov (В. Синяев и Е. Тарасов). It was from the Naumann collection, and was deposited in the Zoölogisch Museum, Amsterdam. The

holotype was figured in color in the original description.

There are 16 male paratypes, now in the collections of the Museum Zoologicum Bogoriense, Cibinong, Java; The Natural History Museum, London; Nationaal Natuurhistorisch Museum, Leiden; Senckenberg-Museum, Frankfurt am Main; Zoölogisch Museum, Amsterdam; Naumann; Paukstadt; and Peigler. Some of the paratypes were collected by Naumann at the type locality in 1994. Label data for all paratypes are cited below under "Material Examined." No females were known at the time of the original description.

**Geographical Distribution** (Map 6). *Samia peigleri* is only known from a few mountains in southern Sulawesi (= Celebes) in central Indonesia. Those localities are in the provinces of Sulawesi Selatan and Sulawesi Tenggara.

**Diagnosis.** *Samia peigleri* stands somewhat alone in the genus (like *S. watsoni*) by having some unique characteristics. These are the very prolongated and falcate forewing apex with a large black eyespot (subapical ocellus), the proportions of a small body to large wingspan, and the much reduced saccus in the male genitalia. It can easily separated from the sympatric *S. vandenberghi* and its eastern neighbor *S. naumanni* by these features and the more chocolate, or in some specimens even reddish, ground color, the larger forewing length, the broadly black bordered crescents, the broader and longer antennae in both sexes, and the male genitalia structures, which in the valves somewhat resemble those of the continental *S. kohlli*.

**Description.** Adult ♂ (Figs. 42-44, 46). *Head.* Frons and occiput dark brown. Antennae 12-13 mm long, 5-6 mm wide. *Thorax.* Tergum and sternum dark brown. *Forewing.* Length 55-67 mm. Ground color chocolate brown to maroon; costal margin of ground color; antemedian area lighter than ground color; antemedian line prominent; median area of ground color; postmedian line undulating, black, white, broad rose reddish, and light pink components; postmedian area with pink suffusion sometimes concentrated near veins; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-13 mm; submarginal line faint; outer margin ochre brown; crescent almost straight, very long, narrow; apex very falcate, 15 mm long, 19 mm wide; eyespot black and large, broad white border on top and inner edge; underside lighter brown. *Hindwing.* Length 55-58 mm. Antemedian area slightly lighter; antemedian line between faint and prominent; median area of ground color; postmedian line undulating, with black most developed at crescent; postmedian area broad, suffused with pink, sometimes concentrated near veins; submarginal line obsolete; submarginal ornamentation faint; outer margin rounded; crescent short and open; tornus rounded. *Abdomen.* Tergum brown, with few or no white tufts near base; spiracular ornamentation dark brown; sternum brown. *Genitalia* (Fig. 178). Uncus bifid, with heavily sclerotized tips of processes; transtilla with central indention from dorsal and ventral ends, separating it into two larger lateral portions; valves with very well defined sacculusappearing as a ventral lobe, the long ventral process is situated far dorsally, nearly in the center of the valve; central process shorter and directed more dorsally, dorsal one highly reduced to a dorsal tip of the costa; processes somewhat similar to those in *Samia kohlli*, but the sacculus is unique, as well as the reduced saccus which looks like a small lobe of the vinculum; aedeagus with only slightly stronger sclerotization of the distal left lateral area; a sclerite of the vesica with only weak bulbs is situated right lateral, a feature which is also unique in *Samia*.

Adult ♀ (Fig. 45). Differing from ♂ as follows. *Head.* Antennae 9-10 mm long, 2.9 mm wide. *Forewing.* Length 77 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 13 mm; crescent shorter and more curved than in ♂; apex 13 mm long, 19 mm wide. *Hindwing.* Length 56 mm; crescent very short, open, strongly curved, almost a semicircle; tornus rounded. *Abdomen.* Tergum brown, with few white tufts, in two rows; spiracular ornamentation rings of white; sternum with two rows of white bands. *Genitalia* (Fig. 207). Anal papilles elongated, with pronounced indentation distally, completely covered by long bristles; lamella postvaginalis comparatively short, semicircular, with apophyses connected laterally; lamella antevaginalis comparatively strong, broad, and straight; all four apophyses strong and approximately of equal length.

**Discussion.** In wing area, *S. peigleri* is one of the largest species of *Samia*, although *S. watsoni* has a larger body mass. Females of *S. naumanni* and *S. naessigi* are also quite large, sometimes even larger, supporting the idea that some of the largest saturniids occur on smaller islands (see Peigler 1989: 89); yet specimens of the mainland *S. kohlli* and *S. canningi* are also often equally large. John Cody (pers. comm.), a scientific illustrator and artist, pointed out the remarkable ratio between the small body and large wings in *S. peigleri*. D'Abrera (1998) commented on the extremely falcate forewings, crediting Alfred Russel Wallace (1869: chapter 18) for first making the observation that some Lepidoptera from Sulawesi show this trait. There are various notable forms involving curvature of the forewing of Sulawesi Papilionidae (13 out of 14 species observed by Wallace), Pieridae (10 species), and Nymphalidae (5 species). From an evolutionary viewpoint, such a correlation may be

hard to explain, but we hope that quantitative morphometric studies will be conducted to investigate this apparent phenomenon, at least to demonstrate whether it is real or coincidental. A student wishing to work on this problem would be well-advised to begin with the color figures in Volume 9 of Seitz's *The Macrolepidoptera of the World*, covering the Indo-Australian Rhopalocera, which was primarily authored by the renowned Swiss lepidopterist Hans Fruhstorfer (1866-1922). Packard (1876: 587; 1895: 50) also noted that trends in wing shapes may be correlated with geographical distributions of some Geometridae.

Although less so than in *Samia peigleri*, a strongly produced forewing apex occurs in *Samia vandenberghi*, also an endemic of Sulawesi. All of the other insular species of *Samia* have more produced forewing apices compared to those on the mainland, except for *S. fulva*, whose affinities lie closer to the latter. In the genus *Attacus*, the most recurved forewing apex belongs to *A. erebus* Fruhstorfer, also an endemic of Sulawesi. The forewing apices of both species of *Archaeoattacus* are quite well developed and recurved, yet neither occurs on Sulawesi. If we accept the hypothesis that *S. watsoni* shows more plesiomorphic traits, then the well developed forewing apices seen in *S. peigleri* and *Archaeoattacus* might be viewed as a convergence. However, the dark reddish coloration, large size, montane habitat, and falcate wings collectively lead us to propose that *S. peigleri* may actually be a relict species, whose presence in Indonesia may predate its congeners in that region. In fact, the female of *S. peigleri* superficially looks as much like an *Epiphora* as a *Samia*. Relics often have ranges restricted to high elevations. In her chapter about Sulawesi, van Oosterzee (1997) detailed the high number of endemic species that are known from that intriguing island. Geologically, western Sulawesi was a piece of Gondwana 160 million years ago. It has long been isolated from the surrounding large islands (Holloway 1990b).

D'Abrera (1998) referred to a brown form of *S. peigleri*, and figured an example from Naumann's collection (our Figs. 43-44). However, the moths do not occur in discrete color forms, but exhibit a small range of variability from brown to reddish maroon. The reddest specimens we have seen were collected at 1800 meters at Pulu Pulu (Fig. 42). Only a few female specimens are known. One female from Pulu Pulu, 2000 meters, collected 25 May 1995, was figured in color by Peigler and Wang (1996), showing both upperside and underside. The female was first described and figured by Paukstadt et al. (1995). Specimens of *S. peigleri* are still comparatively rare in collections, and the great majority of specimens were collected during the last decade. Singletons in the two Dutch institutions were collected independently in November of 1989, but no specimens are known to us that were collected at an earlier date. We believe that many additional pinned specimens exist in private collections in Japan.

The only available information pertaining to the biology of this species is based on field collected adults taken at lights, namely, altitudinal and habitat preferences, and circadian and seasonal flight times. Based on limited field data, flight times are mainly April through July, with a few records for August, November, December, and February. The species is probably bivoltine. No cocoons have been found, and no eggs have been obtained from captive females to provide livestock for a rearing.

This species has very distinctive genitalia, quite unlike those of most other *Samia*. A cornutus on the vesica having only two bulbs is situated on the right side, which is unique in *Samia*. The statement by Paukstadt et al. (1998: 118) that this sclerite is absent in the genitalia of *Samia peigleri* is erroneous, as we found this structure in all of the genitalia preparations that we examined.

The areas where this moth occurs are covered by lower montane forest, which is defined by altitudes between 1000 and 2100 meters (Whitten et al. 1987: 31). Specimens of *Samia peigleri* have been collected at altitudes between 900 and 1800 meters. (*Samia watsoni* is known to occur between 1300 and 2400 meters in China.) Another source indicates that the eastern and southern portions of Sulawesi are covered by monsoon forest, with the northern and western parts having tropical rain forest (Ripley 1964: 19); the known range of *S. peigleri* falls within the monsoon zone. Mount Sampuraga, which is the type locality, is covered by primary forest, with fruticose lichens abundant on many trees. Because there is a main road connecting south and central Sulawesi in the area, an alarming amount of deforestation is underway (Naumann, pers. obs.). A color photograph taken at that place was published in the original description (Naumann & Nässig 1995: fig. 5). More recently, the moth has been found at Puncak Palopo, where logging is also being done at lower altitudes. The known localities in Sulawesi Selatan (South Sulawesi) are within the northwestern district of Kambupaten Luwu. Pulu Pulu, also known as Pulu Dua, is a small village northwest of Rantepao in Tanah Toraja. Mount Sampuraga is about 5 kilometers south of the border between Sulawesi Selatan and Sulawesi Tengah (Central Sulawesi). The known collecting sites for this moth are in the eastern Quarles Mountains, southern Tineba Mountains, and the Mekongga Mountains. It should also be expected in the Abuki Mountains and Tangkeleboke Mountains, which are adjacent to the Mekonggas in Sulawesi Tenggara (South East Sulawesi). The distribution of *S. peigleri* undoubtedly extends northward into Sulawesi Tengah, but up to now we have not seen specimens to substantiate this.

There are records from all over Sulawesi for *Samia vandenberghi*, where it likewise prefers mountains, but also exists at lower elevations, with records on museum specimens giving altitudes as low as 500 and 700 meters and even coastal (Naumann & Nässig 1995: 22). In some of its higher montane sites, *Samia vandenberghi* was found to be sympatric and synchronic with *S. peigleri*, such as on Mount Sampuraga, Pulu Pulu, and Puncak Palopo. Other saturniids found at those localities include *Loepa minahassae* Mell, *Attacus erebus*, *Cricula quinquefenestrata* Roepke, *Actias isis* (Sonthonnax), *Antheraea cordifolia* Weymer, *Antheraea celebensis* Watson, *Antheraea rosemariae* Holloway, Nässig & Naumann, and *Cricula trifenestrata kransi* Jurriaanse & Lindemans (Naumann 1995).

**Material Examined. INDONESIA**: 1♂ paratype, Sulawesi [=Celebes], Sulawesi Selatan [South Sulawesi Province], Gunung [Mount] Sampuraga, 1250 m, 3 Aug. 1994, leg. Naumann, genitalia no. 743/95 Nässig (Naumann); 14♂ holotype and paratypes, Gunung Sampuraga, 2˚10'S/120˚45'E, 1400 m, 1-6 Feb. 1995, leg. V. Siniaev & E. Tarasov, genitalia no. 874/95 Nässig (1♂ *ex* collection of Naumann to BMNH; 1♂ MZB, 2♂ Nässig; 7♂ Naumann, one figured by D'Abrera 1998: 91; 1♂ Paukstadt; 1♂ Peigler, figured by Peigler & Wang 1996: 88; 1♂ holotype ZMA); 1♂ same locality, July 1992, leg. local collector (Brechlin); 1♀ same locality, 11-12 Feb. 1995, leg. V. Siniaev (Brechlin); 1♂ same locality, May 1995 (Naumann); 2♂ same locality, July 1995 (Naumann); 1♂ same locality, July 1995, leg. S. Alam & A. Hakim (Brosch); 1♂ same locality, April 1996 (Beeke); 1♂, same locality, 19 May 1994 (Peigler); 1♂ Pulu Pulu, 1800 m, Feb. 1995 (Kohll); 1♂, same locality, 27 May 1995, *ex* collection of Peigler, received from Pierre Schmit (LACM); 2♂ same locality, July 1995, genitalia no. 113/97 Naumann (Naumann); 1♂, same locality, Aug. 1995, figured by D'Abrera 1998: 91 (Naumann); 1♂ same locality, 1800 m, 26 May 1995, received from Pierre Schmit (Peigler); 1♂ same locality, 1600 m, 20 km north-northwest of Rantepao, July 1995, leg. Samsul Alam & Abdulah Hakim, *ex* collection of Paukstadt no. 57, sent to Peigler (LACM); 1♂1♀ Puncak Palopo, 1300 m, July 1995 (Paukstadt); 8♂1♀, same locality, 900-1300 m, Dec. 1996 (Brechlin); 1♂ same locality, April 1998 (Brosch); 1♂1♀ same locality, June 1998, *ex* collection of Martin Beeke, ♀genitalia no. 623/01 Naumann (Naumann), 1♀ same locality, June 1998, 1300 m, *ex* collection of Martin Beeke (Peigler); 1♂ same locality, Telekom station, 1400 m, March-April 1998, leg. local collector (Naumann); 1♀ Kalewakan, May 1996 (Brosch). Sulawesi Tenggara [South East Sulawesi Province], 1♂ paratype, Gunung Watowila, northeast of Kolaka, 3˚49'S/121˚40'E, 1600 m, Nov. 1989, leg. J. P. Duffels, genitalia no. 745/95 Nässig (ZMA); 1♂ paratype, Gunung Watowila, south of Sanggona, 3˚39'S/121˚40'E, 1250 m, Nov. 1989, leg. van Tol (RMNH).

## *Samia insularis* (Snellen van Vollenhoven)

(Figs. 47-49, 179-180, 208; Map 8)

*Saturnia insularis* Snellen van Vollenhoven 1862b: 337-339, pl. 14, fig. 1 (♀). Guérin-Méneville 1862a: 339. van Westmaas & de Graaf 1862: 117 (footnote). Clugnet 1877: 81.
*Bombyx Cynthia erythrinae* (*insularis*) Guérin-Méneville 1862a: 342. [*nomen nudum*]
*Bombyx Cynthia erythrinae,* Guérin-Méneville 1862a: 342. [*nomen nudum*]
*Attacus insularis*, Butler 1878: 388. Wardle 1881a: 646.
*Attacus Insularis*, Preiss 1888: 4, pl. 3, fig. 1 (♀).
*Attacus Cynthia*, Walker 1855: 1220 (in part). Horsfield & Moore 1860: 407 (in part). Pagenstecher 1890a: 103.
*Attacus cynthia*, Moore 1859: 267 (in part).
*attacus cynthia*, Serre 1906: 348. [misidentification]
*Philosamia Cynthia*, Kirby 1892: 748. Dusuzeau & Sonthonnax 1897: 29. [in part]
*Philosamia cynthia*, Ye & Hu 1996: 30 (in part).
*Samia cynthia walkeri* f. *radiata* Closs 1917: 130, pl. 5, fig. 6 (♂).
*Attacus ricini*, Koningsberger 1915: 141. Dammerman 1919: 118. Menzel 1925: 32, pl. 6 (♂). [misidentifications]
*Philosamia cynthia insularis*, Packard 1914: 243, pl. 76 (♂, ♀ [as *P. cynthia*], pl. 92 (♂, ♀). Rebel 1924: 112. Rebel 1925a: 12, pl. 3, fig. 7 (♂). Rebel 1925b: 157. Schüßler 1933-1934: 27, 520. Jolly et al. 1979: 7.
*Philosamia Cynthia* var. *Insularis*, Silbermann 1897: vol. 1: 319.
*Philosamia cynthia* var. *insularis*, Sonthonnax 1901: 133. Bouvier 1927: 930. Bouvier 1932: 44.

*Philosamia insularis*, André 1908: 76. Watson 1912: 45. Bouvier & Riel 1931: 81. Chowdhury 1982: 6.
*Philosamia Insularis*, Watson 1911: 5.
*Samia cynthia insularis*, Seitz 1928: 504, pl. 55Ab (♀). van Eecke 1930: 413. Bouvier 1936: 317. Dupont & Scheepmaker 1936: 173, fig. 113 (♂), fig. 114 (larva, pupa, cocoon). Collins & Weast 1961: 115.
*Samia insularis insularis*, Naumann 1995: 30. Paukstadt & Paukstadt 1998: 17.
*Samia insularis*, Leefmans 1930: 98. Peigler 1989: 13. Paukstadt et al. 1994: 58. Nässig et al. 1996a: 28. Peigler 1996: 17, 121. Paukstadt et al. 1998: 120. Naumann 1998: 449. Nässig & Treadaway 1998: 252.
*Philosamia insularis vaneeckei* Watson 1913: 49.
*Philosamia cynthia van eecki*, Bouvier 1932: 44.
*Philosamia cynthia* var. *Van Eecki*, Bouvier 1927: 931.
*Philosamia cynthia vanneeckei*, Rebel 1924: 112.
*Philosamia cynthia* form *vanneecki*, Rebel 1925a: 12.
*Philosamia cynthia vaneeckei*, Rebel 1925b: 157, 167. Jolly et al. 1979: 7.
*Philosamia cynthia* f. *Vaneeckei*, Schüßler 1933-1934: 28, 521.
*Philosamia vaneeckie*, Chowdhury 1982: 6.
*Samia cynthia vaneecki*, Bouvier 1936: 317.
*Samia cynthia vaneeckei*, Seitz 1928: 504. van Eecke 1930: 413.
*Semia* [*sic*] *cyntia* [*sic*] *vaneeckei*, Kishida 1977a: 3.
*Samia insularis vaneeckei*, Nässig et al. 1996a: 27, pl. 4, figs. 14-15 (♂♂), 16 (f). Nässig et al. 1996b: 118, pl. 1, figs. 6-8 (eggs, larvae).
*Samia* (*insularis*) *vaneeckei*, Nässig & Treadaway 1998: 255.
*Samia cynthia*, Kalshoven 1951: 557. [misidentification]
*Samia cynthia ricini*, Kalshoven 1981: 318. [misidentification]
*Philosamia cynthia* var. *Vollenhoveni* Bouvier 1927: 932.
*Philosamia cynthia vollenhoveni*, Bouvier 1932: 44.
*Samia cynthia vollenhoveni*, Bouvier 1936: 317.
*Samia* sp., D'Abrera 1998: 86, 87 (♂♀). Brosch et al. 1999: 39.
*Sine nomen latinum:* Subyanto & Sulthoni 1991: 148 (larva).

**Types.** Samuel Constantinus Snellen van Vollenhoven (1862b) stated that he received specimens of this new moth from Sumatra and Java. A female was figured, but the only specimen in the Muséum National d'Histoire naturelle, Paris, that can be identified as a syntype is a male labeled "Ludeking, Sumatra" that both of us examined. We hereby designate that male as lectotype of *Saturnia insularis*, an action which now fixes the type locality as Sumatra. The specimen was collected by E. W. A. Ludeking, who collected in Java and Sumatra (Horn et al. 1990: 243). Another handwritten label reads "Envoyé avec cette étiquette le 6 fevr. 1861 par M. Vollenhoven qui proposé le nom de *S. insularis*" [Sent with this label the 6th of February 1861 by Mr. Vollenhoven who proposed the name of *S. insularis*], on the backside it says "*Saturnia insularis* n. sp." There is a red typeset label that says "TYPE" and a large one written in pencil by Bouvier that has "*Samia cynthia* var. *vollenhoveni* Bouv.; ♂ type; Sumatra; coll. Guérin-Méneville; E .L. Bouvier det." Thus *Philosamia cynthia insularis* var. *Vollenhoveni* is a junior objective synonym of *Samia insularis*, since both names were based on the same type specimen. The female figured in the original description thereby becomes a paralectotype. Most authors have assumed that the type locality for *Samia insularis* was in Java, and have incorrectly cited the name of the author as only Snellen or only Vollenhoven. Bouvier's name *vollenhoveni* was apparently not published by any other authors, not even Schüßler (1933-1934). It was named after S. C. Snellen van Vollenhoven.

In The Natural History Museum in London we examined two pairs of syntypes of *Philosamia insularis vaneeckei* (Watson 1913), but a third male cited in the original description appears to be missing. The type locality is Solok, near the city of Padang on Sumatra's west coast, in Sumatera Barat Province. The label on the male, which we hereby designate as lectotype, reads "Solok Padang 1907n10; P. O. Stoln." The other male and two females hereby become paralectotypes. It was named in honor of Rudolf van Eecke who was a curator of insects at the "Leyden Museum," now Nationaal Natuurhistorisch Museum Naturalis, Leiden, The Netherlands.

It is doubtful that extant type material exists for the names *Bombyx Cynthia erythrinae* Guérin-Méneville (1862a) and *Samia cynthia walkeri* f. *radiata* Closs (1917). In any case, both are invalid in the sense of the Code (1999), the first being a *nomen nudum* and the second a quadrinomial. As indicated below, one of the well known host plants of the caterpillars is *Erythrina*. The name *radiata* refers to the radiating pink patches of the postmedian line extending into the postmedian area along the veins.

**Geographical Distribution** (Map 8). *Samia insularis* ranges mainly on the Indonesian islands of Java and Sumatra. We have also studied specimens from the nearby small islands of Krakatoa and Nias.

**Diagnosis.** *Samia insularis* is defined by its olive brown ground color, fading to an ochre brown, by the falcate violet pink forewing apex, and the nearly straight postmedian line of the forewing, which is indented only at the crescent. The crescent is long and straight, and often pushes through the postmedian line, which is white and pink. From the sympatric *S. abrerai* it can easily be separated by the more falcate forewing apex, the smaller diameter of the apical eyespot and the lack of a black dot below that eyespot, the less intensive ground color and wing pattern differences; *S. abrerai* has shorter crescents (ocelli), more curved postmedian line, but in the male genitalia, *S. insularis* differs in the processes of the valves, a longer aedeagus, and smaller or missing sclerites on the vesica. *Samia tetrica* is smaller and darker; *S. vandenberghi* larger, darker olive brown, with less falcate forewing apex; and *S. kohlli* much larger and more colorful, with a longer ventral process of the valves. The crescent in the forewing of both sexes often shows a conspicuous turn at the outer end, usually not seen in other species.

**Description.** Adult ♂ (Figs. 47-48). *Head.* Frons and occiput golden brown. Antennae 10 mm long, 3.1 mm wide. *Thorax.* Tergum and sternum golden brown. *Forewing.* Length 64-77 mm. Ground color golden brown to ochre yellow; costal margin of ground color; antemedian area lighter than ground color; antemedian line prominent, with white and black components; median area of ground color; postmedian line straight or curving inward below crescent, sharply contrasting with black, white, rose, and pink bands; postmedian area sprinkled with black and ochre scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5 mm; submarginal line contrasting, separating inner light and outer dark zones; outer margin brownish ochre; crescent very slender, swollen at top, usually intersecting postmedian line; apex 11-12 mm long, with purplish patch, and light dash proximal to eyespot; eyespot black with white band along topside, oval, variable in size; underside lighter and paler in all features. *Hindwing.* Length 42-57 mm. Antemedian area lighter than ground color; antemedian line prominent; median area of ground color; postmedian line undulating; postmedian area as in forewing, with rose suffusion concentrated near veins; submarginal line obsolete; submarginal ornamentation boldly marked; outer margin weakly rounded; crescent small and short; tornus pointed. *Abdomen.* Tergum brown with white tufts; spiracular ornamentation dark brown with small bits of white; sternum brown, darker medially. *Genitalia* (Figs. 179-180). Uncus bifid, transtilla with a small indention dorsally; vinculum and saccus broader than in *S. abrerai*; sacculus nearly triangular, situated basally; ventral process of valves basally broader, longer, and bent a little more in dorsal direction than in *S. abrerai*; central process is less developed, blunt, dorsal one similar; aedeagus generally longer than in *S. abrerai*, a weakly developed spine left laterally; vesica with typical three bulbs, on the dorsal one a sclerite smaller than in *S. abrerai*; this sclerite found always in Javanese populations but reduced or missing in Sumatran populations, also confirmed by the observations of Nässig et al. (1996: 28). Paukstadt et al. (1993: 234) apparently confused Javanese and Sumatran populations.

Adult ♀ (Fig. 49). Differing from ♂ as follows. *Head.* Antennae 9 mm long, 2.9 mm wide. *Forewing.* Length 78 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 7 mm; crescent larger yet slender; apex 11-12 mm long, 21 mm wide. *Hindwing.* Length 62 mm; crescent short, evenly curved, variable in size; tornus rounded. *Abdomen.* Tergum ochre yellow with large white tufts; spiracular ornamentation a broken row of white patches; sternum ochre yellow with two rows of white spots. *Genitalia* (Fig. 208). Anal papilles relatively small, elongated laterally, with deep indentation and only very short, thin bristles; lamella postvaginalis cordiform, with rounded distal lobes heavily sclerotized ventro-laterally; lamella antevaginalis rounded, a bit higher medially; posterior apophyses slightly longer than anterior apophyses.

**Discussion.** The name *insularis* means insular, referring to islands. It is an appropriate name for this species, since it's range does not extend onto the Asian mainland. The name *radiata* was correctly synonymized under this species by Seitz (1928: 504), who also pointed out that material he had from Java and Sumatra differed very little, thus implying that the name *vaneeckei* probably did not represent a valid taxon. *Samia insularis* has been confused with *Samia abrerai*, which we described recently as new (Naumann & Peigler 2001). Further comments pertaining to these two species can be found under the discussion of the latter.

As far as we can determine, reports of this species on the Southeast Asian mainland pertain to misidentified or mislabeled specimens. It is replaced in nearby West Malaysia by *S. kohlli* and *S. tetrica*, and on Borneo again by *S. tetrica*. It is sympatric with *S. abrerai* in both eastern and western Java. Zhu and Wang (1983) cited this taxon (as *Philosamia cynthia insularis* Voll) from China, but their figure shows a male of *S. wangi.* Brosch et al. (2000: 39) referred to a male specimen as "*Samia* sp." in the Muséum National d'Histoire naturelle, Paris, labeled as coming from Phontiou, Laos, collected in 1962 by P. Sciama. The genitalia were dissected and the

identification verified by Naumann, but we believe that specimen of *S. insularis* is mislabeled regarding the source locality. That the moth has been collected on Krakatoa invites our attention, as all life on that island was destroyed by volcanic activity in 1883, and Dutch biologists documented the recolonization of plant and animal species during the following decades. Most historical material in museum collections was collected by Dutch entomologists, but there exists newer material provided by various Indonesian collectors (Gideon, Widagdo, and Liem Hwie Tjiang) and the well-known German lepidopterist Eduard W. Diehl who has worked as a medical doctor in Sumatra for many years.

In Java the moth flies mainly in the mountainous areas, inland from the coast. Most known localities are from the provinces of West Java (Jawa Barat) and East Java (Jawa Timur), but it is also known from Central Java (Jawa Tengah) and the vicinity of Jakarta. The large mountains across Java are mostly active volcanoes, and specimens of *S. insularis* have been collected on the forested slopes of several including Bromo, Ardjuno, Gedeh, Salak, Halimun, Sesuru, Sindur, Jampang, Argopuro, or in towns and villages near their bases. Some of these are within protected zones, such as Gunung Gede Pangrango National Park (Mount Gedeh) and Halimun, which has been a nature preserve since the 1930s and became a national park in 1992. Mount Halimun National Park still contains a lot of lowland and montane forests. These areas are extremely important for the protection of birds and mammals, including primates, and should provide some perpetual protection for fine moths like *Samia insularis*, *Samia abrerai*, and *Archaeoattacus staudingeri*. Of course, natural activity by volcanoes will always remain a potential threat.

The foodplants in Java include swamp-peach (*Syzygium aqueum*), quinine (*Cinchona succirubra*), *Erythrina subumbrans*, and tea (*Thea sinensis*), but we did not find reports of this species being cited as a pest of the aforementioned crops. In western Java, the larvae are seen commonly in April and May, and only sporadically in the following months. Then they are even more common in the months of August and September (Dupont & Scheepmaker 1936: 176). These records suggest a bivoltine life cycle in that area. Rebel (1925a: 12) cited *Erythrina indica* as a primary food for *S. insularis*. In December 1999, Naumann collected viable cocoons in the Bandung area on outer branches of tea plants that were growing in rows as low hedges about 60-70 centimeters high. Local insect dealers told Naumann that the cocoons are now difficult to find because of insecticide treatments. Interestingly, the related saturniid *Callosamia securifera* feeds in nature in *Gordonia lasianthus* (L.) Ellis, a tree also in the tea family. Paukstadt and Paukstadt (2000: 44) cited the circadian flight times for males of *S. insularis* arriving at lights at lower elevations in Java as being 3:15 to 4:15 hours. About a century ago, Johannes Elias Teysmann, the director of the Botanical Garden in Bogor, Java, reported on his rearing of *S. insularis*. A female laid 575 eggs, larvae eclosed 9-12 days later, and matured three weeks later. The food he used was *Erythrina indica* (André 1908: 77). Another author stated that the larvae are found most commonly in plantations of quinine, and that in Java they are heavily parasitized by the tachinid fly *Exorista sorbillans* (Kalshoven 1981). Eggs of *S. insularis* are sometimes attacked by the eupelmid *Mesocomys menzeli*, and cocoons of this moth have yielded *Xanthopimpla brullei*, a widely ranging ichneumon specializing on Saturniidae (Townes & Chiu 1970), recorded for example to attacks cocoons of *Cricula* on Sulawesi and Java, *Attacus atlas* on Java and in West Malaysia, and *Samia luzonica* in the Philippines. Undoubtedly many more hostplants and parasitoids of *S. insularis* remain to be discovered.

Biological data for *S. insularis* on the island of Sumatra were outlined by Nässig et al. (1996a, 1996b). The moth can be found commonly at lights, and it occurs frequently in urban and agricultural areas, but it is even more common in primary and secondary forests. Known localities for this moth on Sumatra range from sea level up to 1600 meters, but the majority of known sites are in highlands along the inland mountain range that runs parallel to the southwestern coast of that large island. Even the record from Riau Province of eastern Sumatra is far inland, in the mountains along the western edge of the province. The former Fort de Kock is now surrounded by the city of Bukittinggi in the center of the Agam Valley, about 90 kilometers north of Padang, West Sumatra. The moths have been collected in all months of the year, but a weak peak in flight activity was noted to be in September, which agrees with the Javanese temporal data cited above. In January 1984, Wolfgang Nässig found a clump of about 50 ova on the underside of a leaf on pohon dadap (*Erythrina* sp.), near Brastagi, on the same plant that *Attacus atlas* was feeding. Larvae from another field collection in North Sumatra were reared by H. Plössl in Innsbruck, Austria, in 1986 on *Ailanthus altissima*.

**Material Examined. INDONESIA**: SUMATRA: 1♂2♀ Aceh Province, NW-Aceh, 84 km east of Banda-Aceh, Mount Silawa, 600 m, 23, 28 & 29 March 1993 (Brechlin). 1♂ Perlak, Penruela [Peureulak] (University of Nebraska Museum, Lincoln); 1♀ Sumatera Utara [North Sumatra] Province, Battak [Batak] Mts., leg. Dr. Martin, Rothschild Bequest (BMNH); 6♂1♀ Medan, May & Aug. 1962, 23 Nov. 1967, 20 March 1968, leg. E. Diehl, coll. H. Eckerlein (MHNG); 2♂ Dolok Merangir [3˚08'N/98˚30'E, 1500 m], April 1972, leg. Küppers (Witt); 1♂ road 1, 20 km southeast of Parapat [=Prapat], 15-16 April 1972, leg. Roesler & Küppers (ZFMK); 1♂

"Daraklangkat, east coast of Sumatra" 1909, L. P. DeBussy (USNM); 1♂ Tiga Dolok, 12 km north of Parapat, Lake Toba, 1200 m, 20 June1972, leg. Roesler & Küppers (ZFMK); 1♂ Tele, Lake Toba [2˚31'N/ 98˚38'E], 1150 m, 31 March 1984, leg. E. Diehl (SMFL); 1♂ Tapanuli Utara, 20 km south of Tele, western coast of Lake Toba, 10 March 1984, leg. L. Kobes (SMFL); 1♂ Huta Padang, 500 m, 2˚49'N/99˚14'E, primary forest, 1-4 Sept. 1991, leg. Graul & A. Schintlmeister (LACM); 1♂ same data (SFML); 1♂ same locality, 22 April 1979, leg. E. Diehl, coll. S. Kager, genitalia no. 465/86 Nässig (SMFL); 1♂ Batakland, Holzweg [logging road] No. 2, environs of Pemantangsiantar, 2˚47'N/89˚56'E, 1050 m, 13-31 March 1993, leg. E. Diehl (Brechlin); 2♂ same locality, 12 Sept. 1985 & 11 May 1986, leg. E. Diehl (SMFL); 1♂ Holzweg 2/4, 2˚46'N/98˚59'E, 1000 m, 15 Dec. 1996, leg. E. Diehl (SMFL); 3♂ Brastagi [=Berastagi; 3˚10'N/98˚30'E], Feb. & 17 April 1966, 20 July 1968, leg. E. Diehl, coll. H. Eckerlein (MHNG); 2♂ same locality, 1400-1500 m, 8 Feb. & 2 May 1984, leg. Arbaimun (SMFL); 1♂ same locality, May 1984, received from W. A. Nässig (Naumann); 3♂ same locality, 1350 m, June 1987, March 1988, Jan. 1990, leg. Gideon (Paukstadt); 3♂ Aek Tarum, Gunung [Mount] Malayu [2˚43'N/99˚25'E, 250 m], 14 Aug. 1983, 22 Jan. 1984, leg. E. Diehl, genitalia no. 464/86 Nässig (SMFL); 10♂ Prapat, Holzweg 3, 20 Feb., *ex* pupa 3 March, 7 April, 3 June, 2 July & 12 Aug. 1983, 24 June, 18 Oct. 1984, 9 Jan. 1985, leg. E. Diehl, genitalia no. 372 & 467/86 Nässig (SMFL); 1♂ same locality, 8 Dec. 1983, leg. E. Diehl, received from W. A. Nässig (Naumann). 1♂ Nias Island, [Sumatera Utara Province], North Nias, Kalim Bungo, 1896, leg. L. Z. Kannegieter, Rothschild Bequest (BMNH); 1♂5♀ Central Nias, Dyma, March-May 1895, leg. R. Mitschke, Rothschild Bequest (BMNH). 3♂3♀ Sumatera Barat [West Sumatra] Province, Padang Bovenland, leg. S. G. Schoede (ZMHB); 2♂ Padang, 800 m (SMFL); 2♀ Solok, Padang, 1904, leg. P. O. Stolz (RMNH); 16♂3♀ same data, 1907 (RMNH); 7♀ same data, 1909 (RMNH); 1♀ Fort de Kock, leg. Rims, coll. Staudinger (ZMHB); 2♂1♀ Fort de Kock, April 1914, April & June 1917, leg. Edw. Jacobsen (RMNH); 3♂ Fort de Kock, leg. Wirt Robinson (USNM); 1♂ Lembah Anai, 10 km south of Padang, 0˚30'S 100˚20'E, 500 m, near forest, 18 Oct. 1981, leg. Widagdo, A. Schintlmeister & U. Roesler, genitalia no. 466/86 Nässig (SMFL); 1♀ Loeboek Sikaping [Lubuksikaping], 450 m, 1923-1927, leg. L. Hundeshagen (MZB); 2♂ Padangpanjang, 775 m, March 1982 & Dec. 1985, leg. Widagdo (Paukstadt); 1♂ Harau Mountain, 500 m, March 1982, leg. Widagdo (Paukstadt); 3♂ Lembah Harau, March 1982 & Jan. 1984, leg. Widagdo (SMFL). 1♂ Sumatera Riau Province, Taloek [Taluk, 0˚32'S/101˚35'E], 4 April-12 June 1907, leg. S. G. Maas (ZMHB). 9♂ Bengkulu Province, Lebong Tandai [3˚01'S/101˚54'E], 1920, April 1922, 12-26 Feb. 1923, 16-23 April 1923, 1 Oct.-5 Nov. 1923, B. M. 1936-681 (BMNH); 1♂ "Bankoelen, NE Dempo", 1100 m, May-June 1959, leg. H. van Ges, coll. E. J. Nieuwenhuis (RMNH). 1♀ "Central Sumatra" [*sic*], Lampung Province, 1♂ Krakatau Island, Feb. 1997 (Naumann). Telokbetong [Tanjungkarang-Telukbetung], Kalianda [5˚45'S/105˚38'E], "overgang van natte near droge moesson", 1928 (RMNH); 1♂ Tanjung Sakit, 1200 m, July 1987, leg. Gideon (Paukstadt). 1♂ Sumatra, Sikalang, 7 Sept. 1989, leg. Gideon (Paukstadt); 1♂ Sumatra, coll. Staudinger (ZMHB); 1♂ "f. *vaneeckei*" Sumatra occidental, coll. Staudinger & Bang-Haas (MTD); 1♂ Sumatra (USNM). JAVA: 1♂ Jakarta Raya Province, Batavia [Jakarta], leg. Westermann (ZMHB); 4♂2♀ Jawa Barat Province [West Java], Buitenzorg [Bogor], 250 m, *ex* larva 3-13 Oct. 1932, leg. F. Dupont (RMNH); 1♂ same locality, Jan. 1936, leg. M. A. Kufbrink (MZB); 1♂1♀ Buitenzorg [Bogor], April 1909, leg. Bryant & Palmer, figured by Packard 1914: pl. 76 (USNM); 1♂1♀ environs of Bogor, Dec. 1994, received from F. Meister (Naumann); 1♂2♀ Mt. Gedeh, June 1921, leg. Mrs. M. Steele, Rothschild Bequest, genitalia slide 405 B.M. (BMNH); 1♀ Mount Gedeh, Goalpara, 1220 m, Feb.-June 1935, J. M. A. van Groenendael collection (ZMA); 2♀ Mt. Gedeh, Tjikopo, 700 m, 20 Dec. 1940 & 25 March 1941, leg. Soekarno (MZB); 1♀ Tjikopo, 1000 m, 20 June 1940, leg. J. Olthof (MZB); 1♂ Gunung Halimun, Banten, Bayah, 1200 m, Oct. 1998 (Paukstadt); 1♂ Gunung Halimun, 1000-1200 m, Dec. 1999 (Naumann); 1♂1♀ Salak Mt., *ex* pupa May 1993, leg. U. Paukstadt (Brosch); 2♂2♀, same data, ♂genitalia no. 13/96 Naumann (Naumann); 1♀ Ciawi, 350 m, *ex* cocoon Oct.-Nov. 1973, leg. Liem Hwie Tjiang (Peigler); 1♂ 2♀ same data (LACM);1♂1♀ Puncak, Ciawi, 800 m, *ex* cocoon May 1993, leg. L. H. Paukstadt (LACM); 1♂ same data (Peigler); 1♀ Sukabumi, 1908 (MNHN); 1♀ same locality, bred 15 Feb. 1924, by Walsh (RMNH); 4♀ Sukabumi, Mt. Sesuru, 1914, B. M. 1922-165 (BMNH); 2♂ Sukabumi, Preanger Regentsch., "1ste trintel +-3000 ft", leg. L. Z. Kannegieter, Rothschild Bequest (BMNH); 2♂2♀ 610 m, 19 June 1936, 28 Jan. 1937, 24 March & 27 April 1939, J. M. A. van Groenendael collection (ZMA); 2♂ Malabar, Bandung, Sept. 1906, B. M. 1922-165 (BMNH); 4♂2♀ environs of Bandung, 17-26 May 1924, 27 May 1926, 1927, A. Diakonoff (ZMA); 1♀ Bandung, Sept. 1941, E. J. Nieuwenhuis collection (RMNH); 2♂ Bandung, 750 & 800 m, 1917 & 25 April 1940, leg. F. C. Descher (MZB); 1♂ environs of Bandung, *ex* wild-collected cocoon 26 March 2000, 21:00 hours, reared by S. Naumann (Naumann); 1♀ West Preanger, Salimar, 914 m, Sept.1895, leg. L. Z. Kannegieter, Rothschild Bequest (BMNH); 8♂4♀ Preanger, Palaboekan Ratoe [Pelabuhanratu], B. M. 1922-165 (BMNH); 2♂2♀ Priangan, Jan 1933, 3 Nov 1936, 4 Jan 1938, J. M. A. van Groenendael collection (ZMA); 5♂ Priangan Kulon, Baros, 365 m, 12 June 1941, J. M. A. van Groenendael collection (ZMA); 5♂1♀ Gunung Sindur, Tasikmalaya, 90 km southeast of Bandung, March 1999, ♂genitalia no. 891-896 Paukstadt (Paukstadt); 2♂2♀

West Java, leg. M. Cedic (DEI). 1♂ Jawa Tengah Province [Central Java], Tjilatjap [Cilacap], Banjoemas [Banyumas, 7˚31'S 109˚17'E], June-July 1899, Rothschild Bequest (BMNH); 2♂ Magelang [7˚28'S/110˚13'E], 1886, Staudinger collection (ZMHB); 1♂ Salatiga [7˚19'S/110˚30'E], 22 May 1909 (ZMA); 1♂ Semarang, without further data (RMNH). 3♂2♀ Jawa Timur Province [East Java], Malang (MNHN); 6♂5♀ Nonkodjadjar [northern slopes Mount Bromo], 1220 m, April, May, & June 1934, leg. J. P. A. Kalis, Rothschild Bequest (1♂ figured by D'Abrera 1998, p. 87 as "*Samia* ?sp.") (BMNH); 8♂10♀ Djunggo Ardjuno [Mount Arjuna], 1372 m, June 1934, leg. J. P. A. Kalis, Rothschild Bequest (BMNH); 1♀ Djampang Kidoel [Pegunungan Kidul, 8˚13'S/111˚30'E], Bodjong Asih, 20 July 1939, J. M. A. van Groenendael collection (ZMA); 2♂2♀ Mount Djampang, Feb. 1932, Decart collection (MNHN); 2♂ 550 m, 20 June 1941, J. M. A. van Groenendael collection (ZMA); 1♂2♀ Djampang, Tengah, 300 m, 20 June 1941, J. M. A. van Groenendael collection (ZMA); 10♂1♀ Mount Argopuro, April, May, & Aug 1998, received from Detani (Naumann); 2♂4♀ same locality, April & May 1998, leg. local collector (Brosch); 3♂4♀ same locality, July 1997, April 1998, Jan. 1999, via H. Agusyanto (Löffler). 1♀ without exact locality, Yaroot, 26 Nov. 1929, E. J. Nieuwenhuis collection (RMNH); 1♂ Selabintana, 914 m, 9 Jan. 1933, J. M. A. van Groenendael collection (ZMA); 2♂1♀ Baros, Tjijadas, 300 m, 12 June 1941, J. M. A. van Groenendael collection (ZMA); 1♂ "*var. insularis vollenh.*" in Guer. Revue 1862", Java, Dekaan (ZMHB); 3♂1♀ Java (ZMHB); 1♀ "*Attacus insularis*", Java, Staudinger & Bang-Haas collection (MTD); 2♂1♀ without locality, March & April 1993, ♀genitalia no. 626/01 Naumann (Naumann). 1♂ no locality data, Karl H. Christian collection, donated Dec. 1954 (LACM). Probably mislabeled: **LAOS**: 1♂ Phontiou, 1962, leg. P. Sciama, genitalia no. 223/97 Naumann (MNHN).

## *Samia abrerai* Naumann & Peigler

(Figs. 50-52, 181-182, 209; Map 8)

*Philosamia Cynthia* f. *canningi* ssp. *Leopoldi* LeCerf 1933: 2. [infrasubspecific name; unavailable]
*Samia insularis*, Paukstadt et al. 1994: 59. D'Abrera 1998: 86, 87. [misidentifications]
*Samia* sp., Paukstadt & Paukstadt 2000: 41 (eggs, larvae, ♀).
*Samia abrerai* Naumann & Peigler 2001: 76. Paukstadt et al. 2002: 9.

**Type specimens.** Holotype♂ (Fig. 50): Indonesia, Bali Island, Buleleng District, West Bali National Park, road from Pucaksari to Sepang, 650 m, 25 December 1998, 01:10 hours, secondary forest and coffee-nutmeg-plantations, leg. Stefan Naumann. The holotype was deposited in The Natural History Museum in London.

Allotype♀: Indonesia, Bali Island, Buleleng District, Lake Tamblingan, 1105 m, 9-10 January 2000, leg. U. Paukstadt, *ex* collection of W. A. Nässig. It was deposited in Senckenberg-Museum (Frankfurt-am-Main).

Paratypes (45♂ 7♀ from Bali, 42♂ 31♀ from Java). The data for these are cited below in the section of material examined. Paratypes were deposited in the collections of the following institutions: Museum Zoologicum Bogoriense (Cibinong, Java), Zoologisches Museum der Humboldt-Universität Berlin, Nationaal Natuurhistorisch Museum (Leiden), Senckenberg-Museum (Frankfurt-am-Main), The Natural History Museum (London), Natural History Museum of Los Angeles County, Staatliche Naturhistorische Sammlungen Dresden, Instituut voor Systematiek en Populatiebiologie (Amsterdam). Additional paratypes are also in a few private collections in Germany, as well as those of the two authors.

**Geographical Distribution** (Map 8). *Samia abrerai* is an endemic of Java and Bali as far as known, but is found along the entire span of Java.

**Diagnosis.** This species is well-characterized by the intensive dark olive brown ground color, the broad curved postmedian lines, containing considerable white sprinkling of scales distad to the rose band. Many specimens have a distinctive wing shape with short rounded hindwings and large elongated forewings, as compared to other species of *Samia*. The crescents are larger and broader than those in *S. insularis*.

**Description.** Adult ♂ (Figs. 50, 52). *Head.* Frons and occiput dark brown. Antennae 10-11.6 mm long, 4-5 mm wide. *Thorax.* Tergum and sternum golden brown, with white patches on sternum. *Forewing.* Length 65-

76 mm. Ground color medium brown, sometimes dark grayish brown; costal margin of ground color; antemedian area lighter; antemedian line thick and prominent, with white and black components; median area of ground color; postmedian line almost straight, contrasting, blackish brown, white, and rose bands, and pink suffusion; postmedian area suffused with pink proximally, sprinkled with black distally; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9 mm; submarginal line contrasting, separating lighter inner and darker outer zones; outer margin ochre brown; crescent large and slender, with swollen top end; apex 9-10 mm long, 18-20 mm wide; eyespot black with white edge on topside, sometimes with second small black eyespot below it; underside paler, with more pink suffusion in postmedian area. *Hindwing*. Length 46-53 mm. Antemedian area slightly lighter than ground color; antemedian line prominent; median area of ground color; postmedian line curved inward higher up on anal margin; postmedian area with radiating pink patches along veins; submarginal line obsolete; submarginal ornamentation faint; outer margin straight or weakly rounded; crescent large, angled or evenly curved; tornus usually very pointed. *Abdomen*. Tergum with only two rows of white tufts; spiracular ornamentation dark brown, with white above and below in bands; sternum brown. *Genitalia* (Fig. 181-182). Uncus bifid; transtilla more lobed than in *S. insularis*, with stronger dorsal indentation; saccus narrower than in *S. insularis*; typical differences between both species can be found in the form of the valves: the ventral process is slimmer, little shorter and less bent than in *S. insularis*, central process more developed, and dorsal process reduced to a dorsal curve of the valve; lateral process of the juxta longer, terminating with tip, slightly sclerotized in some specimens; aedeagus much shorter than in *S. insularis*, only 75-80% as long as in the latter, with a distal thornlike sclerite left ventrolaterally and a further right lateral process without further sclerotization; vesica with three bulbs, two smaller lateral ones and dorsal one with typical large sclerite medially, which is much less developed or sometimes even missing in *S. insularis*.

Adult ♀ (Fig. 51). Differing from ♂ as follows. *Head*. Antennae 7.6-9.1 mm long, 3.1 mm wide. *Forewing*. Length 60-70 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 7 mm; crescent very large and long; apex 9 mm long, 18 mm wide. *Hindwing*. Length 44-57 mm; crescent very large, with mainly transparent component; tornus very rounded. *Abdomen*. Tergum ochre brown, with 3 rows of white tufts; spiracular ornamentation brown and white; sternum brown. *Genitalia* (Fig. 209). Anal papilles strongly indented medially, with numerous relatively long bristles; oviporus covered by a membranous lobe, posterior to that are two lateral lobes; lamella postvaginalis heavily sclerotized, square plate with rounded side medially, not cordiform as in *S. insularis*; lamella antevaginalis one large, rounded lobe; anterior apophyses two-thirds as long as posterior apophyses; bursa copulatrix comparatively long. No differences were noted between Balinese and Javanese specimens.

**Discussion.** This species was named by us in honor of Bernard D'Abrera whose taxonomic work and excellent photography have made enormous contributions to the study and appreciation of Macrolepidoptera, and who has been maximally helpful to both of us during this project. Although the Paukstadts and we had recognized before the appearance of D'Abrera's (1998) book that there are two species of *Samia* in Java, he was the first to show the differences clearly, by providing color figures of both genders of both species, side by side. However, on D'Abrera's plate, the pair labeled as *S. insularis* is actually this species, and vice-versa, because he selected a male of *S. abrerai* that had been given a determination label as *S. insularis* by Peigler in 1979.

The name *leopoldi* is placed here in the synonymy of *S. abrerai*, but it is not certain whether the specimen was what we now call *S. abrerai* or *S. insularis*; also some other citations in the synonymy of *S. insularis* may belong under *S. abrerai*, but there have been no valid taxonomic acts concerning the species treated here which we call *S. abrerai*. Specifically, *leopoldi* was published by LeCerf as a quadrinomial, so it is unavailable according to the Code (1999). Claude Lemaire (pers. comm.) concurred that *leopoldi* was published as a quadrinomial.

A series of males of *S. abrerai* received by Peigler from an American dealer was evidently mislabeled. They were reported to be from northern Sulawesi, but the species is not otherwise recorded from that island, which has been intensely collected. We did not include them among the type series. Further verification that they are Javanese or Balinese specimens that were mislabeled is the fact that some *Cricula trifenestrata* from the same lot sent by Peigler to Wolfgang Nässig were considered by Nässig (1995: 34) to also be mislabeled, and not actually from Sulawesi. Another male specimen of *S. abrerai*, verified by Naumann by genitalia dissection, mislabeled "Ceylon, A. Heyne" is in the Deutsches Entomologisches Institut (Eberswalde). Alexander Heyne was an entomological dealer in Berlin in the early 1900s (Horn & Kahle 1935: 112). A male in the Paukstadt collection was said to be collected on an offshore oil rig near Bunguran Island (also known as North Natuna and Natuna Besar), which is the main island of the Natuna Islands, between Sumatra and Borneo. We have not included it on Map 8, because doing so may lead to confusion, as we believe that the specimen originated on Bali or Java, and was apparently transported by a ship before being captured. In the section below of material examined for this and other Indonesian species, we have changed the original Dutch spellings on the labels to the current Bahasa

Indonesia spellings, for example, Djoenggo-Ardjoeno to Junggo-Arjuno, Soekaboemi to Sukabumi, Batoeriti to Baturiti, etc.

*Samia insularis* is sympatric with *S. abrerai*. Both species are known to exist at certain locales, such as at 1200 meters on Mount Halimun in West Java and the same altitude on Mount Nonkodjadjar in East Java. It is somewhat surprising that two species of *Samia* would occur sympatrically over large areas of Java, yet not be recognized until recently. The lepidopterous fauna of Java has been intensively collected and studied by many Dutch workers (e.g., Roepke 1932, Dupont & Scheepmaker 1936), and there are many historical specimens in museum collections in Leiden, Amsterdam, London, and elsewhere. Specimens of the two species look alike superficially, but they are probably not sister taxa (i.e., each other's nearest relative), because *S. abrerai* shows an affinity with *S. yayukae*.

Although there are many scattered records for *S. abrerai* on Bali and all across Java, those are generally from the inland areas with higher elevations. There is a lack of records from Central Java Province (Jawa Tengah), but the species undoubtedly occurs there. We would not be surprised to learn that the species also exists on the adjacent islands of Madura and Lombok, but no specimens of the genus have been collected there, as far as we could determine. Two expeditions by Naumann to Lombok in January 1999 and April 2000 did not result in any *Samia* specimens, despite collecting in various habitats and elevations.

Various habitats for *Samia abrerai* have been noted at certain localities, as follows. On a south-facing slope of Mount Papandayan at 1600 meters, near Kramat Wangi, there was primary rainforest and a plantation of pine trees (*Pinus*). Near Tiris at only 580 meters on a west-facing slope of Mount Argopuro, Ulrich Paukstadt saw primary rainforest alongside fields of fruit trees and corn (*Zea mays*). Sites in Bali where Naumann collected these moths included large plantations of coffee (*Coffea arabica*) and nutmeg (*Myristica fragrans*), among patches of secondary forest. Flight times recorded by Paukstadt and Paukstadt (2000) for females in Bali were 20:00 to 22:30 hours, and for males in both Bali and Java were 23:00 to 04:00 hours. At the type locality in Bali, Naumann recorded moths arriving at light at about 00:30, 00:35, 00:40, 00:45, 00:50, 01:05, 01:10, 01:20, 01:35, and 01:40 hours. For comparison, males of *S. insularis* in Java arrived from 03:15 to 04:15 hours.

The larval stages and a pinned female were figured in color by Paukstadt and Paukstadt (2000: 48). They also provided scanning electron micrographs of the chorion of the egg. The first instar is solidly black after hatching, but becomes olive, with yellow intersegmental membranes and blackish thoracic shields. The second instar is yellow with a black head, black tips on the yellow scoli, and many black spots on the integument, normal for the genus. The third instar is similar to the second, but the scoli are larger and thicker, and the black plates on the anal prolegs are more prominent. The fourth instar has a whitish integument, with waxy secretions, and a yellow head and prolegs. The mature larva (fifth instar) is white with small black specks on the integument, widely scattered, and waxy secretions covering the scoli. The head is yellow, as are the prolegs, anal prolegs, and anal plate, with some turquoise markings between these posterior structures. The mature larva superficially resembles that of *S. cynthia*, except it lacks bluish scoli and has smaller black specks.

**Material Examined. INDONESIA**: BALI: 1♂ Tabanan District, East Bali, Batoeriti, 1067 m, April 1936, leg. J. P. A. Kalis, Rothschild Bequest (BMNH); 1♂ Batukau, April 1997 (Naumann); 1♂ Mount Bedugul, 1100 m, Nov. 1982 at light, leg. U. Paukstadt, genitalia no. 360 Paukstadt (Paukstadt); 3♂1♀ Bedugul, 1300 m, May 1998 (Paukstadt); 2♂ Bedugul, 1200 m, Sept.-Oct. 1998 (Naumann); 2♂1♀ environs of Bedugul, 1350 m, Nov. 1999, leg. local people (Paukstadt); 4♂ same locality, Jan. 2000, leg. local people (Paukstadt); 2♂ same data (SMFL); 1♂ same data (Brechlin). Buleleng District, 1♂ West-Bali Reserve, Titap, near Papuan, rainforest, 550 m, 8˚25'N/114˚58'E, 29-30 Jan. 1998, leg. Jakl, A. Schintlmeister, & Cervenka, genitalia no. 275/98 Naumann (Naumann); 1♀ same data (Brechlin); 9♂ including holotype, West Bali National Park, Pucaksari to Sepang, 650 m, 25 Dec. 1998, leg. S. Naumann, genitalia no. 355 & 356/99 Naumann (Naumann); 2♂ paratypes, same data (LACM, Peigler); 1♂1♀ Lake Buyan, 1550 m, *ex* pupa Aug. 1991, cocoon on avocado, leg. Paukstadt, genitalia no. 362 Paukstadt (Paukstadt); 4♂ Lake Tamblingan, 1105 m, 4-5 Jan. 2000, leg. U. Paukstadt (Paukstadt); 1♂1♀ same data (Brechlin); 1♂ same data (SMFL); 4♂ same locality, 8-9 Jan. 2000, leg. U. Paukstadt (Paukstadt); 3♂ same locality, 9-10 Jan. 2000, leg. U. Paukstadt (Paukstadt); 1♀ allotype, same data (SMFL); 1♂ same data (Brechlin); 1♂ same locality, 1050 m, 7 July 2000, leg. local people (Paukstadt); 1♀ same locality, *ex ovo* 20 June 2000, reared by Laela H. Paukstadt (Paukstadt). Bangli District, 1♂ North Bali, 2 km west of Penulisan, 1650 m, 28 Dec. 1998, leg. Naumann, genitalia no. 357/99 Naumann (Naumann); 1♂ North Bali, Batur village, Pura Batur Temple, 1650 m, found dead on ground, 28 Dec. 1998, leg. Naumann (Naumann). JAVA: West Java, 1♀ Sindanglaya, 1882, *in coitu* (RMNH); 1♀ Preanjer, 1888 (RMNH); 1♂1♀, Mount Gede, West Java, 1893, Grel., coll. Staudinger, genitalia no. 329/98 Naumann (ZMHB); 1♀ Gouv. Kina-Ondern, Malabar Geb. [Mts.], Tjinjiroean, 1700 m, Nov. 1909, leg. van der Weele (RMNH); 1♀ Buitenzorg [Bogor], June 1927, leg. Frangenheim (ZMA); 1♀ West Java, Tjibodas, 1400 m, 4 June 1940, leg. L. J. Toxopeus (MZB);

1♂ West Java, Tjibodas, south of Sukabumi, 1400 m, 27 Sept. 1940, leg. A. M. Neervoort (MZB); 1♂ same locality, 20 June 1956, leg. A. M. R. Wegner, genitalia no. 319/98 Naumann (SMFL); 1♂ environs of Bogor, Dec. 1994 (Meister); 5♂ West Java, Mount Ranung, Sempolan, 410 m, secondary forest, 8˚10'N/113˚40'E, 28 Jan. 1998, leg. Jakl, Schintlmeister, & Cervenka (Brechlin); 3♂ Mount Karang, ca. 1400 m, Pandegalang, Baya [ca. 80 km west of Jakarta], Dec. 1998, leg. local people, genitalia nos. 889, 890, 894 Paukstadt (Paukstadt); 4♂ West Java, south slope of Mount Papandayan, 1590 m, Kramat Wangi, 31 Dec. 1999/1 Jan. 2000, leg. U. Paukstadt (Paukstadt); 2♂ south slope of Mount Papandayan, 1590 m, Kramat Wangi, 13-15 Jan. 2000, leg. U. Paukstadt (Paukstadt); 1♂ same locality, 1480 m, 15/16 Jan. 2000, leg. U. Paukstadt (Paukstadt); 5♀ Mount Halimun, 1300 m, March 2000, leg. local people (Paukstadt). South Java, 1♂ Malang, coll. Poujade 1909, *Samia cynthia* var. *insularis*, det. E. L. Bouvier, genitalia no. 229/97 Naumann (MNHN). East Java, 1♀ Java O.K. [east coast], Kadiri [Kediri], 1913, coll. van den Bergh (ZMA); 1♂ East Java, Nonkodjadjar [east of Malang], 1220 m, June 1934, leg. J. P. A. Kalis (BMNH); 1♂ Tengger, Nonkodjadjar, Nov. 1934, leg. J. P. A. Kalis, coll. van Groenendael (ZMA); 1♀ Tengger, Singalangu, 1524 m, May 1934, leg. J. P. A. Kalis, coll. Rothschild (BMNH); 4♂6♀, Junggo-Ardjuno, 1372 m, July 1935, Jan. & July 1936, July, Aug., Sept. 1939, leg. J. P. A. Kalis, coll. van Groenendael, ♂genitalia no. 305 & 306/98 Naumann (ZMA); 3♂2♀ Mount Argopuro, Dec. 1997, Jan. 1998, 1998, ♂genitalia no. 358 & 359/99, ♀genitalia no. 620/01 Naumann (Naumann); 3♂6♀ Mount Argopuro, Dec. 1997, Jan., Feb., & April 1998 (Paukstadt); 2♂ paratypes, same locality, April 1998, via Detani (Peigler, LACM); 1♂ same locality, April 1998 (Brosch); 4♂1♀ Mount Sidoramping, 23-25 Oct. 1998, leg. local people, genitalia no. 897, 898, 899, 900 Paukstadt (Paukstadt); 3♂ west slope of Mount Argopuro, 580 m, Tiris, 10-11 Jan. 2000, leg. U. Paukstadt (Paukstadt). without exact locality, 1♂ Java, coll. Staudinger & Bang-Haas (MTD); 1♀ Java, leg. M. R. Piepers (RMNH); 1♂1♀, Java, 1932 (MHNL); 1♀ Blawan [could locate on maps], 15 March 1934, leg. W. K. J. Roepke (RMNH). SUMATRA, 1♂ Riau, Natuna Besar, Bunguran Island, Oct. 1990, leg. E. Fahindar, collected on offshore oil rig, genitalia no. 347 Paukstadt (Paukstadt). 9♂ mislabeled by dealer as "Manado, Sulawesi, Jan. 1994" [see discussion above], Peigler coll. (LACM).

## *Samia yayukae* U. Paukstadt, Peigler, & L. Paukstadt

(Figs. 53-56, 102-106, 136, 183-184, 210)

*Samia yayukae* Paukstadt et al. 1993: 229. Paukstadt & Paukstadt 1993: 357. Paukstadt & Paukstadt 1995: 158, pl. 3 (larvae). Naumann 1995: 26. Peigler & Wang 1996: 82 (all stages except eggs). Paukstadt et al. 1998: 120. Nässig & Treadaway 1998: 255. D'Abrera 1998: 84, 85 (♂♀). Paukstadt & Paukstadt 1998: 3. Paukstadt et al. 2002: 3, col. figs. 11-12 [also cited there as figs. 3-4] (♂, underside).

*Samia kikibudiamini* U. Paukstadt, L. Paukstadt & Suhardjono 2002: 5, col. figs. 9-10 [also cited there as figs. 1-2] (♂, underside).

**Types.** The holotype (Fig. 53) is a male with these data: Mount Golo Lusang, 1500 m, 7 km south of village of Ruteng, Manggarai district, island of Flores, province of Nusa Tenggara Timur, Indonesia. It was collected 25 July 1991 by Ulrich Paukstadt & Laela Hayati Paukstadt. The genitalia are mounted on a slide labeled "U. Paukstadt no. 0361." There is also a red holotype label. The holotype was examined in July 1993 by Peigler (while the museum was still in Bogor) and in March 2000 by Naumann at the Museum Zoologicum Bogoriense, Cibinong, Java. It was figured in color by Paukstadt et al. 2002.

There are single male paratypes in the collections of Senckenberg Museum, Museum Zoologicum Bogoriense, and Natural History Museum of Los Angeles County; and four male paratypes in the collection of Laela Paukstadt. The data are: Indonesia, island of Flores, 9 km south of Ruteng, Mount Golo Lusang, 1820 m, 27 Feb.-9 March 1992, U. Paukstadt; 7 km south of Ruteng, 1750 m, 20 Sept.-1 Oct. 1992, U. Paukstadt. The type series contained no females.

The holotype of *Samia kikibudiamini* is pledged to the collection of the Museum Zoologicum Bogoriense, Cibinong, Java. Its data are Mount Muna, 920 m, Desa Maiwal, Dusun Pintu Mas, Kec. Alor Barat Daya, Kab. Alor, island of Alor, province of Nusa Tenggara Timur, Lesser Sunda Islands, Indonesia, 19 January 2002. There are two male paratypes collected 21 and 22 January 2002, one in the collection of Laela H. Paukstadt (Wilhelmshaven, Germany), the other pledged to the Museum Zoologicum Bogoriense.

**Geographical Distribution** (Map 10). This moth ranges in the province of Nusa Tenggara Timur in the Lesser Sunda Islands of Indonesia, and in East Timor. Records thus far are only from the islands of Alor, Timor, and Flores. The island of Alor is labeled as Ombai on some older maps.

**Diagnosis.** *Samia yayukae* is easily recognizable by its purplish gray ground color, which is not shared by any other species of *Samia*. The postmedian lines are quite straight, especially in the forewings, and have sharply contrasting bands of white, rose, and pink, without extensions of the pink into the postmedian area along the veins, as is commonly seen in the more olive-green *S. abrerai*. The crescents are probably the most narrow of all species of *Samia*. There is a sharp contrast between the colors along the submarginal line of the forewing, ochre yellow proximally, and ochre brown distally. The forewing apex is less falcate than in *S. insularis* and not as rounded as those of *S. abrerai*. On the underside, nearly all of the pattern is colored as on the upperside.

**Description.** Adult ♂ (Figs. 53-54). *Head.* Frons and occiput brown. Antennae 10 mm long, 4.1 mm wide. *Thorax.* Tergum and sternum grayish brown. *Forewing.* Length 65-75 mm. Ground color grayish brown; costal margin of ground color; antemedian area of ground color; antemedian line thick, prominent; median area of ground color; postmedian line very straight, with black, broad white, rose, and narrow pink suffusion; postmedian area sprinkled with black scales, lacking pink suffusion; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9-10 mm; submarginal line prominent, separating inner yellow and outer brown areas; outer margin ochre brown; crescent straight and narrow, surrounded by black; apex 11-12 mm long, 16-17 mm wide, pointed; eyespot black, small; underside paler and lighter. *Hindwing.* Length 46 mm. Antemedian area a bit lighter than ground color; antemedian line weak; median area of ground color, with faint shading distally; postmedian line very straight; postmedian area sprinkled with black scales, lacking pink suffusion; submarginal line obsolete; submarginal ornamentation light but prominent, not very contrasting; outer margin ochre, slightly rounded; crescent short, small, strongly curved; tornus pointed. *Abdomen.* Tergum brown, with minimal light tufts; spiracular ornamentation contrasting; sternum brown, medially lighter. *Genitalia* (Figs. 183-184). Very similar to those of *S. abrerai*, but with following differences: transtilla even more rounded or lobed, only rarely with small central indentation, less often and then less pronounced that in *S. abrerai*; saccus similar; lateral processes of juxta less tapering and more rounded; sacculus, ventral and dorsal process of valve look similar, but central process shorter and more rounded than in *S. abrerai*; aedeagus with quite rounded distal sclerite left lateral and a second less sclerotized process right lateral; vesica with three bulbs, one large dorsal one with a median sclerite, similar in size to *S. abrerai*, a medium left lateral bulb, and a small one distal-ventral.

Adult ♀ (Figs. 55-56). Differing from ♂ as follows. *Head.* Antennae 9-10 mm long, 3 mm wide. *Forewing.* Length 66 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10 mm; crescent rounded and straight; apex 9-10 mm long, 18 mm wide. *Hindwing.* Length 46 mm; crescent short, open, strongly curved; tornus weakly rounded . *Abdomen.* Tergum ochre with prominent white tufts; spiracular ornamentation composed of prominent rings of white; sternum golden brown, with two weak rows of white. *Genitalia* (Fig. 210). Anal papilles strongly indented, with many long hairs; oviporus covered by thick membranous lobe; lamella postvaginalis almost triangular, with ones side ventral and posterior; lamella antevaginalis a broad, sclerotized lobe; anterior apophyses very short and gently curved; posterior apophyses almost twice as long as anterior ones.

**Discussion.** This species was named for the Indonesian entomologist Dr. Yayuk Suhardjono. She is a specialist in tiny insects of the order Collembola, working at the Museum Zoologicum Bogoriense, which was moved from central Bogor to Cibinong several years ago. Most of the specimens in collections were collected by Captain Ulrich Paukstadt and his wife Laela Hayati Paukstadt, either as cocoons or adults coming to lights. We are indebted to them for the gift of a long series of both sexes from western Timor, color slides of the larval stages, as well as some empty cocoons, material which was very valuable to this study. Laela Paukstadt was the first person to rear this species in Germany.

A female from western Timor that is in The Natural History Museum from the collection of Eugène Le Moult was noted by the authors in the original description, but at that time could not be associated with certainty with the males from Flores. *Samia yayukae* is sympatric with *Attacus dohertyi* on Timor, with *Attacus inopinatus* Jurriaanse & Lindemans on Flores, and with *Actias groenendaeli* Roepke and *Cricula hayatiae* U. Paukstadt & Suhardjono on both islands. The larval stages and cocoons of *S. yayukae* were described by Paukstadt and Paukstadt (1993), and later shown in color by Peigler and Wang (1996). We present these again in our color figures 102-106 and 136. The stout scoli on the mature caterpillars are superficially reminiscent of the thick spines of certain kinds of sea urchins, as for example species of the genera *Eucidaris* and *Phyllacanthus*. The mature larva of *S. yayukae* has a bluish green integument, without white waxy secretions, although these

secretions are on the scoli themselves, making them appear white. The head, legs, and prolegs are glossy olive green, and there are large black spots on the integument.

The habitat in western Flores was stated to be primary montane forest in the English summary, and primary monsoon forest in the German text of the original description. At any rate, the insect prefers moist, undisturbed forests at moderate elevations (800 to 1750 meters), as is normal for most species of the genus. The moths fly from January to June and again in late September until November. The holotype was collected at a higher elevation in late July, and moths emerged from some cocoons in Germany in various months including January, February, March, April, and August. We believe that the species has two generations annually in nature. Five moths came to lights on Flores from April to June 2000 between 18:00 and 20:00 hours and one at 02:00 hours, whereas three arrived at light on Alor in January within one hour on either side of midnight (Paukstadt et al. 2002). It is noteworthy that the ground color of the wings of *S. yayukae* is the grayest in the genus. This corresponds to the purplish gray of specimens of *Attacus dohertyi*, especially the undersides of the wings, and apparently has an ecological basis. The habitats on the island of Timor are even drier, with no tropical rainforest. There may be selection pressure favoring the grayish purple phenotypes of both species in that region.

Two hostplants were discovered by Ulrich Paukstadt on Timor, who found cocoons and caterpillars at several locations between 800 and 1300 meters above sea level. One was *Toddalia asiatica* and the other *Zanthoxylum armatum*. The generic name is sometimes spelled *Xanthoxylum*. Both are spiny shrubs in the Rutaceae, and the local vernacular names are kayu duri, meaning spiny bush. The first one is found widely in India and China, and is used particularly in southern India to relieve stomach ache. Its vernacular names include vellari and tharani in the Malayali language of Tamil Nadu. *Zanthoxylum armatum* is also native to the mainland of southeastern Asia, where an oil is distilled from its dried fruits. Evidently both plants were introduced to Timor long ago. These two hostplants were identified for Capt. Paukstadt by botanists at the Herbarium Bogoriense, Java.

In Germany, Laela Paukstadt reared larvae of *S. yayukae* on guava (*Psidium guajava*, Myrtaceae), ailanthus (*Ailanthus altissima*), lilac (*Syringa vulgaris*), privet (*Ligustrum ovalifolium*), and oak (*Quercus* sp., Fagaceae). Young larvae refused the latter two plants, but older larvae fed on them. Except for oak, the alternate foods are well known to be suitable for rearing other species of *Samia*. We omit *Quercus* from the Hostplant Appendix because we do not believe that larvae can survive very long on oaks.

*Samia yayukae* was recently found in the small nation of East Timor. Two males were collected at an elevation of about 1000 meters near Bobanaro (9˚00'40"S/125˚21'49"E) on 4 November 2002 by M. D. Lane. The specimens are in the collection of D. Lane (Atherton, Queensland), who sent scans of photographs to Naumann. *Samia yayukae* possibly exists also on the little island of Wetar, to the north of Timor. It may even be collected eventually on Sumba, Sumbawa, or even Lombok, but the genus is not recorded from any of those islands. If on Lombok or Sumbawa, Wallace's Line would form a boundary between the range of this species and the ones on Bali and Java. Although the islands of Timor and Flores are comparatively large, very little entomological material has been collected and placed in western museums, so specimens of *S. yayukae*, *Attacus dohertyi*, and *A. inopinatus* have remained quite rare in collections. Peigler visited the islands of Komodo, Rinca, Sumba, Sumbawa, and Lombok briefly in July 1993, but no *Samia* were seen. During two expeditions to Lombok in January 1999 and April 2000 Naumann intensively searched for representatives of the genus on that island, but no *Samia* were found in the remaining forested areas at various altitudes from lowland in the Southwest up to 350 meters on the western and 1620 meters on the eastern slopes of Mount Rinjani, all still covered with primary forest at that time.

The male genitalia are closest to those of *Samia abrerai*, but differ from those in significant ways. The transtilla is even more rounded or lobed, and only rarely has a small central indentation, which when present, is weaker than in *S. abrerai*. The saccus of the two species looks similar, but is more rounded and less tapering in *S. yayukae*. The sacculus and ventral and dorsal lobes of the valves also are similar, but the central process is shorter and more rounded in *S. yayukae*. In the original description of *Samia yayukae* (Paukstadt et al. 1993), the authors stated that the costal margin or the dorsal lobe of the valve is rolled inward, but this is just an artifact of the preparation technique. Moreover, they compared the aedeagus of *S. yayukae* to specimens of "*S. insularis* from Sumatra, Java, and Bali," but it is now known that those samples represented both *S. insularis* and *S. abrerai*.

The recent description and naming of the population on Alor we consider to be unfortunate, and we treat the name as a synonym of *S. yayukae*. We did not find genitalia or significant wing pattern or color differences between series from Flores and Timor, yet the authors who described the Alor population as *Samia kikibudiamini* (Paukstadt et al. 2002) reported that the supposed new species also includes the Timorese population, claiming that to be distinct from the Flores population. Although we have not seen material from Alor, the description and figures in the publication provide ample information to support our intepretation of its taxonomic status as a synonym. The authors stated the genitalia traits of *S. kikibudiamini* to be a straight dorsal apex of the valves and

a less sclerotized cornutus of the vesica. The first one is invalid as it was compared to an *S. yayukae* with a curved dorsal apex that was simply an artifact of the preparation and mounting, and is not consistent in additional preparations. The reduced sclerotization of the cornutus could not be found by us in a series of ten preparations from Timorese specimens (nos. 328-336 Paukstadt, 160/97 Naumann), all with a cornutus that agree with those from Flores (nos. 346 & 348 Paukstadt). The cornutus may actually be consistently larger in ones from Alor, but we doubt it, and we could find no difference in this trait among material from Flores and Timor.

The islands across Indonesia and the Philippines contain many populations of *Samia* that are geographically isolated from one another, but it contributes nothing to the understanding of the evolutionary history or classification of this genus to assign a name to every population on every island based on trivial and in some cases inconsistent differences. In fact, one would expect such variation to be visible and consistent, albeit not significant enough to justify proposing new species (or even subspecies).

**Material Examined. INDONESIA**: 1♂ holotype, Nusa Tenggara Timur Province, FLORES ISLAND, Manggarai district, 7 km south of Ruteng, Mount Golo Lusang, 1500 m, 25 July 1991, leg. U. & L. H. Paukstadt, genitalia no. 361 Paukstadt, MZB collection no. 480 (MZB); 3♂ 9 km south of Ruteng, Mount Golo Lusang, 1820 m, 27 Feb.-9 March 1992, leg. U. Paukstadt, genitalia no. 350 Paukstadt, MZB collection no. 481 (MZB, Paukstadt); 4♂ 7 km south of Ruteng, 1750 m, 20 Sept.-1 Oct. 1992, leg. U. Paukstadt (Paukstadt, LACM, SMFL); 5♂, same locality, 1750 m, 17-18 Oct. 1995, leg. Amin & Gaul (Paukstadt); 1♂ same locality, 16 Oct. 1995, at light 03:00 hours, leg. Amin & Gaul (Naumann); 3♂ environs of Ruteng, Wae Lerong, 20 Oct. 1995, leg. Amin & Gaul (Paukstadt); 2♂ environs of Ruteng, Wae Batang, 22 Oct. 1995, leg. Amin & Gaul (Paukstadt); 1♂ environs of Ruteng, Bajawa, 28-30 Oct. 1995, leg. Amin & Gaul (Paukstadt); 1♂3♀ Kampung Ruteng Puu, 800 m, Feb. 1994, leg. Gaul (Paukstadt); 4♂ West Flores, Gunung [Mount] Ranaka (E), 3 km south of Mano, 18 km southeast of Ruteng, primary forest, 1270 m, 17-21 April 1996, leg. R. Brechlin (Brechlin); 1♂ Moni, 794 m, cultivated land/secondary forest [GPS: S 08.74751 E 121.84627], 2-3 Feb. 2002, at light 19:00-24:00 hours, leg. M. Hofmann & R. Richter (Löffler); 1♂ Bena, near Bajawa, 1106 m, grassland [GPS: S 08.5744 E 120.96950], 5-6 Feb. 2002, at light 19:00-06:00 hours, leg. M. Hofmann & R. Richter (Löffler). TIMOR ISLAND, 3♂4♀ West Timor, Kapan, southeastern slope of Gunung [Mount] Mutis, 1000-1300 m, wild cocoons collected April 1993, emerged March & 20 April 1994, leg. U. Paukstadt (LACM); 1♂1♀ same data, figured by D'Abrera 1998 (BMNH); 1♂1♀ same data, 1000 m (Peigler); 1♂ same locality, 1000 m, *ex* pupa April 1993, leg. U. Paukstadt (Brechlin); 2♂ same data (MZB); 2♂2♀ same data (Paukstadt); 2♂2♀ same data, ♂genitalia no. 160/97, ♀genitalia no. 628/01 Naumann (Naumann); 1♂ same locality, 1310 m, 28 March-3 April 1993, leg. U. Paukstadt (LACM); 2♀ same locality, 1320 m, 19-24 April 1993, leg. U. Paukstadt (LACM); 1♀ same locality, 1300 m, *ex* pupa April 1993 (MZB); 1♀ same data (Beeke); 1♀ same locality, 1320 m, *ex* pupa Aug. 1993, reared by L. H. Paukstadt (MZB); 1♂ eastern slope of Gunung Mutis, Eban, 1300 m, Oct.-Nov. 1992, leg. J. Meon (LACM); 1♂1♀ same locality (Paukstadt); 1♂ same locality, *ex* pupa Oct.-Nov. 1992, leg. J. Meon (Brechlin); 1♀ same locality, *ex* pupa 23 Jan. 1994 (Brechlin); 3♀ same locality, *ex* pupa 11 & 17 Jan., 2 Feb. 1994, reared by L. H. Paukstadt (Naumann); 1♂ southeastern slope of Gunung Mutis, Fatumnasi, 1720 m, April 1993, leg. U. Paukstadt (Paukstadt); 1♀ Gunung Mutis, Fatumnasi, cultivated and secondary vegetation, 200 m to primary forest at 1460 m, 21-23 March 1996, leg. R. Brechlin (Brechlin); 1♀ Central Timor, Söe [Soe], "39.29", 880 m, Feb. 1929, coll. E. Le Moult, Joicey Bequest (BMNH).

## *Samia vandenberghi* (Watson)

(Figs. 57-59, 112-116, 121, 132, 185-186, 211; Map 6)

*Philosamia insularis vandenberghi* Watson 1915: 280.
*Philosamia cynthia vanderberghi* [*sic*], Rebel 1924: 112. Rebel 1925a: 12. Rebel 1925b: 157. Seitz 1928: 504. Bouvier 1932: 44. Jolly et al. 1979: 7. [misspelling]
*Philosamia cynthia* f. *Vanderberghi* [*sic*], Schüßler 1933-1934: 28, 521. [misspelling]
*Philosamia vander-berghi*, Chowdhury 1982: 6. [misspelling]
*Samia cynthia vandenberghi*, Bouvier 1936: 317.
*Samia vandenberghi*, Paukstadt et al. 1993: 229. Naumann 1995: 29. Paukstadt et al. 1996: 353, figs. 1-6 (larvae), 7(♂), 8(♀). Peigler & Wang 1996: 91, 93. Paukstadt et al. 1998: 114. Nässig & Treadaway 1998: 254. D'Abrera 1998: 90, 91 (♂♀).

*Samia vandenberghi vandenberghi*, Naumann 1995: 105.

**Types.** This species was described from two pairs, of which we found two males and one female in the Natural History Museum, from the collection of J. H. Watson. The male lectotype was designated by Paukstadt et al. (1993: 234-235), and has labels reading "Gorontalo, Celebes, coll. P. J. van den Bergh; *P. insularis vandenbergi* [*sic*] Wats. Type ♂ 1915." The two paralectotypes (Fig. 58) have labels that read "Gorontolo, N. Celebes 1914, van d. Bergh" The type locality can thus be cited as Gorontolo, Minahasa Peninsula, province of Sulawesi Utara, Indonesia.

**Geographical Distribution** (Map. 6). This moth is recorded from all over the large island of Sulawesi (=Celebes) in central Indonesia. A few specimens have also been collected on the nearby small island of Selajar.

**Diagnosis.** This is a large species in which the male has a very pointed tornus of the hindwing and a very produced (but not recurved) apex of the forewing. The black eyespot often has a small tail, as in a comma, on the top and outer edge. It differs from the two Javanese species by having a straight postmedian line of the forewing, and from *S. tetrica* by the much larger size and lighter brown color. From *S. luzonica* it differs in the more pointed tornus and more produced forewing apex. The hindwing crescent sometimes has a distinct angle halfway along its outer edge.

**Description.** Adult ♂ (Figs. 57-58). *Head.* Frons and occiput dark brown. Antennae 12 mm long, 5 mm wide. *Thorax.* Tergum and sternum solidly brown, no white on legs. *Forewing.* Length 74-81 mm. Ground color medium dark chocolate brown; costal margin of ground color; antemedian area a bit lighter than ground color; antemedian line medium in development; median area of ground color; postmedian line very straight, except at crescent, dark brown, white, rose, and suffused with pink; postmedian area heavily sprinkled with black scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-12 mm; submarginal line varying from faint to distinct, sometimes with lighter zone proximal to it; outer margin ochre; crescent narrow, long, evenly curved; apex 13-15 mm long, 20-22 mm wide, large purple patch; eyespot black, sometimes with black tail off top and outer edge; underside lighter and paler. *Hindwing.* Length 54-56 mm. Antemedian area lighter; antemedian line medium; median area of ground color; postmedian line undulating; postmedian area with suffusion of pink concentrated near veins; submarginal line obsolete; submarginal ornamentation prominent; outer margin straight to evenly rounded; crescent large, sometimes with angle; tornus pointed to very pointed. *Abdomen.* Tergum brown, with faint traces of white median tufts; spiracular ornamentation none; sternum brown. *Genitalia* (Figs. 185-186). Uncus bifid; transtilla one of the broadest in genus, due to its central indentation being nearly bilobed; saccus very long, longer than the width of the vinculum and longer than in other allied species; valve with well developed ventral process, rounded short central one and dorsal weakly defined lobe; relatively broad aedeagus with small distal sclerite ventrolaterally on end of unsclerotized process; vesica with three bulbs, large dorsal one on which the presence of a sclerite is quite variable and correlated with geographical distribution on Sulawesi, and two left and right lateral ventral medium sized ones; several closely related species from surrounding islands have similar genitalia structures but differ in details of processes of the valves, size and form of saccus, and in form and presence of sclerites on the vesica; only the sympatric *S. peigleri* has totally different genitalia structures.

Adult ♀ (Fig. 59). Differing from ♂ as follows. *Head.* Antennae 10 mm long, 3 mm wide. *Forewing.* Length 72-77 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-11 mm; crescent medium length and width; apex 7 mm long, 17 mm wide. *Hindwing.* Length 54-59 mm; crescent broad, evenly curved; tornus rounded. *Abdomen.* Tergum light brown, with minimal white tufts; spiracular ornamentation faint white bands; sternum brown, darker medially. *Genitalia* (Fig. 211). Anal papilles heavily covered with numerous hair bases yielding long thin hairs, very deeply bifurcate; posterior to the oviporus two lateral membranous lobes united centrally with an indentation between; lamella postvaginalis longest medially, laterally elongated to processes down to apophyses; lamella antevaginalis heavily sclerotized and almost straight; anterior apophyses slightly curved, two-thirds as long as posterior ones.

**Discussion.** Although Watson did not so indicate in the original description, the species was named in honor of a Dutch collector of Lepidoptera named P. J. van den Bergh (see van den Bergh 1915) who collected in Indonesia during those years. The species was not named for J. D. van den Bergh who was a missionary on Sulawesi and Banggai from 1932 to early 1939 (Nieuwenhuis 1944; Peigler 1989: 79). Some European museums own specimens of *Attacus aurantiacus, A. crameri*, and *A. erebus* collected from 1914 to 1916 by P. J. van den Bergh (Peigler 1989: 46, 54, 61). Several of the specimens that we examined were collected by J. M. A.

van Groenendael who was a medical officer in Indonesia. His extensive moth collection contains a lot of rare material from the Lesser Sunda Islands, and is now in the Zoological Museum in Amsterdam.

The female and larval stages of *S. vandenberghi* were first illustrated by Naumann (1995), followed by Paukstadt et al. (1996). The English summary of the latter paper gives descriptions of all immature stages. Naumann's figures were in color and included undersides of both sexes. D'Abrera (1998) also figured both sexes in color. One male we examined from southern Sulawesi has unusually broad white and rose components of the postmedian line, and is probably not an aberration but instead an extreme form showing this coloration. Regarding the variation in male genitalia, none of this variation can be correlated with the geographical distribution of specimens in Sulawesi, worth pointing out because some authors have claimed that different subspecies of *Samia insularis* exist on Java and Sumatra based on trivial genitalia differences.

In our discussion under *Samia peigleri*, we already presented comments about the habitats and relationship between the two species of *Samia* that share the island; other comments pertaining to *S. vandenberghi* are given below in the discussion under *S. naumanni*. Sulawesi, formerly known to westerners as Celebes, is one of the most interesting places in the world from a biogeographer's viewpoint. It is an ancient land mass that has long been isolated, and it harbors many endemics and relics among its biota. Sulawesi is well known to lepidopterists for highly sought-after species like *Actias isis* and *Papilio blumei* Boisduval, the latter a large swallowtail with brilliant blue and green wings. Excepting bats, most of the mammals on Sulawesi are endemic. They include the babirusa, four species of black macaques, the tiny spectral tarsier, and marsupials called the bear cuscus and dwarf cuscus (Whitten & Whitten 1992: 53-54, 165; van Oosterzee 1997). Many Lepidoptera new to science are being discovered in the same localities where the two *Samia* occur on Sulawesi. For example, the ennominine geometrid *Ourapteryx diluculum* Inoue and the catocaline noctuid *Dysgonia marginata* Yoshimoto were both named in 2002.

Field observations by S. Naumann demonstrated that moths of *S. vandenberghi* arrive at lights during the hours immediately preceding dawn. This is probably when females emit pheromone, and we assume that matings last all during the next day, with ovipostion during early hours of the following night. (Near the Equator, sunset is at 18:00 [= 6:00 PM) and sunrise is at 6:00 [6:00 AM] hours, throughout the year.) On Mount Sampuraga males arrived at light between 3:00 and 5:30 hours; at Taripa they came between 3:00 and 4:40 hours; in Malili they arrived between 1:35 and 4:55 hours (Paukstadt et al. 1996).

The eggs are shown in Figure 132. The larval stages are shown in Figures 112-116 and a form of the mature larva with another color of scoli in Figure 121. Mature larvae have a greenish blue integument with long slender orange or yellowish dorsal and subdorsal scoli, with no evidence of white waxy secretions on the integument nor the scoli. The larval instars were illustrated with black-and-white photographs and described in detail by Paukstadt et al. (1996), and again with color figures by Naumann (1998).

**Material Examined. INDONESIA**: Island of Sulawesi, Sulawesi Utara [North Sulawesi], 1♂ (lectotype) Gorontalo, coll. P. J. van den Bergh (BMNH); 1♂1♀ paralectotype, same locality, 1914, coll. P. J. v. d. Bergh (BMNH); 1♀ Minahasa, 1885, leg. Platen, coll. Staudinger (ZMHB); 2♂1♀ 1912, coll. P. J. v. d. Bergh (ZMA); 1♂2♀ 1920, coll. v. d. Bergh (ZMA); 1♀ without data, leg. Platen, coll. Staudinger (ZMHB); 1♂1♀ Manado, 700 m, May 1926, coll. R. Gschwandner (NHMW); 1♀ Manado coast, Sept. 1938, coll. van Groenendael (ZMA); 2♂ Sawangan, Rothschild Bequest (BMNH); 1♀ Tangari [near Tondano], June 1931, leg. Rademakers, coll. Pastor A. Munsters (ZMA); 2♂, same locality, 600 m, Sept. 1947, leg. van Laer, coll. Niewenhuis (RMNH); 1♂ Tondano, 1927, coll. van Veldhoven (RMNH); 1♂1♀ Tonsea Lama [near Manado], Oct. 1937 (ZMA); 1♀, same locality, Oct. 1928, Joicey Bequest (BMNH); 1♂ Dumoga-Bone National Park, Project Wallace, 0˚34'N/123˚54'E, 256 m, July 1985, leg. Kirk-Spriggs, *ex* National Museum of Wales (BMNH); 1♂ Toraut, Tumpa River, 50 km west of Kotomobagu, 350 m, 9-11 Aug. 2000, leg. Zorn, Röschmann, Zeides (Naumann); 1♂1♀ without further data, Rothschild Bequest (BMNH); 1♀, coll. Fruhstorfer (BMNH). Sulawesi Tengah [Central Sulawesi], 1♂ Gunung [Mount] Tumpu, Palu, 820 m, Feb. 1937, leg. J. P. A. Kalis, Rothschild Bequest (BMNH); 1♂ Piala, 2 km north of Air Terjun Ranga Ranga, west-northwest of Luwuk, 700 m, 29 Aug. 1994, leg. Naumann, genitalia no. 161/97 Naumann (Naumann); 4♂ Taripa-Tentena, 5 km north of Taripa, 700 m, Aug. 1995, leg. Naumann & Amin (Naumann, Paukstadt); 1♀ without further data (BMNH). Sulawesi Tenggara [South East Sulawesi], 1♀ Ulu Kolaka, 500 m, June 1939, coll. J. M. A. van Groenendael (ZMA). Sulawesi Selatan [South Sulawesi], 1♀ Bantaeng, Ereng Ereng, 500 m, Sept. 1938, coll. van Groenendael (ZMA); 1♂ Malakadji, NW Bantaeng, 750 m, Aug. 1938, coll. van Groenendael (ZMA); 2♂1♀ Camba, 50 km east-northeast of Maros, 100 m, July 1995, leg. local collector, ♀genitalia no. 629/01 Naumann (Naumann); 1♂ Mamasa, Feb. 2000, leg. local collector (Naumann); 1♀ Pulu Pulu, West-Torajaland, July 1994, leg. local collector (Naumann); 1♂ same locality, 1800 m, July 1995 (Naumann); 1♂1♀ same locality, Aug. 1995 (Naumann); 10♂ 1800 m, July 1995 (Beeke, Naumann, Paukstadt); 1♂ Pulu Pulu, 7 July 1995 (Peigler); 1♂ same locality, 26 May 1995

(LACM); 4♂ same locality, 3, 4, 4, & 5 July 1995, from Pierre Schmid, Peigler coll. (LACM); 7♂ Puncak Palopo, 1200 m, 31 July 1994, leg. Gala, genitalia no. 14/96 Naumann & 744/95 Nässig (Naumann); 21♂4♀ same locality, 1300 m, Aug. 1995, leg. Gala (2♂ Beeke, 6♂2♀ Naumann, 10♂1♀ Paukstadt, 1♂1♀ Peigler; 3♂ LACM); 1♂ same locality, 19 Aug. 1995, leg. Naumann & Amin (Naumann); 2♂1♀ same locality, bred in Germany from wild collected female 25-31 Aug. 1995, *ex ovo* 1, 19, & 30 June 1996 on *Ligustrum japonicum*, collected and reared by S. Naumann (Naumann); 5♂, same locality, Telekom station, 1400 m, March-April 1998 (Naumann); 3♂ same locality, bred in Germany from wild collected female Oct. 1998, *ex ovo* 25 April, 16 May 1999 on *Ligustrum japonicum*, leg. Gala, reared by S. Naumann (Naumann); 1♂ To'Rea, 4 Sept. 1998, Peigler coll. (LACM); 1♂ Salu Tai , 19 March 1998, received by Peigler from Pierre Schmid (LACM); 1♂ Gunung Sampuraga, 2˚10'S/120˚45'E, 1400 m, Feb. 1995, leg. V. Sinjaev & E. Tarasov (Naumann); 1♂ road Malili-Soroako, km 23, 280 m, Aug. 1995, leg. Naumann & Amin (Naumann); 1♀ Seleyer [Selajar Island], Somarisi, 1660 ft, Dec. 1938, leg. J. P. A. Kalis (BMNH); 2♀, same data, 500 m, Dec. 1936 & Dec 1938, coll. J. M. A. van Groenendael (ZMA). Sulawesi without data: 1♀ Celebes (RMNH); 3♂ Celebes, leg. Neuburger (DEI); 1♀ leg. Dobiasch (NHMW); 1♂ Süd Celebes, coll. Staudinger & Bang-Haas (MTD); 1♀ Celebes, coll. Staudinger & Bang-Haas (MTD).

## *Samia naumanni* U. Paukstadt, Peigler & L. Paukstadt

(Figures 60- 61, 187-188, 212, Map 6 )

*Samia vandenberghi* ssp. nov., Naumann 1995: 33, pl. 8, figs. 5, 6 (♂ ), pl. 14, fig. 4 (♂ genitalia).
*Samia naumanni* Paukstadt et al. 1998: 114. Nässig & Treadaway 1998: 257. D'Abrera 1998: 89(♂), 90. Naumann & Peigler 2001: 78.

**Types.** The holotype is a male from 2 kilometers west of Wai Bau, 180 meters, Kecematan Sanana, island of Sanana, Sula Archipelago, Maluku Utara District, Province of Maluku [Moluccas], Indonesia. It was taken on 2 August 1995 by Ulrich Paukstadt and Stefan Naumann, and was deposited in the Museum Zoologicum Bogoriense, Cibinong, Java, with collection number MZB.LEPI.4443. The allotype is a female with the same data except for the altitude of 250 meters and the date of 4 August 1995. It is in the collection of Laela Hayati Paukstadt. There are 25 male paratypes, distributed into the following collections: The Natural History Museum, London; Museum Zoologicum Bogoriense, Java; Natural History Museum of Los Angeles County, Los Angeles; Laela Paukstadt; R. Peigler; S. Naumann.

**Geographical Distribution** (Map 6). *Samia naumanni* is known only from three small islands in north-central Indonesia. These are Peleng in the Banggai Archipelago (Kepulauan Banggai, Sulawesi Tengah Province), and Mangole and Sanana (=Sulabesi) in the Sula Archipelago (Kepulauan Sula, Maluku Utara Province).

**Diagnosis.** *Samia naumanni* is one of the largest species, somewhat resembling *S. vandenberghi*, *S. ceramensis*, and *S. naessigi*, but can be separtaed by the following characters. Compared to *S. vandenberghi* the forewing crescent is more bent in the proximal third, the black eyespot is larger in diameter, and the apical area is more pink than purplish; the postmedian line is straighter and it contains more rose, especially in ones from Banggai. Compared to the other two Moluccan species, *S. naumanni* averages smaller, the postmedian line is less curved and contains less black and less intensive rose, the apical eyespot is smaller, and the orange patch and second black dot below it are lacking. The scaling on the wings is denser in *S. naumanni*, giving the moths a less translucent appearance than allied species. Females of *S. naumanni* are among the largest in the genus.

**Description.** Adult ♂ (Fig. 60). *Head.* Frons and occiput brown. Antennae 13.1 mm long, 4 mm wide. *Thorax.* Tergum and sternum light brown. *Forewing.* Length 73-84 mm. Ground color medium brown; costal margin of ground color, or slightly lighter; antemedian area of ground color; antemedian line prominent; median area of ground color, with dark areas of shading; postmedian line straight, with normal black, white, rose components, but with minimal pink suffusion; postmedian area sprinkled with black scales, with pink suffusion

along veins; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 12 mm; submarginal line prominent; outer margin ochre; crescent short, thick, curved proximally; apex 12 mm long, 20 mm wide, with large purplish patch, ochre dash inside of eyespot; eyespot oval, black and large, with white edge and suffusion; underside lighter and paler. *Hindwing*. Length 49-58 mm. Antemedian area lighter than ground color; antemedian line of medium development; median area of ground color; postmedian line undulating, colored as in forewing but with much more pink outer suffusion in postmedian area; submarginal line obsolete; submarginal ornamentation contrasting; outer margin ochre; crescent short, curved, and wide; tornus weakly pointed. *Abdomen*. Tergum brown, with minimal white tufts visible; spiracular ornamentation absent; sternum brown, with two lighter medial bands. *Genitalia* (Figs. 187-188). Uncus bifid; transtilla even more bilobed than in *S. vandenberghi*; saccus intermediate in length between longer one of *S. vandenberghi* and reduced one of *S. peigleri*, much rounded at its end; sacculus strong, as well as the ventral process of the valve which is more prominent compared to *S. vandenberghi* and *S. ceramensis*; central process much reduced to just a rounded dentation, dorsal lobe similar to *S. vandenberghi*; aedeagus longer and taller than in the latter and *S.ceramensis*, with only a small, minor sclerotized but heavily dentated sclerite; vesica with three bulbs, but always lacking sclerites.

Adult ♀ (Fig. 61). Differing from ♂ as follows. *Head*. Antennae 12 mm long, 4 mm wide. *Forewing*. Length 64 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10 mm; crescent rounded, surrounded by black, with well-developed yellow and transparent portions. *Hindwing*. Length 61 mm; crescent large, thick, short, almost a semicircle; tornus rounded. *Abdomen*. Tergum brown with small white tufts; spiracular ornamentation weak; sternum brown. *Genitalia* (Fig. 212). Anal papilles quite tall and elongated, deeply bifurcate; a very long bifurcate lobe covering oviporus; lamella postvaginalis lacking indentation; lamella antevaginalis a single, prominent, rounded structure; anterior apophyses two-thirds as long as posterior ones, which are generally large.

**Discussion.** In general, all saturniids known from the islands of Banggai and Sula have thus far been found only at lower elevations, and always in areas partially converted to agriculture. On Pulau Peleng, Naumann collected near rice fields, fruit tree (jambu, orange, coconut, mango, etc.) plantations, or freshly cut forest clearings. Access to primary forest was impossible because paths were impassable, and it would have required several days to reach more remote areas in the center of the island. Banggai Island was found to be widely deforested in 1994. On Pulau Sanana, Paukstadt and Naumann (1996) never found any places with primary forest; most parts of the island were either inhabited lowlands or low mountains with garden areas (nutmeg, fruit trees) among remnants of secondary forest. Specimens of *Samia naumanni* have been collected at elevations between 60 and 250 meters. The highest altitudes on Peleng are around 500 meters in the east and 1000 meters in the west, on Sanana 700 meters, and only on the less accessible islands of Taliabu and Mangole can higher elevations be found. No precise altitude for the 1897 record from Mangole was noted. Some maps label Sanana Island as Pulau Sulabesi, with Sanana being the name of a village on the northeastern end.

For those who enjoy studying the annals of natural history exploration, it may be interesting to note that the famed American collector William Doherty (1857-1901) collected at least one specimen of this species more than a century ago and sent it to Lord Rothschild in London, but apparently Rothschild did not see that it represented a new species. That moth was taken on Doherty's second collecting trip to Indonesia and New Guinea, which lasted from 1895 to 1898 (Horn & Kahle 1935: 58). On that same voyage, he collected the original specimens of *Attacus dohertyi* Rothschild on Timor. A portrait of Doherty can be seen in Horn and Kahle (1937: 420). Over 30 species and subspecies of butterflies were named after Doherty, by taxonomists like William Holland, Walter Rothschild, Charles Oberthür, Frederic Moore, and Hans Fruhstorfer.

*Samia naumanni* is a large and finely colored species, probably most closely related to *S. vandenberghi*, judging from the wing pattern and male genitalia. As pointed out earlier in our general discussion on "Biogeography," there is a faunal relationship between the Sula and Banggai archipelagoes, which were connected to each other during Pleistocene times. This has been substantiated by certain insect groups (see for example Townes and Chiu 1970: 17) as well as by the genus *Attacus*. *Attacus paraliae* Peigler was originally known only from a single male from Peleng Island (Banggai Archipelago) (Peigler 1989), but specimens were later collected on Sanana (Sula Archipelago) by Ulrich Paukstadt and Stefan Naumann on the same excursion that led to the discovery of *Samia naumanni*. These two Attacini probably have an identical dispersal history. Their nearest relatives appear to be endemics of Sulawesi, namely *Attacus erebus* Fruhstorfer and *Samia vandenberghi*. The significance of former land connections is critical to understanding the current ranges of these large moths. Although the distance between Sulawesi and Banggai is less than 20 kilometers, there may be important habitat differences that preclude reciprocal colonization. We point out here that *Samia insularis* has re-colonized Krakatoa in recent times over a greater distance from Java and Sumatra.

This species was treated as an unnamed subspecies of *Samia vandenberghi* by Naumann (1995: 33-35; pl. 8,

figs. 5, 6; pl. 14, fig. 4). Although it was described and figured, no name was proposed. A male from Sanana from the Naumann collection was shown in its actual size by D'Abrera (1998: 89).

Nothing is known of the immature stages of *S. naumanni*. Circadian flight activity data were recorded in the field by Ulrich Paukstadt and Stefan Naumann, and presented in a table in the original description (Paukstadt et al. 1998). On Peleng, specimens arrived at light between 2:00 and 4:00 hours, and on Sanana, where many more specimens were collected, they arrived between 2:15 and 5:45 hours, with peaks around 3:00 and 5:00 hours. Comparing these data to those derived from captive cultures of *S. cynthia*, we interpret that mated females fly early in the evening to oviposit on trees, unmated females emit pheromone in later hours, and mating occurs throughout the following day, with copulation broken at nightfall. An alternate interpretation of these data, which we do not believe to be correct, would be that pairs mate early in the night, and copulation lasts several hours, then when pairs separate, often just prior to sunrise, the males fly to lights. At the time of the original description, only a single female was known, but at this writing we have examined four additional females. We figure a female from Peleng, and a male from Sanana.

**Material Examined. INDONESIA**: Maluku Province [Moluccas], Maluku Utara [= Northern Moluccas District],♂ holotype, 18♂ paratypes, ♀ allotype, Sula Archipelago, Sanana Island, Kecamatan Sanana, 1-2 km west of Wai Bau, 150-250 m, 1-10 Aug. 1995, leg. S. Naumann & U. Paukstadt, genitalia no 15/96, 114/97 Naumann, 499-502 Paukstadt (holotype, 2 paratypes MZB; 9 paratypes Naumann; 5 paratypes and allotype Paukstadt; 1 paratype Peigler; 1 paratype LACM); 5♂ Sanana Island, Oct. 1998 (Brechlin); 1♂ paratype, Mangoli [= Mangole Island], Oct. 1897, leg. W. Doherty (BMNH). Sulawesi Tengah [= Central Sulawesi Province], 3♂ paratypes, Banggai Archipelago, Peleng Island, 1 km southwest of Luksagu, 60 m, 24 Aug. 1995, leg. S. Naumann & M. Amin, genitalia no. 927/95 Nässig, 496 Paukstadt (2♂ Naumann, 1♂ Paukstadt); 1♂ paratype, Luksagu, Feb. 1997, leg. local collector (Naumann); 1♂2♀ Luksagu, Feb. 1997, leg. local collector (Löffler); 3♂ 2 km west of Sambiut, 150 m, July 1998, leg. local collector (Brechlin); 1♂2♀, Peleng Island, Sept. 1998, local collector, via Detani, ♀genitalia no. 621/01 Naumann (Naumann).

## *Samia ceramensis* (Bouvier)

(Figs. 64-65, 189; Map 6)

*Philosamia cynthia ceramensis* Bouvier 1927: 921. Bouvier 1932: 44. Jolly et al. 1979: 7.
*Philosamia Cynthia ceramensis,* Bouvier 1928a: 138.
*Philosamia cynthia* f. *ceramensis*, Schüßler 1933: 30.
*Philosamia ceramensis*, Chowdhury 1982: 6.
*Samia cynthia ceramensis*, Seitz 1928: 505. Bouvier 1936: 317. Paukstadt et al. 1993: 229.
*Samia ceramensis*, Naumann 1995: 26. Paukstadt et al. 1998: 121. D'Abrera 1998: 80, 81 (♂).
Naumann & Peigler 2001: 78.

**Type.** We examined the holotype (Fig. 65) of *Philosamia cynthia ceramensis* in The Natural History Museum (London), which was transfered there from the Hill Museum. It bears the label data: "Central Ceram, Mansuela [*sic*: Manusela] 6000 ft., Oct. & Nov. '19, C. F. & J. Pratt; TYPE" and in the usual large label written in pencil by Bouvier: "*Philosamia cynthia ceramensis* Bouvier ♂ type; E. L. Bouvier det." One further label reads "Joicey Bequest Brit. Mus. 1934-120." Another label reading "Sat. genitalia no. B.M. 682" was added later.

**Geographical Distribution** (Map 6). The species is only known to occur on Ceram (=Seram) in the central Moluccas of eastern Indonesia.

**Diagnosis.** This species has an accessory black spot below the black eyespot of the forewing apex, but such can occur in several other species including *S. yayukae* and even *S. cynthia*, and is always present in *S. watsoni*. The pattern of the wings is divided in half by the postmedian line, and the postmedian area is broadly suffused with pink and white, which are hardly discernable as bands within the postmedian line itself. The oval, black apical eyespot is large and elongated.

**Description.** Adult ♂ (Figs. 64-65). *Forewing*. Length 66-70 mm. Ground color light brown; antemedian area of ground color; antemedian line white and blackish, extending to postmedian line along veins $Cu_{1a}$ and $Cu_{1b}$; median area light brown, reduced in area; postmedian line almost straight, and proximally located to divide wing in equal halves, dark brownish black, white, and wide pinkish zones; postmedian area expansive, broadly suffused with light pink, dark scales in outer section; submarginal line faint and notched; outer margin light brown; crescent small, weakly curved, with equal yellow and whitish (transparent) components, a small amount of dark scales on outer arc; apex narrow and elongated, 10-12 mm long; eyespot very large, 6-7 mm long, oval, with black only in outermost portion. *Hindwing*. Length 50-51 mm. Antemedian area of ground color; antemedian line broad, with white and dark components; median area of ground color; postmedian line gently curved inward below crescent, dark brownish black, white, and rose, terminating high on anal margin; postmedian area large, and broadly suffused with pink, concentrated along veins; submarginal ornamentation consisting of three parallel, elongated, dark brown bars, separated by veins; outer margin ; crescent small, evenly curved, with larger transparent component; tornus gradually tapering to a point. *Genitalia* (Fig. 189). Uncus bifid, transtilla even more bilobed than in *S. vandenberghi*; saccus intermediate in length between the longer one of *S. vandenberghi* and the reduced one of *S. peigleri*, quite rounded at the end; sacculus stout, as well as the ventral process of the valve, which is more prominent compared to *S. vandenberghi* and *S. ceramensis*; central process highly reduced to a mere rounded dent, the dorsal lobe similar to *S. vandenberghi*; aedeagus longer and thicker than in allied species, with only a small, minor sclerotization, heavily dentated; vesica with three cornuti, without sclerites.

Adult ♀. Unknown.

**Discussion.** This species is very rare in collections, known only to us from two males in poor condition. The holotype is badly rubbed, and has a forewing length of 70 mm, and a hindwing length of 51 mm. The forewing crescent pushes through the postmedian line, and there is an additional black spot below the apical eyespot of the forewing. It was figured by D'Abrera (1998: 81). The female and immature stages of *S. ceramensis* remain unknown. Most publications that mention this taxon erroneously cite the year of the original description as 1928. Newer maps and texts show a spelling of Seram (or Seran) for the island traditionally known as Ceram, we assume because the letter "c" in Bahasa Indonesia is pronounced like the English "ch."

A specimen (Fig. 64) in the Carnegie Museum of Natural History in Pittsburgh almost certainly belongs to this species. Like the holotype, it is another male in poor condition, and is labeled: "From New Guinea and adjacent islands during 1945, J. E. Tesner, collector." Although the lot containing this specimen had vague data, it was retained by the museum because material from that area is rare in collections (John Rawlins, pers. comm. to Peigler). A photograph of the Tesner specimen was compared with the figure of the holotype in D'Abrera (1998) when writing the above description. Figure 189 shows the genitalia of the holotype; the Carnegie Museum specimen was not dissected.

In the late 1990s a few specimens were received from a dealer in Jakarta that were labeled as originating from Ceram, but Naumann examined those specimens including genitalia preparations, and concluded that they were mislabeled *S. insularis*. *Samia ceramensis* possibly also occurs on Misool, Ambon, and Buru, and if so, would have a range corresponding to that of *Attacus crameri* C. Felder. However, Ambon (formerly Amboina) has been a major trade center for ships for centuries, and it is likely that the easily visible cocoons of a *Samia* would have been found and reported in publications if a representative of the genus existed on that small island. At least three collecting trips to Ceram and Ambon in recent years by Alexander Schintlmeister, S. Naumann & U. Paukstadt, and Peter Salk failed to yield any specimens of the genus *Samia*. The type locality is now in Manusela National Park which covers 100,000 hectares and is increasingly becoming a destination for birders and others who participate in eco-tourism. Unfortunately, the park is still not fully protected from poachers of timber and wildlife.

*Samia ceramensis* appears to be most closely allied to *S. naessigi*, its neighbor to the north, instead of to *S. yayukae*, its neighbor to the southwest. This is to be expected since the distance from Ceram across the Ceram Sea is less than a third of the distance across the Banda Sea. A zoogeographical relationship exists between the Lepidoptera of Halmahera and Seram (de Jong 1998). *Samia ceramensis* is the easternmost representative of the genus.

Charles Pratt, Felix Pratt, and Joseph Pratt were brothers who caught the holotype of *Samia ceramensis* during their collecting travels from 1913 to 1920 in eastern Indonesia and New Guinea (D. Goodger, pers. comm.; Horn & Kahle 1936: 214). Many of the specimens they collected were sent to James John Joicey at the Hill Museum, the material of which has since been incorporated into The Natural History Museum. Numerous species of Lepidoptera from the Indo-Australian region bear the names *pratti* and *prattorum* in their honor, such as the birdwing butterfly *Troides prattorum* Joicey & Talbot (Papilionidae) from Buru. Very few specimens of

*Attacus crameri* are known from Buru and Ceram, most of which were collected by the Pratt brothers (Peigler 1989: 54). Eight decades later, we still have very little entomological material available for study in western collections from the Moluccas.

**Material Examined. INDONESIA**: 1♂ Maluku Tengah Province, central Ceram Island, Manusela, 6000 feet [=1828 m], Oct.-Nov. 1919, C., F. & J. Pratt (BMNH). 1♂ locality uncertain (see discussion above), 1945, J. E. Tesner (CMNH).

## *Samia naessigi* Naumann & Peigler

(Figs. 62-63, 190, 213, Map 6)

*Samia naessigi* Naumann & Peigler 2001: 77.

**Types.** All material known so far was included in the type series. The holotype and allotype were deposited in the Zoologisches Museum der Humboldt-Universität Berlin. Red labels were affixed to the pins of these two, and blue paratype labels to all others. The label data are as follows. Holotype ♂, Indonesia, Maluku Utara, Halmahera (Nordwest), Stichstraße Baru-Basale, ca. 500 m, 6 March 1997, 03:00 h, leg. Stefan Naumann (ZMHU). Paratypes (10♂♂, 4♀♀). Allotype♀, Stichstraße Baru-Basale, ca. 500 m, 6 March 1997, ♀ 00.55 h, leg. S. Naumann (ZMHU); ♂ [Indonesia], Halmaheira, Tobelo, bought by E. Le Moult (BMNH); 2♀♀, Mount Talagarama, 15 km southeast of Baru, 600 m, 1˚12'N/127˚32'E, primary forest, 22-31 Jan. 1996, leg. V. Sinjaev (Brechlin); 2♂♂, Halmahera (Nordwest), Stichstraße Baru-Basale, ca. 550 m, 5 March 1997, 04:25 & 05:10 h, GP 78/97 & 79/97 Naumann, leg. S. Naumann (Naumann); 1♂ same locality, ca. 550 m, 4 March 1997, 04:40 h, leg. S. Naumann (LACM); 1♂, same locality, ca. 500 m, 6 March 1997, 03:50, leg. S. Naumann (Naumann); 1♂, same locality, 7 March 1997, 04:50 h, leg. S. Naumann (Naumann); 1♂, Gunung Api Gamkonora, ca. 5 km east of Baru, 350 m, 8 March 1997, 02:40 h, leg. S. Naumann (Naumann); 2♂♂, Gunung Gagagutu, 16 April-9 May 1997, leg. A. Sumbala (Naumann); 1♂, Gunung Saululu, Nov.-Dec. 1998, leg. A. Sumbala (Naumann); 1♂1♀, without specific locality data, June 1998, GP 709 Paukstadt, leg. local people (Paukstadt). Some specimens from Naumann's collection were deposited in the Senckenberg Museum, Frankfurt-am-Main, and one from Peigler's collection is in the Natural History Museum of Los Angeles County.

**Geographical Distribution** (Map 6). *Samia naessigi* is known only from the northern part of Halmahera Island, Maluku Utara [Northern Moluccas District], Maluku Province, eastern Indonesia.

**Diagnosis.** *Samia naessigi* can be distinguished from other *Samia* by its larger size and its intensive coloration; the ocelli are broadly bordered with yellow, there is a black inner portion of the postmedian line. All specimens have a second small subapical eyespot and orange scales in the forewing apex. The genitalia are quite massive, larger than in *S. ceramensis*, and the vesica can be separated from allied species by the form of the sclerite.

**Description.** Adult ♂ (Fig. 62). *Head.* Frons and occiput coppery brown. Antennae stramineous, 9.8-11.9 mm long, 3.8-4.8 mm wide. *Thorax.* Tergum with white collar, tergum and sternum coppery brown. *Forewing.* Length 61-78 mm. Ground color light brown; costal margin of ground color; antemedian area light brown; antemedian line with thick white and dark smoky brown components; median area ground color, darker along outer edge; postmedian line very straight, except where crescent penetrates, with blackish brown, white, purplish rose, lighter pink components; postmedian area peppered with numerous dark brown scales among golden brown ones; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 9 mm; submarginal line faint and weakly wavy; outer margin ochre inside submarginal line, darker gray brown outside; crescent gently curved, slender, transparent, very narrow white, and yellow components; apex purplish brown and ochre gold, suffused with orange scales, 14-16 mm long; eyespot oval and elongated, black with much whitish and pinkish suffusion; underside with antemedian line absent, minimal dark shading. *Hindwing.* Length 54-58 mm. Antemedian area ground color; antemedian line as in forewing but narrower; median area ground color, darker along outer edge; postmedian line mainly straight with gentle indentation below crescent; postmedian area divided into patches by

pinkish suffusion extending along veins; submarginal line obsolete; submarginal ornamentation linear strips of dark brown surrounded by lighter ochre; outer margin straight; crescent evenly curved, clear and yellow, boldly edged with black; tornus tapering to a point. *Abdomen*. Tergum with white tufts nearly obsolete. *Genitalia* (Fig. 190). Uncus bifid, transtilla the most indented of all *Samia*; saccus quite large, somewhat rectangular, with broad vinculum; juxta with almost no well defined processes; sacculus very reduced; valve with long ventral process, blunt small central one more prominent than in *S. ceramensis*, and much reduced dorsal one; aedeagus, corresponding to the strong saccus, also very broad and strong, with a left lateral sclerite distally; vesica with three bulbs, in some specimens with a fourth small bulb left laterally. While *S. naumanni* has no sclerite and *S. ceramensis* an acute one on the dorsal bulb, there is only a small round sclerite at this location in *S. naessigi*.

Adult ♀ (Fig. 63). Differing from ♂ as follows. *Head*. Antennae 1.2 mm long, 3.4-4.0 mm wide. *Forewing*. Length 79-81 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 14 mm; crescent large and weakly curved, containing twice the transparent area as in ♂ ; apex blunt, black eyespot twice as large as in ♂. *Hindwing*. Length 64 mm; crescent almost a semicircle, with large transparent component; tornus medium in shape, neither rounded nor pointed, due to curved outer edge of hindwing. *Abdomen*. Tergum light brown with small white tufts. *Genitalia* (Fig. 213). Lamella postvaginalis almost semicircular; lamella antevaginalis almost straight, a long arc with a small central, curved projection oriented posteriorly; all four apophyses of nearly equal length.

**Discussion.** Specimens of this species are very rare in collections, because it is only known from the remote island of Halmahera in far eastern Indonesia, where it is probably endemic. It was named after our friend Dr. Wolfgang A. Nässig, a saturniid taxonomist at the Senckenberg-Museum in Frankfurt am Main, who has done much to further the knowledge of Lepidoptera of the Palaearctic and Indo-Australian regions. *Samia naessigi* is sympatric on Halmahera with other saturniids, including *Coscinocera rothschildi* Le Moult, *Syntherata sinjaevi* Naumann & Brechlin, and *Cricula trifenestrata* (Helfer). Under his treatment of *S. ceramensis*, D'Abrera (1998: 80) wrote "There is another specimen in B.M.(N.H.) from Halmahera which resembles this taxon, but could itself be a separate species." We agree with D'Abrera that *S. ceramensis* is probably the nearest relative of *S. naessigi*. Generally, the genitalia are the largest in the genus, corresponding to the large overall size of the moths. The abdomen of the single specimen used for dissection of the female genitalia was damaged by mold, so the genitalia disintegrated into small pieces during preparation. Nevertheless, most structures could be characterized using those pieces, although the anal papilles and covering of the oviporus were missing.

Thus far this moth has only been collected on the northern peninsula of Halmahera, as no expeditions have been made to the southern part of the island. The northern part mainly consists of a landscape of rolling hills, with many active and dormant volcanoes (Hall 1996, 1998; Wallace 1869), and the central part of the island is still covered with primary forests. Nevertheless, considerable deforestation was noted in recent years by the Russian lepidopterist Viktor Sinjaev, followed by S. Naumann, in which trees were cut and brought to small harbors. Typically, local farmers follow these clear cuts by fire to further clear the areas, and then establish small plots of vegetables within these openings of the forest. Naumann and other collectors found that such widely open areas were excellent sites for setting up lights for moth collecting, and specimens of *Samia naessigi* and *Coscinocera rothschildi* were taken. A female of the latter taken by Naumann was figured by D'Abrera (1998: 155). The open areas were accessible via side roads with dead ends deep within the forest; such roads are called Stichstraße in German. While the hills still had sufficient forest areas in 1997, the lowland areas were covered with high grass, as was noted as early as 1858 by Wallace (1869), probably because deforestation had taken place there much earlier. The type locality of *Samia naessigi* is along a road between the villages of Basale and Baru, at an altitude of 500 meters.

It may be worthwhile to cite here the phototactic data recorded in the field for the Saturniidae of that remote island. For *Samia naessigi*, males arrived at 02:40, 03:00, 03:50, 04:25, 04:40, 04:50, and 05:10 hours, the last one arriving near dawn; and a female at 00:55 hours. For males of *Coscinocera* 02:15, 02:45, 03:50, 04:15 hours; for males of *Syntherata* 20:30, 20:40 hours (as for *Syntherata* on Ambon, also an early evening flier); for males of *Cricula* 05:20 hours. All of these moths were collected between 350 and 600 meters in altitude.

There is a biogeographical link between Halmahera, the Central Moluccas, and Sulawesi (Katili 1989). Three collecting trips in recent years to Talaud, which is not of volcanic origin (unlike nearby Sangihe which is), yielded no Saturniidae. Likewise, Viktor Sinjaev did not find any Saturniidae on Bacan (=Batjan) in 1996.

**Material Examined. INDONESIA**: Maluku Utara, 1♂ holotype, 1♀ allotype, northwestern Halmahera Island, road Baru to Basale, ca. 500 m, 6 March 1997, ♂ 03:00 hours, ♀ 00:55 hours, leg. S. Naumann, collection of Naumann, ♀genitalia no. 622/01 Naumann (ZMHB); 1♂, same data, 03:50 h (Naumann); 1♂, same locality, ca. 550 m, 4 March 1997, 04:40 h, leg. S. Naumann, sent to R. Peigler (LACM); 2♂, same locality, ca.

550 m, 5 March 1997, 04:25 & 05:10 h, genitalia no. 78/97 & 79/97 Naumann, leg. S. Naumann (Naumann, SMFL); 1♂, same locality, ca. 500 m, 7 March 1997, 04:50 h, leg. S. Naumann (Naumann); 1♂, Tobelo, bought by E. Le Moult (BMNH); 2♀, Mount Talagarama, 15 km southeast of Baru, 600 m, 127˚32'E/ 1˚12'N, primary forest, 22-31 Jan. 1996, leg. V. Sinjaev (Brechlin); 1♂ paratype, Mount Api Gamkonora, ca. 5 km east of Baru, 350 m, 8 March 1997, 02:40 h, leg. S. Naumann (Naumann); 2♂, Mount Gagagutu, 16 April-9 May 1997, leg. A. Sumbala (Naumann, SMFL); 1♂, Mount Saululu, Nov.-Dec. 1998, leg. A. Sumbala (Naumann); 1♂1♀, without locality, June 1998, genitalia no. 709 Paukstadt, leg. local people (Paukstadt).

## *Samia tetrica* (Rebel)

(Figs. 66-69, 107-111, 191-192, 214; Map 9)

*Philosamia cynthia tetrica* Rebel 1924: 109. Rebel 1925a: 12. Rebel 1925b: 157, pl. 9, fig. 4 (♂), fig. 5 (♀). Bouvier 1927: 932. Bouvier 1928a: 138. Jolly et al. 1979: 7.
*Philosamia cynthia* f. *tetrica*, Schüßler 1933-1934: 28, 521.
*Philosamia tetrica*, Chowdhury 1982: 6.
*Samia cynthia tetrica*, Seitz 1928: 504. Bouvier 1936: 316.
*Semia* [*sic*] *cyntia* [*sic*] *tetrica*, Kishida 1977a: 3. [misspellings]
*Samia insularis tetrica*, Nässig et al. 1996a: 28. Nässig et al. 1996b: 118, figs. 72-73 (larvae).
*Samia* (*insularis*) *tetrica*, Nässig & Treadaway 1998: 252.
*Samia tetrica*, Holloway 1987: 113, pl. 12, fig. 1 (♂). Peigler 1992: 167. Paukstadt et al. 1994: 58. Paukstadt et al. 1998: 120. Naumann 1998: 454. D'Abrera 1998: 86, 87 (♂♀).
*Philosamia cynthia borneensis* Rebel 1925b: 168 (footnote). Jolly et al. 1979: 7.
*Philosamia cynthia* f. *borneensis*, Schüßler 1933-1934: 30, 524.
*Philosamia borneensis*, Chowdhury 1982: 6.
*Samia cynthia borneensis*, Seitz 1928: 504.
*Semia* [*sic*] *cyntia* [*sic*] *borneensis*, Kishida 1977a: 3. [misspellings]
*Samia borneensis*, Allen 1981: 111, pl. 4, upper (♂). Barlow 1982: 49, pl. 9, fig. 2 (♀). Holloway *in* Barlow 1982: 192. Lampe 1984: 6, pl. 2, fig. 1 (♂), fig. 3 (♀). Lampe 1985: 8, pl. 2, fig. 1 (♂), fig. 3 (♀)
*Samia insularis borneensis*, Nässig et al. 1996a: 29.

**Types.** Hans Rebel described this taxon from one male and four females, all from Singapore. These specimens were examined by Naumann in the collection of Naturhistorisches Museum Wien (Vienna, Austria). We hereby select the male (Fig. 66) to be lectotype of *Philosamia cynthia tetrica*. Its handwritten labels read "Singapore, Löbell 1900; 4; *Philosamia tetrica* Rebel Type." The latter word is written in red ink, and the entire label is in the handwriting of Rebel (Horn & Kahle 1936: pl. 26, fig. 20). Identical labels are on the four females (two labels on each specimen), which we hereby designate as paralectotypes. The specimens are in excellent condition, and a red lectotype label and blue paralectotype labels were recently placed on their pins.

In the Naturhistorisches Museum Wien, Naumann also examined and photographed the holotype female of *Philosamia cynthia borneensis* (Fig. 69). This single specimen was received by Rebel from Charles Oberthür during the final page proof stage of his 1925b paper, and a description was entered as a footnote. Label data are as follows: a typeset label with "Nord Bornéo, Mount Kina Balu, 5-8-1903, John Waterstradt" and a handwritten label with "*Philosamia cynthia borneensis* Rbl.♀. Type." The latter word is in red ink, and the entire label is in the handwriting of Rebel. The moth is in good condition, except that some small portions of the outer edges of the right forewing and right hindwing are torn away.

**Geographical Distribution** (Map 9). *Samia tetrica* occurs in the small countries of Singapore and Brunei, and in the Indonesian part of the island of Borneo known as Kalimantan. It also ranges in both sections of the country of Malaysia, namely East Malaysia on the island of Borneo (states of Sarawak and Sabah) and West Malaysia on the Malay Peninsula extending off of the mainland of southeastern Asia.

**Diagnosis.** *Samia tetrica* is generally the smallest and darkest species in the genus and is unlikely to be

confused with any other, except some dark morphs of *S. canningi* from southern Thailand and Myanmar, which are almost as dark but are generally larger and have a different wing shape. Other characters that identify *S. tetrica* include a high and elongated forewing apex, and a somewhat triangular shape of the hindwing in males, the nearly straight postmedian lines which contains very dark pink violet portion, and the distal end of the crescents in both forewing and hindwing being expanded instead of pointed. The male genitalia are similar to those of *S. treadawayi*, *S. luzonica*, and *S. insularis*, but have longer ventral processes on the valves.

**Description.** Adult ♂ (Figs. 67-68). *Head.* Frons and occiput dark brown. Antennae 9 mm long, 2.1 mm wide. *Thorax.* Tergum and sternum dark brown. *Forewing.* Length 50-58 mm. Ground color dark brown; costal margin dark brown; antemedian area dark brown; antemedian line faint, barely visible in Bornean specimens, more prominent in West Malaysian ones; median area of ground color; postmedian line very straight, except for indentation at crescent; postmedian area narrow and suffused with rose; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 5-6 mm; submarginal line weak, straight, and slightly notched; outer margin dark ochre yellow; crescent small, with very slender transparent portion, olive outer portion; apex 8-9 mm long, 13-16 mm wide, suffused with dark purple, a diffuse light dash proximal to eyespot; eyespot black and elongated; underside paler brown with paler rose component of postmedian line. *Hindwing.* Length 40-43 mm. Antemedian area dark brown; antemedian line faint; median area of ground color; postmedian line straight, with slight indentations; postmedian area suffused with rose, concentrated around veins; submarginal line obsolete; submarginal ornamentation brown and ochre, lacking contrast; outer margin dark ochre; crescent small and even; tornus tapering evenly to a point. *Abdomen.* Tergum dark brown with white at base and tip of abdomen; spiracular ornamentation weak; sternum dark brown. *Genitalia* (Figs. 191-192). Most closely resembling those of *S. insularis* and the two Philippine species; uncus bifid, processes long; transtilla with median indentation, with two small lobes; saccus small and rounded; saccular lobe of valve as in aforementioned species; ventral process of valve originating quite dorsally, and longer than other species; median process blunt but prominent; dorsal process greatly reduced; aedeagus very similar to that of *S. insularis* and longer than in *S. treadawayi*, with sclerite left ventrolaterally; vesica with three bulbs; dorsal one with small median sclerite in some Bornean specimens but never in West Malaysian ones; smaller left and right lateral bulbs lacking cornuti.

Adult ♀ (Fig. 69). Differing from ♂ as follows. *Head.* Antennae brown, 8-9 mm long, 1.9 mm wide. *Forewing.* Length 68-75 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-12 mm; crescent with more transparent and white components, and lighter yellow component; apex short, 7-9 mm long 15-18 mm wide; submarginal line with contrast between distal and proximal side. *Hindwing.* Length 55-66; crescent larger with more black, white and yellow; tornus pointed, but less so than in ♂. *Abdomen.* Tergum golden ochre with separate white tufts; spiracular ornamentation still not very contrasting but more visible; sternum brown. *Genitalia* (Fig. 214). Anal papilles greatly indented centrally, and again with incisura in proximal third, this unique in the genus along with *S. treadawayi*; many small hair bases ventrally; oviporus covered by large membranous lobe; lamella postvaginalis rounded and triangular, laterally with comparatively broad intersegmental process; lamella antevaginalis straight; anterior apophyses half the length of posterior apophyses.

**Discussion.** The name *tetrica* means "having four angles," referring to the crescentic markings in each wing. Holloway (1987) was first to point out the synonymy of the names *tetrica* and *borneensis*. As he added a footnote to the proofs of his paper, we suppose that Rebel (1925b) was too hasty in assuming that the female specimen he called *borneensis* was specifically distinct from his *tetrica*, described the previous year (Rebel 1924). According to the label data, the holotype of *Philosamia cynthia borneensis* was collected in 1903 on Mount Kinabalu by "John Waterstradt." In their discussion of collectors in the Indo-Australian region, Corbet and Pendlebury (1956: 67) wrote that Johannes Waterstradt, who was Danish, ascended Mount Kinabalu in 1885-1887 and went on several more collecting expeditions in the area during the following years. Some of the specimens of *Attacus atlas* that Waterstradt collected in Brunei are in The Natural History Museum (Peigler 1989: 37). The collector of the lectotype of *tetrica* was Löbell, but we found no mention of his name in pertinent sources (Horn & Kahle 1935-1937, Corbet & Pendlebury 1956, Horn et al. 1990, Gaedike 1995). We examined a female from the Rothschild collection in The Natural History Museum that was apparently collected by Charles Hose, the famous biologist and anthropologist who studied the animals and Indigenous Peoples of Borneo. Other specimens that we examined were collected by the neuropterist Hermann Willem van der Weele (1879-1910), whose collection is now in the Nationaal Natuurhistorisch Museum; Cecil Joslyn Brooks (1875-1953), whose extensive collection from Sumatra and Borneo is now in The Natural History Museum and the Norwich Castle Museum (Horn et al. 1990: 57); Maria E. Walsh-Held, a dealer who collected and sold Indonesian insects in the

early 1900s; and Colonel Michael G. Allen, whose publications on Bornean and Nepalese Saturniidae are cited in our bibliography. Resident collectors of more recent material, such as G. R. Ping, Loh Khai Tong, Wong Tet Fatt, and H. F. Wong, are mostly commercial dealers, to whom we also owe a debt of gratitude for providing thousands of valuable specimens of insects to the scientific community.

The report of this species from the Indonesian island of Lombok by Paukstadt et al. (1994: 59) is incorrect. It was based on a specimen which is larger than normal, and although correctly identified (verified by genitalia dissection), has erroneous locality data. The specimen belonged to the late Gilles Terral, whose collection is now in the Muséum d'Histoire naturelle de Lyon, France.

Barlow (1982) listed castor bean and crepemyrtle (*Lagerstroemia indica*, Lythraceae) as foods of *Samia*, but we do not believe that he was referring to *S. tetrica* or *S. kohlli* (both of which he illustrated), because he cited Sevastopulo (1946) in his bibliography, an author who used crepemyrtle to rear *S. canningi*. In his book on Bornean moths, Holloway (1987: 113) listed 37 genera of plants that were recorded to be fed upon by species of *Samia* in Asia; he omitted records of foodplants used in Europe and the United States. It is not possible for us to sort out which, if any, of these pertain to *S. tetrica*. However, as pointed out in our general discussion on hostplants, we believe that the reports of celery (*Apium*) and the palm *Trachycarpus* are erroneous, as these do not agree with the normal suite of hosts used by Saturniinae. Larvae of *S. tetrica* have been reared in recent years in Germany on ailanthus and privet.

A mature larva was collected by Holloway (1987: 114) in Gunung Mulu National Park, in Sarawak, East Malaysia. He described it as being very unlike that of *S. cynthia*, having a brownish integument and yellowish tubercles. We are grateful to our long-time colleague and friend Rudolf E. J. Lampe of Nuremberg for sending his series of larval photographs that we are able to reproduce in color (Figs. 107-111). Lampe's livestock came from West Malaysia. Although no photograph of the mature larva was available to us, one was shown by Nässig et al (1996b: fig. 73). The scoli of the mature larva are yellow, so in that regard agree with a brief description of the larva by Holloway from East Malaysia, on the island of Borneo. The integument no longer has the waxy covering, and there are prominent black patches, close to our Figure 111 of the penultimate stage from the same rearing. The scoli have no hint of red, orange, or blue, i.e., colors often seen on larval scoli of other species of *Samia*. The brownish integument cited by Holloway remains a bit of a mystery, but possibly some variation occurs in larvae of *S. tetrica*. Unlike larvae of *Saturnia*, *Actias*, and many other Lepidoptera, mature larvae of *Samia* do not show darkening of the integument before surrounding themselves with cocoons.

Like most members of the genus, *Samia tetrica* may prefer foothills and mountains, but some specimens have been seen in coastal areas. Holloway cited the habitat as lowland forest, but pointed out that occasional specimens had been collected at high altitudes, such as at 1618 meters on Bukit Retak, Brunei, and a similar altitude on Mount Mulu (=Gunung Mulu). In West Malaysia, records include altitudes from coastal up to 1800 meters. It is sympatric with *Samia kohlli* at stations such as the Cameron Highlands and Genting Highlands in West Malaysia, where the two moths and their caterpillars cannot be confused. It is the only species of *Samia* known to occur on Borneo, and its affinities belong with *Samia treadawayi* of Palawan to the north of Borneo. Therefore, it is assumed to have originated in the Borneo/Palawan region, and later expanded its range to the Malay Peninsula, but not yet on Java, Sumatra, or further north on the Asian mainland. Thus we hypothesize that the two species of *Samia* inhabiting the West Malaysian highlands have different origins and affinities, so are not sister-species. Regarding the East and West Malaysian populations of *S. tetrica*, we consider them to be conspecific, but moths from West Malaysia are generally larger, and there is a minor difference between the male genitalia that we pointed out in the description above.

Along with *Samia watsoni*, specimens of *S. tetrica* are the darkest moths in the genus for ground color, and therefore may resemble moths of the genus *Lyssa* (Uraniidae) in nature, such as *L. menoetius* (Hopffer) on Borneo and *L. zampa* (Butler) in West Malaysia (Barlow 1982: 136, pl. 47), large moths that also rest with the wings opened and flattened. Specimens of *Lyssa* are probably protected from bird predators by toxins derived from their euphorbiaceaous hostplants. *Samia tetrica* is also the smallest species of *Samia*, with forewing lengths of only about 50 mm in male Bornean specimens. Possibly not coincidentally, the smallest specimens of *Attacus atlas* also occur on Borneo. *Samia tetrica* has been recorded at the Ulu Gombak Field Studies Centre in West Malaysia. As can be inferred from our section below on material examined, *Samia tetrica* is less common in museum and private collections than most other species of the genus, including *S. kohlli* which co-exists with it on Peninsular Malaysia. Lampe (1984, 1985) considered *S. tetrica* to be uncommon in West Malaysia, and had only a single pair of specimens. However, as long as butterfly farmers continue to supply live cocoons of "*Samia cynthia*" from West Malaysia to many of the butterfly houses and arthropod zoos in North America and Europe, living specimens of *S. tetrica* can be seen by visitors at those educational institutions.

**Material Examined. BRUNEI**: 2♂ Brunei, Labi, 30-60 m, lowland forest, 6 Feb. 1979 & 3 Aug. 1979,

genit. no. 418 B.M., leg. M. G. Allen (BMNH); 2♂ Brunei, Ulu Belait, 60 m, lowland forest, 21 & 22 Feb. 1980, leg. M. G. Allen (BMNH); 3♂ Brunei, Sungai Burong, 27 & 30 Nov. 1997, leg. G. R. Ping (Naumann); 1♂ 30 Nov. 1997, leg. G. R. Ping (Peigler). **INDONESIA**: BORNEO: 4♂1♀ without data (MZB); 1♂ Kalimantan Timur Province, Tengaran (=Tenggarong), leg. Jesp., coll. Staudinger, genit. no. 179/97 Naumann (ZMHB); 2♂ Samarinda, Oct. 1938 & Dec. 1938, leg. M. E. Walsh, B.M. 1939-182, genit. no. 402 B.M. (BMNH); Kalimantan Barat Province, 3♂1♀ Pontianak, ca. 20 m, June 1999, from Paukstadt (Naumann); 1♂ same data (MZB); 2♂ same data (Brosch). Nusa Tenggara Barat Province: 1♂ Lombok Island, *ex* coll. G. Terral, genit. no. 436 Paukstadt [locality erroneous] (MHNL). **MALAYSIA**: EAST MALAYSIA: 1♀ Sabah State, Pulau Labuan [Labuan Island], 1890, leg. Waterstradt & Jesp. (ZMHB); 1♂ Kinabalu, 1200-1500 m, 1895, leg. Waterstradt, genit. no. 178/97 Naumann (ZMHB); 1♂ Kinabalu National Park, Poring Hot Spring, 500 m, 12 Sept. 1994 at light, leg. E. Aug (SMFL); 1♂ Kinabalu National Park, park headquarters, 1400 m, 2 March 1994 at light, leg. C. Schulze (SMFL); 1♂ same locality, 1500 m, 13-25 Feb. 2000 at light, leg. P. Spona (Löffler); 2♂1♀ Trus Madi, 1150 m, 9-14 April 1996, leg. B. Martini, ♀genit. no. 619/01 Naumann (Naumann); 1♂ same data (Paukstadt); 2♂1♀ same locality, 1600 m, April 1997, leg. B. & C. Martini (Naumann); 4♂2♀ same locality, *ex ovo* Nov. 1997 in Germany on *Ligustrum*, reared by B. Martini (Brechlin); 3♂ road from Ranau to Tambuan, 500 m, 16 Feb. 1999, leg. F. Meister (Meister); 1♀ Keningau, 800 m, 10 Aug. 1986, leg. Martini (Naumann). Sarawak State, 1♀ Baram District, leg. C. Hose, Rothschild Bequest B.M. 1939-1 (BMNH); 1♂ Bidi, 1907-1908, leg. C. J. Brooks, B.M. 1934-120 (BMNH); 1♂ Long Palai, *ex* larva in alluvial forest, May 1978, leg. J. D. Holloway [see Holloway 1987: 114] (BMNH). WEST MALAYSIA: Perak State, 1♀ coll. Staudinger (ZMHB); 1♂ Kampong Sahom, June 1974, bought from USA dealer in 1975 by Peigler (LACM); 1♀ Pahang State, Genting Highlands, 1500 m, Feb. 1981 (Lampe); 1♂ Genting Highlands, 1800 m, bought by W. Nässig in 1984 from Loh Khai Tong, sent to Peigler (LACM); 1♂1♀ Kepong, Forest Research Institute, 2 & 4 Jan 1988, leg. K. Fiedler, ♂ genit. no. 1080/97 Nässig (SMFL); 1♂ Cameron Highlands, *ex ovo* Nov. 1988 on ailanthus (Lampe); 1♂2♀ Cameron Highlands, Oct. 1987, May 1989, June 1989, ♂ genit. no. 31/96 Naumann, leg. H. F. Wong (Naumann); 2♂ Cameron Highlands, Tanah Rata, ca. 1500 m, Dec. 1993-Feb. 1994, leg. Wong Tet Fatt (Naumann); 1♂1♀ Cameron Highlands, Tanah Rata Hill, *ex* pupa 10 & 18 July 1991, reared by Helmut Probst, genit. no. 439 Paukstadt (Paukstadt); 1♂ Cameron Highlands, *ex* pupa July 1990 (Brosch); 2♂ Cameron Highlands, *ex* pupa May 1995, reared by. M. Mayr (Beeke); 1♂ 1995 (Brosch); Selangor State, 1♂ Ulu Gombak F. St. C., 18 March 1986, 23:10 h, leg. W. A. Nässig, genit. no. 468/86 Nässig (SMFL); 1♀ same locality, 19 March 1991, leg. D. Kovac (SMFL). **SINGAPORE**: 1♂1♀ Singapore, 23 April 1909, leg. H. W. van der Weele, ♂ genit. no. 33/96 Naumann (RMNH).

## *Samia treadawayi* Naumann

(Figs. 70-72, 193, 215; Map 5)

*Attacus Ricini*, Pagenstecher 1890: 14. [misidentification]
*Attacus ricini*, Semper 1896: 384. (in part)
*Samia treadawayi* Naumann 1998: 449, figs. 1-2 (♂♂), 3 (♀). Nässig & Treadaway 1998: 255, col. pl. 3, fig. 16 (♂), col. pl. 13, figs. 85 (♂), 86 (♀). D'Abrera 1998: 88, 89 (♀♂).
*Samia tredawayi*, Brechlin 2001: 44. [misspelling]

**Types.** Holotype ♂: The labels read "C. Palawan, Mt. Salakok, 350 m, 20.iii.1996; GP 183/97SNB = 1150/97CWAN. CCGT, assigned to SMFL, Frankfurt/Main (SMFL-no. 4165)." The holotype in the Senckenberg Museum was collected on Mount Salakot, 350 m, central Palawan Island, Palawan Province, Philippines, on 20 March 1996, by Colin G. Treadaway. The genitalia are mounted on a slide labeled "GP 183/97 Naumann = 1150/97 CWAN. It also bears a red holotype label. The holotype was figured in the original description (upperside and underside) and in color by Nässig & Treadaway (1998: pl. 3, fig. 16).

No allotype was designated. Paratypes (36♂ 7♀) are in several collections, cited below among the material examined.

**Geographical Distribution** (Map 5). *Samia treadawayi* is an endemic of the island of Palawan, in the southwestern Philippines. Its occurrence on the nearby islands of Culion and Busuanga is probable.

**Diagnosis.** This species is phenotypically intermediate between *S. luzonica* and *S. tetrica*. It is smaller and darker that *S. luzonica*, but larger and lighter than *S. tetrica*. These size differences pertain mainly to males. The white band of the postmedian line is thinner than in the related species. Diagnostic characters of the genitalia are given in the description below.

**Description.** Adult ♂ (Figs. 70-71). *Head.* Frons and occiput dark brown. Antennae 11 mm long, 3.8 mm wide. *Thorax.* Tergum and sternum dark brown. *Forewing.* Length 58-59 mm. Ground color dark chocolate brown; costal margin same as ground color; antemedian area of ground color; antemedian line weakly defined; median area of ground color; postmedian line straight, with small indentation at crescent, dark brown, narrow white, purplish rose, suffusing into postmedian area; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 8 mm; submarginal line obscured by dark edges; outer margin dark ochre brown; crescent narrow with normal white and yellow components, dark brown instead of black outer edge; apex 8 mm long, 14 mm wide, not brightly marked; eyespot black with broad white inner edge; underside lighter and paler. *Hindwing.* Length 42-49 mm. Antemedian area of ground color; antemedian line very faint; median area of ground color; postmedian line straight, but slightly undulating; postmedian area as in forewing, with pink scales concentrated at veins; submarginal line obsolete; submarginal ornamentation obscure; outer margin more straight than rounded; crescent small and evenly curved; tornus pointed. *Abdomen.* Tergum brown with tiny white tufts; spiracular ornamentation faint; sternum brown, lighter medially. *Genitalia* (Fig. 193). Generally similarity to *S. tetrica* and *S. luzonica*, but with several specific and consistent differences; uncus bifid, the processes much taller than in *S. insularis*; transtilla with central indentation, like two small lobes; saccus small and rounded, smaller than in the other mentioned species; sacculus of the valve quite similar in all of these species; ventral process of the valve emerges far dorsally, somewhat longer and taller than in the *S. tetrica* and *S. luzonica*, ventral one blunt yet prominent, dorsal one well developed and more prominent than in other allied species; aedeagus shorter and broader than in *S. tetrica* and *S. luzonica*, with no apical spine left ventrolaterally; vesica with three bulbs, a large dorsal one with very small more sclerotized field medially, a smaller left ventrolateral one and a small right lateral one which is directed distally.

Adult ♀ (Fig. 72). Differing from ♂ as follows. *Head.* Antennae 10 mm long, 3 mm wide. *Forewing.* Length 64-67 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-11 mm; crescent broader than in ♂; apex 4 mm long, 13 mm wide. *Hindwing.* Length 51 mm; crescent very broad, sometimes almost a semicirle; tornus rounded. *Abdomen.* Tergum brown; spiracular ornamentation faint; sternum brown. *Genitalia* (Fig. 215). Oviporus with quite large anal papilles, less strongly indented distally (as in *S. luzonica*), with slight notch in the proximal third; lamella postvaginalis strongly sclerotized, evenly curved distally and medially, anterior with broad base; lamella antevaginalis narrow; anterior apophyses two-thirds as long as posterior ones; ductus bursae slightly sclerotized dorsally, expanded distally and laterally.

**Discussion.** Somewhat isolated, Palawan is home to the endemic species *Attacus lemairei* Peigler, *Loepa palawanica* Nässig & Treadaway, *Cricula palawanica* Brechlin (2001), and *Samia treadawayi*, but no other species of those genera. Several so-called subspecies of doubtful validity were also recently described from the island, mainly in the genus *Antheraea*, conspecific with populations on Borneo or other Philippine islands. Records for *Attacus caesar* on Palawan cited by Peigler (1989) are now known to be erroneous (Nässig & Treadaway 1998), resulting from specimens originally mislabeled by dealers. Almost half of the island is still covered by primary rainforest, and it has about 445 species of Rhopalocera, which is fully half of the national total for the Philippines, and for which 32 are endemic to the island. Some taxa reveal that Palawan is linked more closely to Borneo than to Mindanao, an example being the close relationship between *Samia treadawayi* and *Samia tetrica*. An excellent reference for those interested in Philippine biogeography was written by Colin Treadaway (1998), who has made numerous collecting expeditions to that country. Vane-Wright (1990) also provided an instructive discussion of this topic. During Pleistocene times of glaciation when ocean levels dropped, Palawan was connected to Borneo, but not to other Philippine islands such as Mindoro, Luzon, Panay, or Mindanao (Townes & Chiu 1970: map on p. 18). However, the smaller Philippine islands of Culion and Busuanga, belonging to the Calamian Group, were connected to the northern end of Palawan, causing us to predict that *Samia treadawayi* may eventually be found on those two islands, or some of the tiny associated ones. This species is well represented in the Zoologisk Museum at the University of Copenhagen, because that institution has sponsored a number of collecting trips to Palawan. Specimens of *Attacus lemairei*, a species which is still fairly rare in collections, are also in the Zoologisk Museum.

*Samia treadawayi* occurs at lower elevations than most of the other species in the genus. Habitat data (German: Mittelgebirgsurwald) on labels of specimens collected near Roxas can be termed interior montane primary forest and described as mid-elevation primary forest. We are not certain whether *S. treadawayi* is more

closely related to the Bornean *S. tetrica*, or the Philippine *S. luzonica*. Nothing is known of the immature stages. Since the species can be easily collected on Palawan, we hope that entomologists will find larvae and cocoons in the field (yielding natural hostplant records), or obtain eggs from a female taken at light and rear the resulting larvae (yielding captive hostplant records). The caterpillars of *S. treadawayi* should provide an important clue to relationships, because those of *S. luzonica* and *S. tetrica* look quite different from each other.

**Material Examined. PHILIPPINES**: Palawan Island, 1♀ paratype, 1888, leg. K. K. Platen, coll. Otto Staudinger (ZMHB); 1♂ paratype, Palawan, Nov. 1981, leg. B. Turlin, genitalia no. 29/96 Naumann (Naumann). South Palawan, 1♂3♀ paratypes, near Brooke's Point, Mount Bayog, 305 m, 20 April 1995, 16 Jan. 1981, Jan. & Aug. 1984, ♀genitalia no. 184 & 185/97 Naumann, leg. C. Treadaway (Naumann, SMFL); 5♂ paratypes, Mount Mantalingajan, 800 m, Dec. 1997, leg. Bal (Brechlin); 12♂1♀ same locality, 6-13 Jan. 2000, leg. D. Mohagan (Brechlin); 5♂4♀ same locality, 4-14 March 2000, leg. D. Mohagan (Brechlin); 2♂ same locality, 2-12 Aug. 2000, leg. D. Mohagan (Brechlin); 1♂ Bataraza, primary forest, 4 km north of Malihud, 8˚43'14"N/117˚33'47"E, 570 m, 3 & 4 June 2000 at light, leg. S. Verdeprado & A. Zwick (Naumann). Central Palawan, 1♂ paratype, Napsan, Mount Salakot, 700 m, 19-20 Feb. 1996, leg. J. Petersen (ZMUC); 3♂ holotype & paratypes, same locality, 600 m, 18 & 20 March 1996 & 16 June 1997, leg. C. Treadaway, genitalia no. 183/97 Naumann = 1150/97 Nässig (SMFL); 1♀ paratype, same locality, 500 m, 19 July 1984, leg. B. Turlin (Turlin); 1♂, same locality, 800 m, 9˚51'N/118˚38'E, 10-27 Feb. 2000 (Brechlin); 2♀ paratypes, Salakot Falls, 16 Jan. & Aug. 1993 (SMFL); 1♂ paratype, same locality, 300 m, 19 March 1996, leg. A. Zwick (Zwick); 1♂ paratype, Napsan, 330 m, 19-20 March 1996, leg. J. Petersen (Naumann via ZMUC); 7♂ paratypes, same locality, 23-25 March 1996, leg. J. Petersen (ZMUC); 2♂ paratypes, Irawan, 50 m, 15 March 1996, leg. J. Petersen (ZMUC); 1♂ paratype, same locality, 1 Oct. 1997, leg. J. Petersen (Naumann); 2♂ paratypes, Solomon, 17 March 1996, leg. C. Treadaway (LACM, SMFL); 1♂ paratype, Narra, Mount Victoria, 150 m, 14 March 1996, leg. J. Petersen (ZMUC). North Palawan, 7♂ paratypes, Languan, 200 m, 5-10 July 1988, leg. J. Settele & C. Treadaway, genitalia no. 1104 & 1105/97 Nässig (Treadaway); 4♂ paratypes, San Vincente, 20 km east-northeast of Roxas, 10˚21'N/119˚10'E, middle elevation primary forest, 400 m, 12-17 Jan. 1988, leg. K. Černý & A. Schintlmeister, genitalia no. 1079/97 Nässig & 151/97 Naumann (SMFL, Naumann, Peigler); 4♂1♀ Mount Italpak, 500-800 m, 2-15 March 1999, leg. Garfil (Brechlin); 3♂ Mount Cleopatra Needle, 600-750 m, 21 Nov.-2 Dec. 2000, leg. D. Mohagan (Brechlin).

## *Samia luzonica* (Watson)

(Figs. 73-80, 120, 194-196, 216; Map 5)

*Attacus ricini*, Semper 1896: 384 (in part), pl. C, fig. 6 (larva), fig. 7 (pupa). [misidentification]
*Philosamia insularis luzonica* Watson 1913 [1914]: 50.
*Philosamia insularis* ssp. *luzonica*, Le Cerf 1933: 1.
*Philosamia insularis luzonicus*, Baltazar & Salazar 1979: 91. [emendation]
*Philosamia cynthia luzonica*, Rebel 1924: 112. Rebel 1925b: 157. Schüßler 1933-1934: 30, 523. Jolly et al. 1979: 7.
*Philosamia Cynthia luzonica*, LeCerf 1933: 2.
*Philosamia cynthia* var. *luzonica*, Bouvier 1927: 932.
*Philosamia cynthia luconica* [*sic*], Rebel 1925a: 12. [misspelling]
*Philosamia luzonica*, Chowdhury 1982: 6.
*Samia cynthia luzonica*, Seitz 1928: 504, col. pl. 56Ac (♂). Bouvier 1936: 317.
*Semia* [*sic*] *cyntia* [*sic*] *luzonica*, Kishida 1977a: 3. [misspellings]
*Samia luzonica*, Naumann 1995: 26. Peigler 1996: 17, 121. Naumann 1998: 449. Nässig & Treadaway 1998: 232, 250, col. pl. 3, fig. 17 (♂), col. pl. 5, figs. 26, 33 (♂♂), 27 (♀), col. pl. 16, figs. 115-122 (larvae). D'Abrera 1998: 88, 89 (♂♀).
*Philosamia cynthia mindanaënsis* Rebel 1924: 109. Rebel 1925a: 12. Rebel 1925b: 157, pl. 8, fig. 1 (♂), fig. 3 (♀). Nässig & Treadaway 1998: 250. Naumann 1998: 449. [emendation]

*Philosamia Cynthia mindanaensis*, Bouvier 1928a: 138.
*Philosamia cynthia mindanaensis*, Bouvier 1927: 932. Jolly et al. 1979: 7.
*Philosamia cynthia* f. *mindanaënsis*, Schüßler 1933-1934: 30, 524. [emendation]
*Philosamia mindanaensis*, Chowdhury 1982: 6.
*Samia cynthia mindanaensis,* Bouvier 1936: 316.
*Samia cynthia mindanaënsis*, Seitz 1928: 504. [emendation]
*Samia mindanaensis*, Naumann 1995: 26.
*Philosamia cynthia*, Collins 1987: Annex 2: 12 (in part). [misidentification]

**Types.** We examined three syntypes of *Philosamia insularis luzonica* in The Natural History Museum, two labeled as such. We hereby designate the male (Fig. 73) labeled "Polangui Albay, Luzon, Philipines [*sic*], Dioscor: Salting per A. F. Porter; Type of Luzonica (Wats.) ♂ 1913" as lectotype of *Philosamia insularis luzonica*. A female labeled "Polangui Albay Luzon, Phil: Isl:, Dioscoria Salting per A. F. Porter 1914; Type of ♀ Luzonica (Wats.) 1913" is hereby designated as a paralectotype. Another female with a label which reads "Polangui, P. I., Dioscoria Salting" is also designated as a paralectotype. Watson stated in the original description that he had two pairs, but we were unable to locate the other male syntype.

Hans Rebel described *Philosamia cynthia mindanaënsis* from a series of specimens, of which Naumann located one male and three females in the Naturhistorisches Museum Wien (Vienna, Austria). The male is labeled with a handwritten label reading "*Philosamia mindanaënsis* Rbl ♂ Type", in Rebel's handwriting (Horn & Kahle 1936: pl. 26, fig. 20), with the word type in red ink, and " 1.", and with typeset label that reads "Schadbg. 1890, Mindanao." This specimen has a forewing length of 53 mm, a hindwing length of 40 mm, antennal length of 9 mm, and an antennal width of 2.6 mm. We hereby designate this male as lectotype (Fig. 76). The labels on the three females, hereby designated as paralectotypes (Fig. 77), are the same handwritten and typeset ones as for the male, but with the ♀ symbol. They have forewing lengths of 56, 59, and 56 mm.

**Geographical Distribution** (Map 5). *Samia luzonica* is an endemic of the Philippines, but ranges throughout all of that country except for Palawan, where it is replaced by *S. treadawayi*. From north to south, the large islands on which specimens have been collected include Luzon, Mindoro, Panay, Samar, Leyte, Negros, and Mindanao. It has also been found on tiny islands such as Camiguin, Marinduque, Borocay, and Jolo. It is to be expected also on the islands of Bohol, Masbate, Cebu, Basilan, and probably Catanduanes and Polillo. Some of the localities indicated on our Map 5 were taken from Map 4 of Nässig and Treadaway (1998: 407).

**Diagnosis.** The dark brown color usually separates *Samia luzonica* from the two Javanese species, and it is usually much larger than *S. tetrica* and *S. treadawayi*. The crescents are large and rounded, almost straight in the forewing; the forewing apex is usually pointed, and the postmedian line is very straight in the forewing.

**Description.** Adult ♂ (Figs. 73-76, 79-80). *Head*. Frons and occiput brown with light edges. Antennae 9-10 mm long, 3.5-5 mm wide, stramineous. *Thorax*. Tergum and sternum brown. *Forewing*. Length 53-69 mm. Ground color dark brown to chocolate brown to dark olive; costal margin of ground color; antemedian area of ground color or lighter; antemedian line variable, weak or prominent, inflated or constricted; median area of ground color; postmedian line very straight, with strong white component, bordered proximally by black, distally by deep rose (purplish pink); postmedian area of ground color, suffused proximally by light bluish or pink scales concentrated around veins, distally with black scales; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 8-11 mm; submarginal line broken at base of apex, relatively straight, sometimes with lighter zone proximal to it; outer margin dark gray or dark ochre yellow; crescent narrow, sometimes intersecting postmedian line, usually with a swollen notch at top; apex pointed, with large bluish purple area, 10-12 mm long, 16-18 mm wide; eyespot black with thick white inner border, patch of ochre within; underside paler, but apex equally bright. *Hindwing*. Length 40-50 mm. Antemedian area large, of ground color; antemedian line very prominent, white, with small black edge; median area of ground color; postmedian line more undulating than in forewing; postmedian area as in forewing; submarginal line obsolete; submarginal ornamentation dark brown and ochre, weakly contrasting; outer margin straight to weakly rounded; crescent shortened; tornus variously pointed or rounded. *Abdomen*. Tergum golden brown, with small white tufts; spiracular ornamentation a mix of white and dark brown, set in lighter brown area; sternum with whitish scales in a median zone. *Genitalia* (Figs.194-196). Generally similar to *S. tetrica* and *S. treadawayi*, but with several specific and consistent differences; uncus in all species bifid, transtilla with a central indentation, similar to *S. insularis*; saccus broader and longer than in *S. treadawayi* or *S. tetrica*, but consistent in all populations of *S. luzonica*; sacculus somewhat outwardly curved ventrally; ventral process of the valve a bit stronger and longer than in the other species mentioned above, and

arising far dorsally from the inner portion of the valve; central process small, blunt, and similar to *S. treadawayi*; dorsal lobe less developed than in the latter species; aedeagus longer than in *S. treadawayi* and *S. tetrica*, with large rounded sclerite at the left ventrolateral end; vesica with three bulbs, a large dorsal one, and two right distal and left ventrolateral ones; dorsal bulb lacking sclerite in populations from most islands, but in some specimens from Mindanao a visible very small left medial sclerite, parallel with the great variation of specimens from that island; in all other genitalia structures we found no other differences in the populations from all other islands.

Adult ♀ (Figs. 77-78). Differing from ♂ as follows. *Head.* Antennae 12 mm long, 4 mm wide. *Forewing.* Length 80-83 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 11-15 mm; crescent large; apex 10 mm long, 20 mm wide. *Hindwing.* Length 62 mm; crescent large, broad, evenly curved; tornus rounded. *Abdomen.* Tergum ochre brown with white tufts; spiracular ornamentation prominent, with white and darker brown components; sternum brown medially, white lines laterally. *Genitalia* (Fig. 216). Anal papilles indented medially, with numerous small hair bases and bristles ventrally and laterally; oviporus concealed beneath membranous lobes; posterior to oviporus are lateral lobes that converge at a central indentation, similar to that in *S. vandenberghi*; lamella postvaginalis distally rounded, with central incurvature and directly lateral processes, anterior also rounded; lamella antevaginalis laterally long, also somewhat rounded; anterior apophyses shorter than posterior ones.

**Discussion.** Although this species is quite variable, there has not been an inordinate amount of naming of the insular forms. Fortunately therefore, the synonymy is comparatively brief, actually only composed of misspellings and emendations of the two names *luzonica* and *mindanaensis*, and a few misidentifications. Polangui, the type locality, is presumably in southeastern Luzon with coordinates of 14˚00'N/123˚33'E, although there are four localities bearing this name listed in gazetteers of the Philippines (Peigler 1989: 74). The type series of Rebel's *mindanaensis* was collected by Alexander V. Schadenberg (Horn & Kahle 1936: 240). The type locality for that name can only be stated as Mindanao, without further specific locality data. Some may expect to find the name *manillensis* in the synonymy of *S. luzonica*, but Bouvier (1927) based that name on a specimen of *Samia canningi* that was mislabeled, so *manillensis* belongs in the synonymy of the latter species. Watson (1913) originally described *Samia luzonica* as a subspecies of *S. insularis*. Although the names *S. insularis* and *S. luzonica* represent two distinct species, Watson was correct in seeing their close relationship, because both belong to the same species group. Specimens of both sexes of both species often have a swollen distal end of the forewing crescent, but this trait occurs to a lesser extent among several of the central Indonesian species.

Some of the material we examined of *S. luzonica* and *S. pryeri* was collected by Alfred Ernest Wileman (1860-1929) who was a prolific field collector (Horn et al. 1990: 423). Peigler (1989: 73-74) also cited specimens of *Attacus lorquinii* C. Felder & R. Felder collected by Wileman in the Philippines. Another indefatigable collector in the Philippines was an American named Charles Fuller Baker (1872-1927), whose insect collection is now in the National Museum of Natural History in Washington. Townes and Chiu (1970) cited hundreds of *Xanthopimpla* (Ichneumonidae) collected by Baker, but his data labels generally lack dates. In recent years, Colin G. Treadaway of the Senckenberg Museum (Frankfurt am Main) has made numerous collecting trips to the Philippines, elucidating the Lepidoptera from many remote localities of that nation (see Naumann 1998b, Treadaway 1998). Several of the localities known for *S. luzonica* are attributable to his persistent efforts in the field.

Although some individual specimens of *S. luzonica* cannot be associated with their geographic origins, it is often possible to assign series to their source islands without reference to their data labels. For example, specimens from Leyte are more rosy in the postmedian area whereas those from Negros show more whitish scales there, but in the median area are darker and generally more intensive colored, as mentioned for several other Saturniidae from that island (Nässig & Treadaway 1998). Some specimens from Mindanao are recognizable, but this island yields the greatest amount of phenotypic variability, not surprisingly due to its large size and diverse habitats. Females from Marinduque and Sampalac look identical, being quite large and golden brown colored. However, despite the consistent phenotypes on some of the islands, the genitalia of all of them are identical, indicating that we are dealing with one widespread and variable species. Peigler (1989) came to the same conclusion regarding the variation of *Attacus lorquinii* that ranges throughout much of the Philippines. To emphasize our point that no valid subspecies can be distinguished for *Samia luzonica*, we figure three males from Mindanao (Figs. 76, 79, 80) showing the different wing phenotypes but which have the same genitalia structure. In some areas more than one color form can be found, whereas in other areas, a single color form predominates. The series collected by Baker on Mount Makiling in Luzon all have their forewing crescents turned inward, so that trait is possibly constant in that population. Up to now, lepidopterists have generally labeled specimens from northern Philippines as *S. luzonica* and ones from southern Philippines as *S. mindanaensis*. Naumann made

genitalia preparations of several males, so in addition to those loaned to us by U. Paukstadt and W. Nässig, we were able to compare examples from the islands Luzon (4), Marinduque (2), Mindoro (1), Borocay (2), Panay (1), Negros (2), Leyte (2), Jolo (1), and Mindanao (7). No significant differences were found among these. Comparison of these preparations led to the conclusion that all of the populations we assign to *S. luzonica* belong to one widespread and variable species, whilst those on Palawan belong to a second species (*S. treadawayi*), which has affinities with *S. tetrica* of nearby Borneo. This correlates well with the historical geology of the Philippines (Treadaway 1998), for which most islands were connected during Pleistocene times, except Palawan, which was not connected to the other main islands of the Philippines, but instead had a land connection to Borneo. Maps showing this pattern of former land connections are widely published, including in Townes and Chiu (1970: 18) and van Oosterzee (1997: 151). *Samia luzonica* is known to live at altitudes from sea level to 2200 meters, with an average of about 800 meters above sea level.

The species has been collected with *Attacus caesar* Maassen on Mount Dalungdong and Mount Apo on Mindanao, and at other sites it is sympatric with *Attacus lorquinii*. In Bukidnon Province, the population level of the *Samia* was observed to be very high; almost 200 cocoons were found on a single avocado (*Persea americana*) tree in February 2001 (Christopher A. Conlan, pers. comm.). Although the Philippine supplier probably sorted the cocoons, no parasitoids were obtained from the lot of 45 received by Conlan. Eggs received by Peigler from C. Conlan hatched in Texas on 29 March 2001. Many larvae died by the third day when kept indoors without ventilation, a problem that has also been noted for several other *Samia* species. Larvae were reared in Texas on *Ailanthus altissima*, and spinning occurred 24-26 days after hatching. Conlan successfully reared larvae in California on camphor (*Cinnamomum camphora*) and avocado. Adults in Texas began to emerge 7 June 2001.

Cocoons are medium to dark brown, uniformly colored, with very smooth surfaces. There is no trace of whitish or reddish in their coloration. A few have ruffled and coarse surfaces on areas between where they were pressed against the leaf. On avocado leaves, some cocoons had wide, sheer flaps of silk to cover the proximal portions of the large leaves, these converging into peduncles. The cocoons are the size of those of *S. cynthia*, or larger, but the larger sizes in the set of 21 empty cocoons received from Conlan may be due to the fact that they had been spun on a hostplant with large leaves. The dark brown color is close to that of cocoons of *S. yayukae*, but the latter are smaller and more compact, again possibly due to a hostplant with smaller leaves or leaflets. Some of these empty cocoons from Bukidnon were deposited in the Natural History Museum of Los Angeles County.

Larvae of this species are apparently variable, as would be expected from the variation in adults and the wide geographical distribution over several islands. The early stages closely resemble those of *S. cynthia* and allied species. They were shown in color by Nässig and Treadaway (1998: pl. 16). The first two instars are yellow with tiny black markings; the middle stages are whitish and covered with wax, as in *S. cynthia*. The final instar becomes a very different looking animal, with the beautiful combination of coral pink scoli set on a bluish green integument. The scoli on siblings reared in California by Conlan on other hostplants (see above) were darker red, as shown in our Figure 120. Among the set of 12 sibling larvae in Texas, no variation was noted. The description below was made from living specimens from Bukidnon. This material agrees with the description and color figure by Semper (1896), which he misidentified as *S. ricini*. Peigler preserved some larvae in alcohol; mature larvae are in the collections of both authors.

Besides ailanthus, avocado, and camphor cited above, another food selected in nature is apparently *Thevetia* (Apocynaceae). This is a highly toxic plant, closely related to oleander (*Nerium oleander* L.). The record itself probably refers to *Thevetia peruviana* (Pers.) K. Schum., the so-called yellow oleander, commonly cultivated around the world in the tropics for its yellow flowers. Other common names for this small tree are zetun and jitong. There are undoubtedly many *native* plants selected by *S. luzonica* in the forests and mountains of the Philippines, but none are known to us. The black-and-yellow ichneumonid *Xanthopimpla brullei* was reared by Laela and Ulrich Paukstadt from a cocoon from Boac, Marinduque. No other parasitoids have been identified as attacking *Samia* in the Philippines, as far as we know.

Mature larva (Fig. 120 and spine of cover). Head pea green, 4 mm wide, 3 mm high, with two tiny black spots surrounded by blue on each side near mouth. Thoracic legs greenish yellow. Integument pale bluish green, with porcelain appearance. Spiracles black. Prothorax yellow green dorsally, with 4 blue minute scoli on anterior edge, and two black spots on posterior edge, lateral scoli blue, with whitish tips, and black spot around base and ventrally, one more black spot at base of leg. Mesothorax and metathorax with 1 median black spot, 2 subdorsal, 2 lateral, and 1 subdorsal black spots on each side; black spot at base of each leg. Scoli all 1.3 to 2 mm long, coral colored, darkening to scarlet with age during final instar and darker dorsally; slender, spineless, tapering; dorsal ones largest, lateral (subspiracular) ones smallest; all scoli with blue bases. Prolegs and anal plate with dark aqua blue and dark yellow components. Dorsal surface of 9$^{th}$ abdominal segment pea green.

Prominent black patches ventrally on last 3 abdominal segments. Length 60-70 mm.

**Material Examined. PHILIPPINES**: Babuyan Islands (Batanes Group) 1♀ Camiguin Island, July 1984 (collection of Colin G. Treadaway). Luzon Island, 1♀ Manila, Jan. 1905, "134," Georg Semper (BMNH); 1♂ Manila (BMNH); 3♂ Manila, Rothschild Bequest (BMNH); 4♀ Manila, Rizal Province, sea level, 4 July 1911, 7 Nov., 26 & 28 Dec. 1913, leg. A. E. Wileman (BMNH); 1♀ Manila, 19 Sept. 1916, presented by J. H. Watson (BMNH); 2♀ Manila, bred 19 Nov. 1916 & 8 Feb. 1917, G. M. Franck (BMNH); 2♀ Manila, sea level, 10 Oct. 1953, coll. Treadaway (SMFL); 4♂2♀ Manila (CMNH); 1♀ Rizal Province, Montalban, 13 April 1914, leg. A. E. Wileman, coll. W. Teinan (BMNH); 1♂ central Luzon, Baguio, coll. Staudinger & Bang-Haas (MTD); 40♂19♀ northern Luzon, Ifugao, Banaue, 1000-1200 m, Feb., March, April, May, Aug., Sept., Oct., & Nov. 1988, May, June, & Aug. 1990, leg. J. Settele & Achilles, C. G. Treadaway (SMFL); 1♂4♀ Mount Makiling [=Maquiling], C. F. Baker (USNM); 3♀ Ifugao, 14 km southeast of Lagawe, Bolog, 500 m, 7 Feb. 1988 (SMFL); 1♂1♀ Ifugao, Kiangan, 750-800 m, 21 June & 13 Nov. 1985 (SMFL); 1♂1♀ southern Luzon, Mount Isarog, March 1983, coll. Treadaway (SMFL); 12♂ southern Luzon, Quezon Forest National Park, 250 m, 8-10 Oct. 1988 (SMFL); 1♂ Nueva Vizcaya, Santa Fé, Dalton Pass, 21 Sept.-17 Oct. 1988 (SMFL); 2♂ Benguet, 15 km south of Baguio, 1600 m, 12 Oct. 1988 (SMFL); 1♀ environs of Legazpi, Camalig, Sept. 1978, leg. Cabides & Lobin (SMFL); 1♂1♀ Laguna, *ex* cocoons Sept. 1995 at Butterfly Pavilion & Insect Center, Westminster, Colorado (LACM); 3♂2♀ same data, ♂genitalia nos. 65 - 67/99 & ♀genitalia nos. 69 & 70/97 Naumann (Naumann). Marinduque Island, 1♂1♀ near Boac, May 1982, coll. Treadaway (SMFL); 2♂2♀ Boac, 12 Aug. 1988 (LACM); 2♂2♀ Boac, 15 & 20 Jan. 1974, leg. Romeo M. Lumawig, bought by Peigler from Lumawig in 1974 (Peigler, LACM); 1♂ Marinduque, June 1984 (LACM); 1♀ Binunga, 15 Sept. 1995, coll. Treadaway (SMFL); 1♀ Sampalac, 1971, bought by Peigler in 1973 from dealer (LACM); 1♂1♀ without exact locality, 2 May 1992 (Brosch); 2♂ 3♀ Nov. 1979, Feb. 1992, April 1994 (Lampe); 2♂ 4♀ Aug. 1992, ♂genitalia no. 30/96 Naumann (Naumann). Mindoro Island, 1♂ southern Mindoro, Calapan, 1890 -91, leg. K. K. Platen, coll. Staudinger (ZMHB); 1♂ Mount Sinai, 20 March 1996, genitalia no. 1102/97 Nässig, coll. Treadaway (SMFL); 1♀ Mount Halcon, 19 June 1996 (Naumann); 2♂ Mount Halcon, July 2001 (Naumann, LACM). Borocay Island, 2♂2♀ *ex* larva Oct.-Nov. 1991 (Beeke); 5♂3♀ Nov. 1991, Oct. & Nov. 1997 (Brosch); 2♂2♀ *ex* larva Oct.-Nov. 1991 (Lampe); 12♂ 7♀ same data, genitalia no. 158 & 159/97 Naumann (Naumann); 3♂2♀ same data (LACM). Panay Island, 1♂ north-western Panay, Mount Madja-as, 28 May 1993, coll. Treadaway (SFML); 1♂ western Panay, Sibalom, Bontol, 50 m, 11 Dec. 1991, leg. K. Černý (SMFL); 12♀ Aklan, Laserna, 300 m, 15 July-15 Aug. 1990, 1 Nov. 1991 (SMFL); 16♂ Panay, 1200 m, May 2000 (Meister); 1♂ same data, received from F. Meister (Naumann); 18♂ 13♀ Panay, May 2001, leg. N. Mohagan (Naumann, LACM, Brosch). Negros Island, 1♀ eastern Negros, Amlan Hydro, 17 April 1981, leg. Schoenig, coll. Treadaway (SMFL); 1♀ eastern Negros, Lake Balin Sasayao, 830 m, 25 July 1985, leg. J. Settele, coll. Treadaway (SMFL); 1♀ Dumaguete, Negros Oriental Province, 1 June-1 Sept. 1913, J. F. Eskridge (USNM); 2♂1♀ Mambucal, 25 Jan. 1990 & 10 June 1992, coll. Treadaway (SMFL); 1♀ southern Negros, Liptong, Aug. 1987, coll. Treadaway (SFML); 5♂ 8♀ western Negros, Mount Kanlaon, 19 Sept. 1985, Nov. 1991, 10 April, 21 Aug., 20 Sept., 3-13 Dec. 1995, 8 June 1996, 13 Jan. 1997, coll. Treadaway (SMFL); 1♂ same locality, 18 Aug. 1997 (Naumann); 7♂, same locality, Feb. & April 1998, genitalia no. 901 Paukstadt (Paukstadt); 4♂ same locality, 800 & 1000 m, 6-10 Oct. 1999, 00:00, 23:00, & 03:00 hours, leg. N. Mohagan (Naumann); 4♂ same locality, 460 m, Sept. & Nov. 1999, Jan. 2000 (Meister); 2♂ same locality, 800 m, 8 Oct. 1999, 01:00 hours & 1000 m, 9 Oct. 1999, 02:00 hours (LACM). Leyte Island, 3♂ central Leyte, Mahaplag, Hilusig, Mount Balocaue, 600 m, 4 May & 2 Dec. 1986, 21 Aug 1987, coll. Treadaway (SMFL); 4♂ same locality, 1400 m, 15-30 March 2000 (Meister); 1♀ southern Leyte, St. Bernard, Catmon, 250 m, 10 March 1977, coll. Treadaway (SMFL); 1♂12♀ southern Leyte, San Juan, reared Dec. 1983-Jan 1984, via E. Brockmann (SMFL); 9♂ Leyte, Mount Lobi, June 2000 (Meister); 1♂ same data, received from F. Meister (Naumann); 1♂ same locality, April 2000 (Brosch); 6♂1♀ Mount Bulokawi, 20-24 Oct. 2000, leg. N. Mohagan (Naumann). Samar Island, 3♂3♀ northern Samar, near Bondo, Dec. 1993 & 9 April 1994, coll. Treadaway (SMFL); 1♂ central Samar, near Hinabangan, Arizona, 27 March 1996, coll. Treadaway (SMFL); 1♂ Catarman, 16 Oct. 1994, coll. Treadaway (SMFL); 4♂ central Samar, Bagacay, 250 m, 1-10 Aug. 1979, coll. Treadaway (SMFL). Mindanao Island, 1♀ leg. I. I. Mounsay, Joicey Bequest (BMNH); 1♂ Kalamluzan [?], Aug.-Sept. 1922, Joicey Bequest (BMNH); 3♂1♀ Bukidnon, Mount Kitanglad, 1250 m, 25 July 1990 & 3 Jan. 1996, coll. Treadaway (SMFL); 4♂ same locality, April & May 2000 (Meister, Naumann); 1♂ Bukidnon, Mount Kitanglad, Intavas, 1700 m, primary forest, 8˚07'N/124˚55'E, 15 Aug.-15 Sept. 1993, leg. V. Sinjaev (Witt); 1♂, same data, 2200 m (Brechlin); 1♂ Mount Apo, 26 Feb. 1994, coll. Treadaway (SMFL); 1♂ same locality, Feb. 2000 (Meister); 1♂2♀ same data, received from F. Meister (Meister); 1♀ Mount Apo, western slopes, 1200 m, 28-30 July 1993 (SFML); 13♂2♀ S. Cotabato, Mount Matutum, Jan., Feb., Oct., & Dec. 1996, March 1997, coll. Treadaway (SMFL); 7♂2♀ south of Cotabato, Mount Busa, 1600 m, Oct. & Nov. 1996,

June 1997, coll. Treadaway (SMFL); 1♂1♀ south of Cotabato, near Koronadal, Barrio; 8, 20, & 30 Dec. 1989, leg. de los Reyes, coll. Treadaway (SMFL); 3♂ same locality, 100-300 m, 12-14 July 1986, leg. R. A. Müller, genitalia no. 410 - 412/99 Naumann (RMNH); 1♂ western Mindanao, Zamboanga del Norte, Mutya, 6 Feb. 1988, coll. Treadaway (SMFL); 1♀ Zamboanga del Norte, Tamuangan, 11 Aug. 1994, coll. Treadaway (SMFL); 1♂1♀ Mount Kalatungan, 700 m, 30 July 1998, ♂genitalia no. 902 Paukstadt (Paukstadt); 2♂ Mount Dalongong, 1200 m, Oct. & Nov. 1999 (Meister); 4♂ 3♀ same locality, 40 km north-northwest of Maramag, 800 m, Apr. 2000, leg. N. Mohagan (Naumann); 2♂ same data, received from S. Naumann (LACM); 2♂ Calyasan, Sept 2000, leg. N. Mohagan (Naumann); 1♂1♀ Bukidnon Province, *ex* cocoon 11 and 15 March 2001 on avocado tree, reared from cocoons by Christopher A. Conlan (Peigler); 1♂ same locality source, reared *ex ovo* on ailanthus in Texas by R. S. Peigler, emerged 7 June 2001 (LACM). Sulu Archipelago, Jolo Island, 1♂7♀ Jolo, 6-11 Dec. 1995 & 14-16 Feb. 1996, coll. Treadaway (SMFL); 3♀ Jolo-City, 10-12 Dec. 1995, coll. Treadaway (SMFL); 16♂9♀ Patikul, 5-15 Dec. 1995, 10-16 Feb. 1996, coll. Treadaway (SMFL); 3♀ Maimbung, 26 Nov. 1994 & 1 June 1995, coll. Treadaway (SMFL). Without locality: 1♂ on *Thevetia*, "living moths common" (ZMHB); 1♂, genitalia no. 404 B.M. (BMNH); 1♂1♀ (MTD); 1♂ no data (LACM).

## *Samia watsoni* (Oberthür)

(Figs. 81-88, 197-198, 217; Map 2)

*Desgodinsia Watsoni* Oberthür 1914: 56, pl. 256, fig. 2159 (♂).
*Desgodinsia watsoni*, Watson 1923: 172. Rebel 1925b: 171, pl. 10, fig. 8 (♂). Bang-Haas 1926: 139. Mell 1935: 363. Bouvier 1936: 312. Fletcher & Nye 1982: 145.
*Philosamia Watsoni*, Schüßler 1933-1934: 41, 564.
*Philosamia cynthia watsoni*, Zhu & Wang 1983: 410, pl. 132, Fig. 2957 (♂).
*Samia cynthia watsoni*, Zhu & Wang 1993: 256. Zhu & Wang 1996: 164, pl. 11, fig. 5 (♂).
*Samia watsoni*, Bollow 1932: 130, pl. 11b (♂). Kishida 1982: 231. Lemaire & Peigler 1982: 175. Peigler 1989: 12, 114. Peigler 1992: 164, 168. Saito 1993: 166. Naumann & Nässig 1995: 23. Naumann 1995: 26. Peigler & Wang 1996: 60. D'Abrera 1998: 82, 83 (♂♀).
*Samia formosana* Matsumura 1931: 731. Sonan 1937: 204. Kishida 1977c: 3. Kishida 1978: fig. 9 (♂). Peigler 1989: 114. D'Abrera 1998: 82.
*Samia watosoni* [*sic*] *formosana*, H. Y. Wang 1988: 49 (♂, ♀). [misspelling]
*Samia watsoni formosana*, Kishida 1982: 231. H. Y. Wang 1994: 85 (eggs, 1st instar larva). Owada & Wang 1992: 156 (Number 117.14a). Owada & Wang 1997: pl. 45, fig. 15 (♂).

**Types.** Since Charles Oberthür did not state categorically that he had only a single specimen on which he based the description, the male from his collection is to be considered a syntype instead of a holotype (Code 1999, Recommendation 73F). We hereby designate this specimen (Fig. 81) as lectotype of *Desgodinsia Watsoni*, which we have examined in The Natural History Museum in London. It came to that museum in 1941 from J. Levick of Birmingham, England. The specimen served as the model for the color figure in the original description, which was reproduced in the color plate of Bollow (1932). The actual specimen was shown in color by D'Abrera (1998: 83).

For the name *Samia formosana*, we located two syntypes, one in Japan from Dr. Shonen Matsumura's collection, the other in France from the collection of Claudius Côte. We hereby designate as lectotype the specimen (Fig. 82) in the entomology collection in Hokkaido University, Sapporo, following Recommendation 74D of the Code (1999). We are grateful to Dr. Kazunori Yoshizawa for sending us a photograph and the label data of that specimen. It bears a typeset label that reads "Formosa/Matsumura" which has written on its underside "Horisha VIII/1924" in Matsumura's handwriting (Horn & Kahle 1937: pl. 37, fig. 31). A separate label in Matsumura's handwriting reads "*Samia formosana* Matsu/Taiwanshinjushan." This last word is Japanese, meaning "Taiwanese ailanthus silkmoth." (We do not believe this to be a record for ailanthus as a hostplant.) We hereby designate as paralectotype another male that Naumann examined in the Muséum d'Histoire naturelle de Lyon, in Lyon, France, from the collection of Claudius Côte. It is labeled "*Samia formosana* Mats. August 1934 [1924], Horisha, Formosa" on paper cut from the original envelope containing the papered specimen. A yellow handwritten label with red letters reading "Type d'Oberthür," probably in the

handwriting of Claudius Côte, and a typeset one with “500" are also on the pin.

**Geographical Distribution** (Map 2). Although endemic to China, the known distribution spans almost 2500 kilometers. The range includes many localities in both The People’s Republic of China and the Republic of China. We have studied specimens from Taiwan, Guangdong, Guangxi, Fujian, Zhejiang, Jiangxi, Shaanxi, and Sichuan. Zhu and Wang (1996) listed some of those provinces, plus Jiangsu andYunnan. Since the known localities for *S. watsoni* are in provinces surrounding Hunan, it is also to be expected in Hunan at appropriate elevations and habitats. It may also eventually be found on mountains in Guizhou, Yunnan, Hubei, and even eastern Xizang or northern Vietnam.

**Diagnosis.** Readily separated from other species in the genus by the large size, burgandy or reddish brown ground color, crescents containing a lot of the transparent component, orange patch on the forewing apex, and a second black eyespot on the outer tip of the forewing.

**Description.** Adult ♂ (Figs. 81-84, 86, 88). *Head.* Frons and occiput brown. Antennae 14 mm long, 5 mm wide. *Thorax.* Tergum and sternum brown, with white collar. *Forewing.* Length 70-80 mm. Ground color burgandy to reddish brown; costal margin suffused with gray; antemedian area of ground color; antemedian line prominent, with more white than black; median area of ground color; postmedian line curving outward at crescent, black, white sharply define, but rose and bluish suffusion broad and scattered; postmedian area dominated by suffusion from postmedian line, including many black scales sprinkled along median portion; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10-15 mm; submarginal line very prominent, divided into paired loops; outer margin golden ochre; crescent large, with black, yellow, and broad transparent components; apex with supplementary eyespots below and above main one, edged distally with bright orange; eyespot black, large, sometimes broken; underside browner and paler, less purplish. *Hindwing.* Length 54-55 mm; antemedian area of ground color; antemedian line weaker than in forewing, drawn in proximally; median area of ground color, sometimes with gray shading above crescent; postmedian line smooth or undulating, colored as in forewing; postmedian area with more of ground color in distal portion, but with same suffusion as in forewing; submarginal line obsolete; submarginal ornamentation very prominent and contrasting; outer margin rounded; crescent broad and open; tornus rounded. *Abdomen.* Tergum reddish brown, lacking white tufts; spiracular ornamentation with whit rings; sternum reddish brown. *Genitalia* (Figs. 197-198). Uncus deeply bifid, transtilla a long lobe with partial central indentation, with long and quite strongly sclerotized lateral processes lateral (interpreted as gnathos by Lemaire & Peigler (1982: 180) but which we disagree after examining 10 specimens); saccus quite long, sacculus of the valves very elongated into a large lobe itself, with a weakly sclerotized rim dentated dorsally; in overall form somewhat as in *Hyalophora* (where a gnathos clearly can be observed) and *Callosamia*, and a bit variable in length and dorsal angle among every population; however, Taiwanese specimens fall within the variation of continental Chinese ones; ventral process of valves longest for *Samia*; central and dorsal processes fused into one large lobe, as in *S. canningi*; aedeagus longest in genus, with a left distal-lateral process having a strongly sclerotized spine directed laterally; vesica with two bulbs, one right dorsolateral with a hook distally and a right lateral sclerotized spine which is unique in the genus; a second smaller left lateral bulb without sclerotization.

Adult ♀ (Figs. 85, 87). Differing from ♂ as follows. *Head.* Antennae 12 mm long, 4 mm wide. *Forewing.* Length 66-78 mm; distance between antemedian and postmedian lines in cell $Cu_{1a}$ 10 mm; crescent very inflated with mostly transparent portion; apex very short and rounded. *Hindwing.* Length 51-60 mm; crescent semicircular or pyriform, with mainly transparent portion; tornus very rounded. *Abdomen.* Tergum solidly reddish brown, lacking tufts or other white markings. *Genitalia* (Fig. 217). Heavily sclerotized and wide bursa copulatrix; anal papilles relatively small compared to overall structure, but comparable in size to other species, with small hair bases and thin bristles; oviporus membranous, barely visible; lamella postvaginalis with two lateral distal earlike lobes and a lateral process; lamella antevaginalis rounded, weakly sclerotized lobe; anterior and posterior apophyses of similar lengths.

**Discussion.** *Samia watsoni* is considered by us to be the most plesiomorphic species in the genus, differing so much from its congeners that Charles Oberthür (1914) established for it a new genus, *Desgodinsia*, in honor of a French missionary named Father Auguste Desgodins (1826-1913). The species itself was named for J. Henry Watson, a well-known enthusiast of Saturniidae who lived in Withington, near Manchester. Watson made several intrageneric crosses in *Samia*, and applied names to some of the resulting offspring, as described in our discussion on hybrids. The name *formosana* refers to Formosa, an archaic name for Taiwan.

The name *Desgodinsia* Oberthür 1914 is a junior homonym of *Desgodinsia* Senna 1894, a generic name in

the Coleoptera (Fletcher & Nye 1982: 145). Bouvier (1936), Rebel (1925b), Mell (1935), and Bang-Haas (1926) accepted the generic ranking, but Schüßler (1933), Matsumura (1931), Bollow (1932), and most subsequent authors did not. No replacement name is necessary because *watsoni* is now widely accepted to be congeneric with *cynthia*. When Watson (*in* Packard 1914: 265) proposed the genus *Archaeoattacus*, he referred to *edwardsii*, *staudingeri*, "and probably a new smaller species, as yet undescribed, from Thibet, which M. Charles Oberthür has shown me in his collection." Of course, Watson was referring to *Samia watsoni*. The female of *S. watsoni* was first figured by Lemaire and Peigler (1982) and first figured in color by Wang (1988). The accompanying color plate in *The Journal of Research on the Lepidoptera* resulted when the manuscript was delayed for more than three years so was withdrawn by the authors, but unfortunately the plate had already been printed by the American journal and was eventually published.

There is some confusion about the labeling of the lectotype, and thus the true type locality, although the two places in question are very near each other. The original description cited Tâ-tsien-lou, Tibet, as the type locality, but the specimen bears a typeset label that reads "Siâo-lou." Tâ-tsien-lou, a French spelling for Tâ-tsien-lu, can be found on more recent maps as either Dardo or K'angting, Szechwan, and most recently, using Pinyin romanization, as Kangding, Sichuan. Kangding is 2600 to 3000 meters in altitude, is about 200 kilometers west-southwest of Chengdu, the capital of Sichuan, and about 120 kilometers west-northwest of Mount Emei, formerly romanized as Mount Omei. Siao-lou [Hsiao-Lu, 24˚57'N/118˚59'E] is a road east of Kangding, close to a village named Tianquan (=Tien-tsuen). Whichever place the lectotype was collected, the type locality is definitely in west-central Sichuan. We define "true type locality" as the actual place where a holotype or lectotype was taken, regardless of whether such can later be determined. An additional label in the handwriting of Oberthür (Horn & Kahle 1935, pl. 5, fig. 14) reads: "*Desgodinsia Watsoni*, Obthr.; Région Sino-thibétaine." The label data, localities, and transfer of this specimen through various collections were all reviewed by Lemaire and Peigler (1982).

The following characters support the hypothesis that this species is the sister-group to all other *Samia*, and has the most plesiomorphic characters. The wing pattern is dark burgundy, and the crescents contain clear portions surrounded by yellow, both revealing a relationship to *Archaeoattacus* and *Epiphora*. The submarginal line of the forewing is much more like that on various African species of *Epiphora* (see Rougeot 1955: col. pl. 4) than on other species of *Samia*. The black marginal spot on the forewing apex represents a "far eye" to complement the larger black eyespot below it which is the "near eye" (Watson 1910a: 30; Fukaya 1994: 109, 170). This marginal spot does not occur in any other *Samia*, but is especially well developed in both *Archaeoattacus* species, and can be seen in *Epiphora antinorii*, with faint indications of it in *Hyalophora*, a few *Rothschildia*, and a few other *Epiphora*, as shown in figures by D'Abrera (1998). The outer margin of the forewing apex in *Samia watsoni* also has yellow and orange coloration not seen in any other *Samia*, but quite visible in *Archaeoattacus edwardsii* and several *Epiphora*. Therefore, we consider *Samia watsoni* to be a montane relic. Our color figures 89-94 show pinned specimens of *Archaeoattacus* and *Epiphora* for comparison.

Genitalia characters are useful in supporting these phylogenetic hypotheses, and for interpreting the taxonomic status of the various populations that we refer to *S. watsoni*. The genitalia of males from Taiwan and various localities in mainland China do not differ significantly. After examination of several preparations, we do not agree with an earlier interpretation (Lemaire & Peigler 1982) that the strongly sclerotized lateral processes of the transtilla should be considered a gnathos. A gnathos does exist in *Hyalophora*, and the saccular lobes of the valves in *S. watsoni* are reminiscent of those in *Callosamia* and *Hyalophora*. The dorsal and median lobes of the valves are fused into a single large lobe, similar to that in *S. canningi*. The aedeagus of *S. watsoni* is the longest in the genus. As might be expected, the male and female genitalia of *S. watsoni* are quite unique among those of all species in the genus, as can be seen in our figures. We do, however, consider that the genitalia structures of *S. watsoni* agree with those in our generic description.

If this species lived in Africa instead of China, we believe that it would be classified in the African genus *Epiphora*. Geography sometimes leads to a strong bias in taxonomic thinking. We expect that larval characters and hostplant preferences will eventually be discovered that are shared by *S. watsoni* and *Epiphora*, but not by other *Samia*. An alternative hypothesis of the phylogeny of *S. watsoni* therefore could even be that all other *Samia* descended from an earlier ancestor that diverged from the clade we now call *Epiphora*, and that *S. watsoni* descended from an *Epiphora*-like ancestor that had a more recent dispersal from Africa to Asia.

Virtually nothing on the larval stages has been published, and cocoons have rarely been collected. Zhu and Wang (1996: 165) cited "sweet potato tree" (*Manihot esculenta*) as a food. If this report is correct, then larvae may have been reared in captivity on this plant, or wild larvae or cocoons may have been found on it. Native to Brazil, that plant is also called tapioca and cassava and is cultivated worldwide in the tropics for its starchy tubers. A female (Fig. 87) described by Watson (1923) emerged from a cocoon collected on Mount Emei by Rev. G. M. Franck, who neglected to record the hostplant, and apparently did not send the empty cocoon to

Watson with the specimen. Eggs and a newly hatched larva were figured by Wang (1994: 87), but the larvae did not accept any of the potential hostplants that he offered (H. Y. Wang, pers. comm. to Peigler, 1999). In the summer of 2001, a few larvae were reared by entomologists in Taiwan from eggs obtained from a female taken in May 2001 by S.-P. Ker at Guan-yuen, Shoulin, Hua-lien Hsien [=Hwalien County], at an altitude of about 2400 meters. The larvae were offered several plants, but refused camphor (*Cinnamomum camphora*) and ailanthus (*Ailanthus altissima*), the latter of which is rare in Taiwan. One larva reached maturity on Chinese sweetgum (*Liquidambar formosana*, Hamamelidaceae) (Shen-Horn Yen, pers. comm. to Naumann October 2001). The half-grown larva showed black markings on the integument and the two rows of dorsal scoli were reddish orange, as is known for some species of *Epiphora* and some other *Samia*. Thus at this writing, we have only a few fragmentary details on the life history of *S. watsoni*.

Flight data are insufficient to determine whether this species is univoltine, bivoltine, or both, i.e., varying with latitude and altitude. Hsiau Yue Wang (pers. comm. 10 Nov. 1999) of the Taiwan Museum sent the following data for the only four specimens he has collected: Tien-chi, Kaoshung County, 2280 m, May 4; Lao-Shao, Hwalien County, 1300 m, April 11; Tzu-en, Hwalien County, 1950 m, May 24. Wang said that the species occurs at higher elevations from 1300 to 2300 meters. The paralectotype of *S. formosana* was collected in August, and other records for Taiwan are from April to July, and we have examined specimens from the mainland of China collected in Guangxi in early April and August or September, and in Jiangxi in August. In January 2002,Yasunori Kishida kindly sent to Naumann color photographs of four specimens in the National Science Museum, Tokyo; the data are Kangding, Sichuan (June 1981); Lishan, Taiwan (July 1972); and Wushe, Nantou County, Taiwan (28 April 1973, leg. S. Okuno). A record for 2 March in Zhejiang we view with skepticism, especially since other specimens were taken in April and June at the same locality and altitude during the same spring (1932). The map of Wolfe (1979, pl. 1) indicates that the habitat at all known localities is notophyllous broad-leaved evergreen forest. *Samia watsoni* is probably sympatric with *S. wangi* in several mountain ranges, as both species are usually found at altitudes between 1000 and 2000 meters, but the latter species also can occur at much lower altitudes, even approaching sea level, that are characterized by a biome called paratropical rainforest.

Geographical variation in *S. watsoni* was noted by Lemaire and Peigler (1982). The Alexander Koenig Museum in Bonn owns short series of males collected in Fujian by Johann Friedrich Klapperich (Gaedike 1995: 35) and in Zhejiang by Hermann Höne (Horn & Kahle 1937: 353), loaned to Peigler in 1977, with approval to keep one specimen in exchange for other Lepidoptera. Specimens from Fujian (Fig. 88) are darker purplish, and have a different wing shape than those from the adjacent province of Zhejiang. Specimens from both populations differ visibly from specimens from Sichuan. A male (Fig. 86) recently obtained from Guangdong (in the Yao Shan, near the border with Hunan) has quite large, inflated, pyriform fenestrae in the hindwings, and one other from the same lot had the same features. However, specimens from Guangxi to the south have fenestrae that agree with ones from Fujian, Zhejiang, and Sichuan. Such variation should be expected in populations, which, although sometimes not very far apart, are isolated on mountains, as if on "islands separated by a sea of lowlands." If subspecies were to be accepted, the nominotypical one would be from Sichuan, and the name *formosana* is available for the populations on Taiwan and in Guangdong. Peigler (1989: 114) synonymized *S. formosana* under *S. watsoni*. The patchy distribution seen today attests to a much wider range in the past, during some cooler period of the Pleistocene. When cold climate recedes to the north, populations are left stranded on mountains; such a pattern is seen in numerous species of plants and animals in Europe, Asia, and North America, leaving them with ranges that are a mixture of higher altitudes at lower latitudes and/or lower altitudes at higher latitudes. The European saturniid *Graellsia isabellae* is another example (Ylla 1997).

Although *S. watsoni* generally occurs at higher elevations than most other species of *Samia*, the altitudes at which it has been collected (1300 to 2400 meters) are appropriately termed as moderate or moderately high, instead of high. In the Himalayas, *Archaeoattacus edwardsii* prefers comparable altitudes, recorded from 350 to 2500 meters (Allen 1993: 54), but in the Greater Sunda Islands one finds *Archaeoattacus staudingeri* at only 300 to 1525 meters above sea level. However, the attacine *Rothschildia renatae* Lampe has been collected at 4600 meters in the Peruvian Andes (Lemaire & Minet 1999: 340), and *Copaxa medea* (Maassen) occurs from 2500 to 4000 meters in that same area (Lemaire 1978: 199). Within the Hemileucinae, *Leucanella stuarti* (Rothschild & Jordan) has been taken at 3650 m, *Cerodirphia cutteri* (Schaus) up to 3250 meters, and some *Erythromeris* between 2900 and 3900 meters (Lemaire 2002: 591, 654, 783). Among the Ceratocampinae, some *Bathyphlebia* are recorded up to 3200 meters (Lemaire 1988: 75). All of the aforementioned Andean species can rightly be described as high altitude moths. True high altitude saturniids in the Himalayas include *Neoris codyi* (Peigler) known from 4000 meters, *Caligula lindia* (Moore) from 3700 and possibly up to 5000 meters (but normally 2300 to 3200 meters), *Salassa royi* Elwes up to 3500 meters, and *Caligula grotei* (Moore) from 3000 meters (Allen 1993). It is tempting to speculate that the darker ground color of *S. watsoni* may be caused by the need to absorb

more solar heat at higher altitudes where temperatures are lower. Other higher altitude Lepidoptera, especially butterflies of the Satyrinae and also the saturniid *Archaeoattacus edwardsii*, have dark phenotypes. Dark ground color in *S. watsoni* may be plesiomorphic for the genus *Samia*, with selection pressure to maintain it at higher altitudes.

A century ago most authors treated the species now placed in *Hyalophora* under the generic name *Samia*, but the name *watsoni* that Tutt (1901) proposed for a hybrid *Hyalophora* (*H. cecropia* ♂ × *H. euryalus* ♀) is not a primary homonym of *S. watsoni* Oberthür, 1914, since Tutt used the generic name *Platysamia*, and generally names proposed for hybrids are not valid under the International Code of Zoological Nomenclature (1999, Article 1.3.3).

This beautiful and highly interesting saturniid remains relatively uncommon in collections, and Chinese field collectors and dealers are currently selling specimens at very high prices, primarily to Japanese and European collectors. A fine specimen is shown on the back cover of this book. We hope that someone will succeed in rearing this species in the near future, and publish a thorough account of the life history, replete with color photographs of the mature larva and cocoon.

**Material Examined. CHINA**: Zhejiang Province: 1♂ 10 April 1932, West Tien-Mu Shan, 1600 m, 20654, H. Höne, *ex* coll. R. Mell (ZMHB); 1♀ West Tien-Mu Shan, 1600 m, 2 March 1932, Steyler-Mission (Witt); 2♂ same data, 23 April & 11 June 1932, leg. H. Höne, genitalia no. ZFMK 95 = 3245 Lemaire (ZFMK); 1♂ same data (MNHN); 1♂ same data, 21 July 1932, no. 856 coll. H. Eckerlein (MHNG); 1♂ same data, no. 857 *ex* coll. H. Eckerlein, coll. Terral (MHNL); 1♂ Ost Tien-Mu Shan, 1300 m, 8 May 1931, leg. H. Höne (ZFMK); 1♂ same data, 7 May 1931, *ex* coll. Frank Johnson (AMNH). Fujian Province: 6♂♂ Kuatun [=Kuatan], 2300 m, 27˚40'N/117˚40'E, 28 May and 1 June 1938, leg. J. Klapperich; genitalia no. 420 & 421/99 Naumann (ZFMK); 1♂ same data, 21 May 1938, Steyler-Mission, leg. Aussem (Witt); 1♂ same data, 28 May 1938; genitalia no. 3246 Lemaire (Peigler); 1♂ Yongan, Baiyian Shan, 1500 m, July 1997, leg. Li; genitalia no. 209/97 Naumann (Naumann). Guangxi Province: 1♂ Dayiao Shan [Dayiao Mts.], Jinxiu, Aug.-Sept. 1997, leg. Fang; genitalia no. 208/97 Naumann (Naumann); 1♂ 1♀ Daiao Shan, Jinxiu, 1800 m, June 2002, leg. Li (Löffler). Jiangxi Province: 3♂ eastern Jiangxi, Wuyi Shan, Yangjialing, 1500 m, Aug. 2000, leg. Yin (Naumann); 2♂ Yangjialing, Licuan, 1500 m, 27˚50'N/115˚40'E, Aug. 2000 (Brechlin). Sichuan Province: 1♂ (lectotype) Siao-lou /Region Sino-thibétaine/*Desgodinsia Watsoni*, Obthr./Levick Bequest 1941 (BMNH); 1♀ Emei Shan [Mount Omei], summer 1921, *ex* cocoon emerged 30 April 1922 at Chengdu, G. M. Franck (BMNH); 1♀, Pehliuting, 6000 ft. [1830 m], 1931/ B.M. 1933-569 (BMNH). Shaanxi Province: 1♂1♀ Daba Shan, Shou-Man village, 32˚08'N/108˚37'E, 1800 m, 25 May-14 June 2000, leg. Sinjaev & Plutenko (Naumann); 1♂ same data (SMFL); 7♂ same data (Brechlin). Guangdong Province: 1♂ Mount Shikengkong, 1600 m, near Ruyuan, end of March 2002, leg. Li (Naumann); 2♂ Yunwu Shan, environs of Zaoqing, 1350 m, July 2002, leg. Dong (Löffler). **Taiwan**: 1♂ Taipei County, Wulai, 11 June 1968, leg. Tomokuni, *ex* coll. Y. Arita; genitalia no. 442/99 Naumann (Naumann); 1♂ Taipei County, Mount Rara, 5 July 1975, genitalia no. 219/97 Naumann =1180/97 Nässig (SMFL); 1♂ Hualin County, 10 km northeast of Tienchih, 24˚04'N/ 121˚20'E, 2100 m, 23 May 1995, leg. Hreblay & Steger (Witt); 1♂ Nantou County, 5 km west of Tayüling, 24˚09'N/121˚17'E, 2900 m, 21 May 1995, leg. Hreblay & Steger (Witt); 1♂ Nantou County, Tungpu, Yu-Shan National Park, 1400 m, 24-25 June 1997, leg. Fabian & Kovács (Naumann); 3♂, Taitung County, 5 km northwest of Lirao, 23˚13'N/120˚59'E, 1760 m, 28 May 1995, leg. Hreblay & Steger (Witt); Taiwan, 1♂ without further data, received by Peigler in 1999 from Hsiau Yue Wang (LACM); 1♂ (lectotype of *Samia formosana*) Horisha, Aug. 1924 (SEHU); 1♂ (paralectotype of *Samia formosana*) "Wamea," Aug. 1924, Horisha, 500, *ex* coll. Ch. Oberthür (MHNL).

This concludes our detailed treatments of each of the 19 taxa that we consider to be species of *Samia*. We have opted to not construct a taxonomic key, in the belief that such keys are rarely used, especially in revisionary works in which colored illustrations are provided. Identifications of specimens by users of this revision can be first attempted using locality data and the color illustrations, then verified using the diagnoses given under each species, and finally (although rarely necessary) with genitalia dissections.

# HYBRIDS OF SAMIA

There are no known cases of natural hybridization for the genus *Samia*. Cross matings are prevented by the fact that most of the species are allopatric. Where species occur in close proximity, such as *S. watsoni* and *S. wangi* in China, the former flies at higher elevations (and sometimes at different seasons), so populations are in effect allopatric. In the cases where two species are sympatric, such as *S. vandenberghi* and *S. peigleri* in parts of Sulawesi, or *S. abrerai* and *S. insularis* in eastern Java, effective isolating mechanisms are obviously in force.

Hybridization studies offer a tantalizing new way to work with insects. The idea that one can make a cross and thus produce individuals that do not look or behave exactly like either parental species is highly appealing, all the more so if such a cross has never before been reared. A few of the earlier writers, such as Tutt (1902, 1906) and Watson (1910a, 1911, 1912, 1913) were certainly intrigued by hybrids of *Samia*, and even applied names to some of the crosses, as will be pointed out below. Hawkes (1916, 1918, 1922), Sweadner (1937), Collins and Weast (1961), Weast (1989), Collins (1997), and others approached the topic from a more scientific viewpoint, demonstrating that hybridization programmes can yield valuable data on genetics and phylogeny.

A detailed summary and analysis of hybridization in Lepidoptera was presented by Tutt (1906: Chapter 1), although he knew nothing of Mendelian genetics at that time. Standfuss (1896) and Sweadner (1937) also devoted much attention to hybridization studies in Lepidoptera. Tutt (1902) cataloged and discussed all known hybrids within the Saturniidae, at least those reports that had been published by European and American workers. James Tutt (1858-1911) produced valuable and exhaustive writings; for example, he covered the taxonomy, ecology, morphology, and distribution of the single species *Saturnia pavonia* in 36 pages of fine print. Unfortunately, his extensive work is insufficiently appreciated by today's lepidopterists.

**Intergeneric Crosses**

As far as we know, the only other genus with which *Samia* has been hybridized is *Callosamia*, a genus that consists of three species found in eastern North America. There are, however, several known instances in which *Samia* females have attracted males belonging to other genera, and also cases where adults of *Samia* have mated with those of other genera, but none of these apparently resulted in adult hybrids. Peigler (1989: 110, 147) summarized most of the intergeneric crosses that have been reported within the tribe Attacini and that resulted in eclosion of larvae, to which can be added *Callosamia promethea* × *Hyalophora gloveri*. This latter cross, made by Caroline Soule in June 1901, resulted in larvae but no adults. The sexes of the parental species were not cited (Packard 1914: 267). Vuattoux (1992) reported on a hybridization of *Hyalophora columbia* × *Attacus atlas* and figured the adult larva and a hatched male specimen; the same worker also sent photos to Naumann of a male hybrid of *Attacus atlas* × *Coscinocera hercules* with elongated hindwings, and a mating of a *Samia cynthia* male with an *Archaeoattacus edwardsii* female. Another hybridization which resulted in fertile eggs but no larvae reaching maturity was made in France by André (1908: 49, 79), who crossed males of *Epiphora bauhiniae* with females of *Samia ricini*. The specimen of *Hyalophora* described (using the generic name *Samia*) in detail by Kirby (1883) may have been a wild hybrid between *H. cecropia* and another species such as *S. cynthia, Callosamia angulifera*, or *C. promethea*.

Pilate (1883) observed that a male *Hyalophora cecropia* was attracted to and mated with a female *S. cynthia* in Dayton, Ohio. The female laid some eggs, but only four hatched. He offered them *Tilia* and ailanthus leaves, but they died "after nibbling for a while." Soule (1902) also had females of *S. cynthia* to mate with males of *H. cecropia* and *C. promethea*, but none of the resulting eggs yielded larvae. A few years later she achieved two matings of *C. promethea* ♂ × *S. cynthia* ♀, but no eggs hatched; the males had been attracted to a female of *C. promethea* near the females of *S. cynthia* (Soule 1907). Alfred Wailly also obtained several pairings of *H. cecropia* ♂ × *S. cynthia* ♀ (Tutt 1902: 291). In Connecticut, Hessel (1955) also had a wild male of *H. cecropia* arrive and mate with a captive female of *S. cynthia*, but the resulting eggs failed to hatch. Rau and Rau (1929: 113-114) observed males of *H. cecropia* coming to captive females of *S. cynthia* in St. Louis, Missouri, a city in which the latter did not occur in the wild at that time. These males would come close to the cages, but not alight upon them, fluttered about the cages for several minutes, and then departed. Those observations of the Raus suggest to us that the primary pheromone for the two species is the same or close, but that one or more secondary pheromones deter close contact. Peigler observed the same behavior with saturniids in central Colorado, working with *Hemileuca nuttalli* (Strecker) and *H. eglanterina* (Boisduval), in which males of the former species would approach briefly a female of the latter, but then depart rapidly after coming within a meter or two.

Collins and Weast (1961: 116) achieved several matings between males of *H. cecropia* and females of *S. cynthia*, most of which were the result of wild males being attracted to tied females. In eight cases the nearest females of *H. cecropia* which were emitting pheromone were more than 7 meters away. The larger genitalia of

*H. cecropia* caused the females of *S. cynthia* to be ruptured, and all but two females died before ovipositing. Ova from one female yielded 36 larvae that were raised to maturity on ailanthus but then lost. These were stated to be "typically *cynthia* in appearance." Collins and Weast also reported the following matings in their rearing cages: *Hyalophora euryalus* ♂ × *Samia cynthia* ♀; *Hyalophora gloveri* ♂ × *Samia cynthia* ♀; *Samia cynthia* ♂ × *Epiphora atbarina* ♀. Additionally, Weast (1998) reported several matings in cages of the cross *Eupackardia calleta* ♂ × *Samia cynthia* ♀. Apparently no eggs from these latter four crosses hatched. The matings between males of *E. calleta* and females of *S. cynthia* occurred at night (R. Weast, pers. comm. to Peigler, 21 October 2001), although the mating behavior of *E. calleta* is diurnal.

Peigler obtained a natural mating of a male of *H. cecropia* and a female of *S. cynthia* on 2 June 1994 at Tinytown, 2085 meters, Jefferson County, Colorado. Three females of *Hyalophora gloveri* and one female of *S. cynthia* were tied in low branches of a tree the evening before, all within one meter of each other. The following morning, the three *H. gloveri* females were all mating with males of *H. gloveri*, but the female of *S. cynthia* was mating with a male of *H. cecropia*. This was surprising because *H. cecropia* was not expected to occur at such a high altitude, although it is common 470 meters below in the suburbs of Denver. The female of *S. cynthia* laid many eggs, but none hatched. Weast (1998) reported further cases of males of *H. cecropia* being attracted to and mating with females of *S. cynthia*.

There has been misinterpretation pertaining to specimens that were assumed to be hybrids but look identical to the female parent in the larval and imaginal characters. Ferguson (1972: pl. 16, fig. 7) pictured one such specimen. The early workers including Caroline Soule and Louis Joutel would achieve a hybrid mating, but then the female would refuse to oviposit, behaving as if still unmated. Those lepidopterists would then remate the female to a male of her own species to induce oviposition. They did not understand the mechanics of mating and fertilization in insects, in which a spermatophore from the male is transferred to the spermatheca of the female abdomen during mating, and then a second spermatophore from the second male is transferred, so that the rule "last one in, first one out" applies. Their comments that "hybrid eggs" resembled those of the female parent also showed a lack of understanding of basic entomology, since almost all eggs are fully formed when a female emerges (in insects that are pro-ovigenic), and each egg is fertilized singly as it passes the spermathecal duct in the oviduct. Mendelian genetics was also not widely known at that time. Many of these purebred specimens were assumed to be hybrids and are labeled as such in museum collections. Incidentally, Louis Joutel of New York City was an illustrator who painted many of the color plates depicting larval instars of Saturniidae in some monographs by Packard (1905, 1914), and executed the very nice pen and ink drawings in the little-known booklet by William Beutenmüller (1898).

Across the Atlantic, the same story was reported by Watson (1912). Joutel sent some cocoons of what he believed to be hybrids between *C. promethea* and *S. cynthia* to Watson, but the resulting moths looked like pure *S. cynthia*, and Watson correctly speculated that the female had mated with males of both species. Hybrids reputed to be of the same cross but appearing like *S. cynthia*, with no characteristics of *C. promethea*, were also reared by Franz Ebner according to a report by a Dr. Kunz in Landeck, Austria, but Ebner speculated incorrectly that mating with *C. promethea* caused the eggs of *S. cynthia* to develop by parthenogenesis (Watson 1913).

True hybrids between *Samia* and *Callosamia* are remarkable and intermediate in the appearance of the larvae and adults. As far as we know, no females have been obtained from these crosses. Many lepidopterists obtain these cross matings in cages, but the eggs rarely hatch. Peigler examined some of the hybrids between *Callosamia* and *Samia* in the American Museum of Natural History, National Museum of Natural History, and the Field Museum of Natural History. In the latter institution the following specimens were noted from the Herman Strecker collection: A hybrid male in good condition labeled "*promethea* × *cynthia*; Brooklyn, N. Y., bred by Smith; Received from J. Doll Dec. 1895." It looks more like a hybrid between *C. promethea* and *C. angulifera*. It could have been the basis for a communication in 1900 by Strecker stating that *S. cynthia* and *C. promethea* will cross in nature, quoted by Packard (1914: 266) and Draudt (1929), but Peigler (1978) expressed skepticism that Strecker's claims were true. A second hybrid male with no antennae resembles the hybrids between *C. angulifera* and *S. cynthia* (see below), but is labeled "*promethea* × *cynthia*; Brooklyn, N. Y. 1881." This specimen has brilliant orange and rose coloration reminiscent of *S. canningi*. Weast (1989, pl. 3) also gave a color photograph of a male hybrid of *S. cynthia* ♂ × *C. promethea* ♀. Two of his specimens are now in the Natural History Museum of Los Angeles County. Ferguson (1972: pl. 16, fig. 6) illustrated a male of the same cross in color, reared about a century ago, now preserved in the National Museum of Natural History in Washington. Some of the hybrid specimens in the American Museum of Natural History are labeled "bred specimen; Bronx, New York, coll. E. Gerstenkorn."

In 1975 a female of *Samia cynthia* from New Haven, Connecticut, was crossed with a male of *Callosamia angulifera* from Clemson, South Carolina, by Peigler, but some of the larvae died from disease and some adults did not emerge because of prolonged diapause (Peigler 1978). The larvae were reared on tuliptree and had

slender orange dorsal scoli (Figs. 127-130), resembling larvae of *S. fulva, S. luzonica*, etc., but lacking black spots on the integument. The cocoons were dark brown in color, like those of the male parent. Four males were obtained, two of which were figured by Lemaire (1978) and Peigler (1978). Deposition of specimens was one in the Lemaire collection, one in the Natural History Museum of Los Angeles County, and two in the Denver Museum of Nature & Science. Immatures in alcohol and the cocoons are also in the latter collection. This hybrid has not previously been figured in color (Fig. 96). Six eggs also eclosed in spring 1976 from a cross of *C. securifera* ♂ × *S. cynthia* ♀, but the larvae were weak and died within a few hours (Peigler 1978). Peigler (1981) also reared numerous intrageneric hybrid crosses within *Callosamia*, and the majority of the resulting pinned specimens were deposited in the Denver Museum of Nature & Science, with representative specimens placed in other collections (see *News of the Lepidopterists' Society*, January/February 1991, page 3).

**Crosses within the Genus**

In Chapter 9 (Hybridism) of his famous classic, *The Origin of Species*, Charles Darwin (1859) referred to a report that hybrids between *S. cynthia* and *S. ricini* (which he called *Bombyx arrindia*) were fertile for several generations, but that report we suspect to be erroneous. Some earlier authors refused to consider crosses in *Samia* to be true hybrids, constrained by the concept that all taxa belong under a single species. Many crosses within *Samia* have indeed been reared to the adult stage, and described and named accordingly. J. H. Watson named the majority of these, following the precedent of earlier writers who named hybrids of butterflies, Sphingidae, and *Saturnia*. We give below a list of the names proposed for these crosses, and what the parental species were. Most were cataloged or at least listed by Watson (1912, 1913), Packard (1914: 267), Rebel (1925b: 159), Seitz (1928: 504), Schüßler (1933: 40-41; 1934: 561-564), Crotch (1957: 130), and Gardiner (1982: 213). We have seen the specimens in The Natural History Museum, London, that Watson considered to be the types of the crosses that he named. As indicated in our Introduction, these names have no standing in formal taxonomy, and type specimens for such names are not valid, but we treat them below as part of the literary history of the genus and for anyone seeking the identity of a name found on the label of a specimen.

1. *vesta* Walker: *ricini* ♂ × *cynthia* ♀; the female from Chinese stock. These specimens look more like the male parent. The name *Attacus vesta* was apparently first published by Walker (1865: 525), and later by Moore (1882: 316, footnote) as *Saturnia Vesta*, followed by other authors including Cotes and Swinhoe (1887: 225) and Kirby (1892b: 267). Rebel (1925a: 4) listed this hybrid as *Philosamia cynthia* ab. *vesta*. Moore stated that the name was already being used in France. A male was shown in color by Watson (1911, pl. 3). Hybrids between *S. ricini* and *S. cynthia* were already being reared in the late 1850s in France (Guérin-Méneville 1862b). Naumann examined a pair of this hybrid cross reared by J. H. Watson in Manchester, England, in the Nationaal Natuurhistorisch Museum, Leiden, The Netherlands.

In the summer of 1994 in Colorado, Peigler reared a brood of this cross indoors on ailanthus, and the resulting moths were large and beautiful, probably examples of heterosis. The parental stock was from the Philippines and the United States. Specimens are in the collections of Naumann, Peigler, and the Natural History Museum of Los Angeles County. Cocoons were beige to brick red and large, but not as puffy as those of pure *S. ricini*, and had well developed peduncles. A pair of the same cross reared in the 1970s was given to Peigler by Claude Lemaire. That female is quite large, with a forewing length of 79 mm.

2. *russelli* Watson: *ricini* ♂ × *cynthia* ♀; the female from USA stock. These hybrids look more like the female parent. A female was shown in color by Watson (1911, pl. 3). This cross and its reciprocal were also reared and reported earlier by Watson (1910a).

3. *wallacei* Tutt: *cynthia* ♂ × *ricini* ♀; the reciprocal cross of *vesta* and *russelli*. Schüßler (1933: 41) cited a paper by Tutt (1901) as the original description for this hybrid, but no *Samia* are included in that listing of hybrids by Tutt. However, Tutt is the one who named this hybrid (see Tutt 1906: 38), apparently in honor of Alexander Wallace who carried out some projects to establish *S. cynthia* in England (Wallace 1866, 1867).

In the spring of 1994, Peigler reared a brood of this hybrid from eggs sent by Robert Mayo. The stock was stated to be from Paris and the Philippines, respectively. The adults were well formed but undersized, because ailanthus had not yet leafed out in Colorado. They were reared on spring foliage of choke cherry (*Prunus virginiana*) and potted seedlings of castor. Adults were deposited in the Natural History Museum of Los Angeles County.

4. *lastoursi* Watson: *cynthia* ♂ × *canningi* ♀; the male from USA stock. Watson (1913: 46) named this cross after his "good friend Mons. Le Baron de Lastours, of Varades, who has taken up the breeding of the exotic Saturnidae [*sic*] so enthusiastically." Adults of this cross were darker than those from the reciprocal cross below, and more closely resembled the female parent. The larvae were reared on lilac (*Syringa vulgaris*) in 1913.

5. *xanthoxylon* Watson: aberration of *cynthia* ♂ × *canningi* ♀. This was reared by Ernst André in 1908 and specimens were sent to Watson, one of which was a golden colored aberration and had a label on the pin with this

name suggested by André. Watson (1912: 48) published the name as "ab. *xanthoxylon*." It had strong pink markings on the wings but no white tufts on the abdomen.

6. *andrei* Watson: *canningi* ♂ × *cynthia* ♀; named for Ernst André, this name was proposed by Watson (1913: 45). In 1974, Peigler received two specimens and one live cocoon of this cross from Sandra Russell, who had made the cross using stock from Worldwide Butterflies Ltd. (England) and New York City, where she lived. These three specimens show some of the orange coloration of the male parent, and are intermediate between the two species. They were deposited in the Natural History Museum of Los Angeles County.

7. *oberthuri* Watson: *pryeri* ♂ × *cynthia* ♀; the female from USA stock. Named for Charles Oberthür. Watson (1913: fig. 3) gave a figure of a male. The adults lacked the brownish color of *S. pryeri*, but the crescents were more like those of *S. pryeri*. The larvae were reared on lilac in 1913.

8. *rothschildi* Watson: *ricini* ♂ × *pryeri* ♀; named for Walter Rothschild. Watson (1913: fig. 2) gave a figure of a female. Three adults emerged in the fall of 1913, but the remainder overwintered (Watson 1913: 48). The sepia colored adults were distinctive, heavily marked with white, not resembling either parental species. They were reared in 1913 on *Ligustrum*.

9. *pryadvena* Watson: *cynthia* ♂ × *pryeri* ♀; the male from USA stock, as the name implies. Watson (1912: 48) reared only four to the pupal stage, and reported that the one female that had emerged thus far was fertile, containing eggs, but no male was available in September to mate with it.

10. *balli* Watson: (*ricini* ♂ × *cynthia* ♀)♂ × *ricini* ♀; this is a backcross. It was named in honor of "Mr. John Ball, of Henbury, the veteran Saturnidist" (Watson 1912: 48).

11. *lefroyi* Watson: (*cynthia* ♂ × *ricini* ♀)♂ × *pryeri* ♀; a hybrid combining three different species, named in honor of H. Maxwell-Lefroy, who was an expert on sericulture and Indian entomology, stationed at Pusa, India. Watson (1912: 48) obtained only one male and three females of this cross.

Robert Vuattoux of France has reared the following hybrids of *Samia*, and sent a few specimens to both of us. *Samia cynthia* ♂ × *S. luzonica* ♀: these are quite intermediate between the parental species. The genitalia are more similar to *S. cynthia*, with the typical form of the valves. At least one male specimen, which is now in the collection of the Muséum d'Histoire naturelle de Lyon, France, bears double apical spots in the forewings. Specimens were bred in August and September 1997. *Samia ricini* ♂ × *S. tetrica* ♀: resulting male specimens show more or less the color and pattern of the male parent part, including the typical white abdomen, but have the typical fairly elongated forewing of *S. tetrica*. No females were seen.

Other intrageneric crosses of *Samia* were made in England in the early 1950s by W. J. B. Crotch, first described in two brief papers by him (Crotch 1953, 1954) and again in his handbook (Crotch 1956). Crotch obtained his stocks from Mr. M. Harrison-Gray, who made the preliminary crossings. Most of these crosses were not true hybrids, for they were made using various color forms of *S. canningi* and *S. ricini*, which biologically are all the same species. The colors range from cinnamon orange, to pinkish brown, to dark sooty gray. Crotch developed a form that had darkened postmedian instead of median areas, and named it *reversa*. When he was able to develop homozygosity for this trait in *S. ricini* (which he called *Philosamia obscura*), he called this the "*obversa* race." A further cross between *S. cynthia* from the United States (which he called *Philosamia advena*) and the *reversa* produced what he called the "*adversa* race." This latter was a true hybrid. Backcrossing *obversa* to *S. canningi*, he produced a race that he named the "*obscans* race." The supposed hybrids discussed and illustrated by Chowdhury (1962: figs. 3-4; 1982: 55-56, fig. 21) between *S. ricini* and *S. cynthia* are also not true hybrids, because the taxon that he called *S. cynthia* is actually *S. canningi.*

Hybridization data have been used to study inheritance of characters in *Samia*. Hawkes (1916, 1918, 1922) made many observations in her studies of hybrids between *S. ricini* from Assam and *S. cynthia* from Ningbo, Zhejiang. Her first study dealt with the coloration of cocoons, white vs. reddish; moisture makes the beige or grey cocoons become redder. She published a detailed study on the spots of the integument and size and structure of the scoli on caterpillars of *Samia* (Hawkes 1918). Onera A. Merritt Hawkes also carried out novel and extensive experiments on the size, color, and shape of wing scales, discussing her results in terms of Mendelian genetics (Hawkes 1922). Saito (1994a) examined pupal dormancy in this genus, by crossing non-diapausing and diapausing stocks. See our earlier remarks under the topic of diapause (p. 50).

# HOSTPLANT APPENDIX

Records of plants known to be used by each species of *Samia* are given in the discussions under the respective species, and common names of the plants are given there also, as well as the original literature or sources for each record. Literature is cited below for those records of simply "*Samia* sp." In the lists below, plants used in captivity are separated from those used in nature. The latter are selected by ovipositing females, but several are not native to the areas where the moths occur. For example, *Samia luzonica* uses avocado (*Persea americana*) in the Philippines, but the tree is native to tropical America. Since *Samia ricini* exists only in cultivation, its known hostplants are all cited in Part 2.

## Part 1: Plants Recorded in Nature

Anacardiaceae - Cashew Family
*Cotinus coggygria* Scopoli - *Samia cynthia*

Apocynaceae - Dogbane Family
*Thevetia* sp. - *Samia luzonica*

Aquifoliaceae - Holly Family
*Ilex asprella* (Hook. & Arn.) Champ ex Benth. - *Samia wangi*
*Ilex chinensis* Sims. - *Samia* sp. (Zhu & Wang 1983)
*Ilex rotunda* Thunb. - *Samia pryeri*

Araliaceae - Ginseng Family
*Heteropanax fragrans* (Roxb.) Seem - *Samia fulva*

Berberidaceae
*Berberis asiatica* Roxb. - *Samia canningi*

Bignoniaceae - Trumpet-creeper Family
*Paulownia tomentosa* (Thunb.) Steud. - *Samia pryeri*

Caprifoliaceae - Honeysuckle Family
*Sambucus* sp. - *Samia cynthia*
*Viburnum lentago* Linn. - *Samia cynthia*

Coriariaceae - Coriaria Family
*Coriaria nepalensis* Wallich - *Samia canningi*

Euphorbiaceae - Spurge Family
*Glochidion hongkongense* Muell.-Arg. - *Samia wangi*
*Manihot esculenta* Crantz (= *Manihot utilissima*) - *Samia watsoni*
*Triadica cochinchinensis* Lour. (= *Sapium discolor*) - *Samia wangi*
*Triadica sebifera* Small (= *Sapium sebiferum*) - *Samia wangi*
*Triadica* (*Sapium*) sp. - *Samia pryeri*

Fabaceae (Papilionaceae)
*Erythrina subrumbrans* - *Samia insularis*

Lauraceae - Laurel Family
*Cinnamomum camphora* Nees & Eberm. - *Samia cynthia, S. pryeri, S. wangi, S. kohlli*
*Lindera benzoin* (Linn.) Blume - *Samia cynthia*
*Lindera megaphylla* Hemsley - *Samia wangi*
*Persea americana* Miller - *Samia canningi* (Fig. 141), *S. luzonica*, *S. abrerai*
*Sassafras albidum* (Nuttall) Nees - *Samia cynthia*

Lythraceae - Loosestrife Family
*Lawsonia inermis* Linn. - *Samia* sp. (Arora & Gupta 1979)

Magnoliaceae - Magnolia Family
*Liriodendron tulipifera* Linn. - *Samia cynthia*
*Michelia alba* DC. (a cultivated hybrid between *M. champaca* and *M. montana*) - *Samia wangi*
*Michelia figo* (Lour.) Spreng. (= *M. fuscata*) - *Samia wangi*
Note: Recent botanical classifications place the above two plants in a highly expanded generic concept: Genus *Magnolia*, Subgenus *Yulania*, Section *Michelia*.

Myrtaceae - Myrtle Family
*Syzygium aqueum* (Burm. f.) Alst. (= *Eugenia aquea*) - *Samia insularis*

Oleaceae - Olive Family
*Ligustrum japonicum* Thunb. - *Samia pryeri*
*Osmanthus fragrans* Lour. - *Samia pryeri*

Rhamnaceae - Buckthorn Family
*Rhamnus formosana* Matsum. - *Samia wangi*

Rubiaceae - Madder Family
*Cinchona succirubra* Pav. ex Klotzsch - *Samia insularis*

Rutaceae - Rue Family
*Evodia* (= *Euodia*) *fraxinifolia* (Don.) Hook. (=*Tetradium trichotonum*) - *Samia canningi*
*Phellodendron amurense* Ruprecht - *Samia pryeri*
*Toddalia asiatica* (Linn.) Lam. - *Samia yayukae*
*Zanthoxylum acanthopodium* DC. - *Samia canningi*
*Zanthoxylum ailanthoides* Sieb. & Zucc. - *Samia pryeri*
*Zanthoxylum alatum* Roxb. (= *Xanthoxylon hostile*) - *Samia canningi*
*Zanthoxylum armatum* DC. - *Samia yayukae*
*Zanthoxylum avicennae* (Lamarck) DC. - *Samia cynthia*
*Zanthoxylum japonicum* (possibly a synonym of *Z. ailanthoides*) - *Samia cynthia*
*Zanthoxylum piperitum* DC. - *Samia wangi*
*Zanthoxylum rhetsa* (Roxb.) DC. (= *Z. limonella*) - *Samia fulva*

Sapindaceae - Soapberry Family
*Sapindus mukorossii* Gaertn. - *Samia wangi*

Simaroubaceae - Quassia Family
*Ailanthus altissima* (Miller) Swingle (= *A. glandulosa*) (Figs. 138-139) - *Samia cynthia*, *S. pryeri*, *S. wangi*
*Ailanthus excelsa* Roxb. - *Samia canningi*
*Picrasma javanica* Blume - *Samia fulva*
*Picrasma* sp. - *Samia pryeri*

Sterculiaceae - Chocolate Family
*Firmiana platanifolia* (Linn. f.) Schott & Endl. (= *F. simplex*) - *Samia pryeri*, *S. wangi*

Staphyleaceae - Bladdernut Family
*Euscaphis japonica* (Thunb.) Kanitz - *Samia wangi*

Styracaceae - Snowbell Family
*Styrax japonica* Sieb. & Zucc. - *Samia pryeri*

Theaceae - Tea Family
*Thea sinensis* Linn. - *Samia insularis*

Ulmaceae - Elm Family
*Celtis sinensis* Pers. - *Samia pryeri*

Verbenaceae - Verbena Family
*Clerodendrum* (= *Clerodendron*) *trichotonum* - *Samia pryeri*
*Lantana* sp. - *Samia wangi*

## Part 2: Plants Recorded to be Used in Captivity

Apocynaceae - Dogbane Family
*Plumeria rubra acutifolia* (Poir.) Tourn. (= *P. acuminata*) - *Samia ricini*

Araliaceae - Ginseng Family
*Heteropanax fragrans* (Roxb.) Seem - *Samia ricini*

Berberidaceae - Barberry Family
*Berberis vulgaris* Linn. - *Samia* sp. (Voelschow 1904: 69, 72)

Caricaceae - Papaya Family
*Carica papaya* Linn. - *Samia ricini*

Combretaceae - Combretum Family
*Terminalia catappa* Linn. - *Samia ricini*

Cucurbitaceae - Gourd Family
*Hodgsonia heteroclita* H. F. & Thoms. - *Samia ricini* [erroneous record]

Euphorbiaceae - Spurge Family
*Jatropha curcas* Linn. - *Samia ricini*
*Jatropha multifida* Linn. - *Samia ricini*
*Manihot esculenta* Crantz (= *Manihot utilissima*) - *Samia ricini*
*Ricinus communis* Linn. (Fig. 140) - *Samia ricini*
*Sapium eugeniifolium* Buch.-Ham. - *Samia ricini*

Fabaceae - Legume Family
*Erythrina indica* Linn. - *Samia insularis*

Hamamelidaceae - Witch-hazel Family
*Liquidambar formosana* Hance - *Samia watsoni*

Lauraceae - Laurel Family
*Cinnamomum camphora* Nees & Eberm. - *Samia luzonica*
*Cinnamomum cecidodaphne* Meissn. - *Samia ricini*
*Sassafras albidum* (Nuttall) Nees - *Samia cynthia*

Lythraceae - Loosestrife Family
*Lagerstroemia indica* Linn. - *Samia canningi*

Moraceae - Mulberry Family
*Ficus religiosa* Linn. - *Samia ricini*

Myrtaceae - Myrtle Family
*Psidium guajava* Linn. - *Samia yayukae*

Oleaceae - Olive Family
*Fraxinus velutina* Torrey - *Samia cynthia*, *S. ricini*

*Ligustrum japonicum* Thunberg - *Samia vandenberghi*
*Ligustrum lucidum* Aiton f. - *Samia cynthia*
*Ligustrum ovalifolium* Hasskarl. - *Samia abrerai, S. cynthia, S. vandenberghi, S. kohlli, S. yayukae*
*Ligustrum vulgare* Linn. - *Samia cynthia*
*Ligustrum* sp. - *Samia cynthia, S. tetrica*
*Syringa vulgaris* Linn. - *Samia cynthia, S. yayukae*

Rhamnaceae - Buckthorn Family
*Ziziphus jujuba* (Linn.) Miller - *Samia ricini*

Rosaceae - Rose Family
*Prunus serotina* Ehrh. - *Samia cynthia*
*Prunus spinosa* Linn. - *Samia cynthia*
*Prunus virginiana* Linn. - *Samia ricini*

Rutaceae - Rue Family
*Evodia* (= *Euodia*) *fraxinifolia* (Don.) Hook. (=*Tetradium trichotonum*) - *Samia ricini*
*Phellodendron amurense* Ruprecht - *Samia cynthia*
*Phellodendron chinense* Schneid. - *Samia cynthia*
*Zanthoxylum alatum* Roxb.- *Samia ricini*
*Zanthoxylum simulans* Hance - *Samia cynthia*

Simaroubaceae - Quassia Family
*Ailanthus altissima* (Miller) Swingle (= *A. glandulosa*) - *Samia canningi, S. cynthia*, *S. insularis, S. kohlli, S. luzonica, S. pryeri, S. ricini, S. tetrica*, *S. wangi*, *S. yayukae*
*Ailanthus excelsa* Roxb. - *Samia ricini*
*Ailanthus grandis* Prain - *Samia cynthia*, *S. ricini*

Tiliaceae - Linden Family
*Tilia cordata* Miller (= *T. parvifolia*) - *Samia canningi, S. pryeri*

Verbenaceae - Verbena Family
*Gmelina arborea* Roxb. - *Samia ricini*

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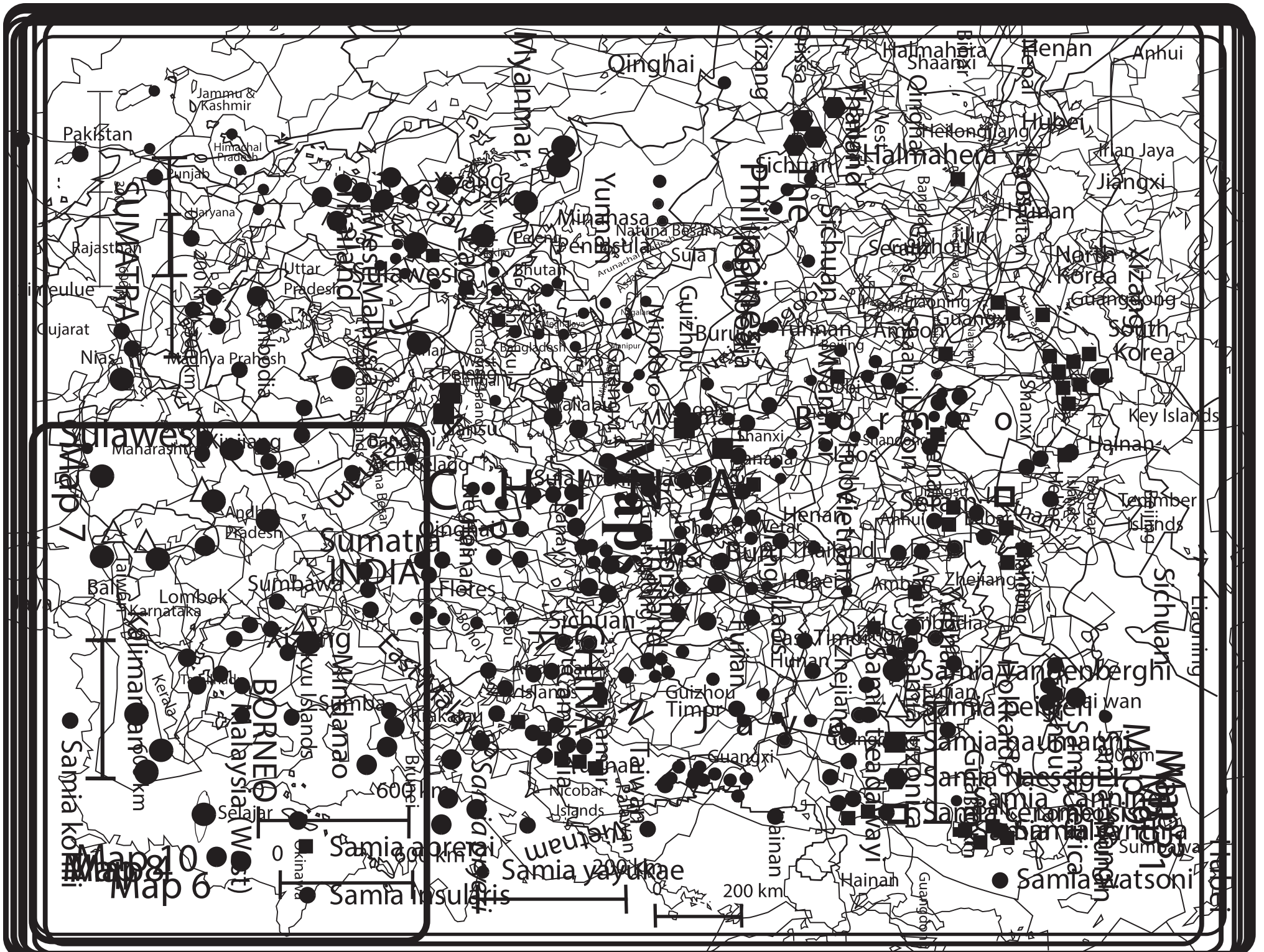
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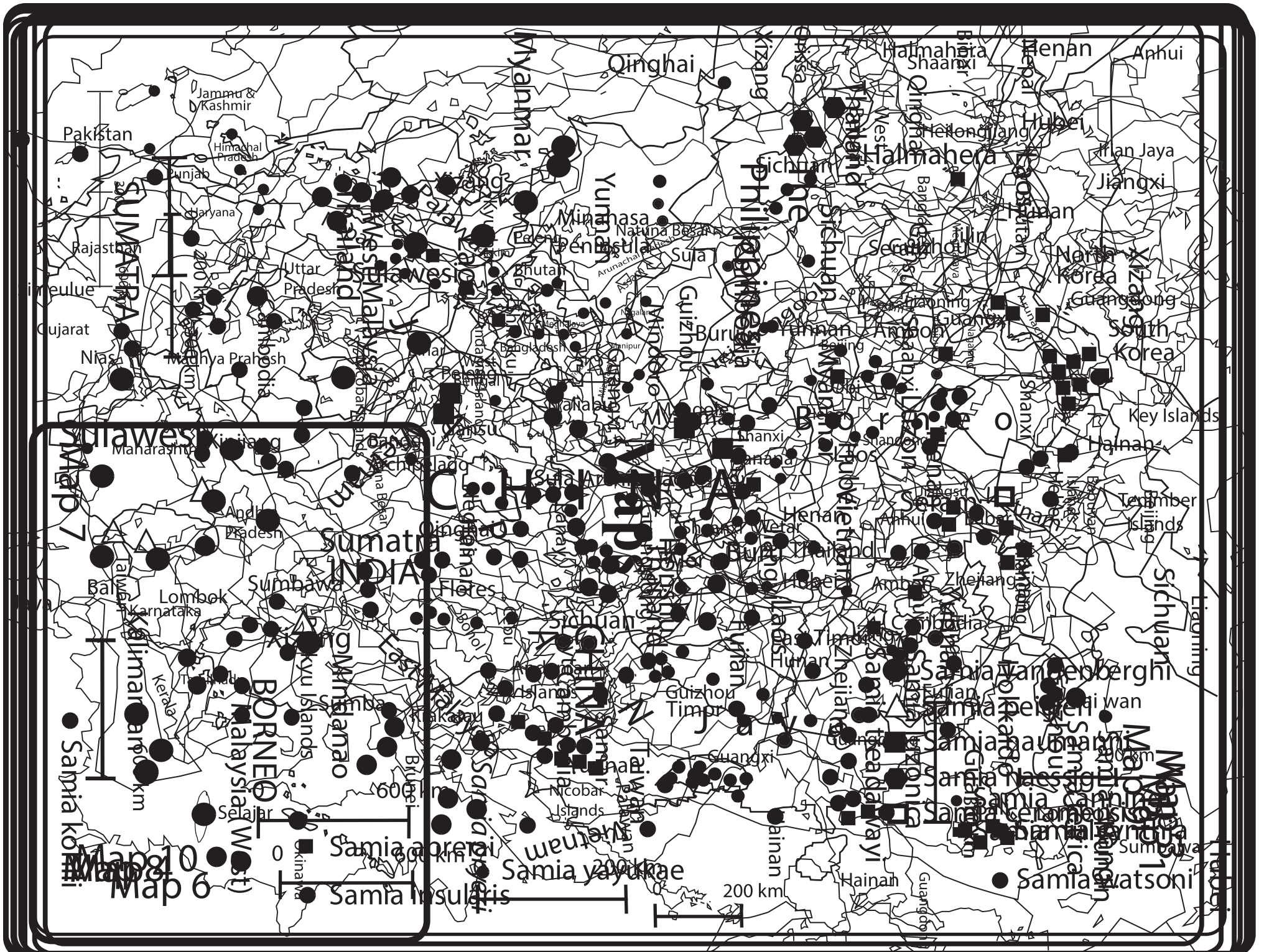
Valid names for species of *Samia* are given in boldface type. Homonyms, junior synonyms, and names for hybrids, forms, and aberrations of *Samia* are given in italics. Page numbers for the main treatments of the 19 species of *Samia* are cited in boldface type. Misspellings and emendations are not given here, but can all be found in the synonymies of the respective species. Only a few economically or biologically important hostplants are included.

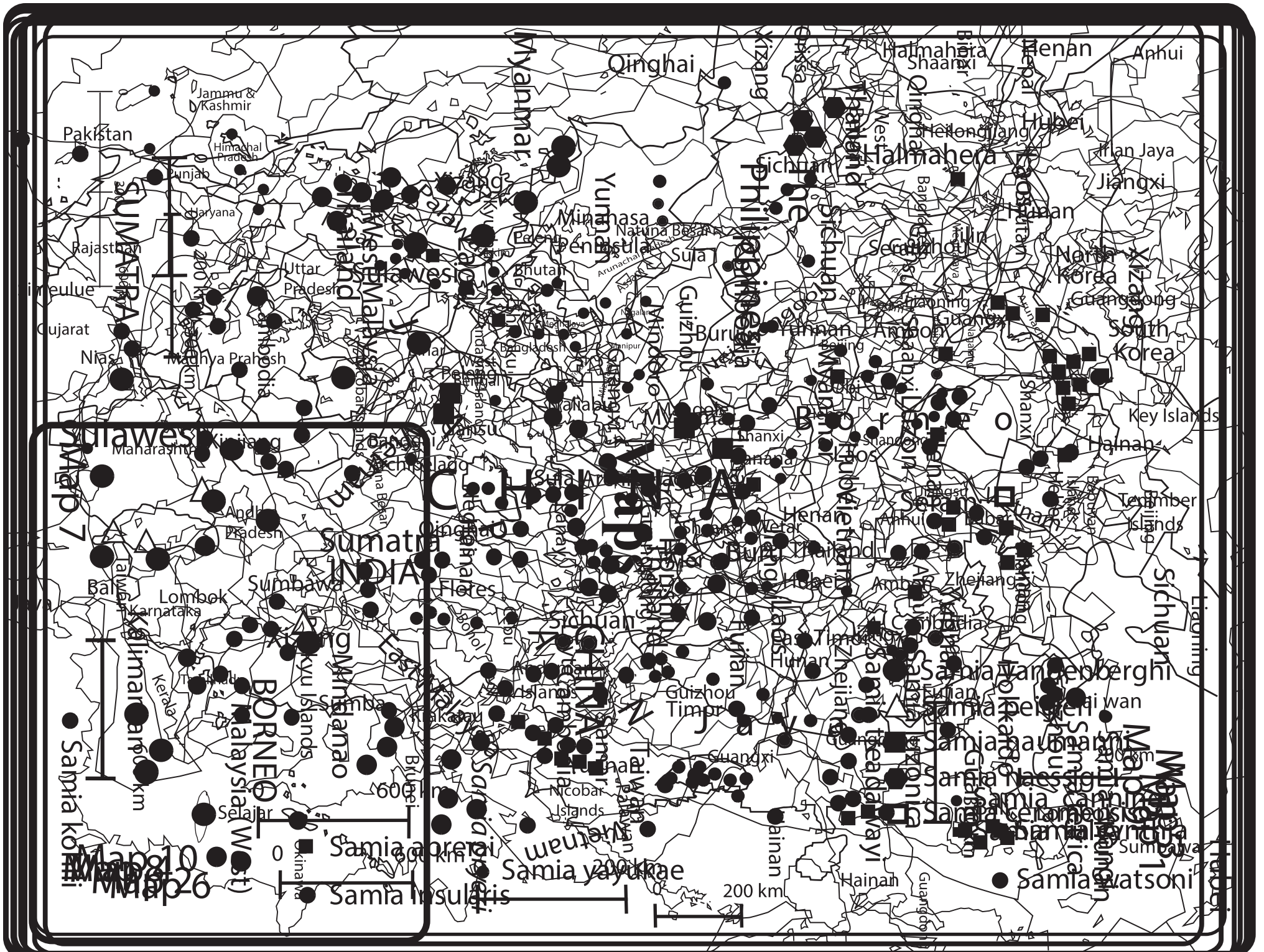

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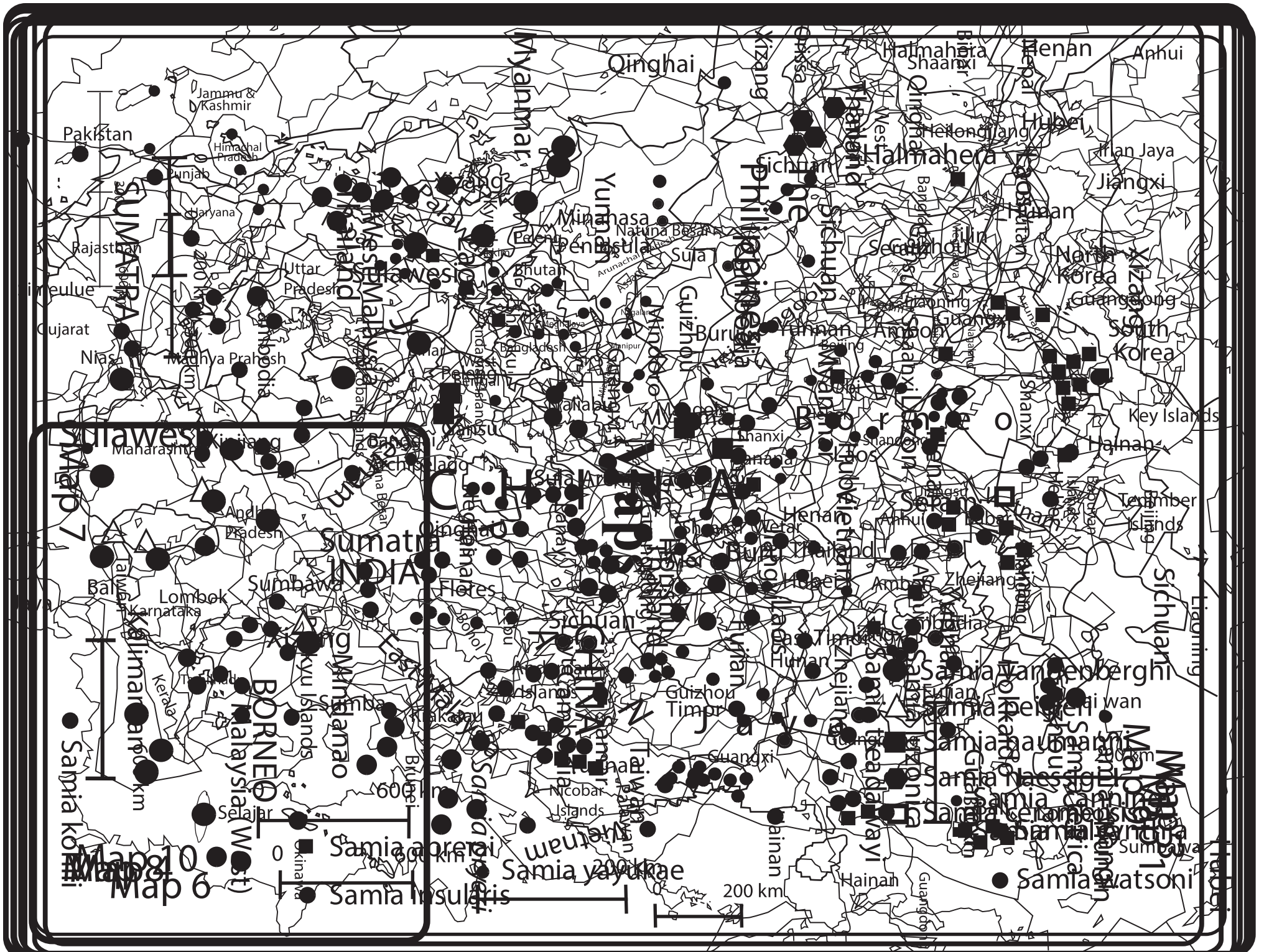
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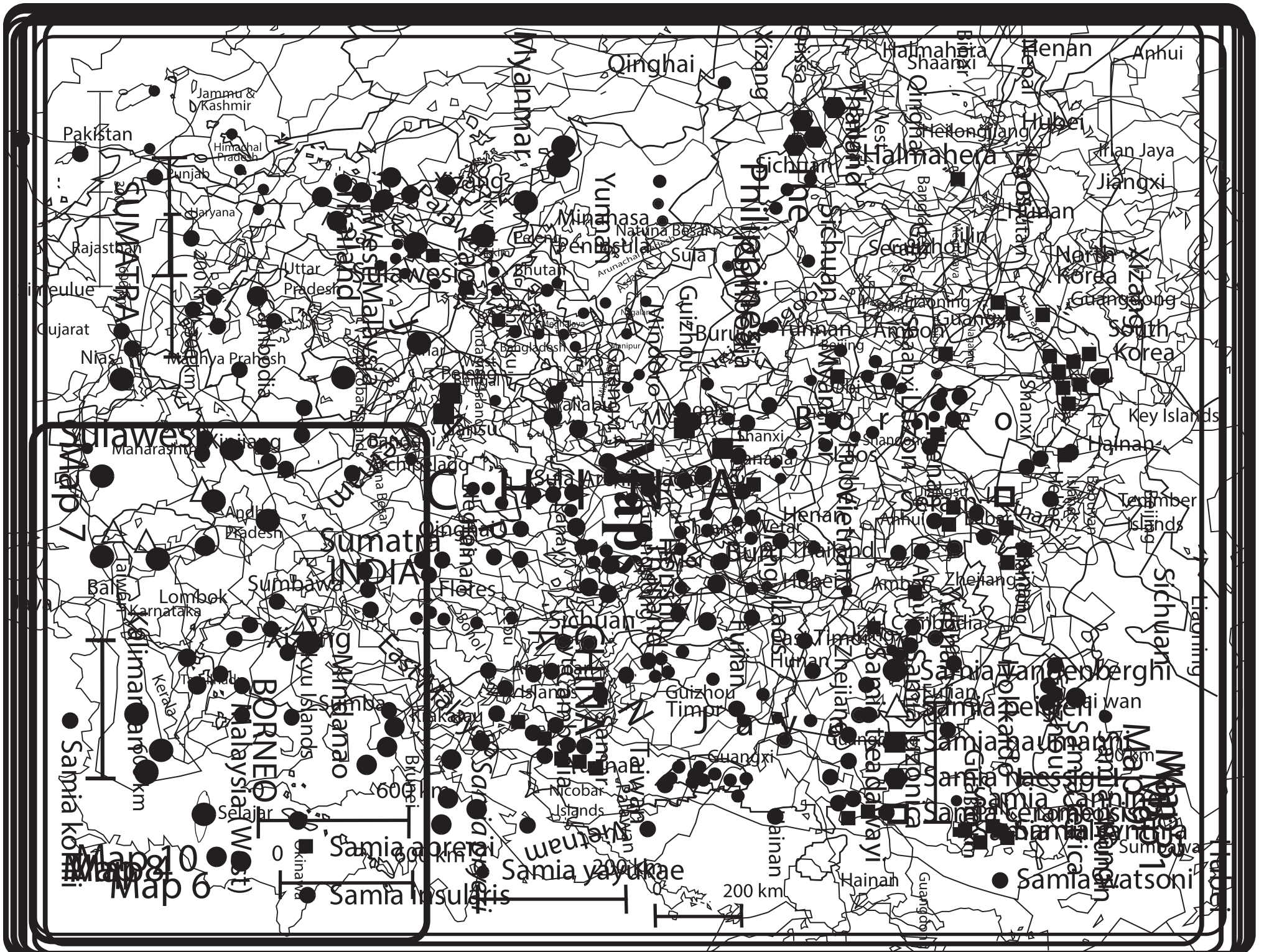
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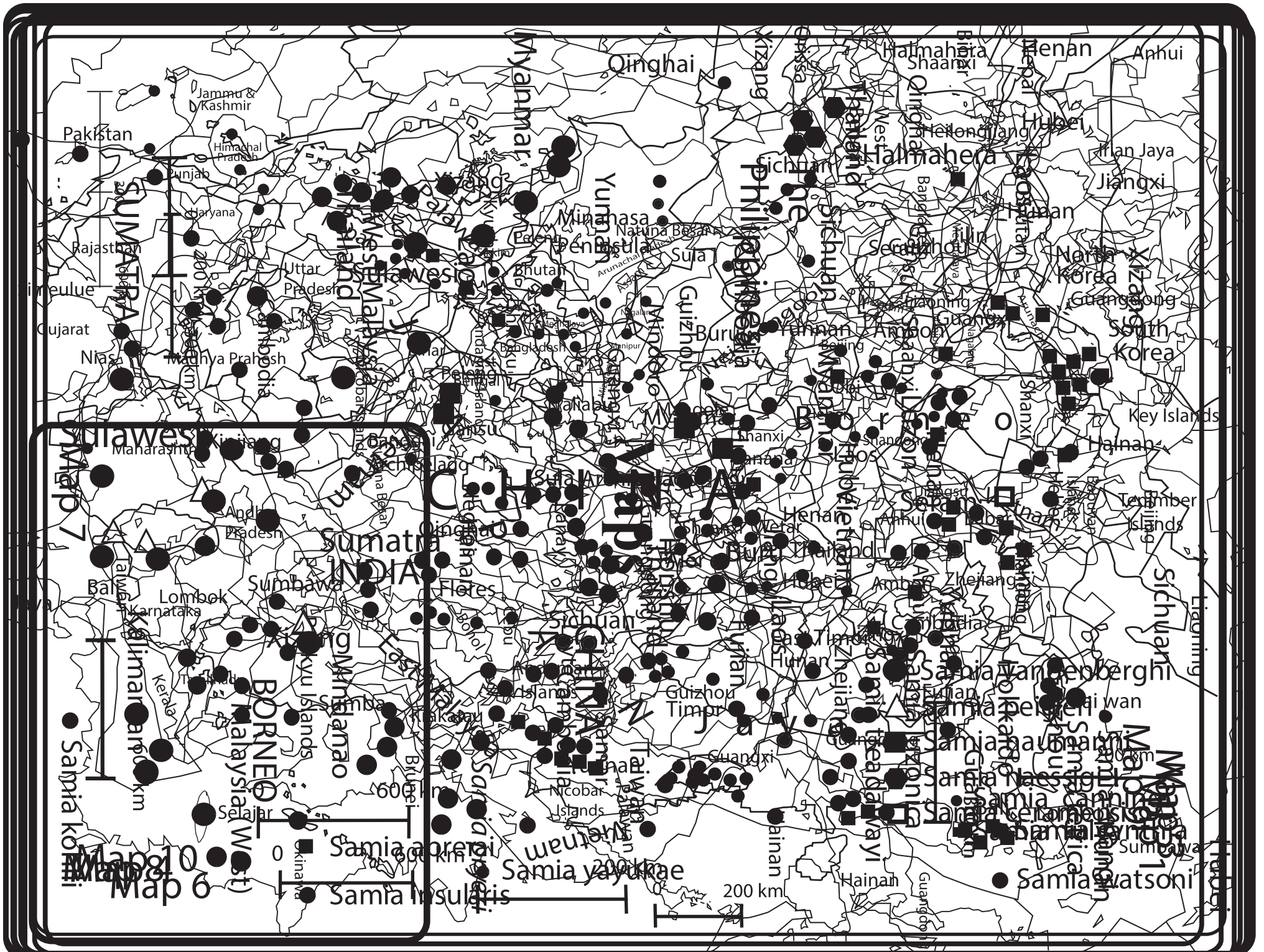

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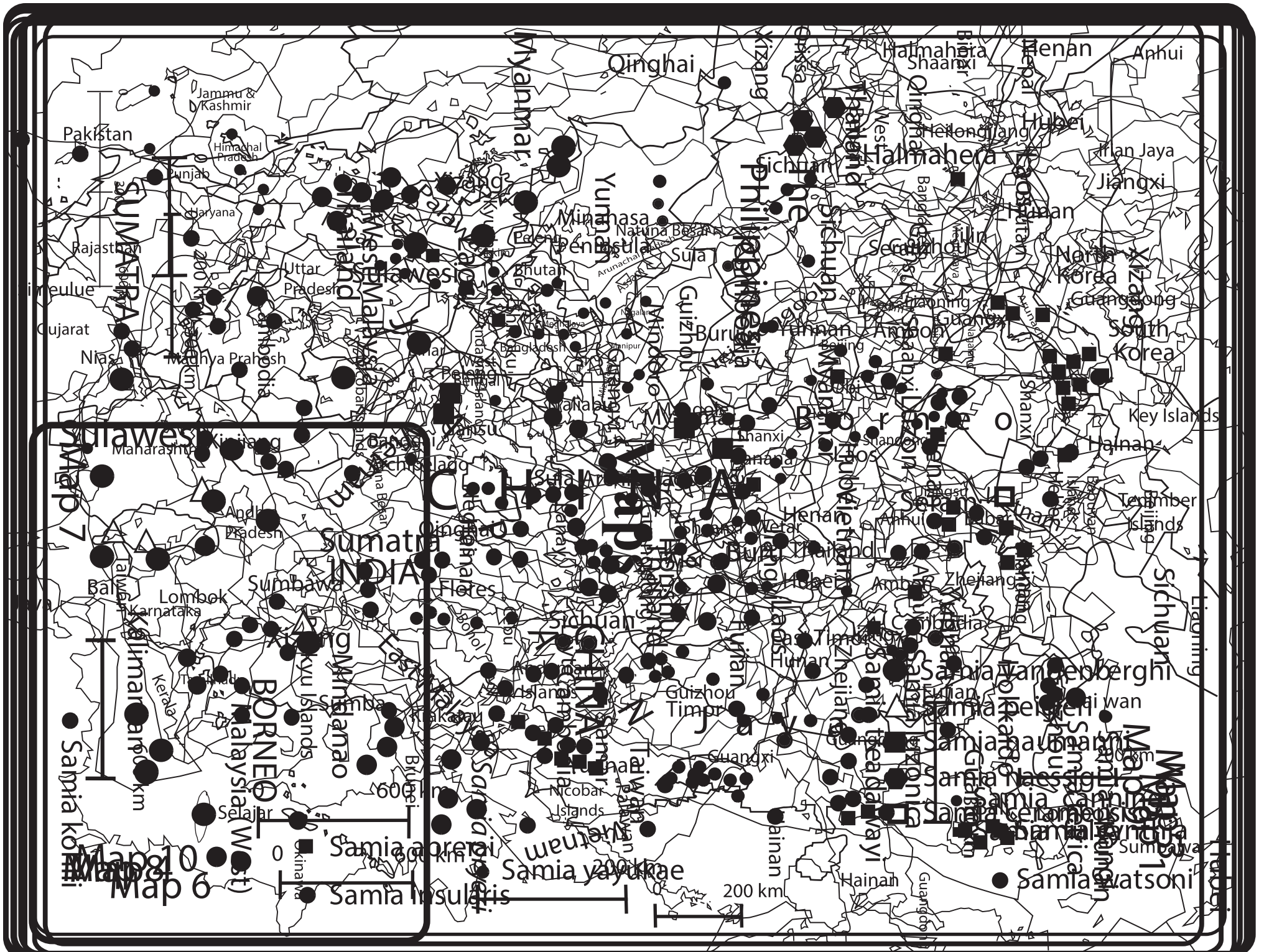

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Samia kerea
Samia kerea
Samia kerea

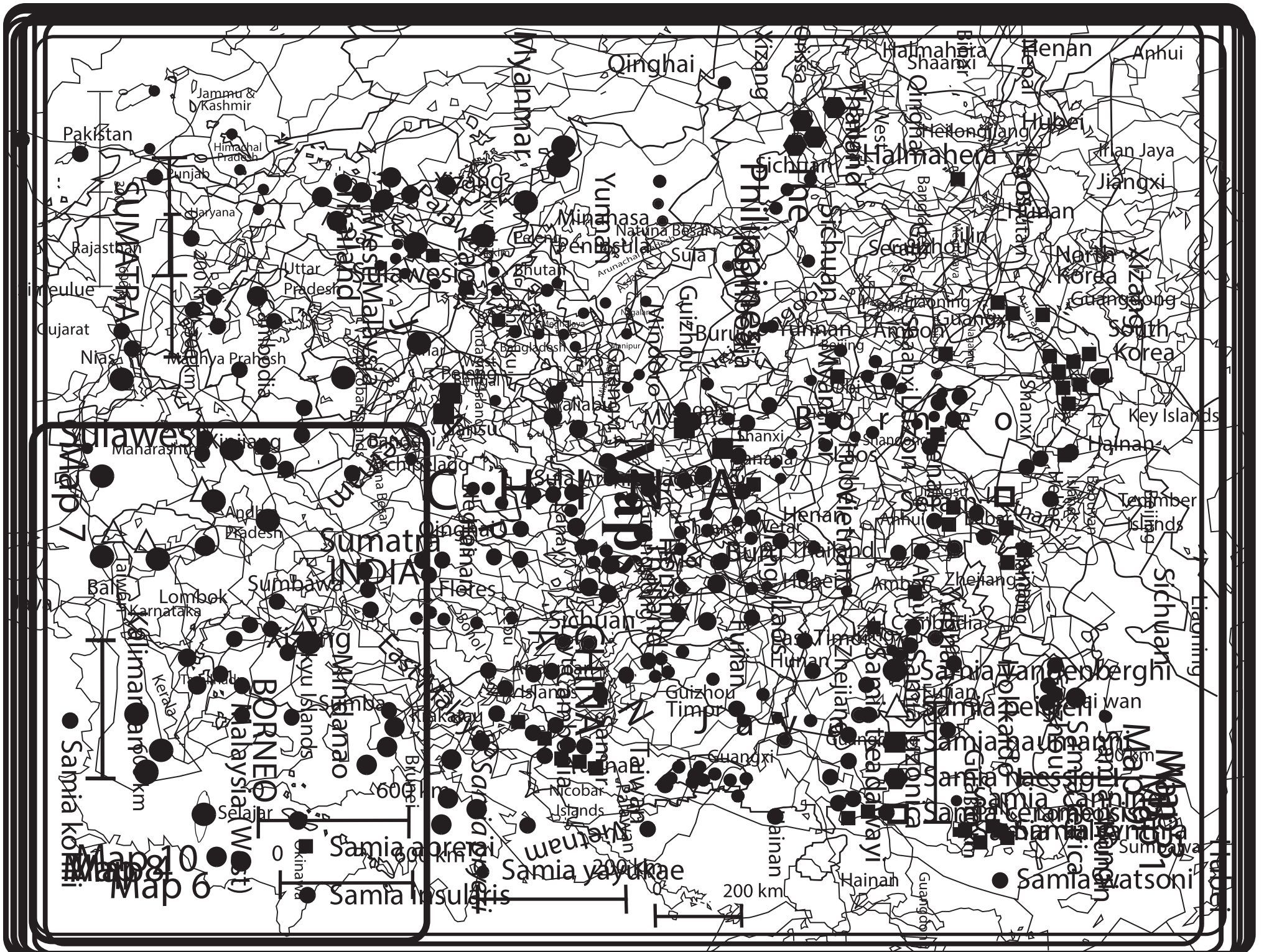

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Map 20
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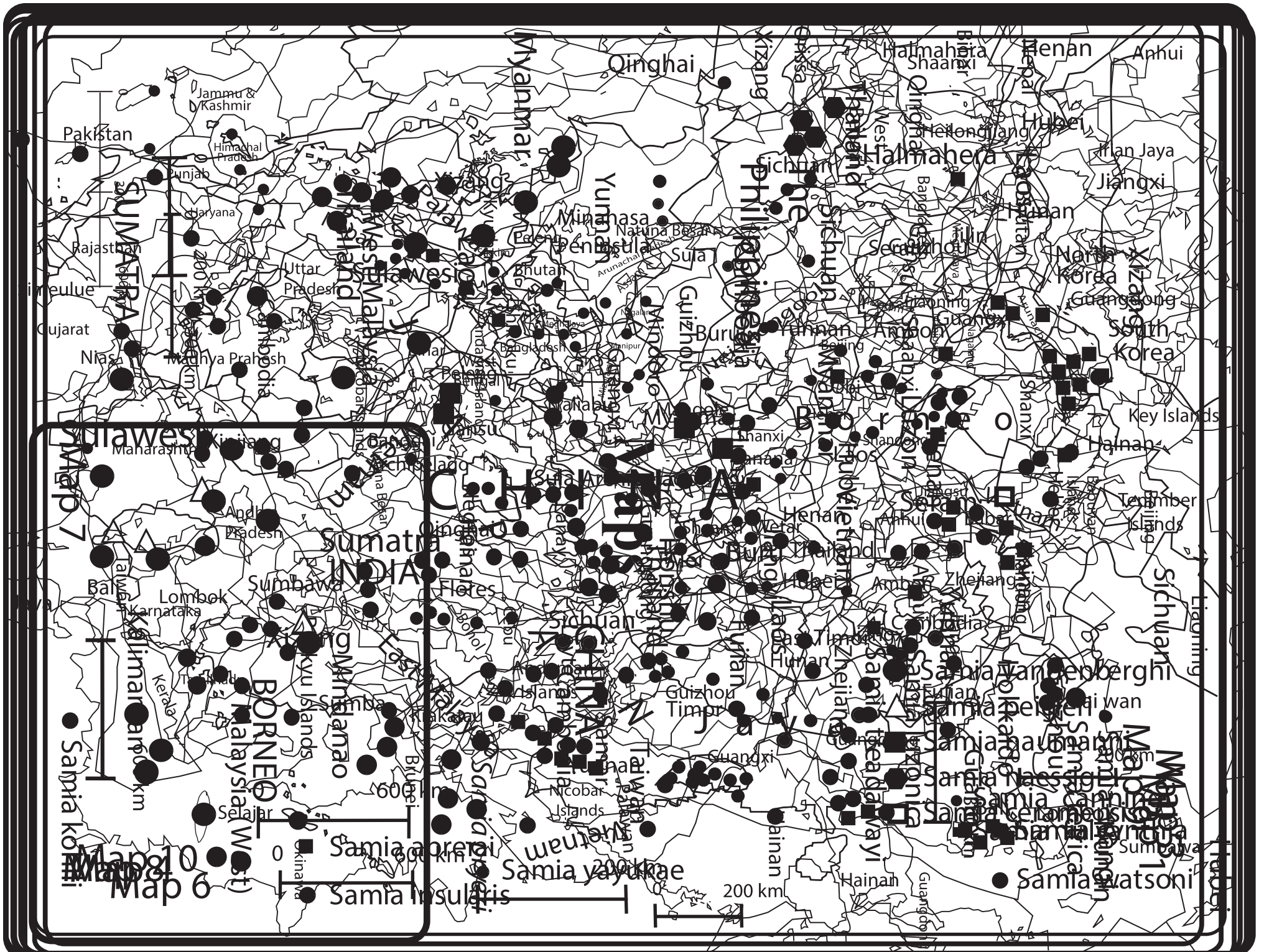

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Samia insularis
Samia yayukae
Samia aprerai
Samia watsoni
Samia yamamotoi
Samia yanbenberghi
Samia peigleri
Samia naumanni
Samia kolimarana
Samia kotoi
Samia cynthia
Samia ricini
Samia canningi
Samia walkeri
Samia wangi
Samia cynthia
Samia ricini
Samia canningi
Samia walkeri
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Samia kotoi
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Samia aprerai
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CHINA
Myanmar
Philippines
Malaysia (W.)
Malaysia (E.)
Indonesia
Thailand
Vietnam
Laos
Cambodia
Taiwan
Japan
North Korea
South Korea
Pakistan
Nepal
Bhutan
Bangladesh
Qinghai
Sichuan
Yunnan
Guizhou
Guangxi
Guangdong
Hainan
Henan
Hubei
Hunan
Jiangxi
Anhui
Shaanxi
Shanxi
Gansu
Ningxia
Shandong
Jilin
Heilongjiang
Liaoning
Inner Mongolia
Xinjiang
Tibet
Halmahera
Seram
Sula
Buru
Flores
Sumbawa
Lombok
Bali
Timor
Nias
Mentawai Islands
Key Islands
Tenimber Islands
Andaman Islands
Nicobar Islands
Jammu & Kashmir
Himachal Pradesh
Punjab
Haryana
Rajasthan
Uttar Pradesh
Madhya Pradesh
Gujarat
Maharashtra
Andhra Pradesh
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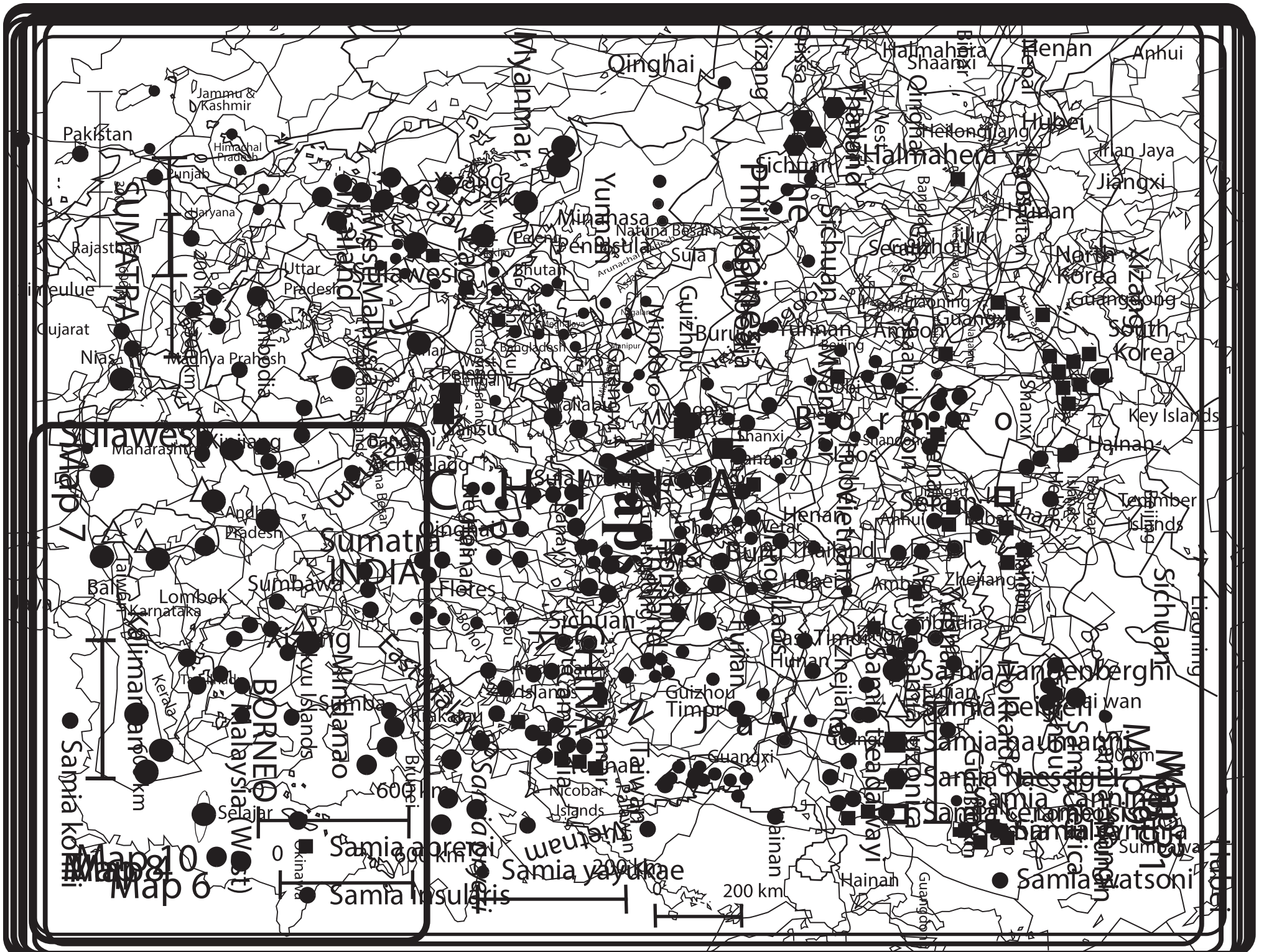

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Samia cannineae
Samia kotoi
Samia kolimani
Samia kerea
Samia kerea
Samia kerea

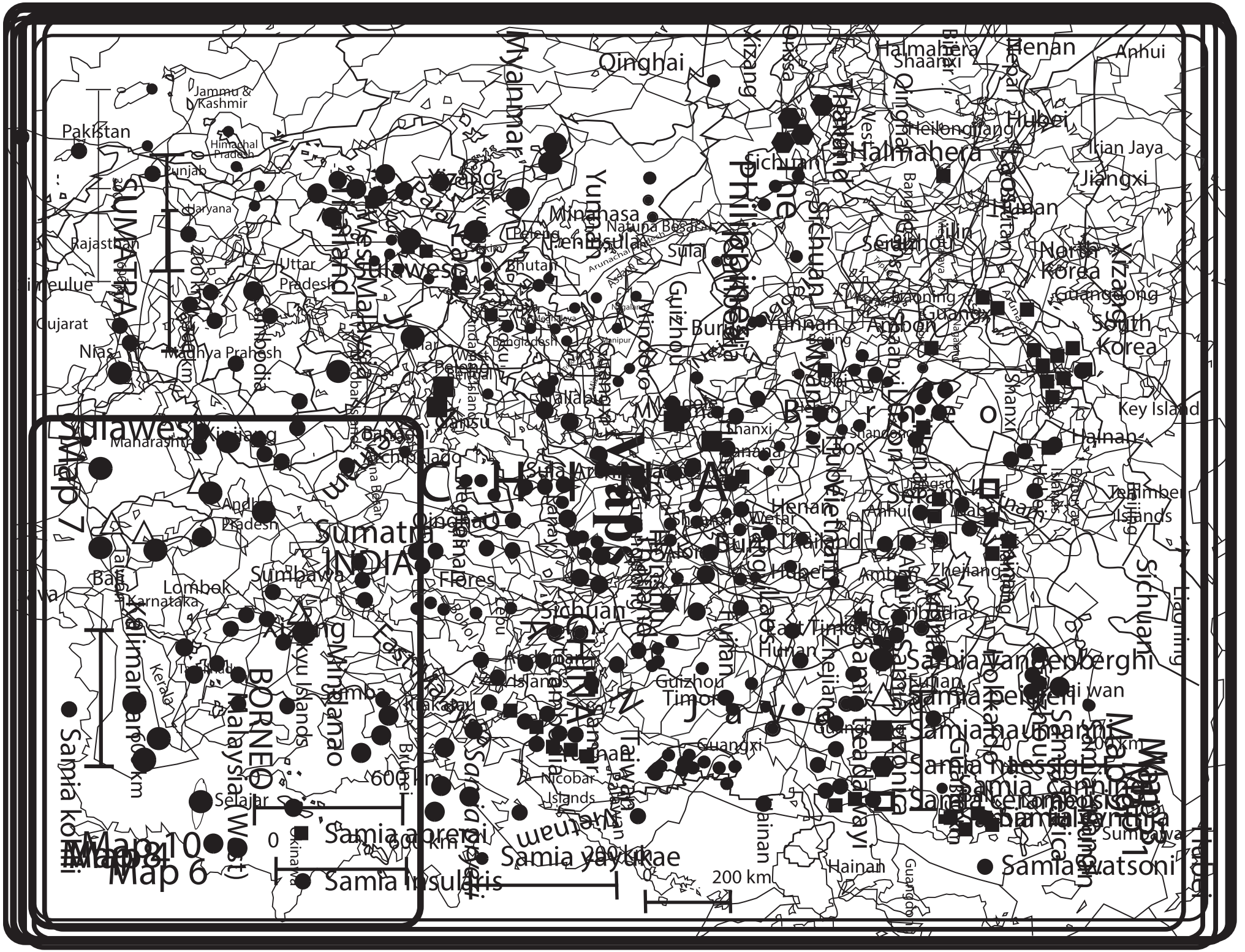

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Samia yanbenberghi
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Sulawesi
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Malaysia (W.)
Samia arrerai
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Samia yayukae
Samia watsoni
Samia yanbenberghi
Samia peigleri
Samia naumanni
Samia kolbi
Samia cynthia
Samia ricini
Samia cynthia ricini
Samia cynthia pryeri
Samia canningi
Samia walkeri
Samia wangi
Samia cynthia walkeri
Samia cynthia wangi
Samia cynthia canningi
Samia cynthia watsoni
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Samia jamamadi
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Samia subsp.
Samia cynthia
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Philosamia ricini
Philosamia cynthia ricini
Philosamia cynthia pryeri
Philosamia canningi
Philosamia walkeri
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Guizhou
Guangxi
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Hubei
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Fujian
Zhejiang
Jiangsu
Liaoning
Jilin
Heilongjiang
Inner Mongolia
Ningxia
Gansu
Xinjiang
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Uttar Pradesh
Madhya Pradesh
Rajasthan
Gujarat
Maharashtra
Andhra Pradesh
Karnataka
Kerala
Himachal Pradesh
Punjab
Haryana
Jammu & Kashmir
Nias
Bali
Lombok
Sumbawa
Flores
Timor
Halmahera
Minahasa
Peninsula
Sula
Nicobar Islands
Andaman Islands
Key Islands
Tenimber Islands
Ambon
Seram
Buru
Sumba
Selajar
Kakabaru
Banggai
Taliabu
Mangole
Peleng
Natuna Besar
Kinmen
Okinawa
Taiwan
Hainan
Guangzhou
Beijing
Wuhan
Chongqing
Kunming
Lhasa
Urumqi
Lanzhou
Yinchuan
Hohhot
Harbin
Changchun
Shenyang
Tianjin
Shijiazhuang
Taiyuan
Zhengzhou
Jinan
Nanjing
Hefei
Wuhan
Changsha
Nanchang
Fuzhou
Hangzhou
Shanghai
Guiyang
Nanning
Haikou
Taipei
Kaohsiung
Macau
Hong Kong
Ulaanbaatar
Pyongyang
Seoul
Busan
Tokyo
Osaka
Nagoya
Sapporo
Fukuoka
Hiroshima
Kyoto
Yokohama
Kobe
Sendai
Niigata
Kanazawa
Matsuyama
Kagoshima
Naha
Okinawa
Miyazaki
Nagasaki
Kumamoto
Oita
Yamaguchi
Tottori
Shimane
Okayama
Kochi
Tokushima
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Aichi
Mie
Toyama
Ishikawa
Fukui
Yamanashi
Nagano
Gunma
Tochigi
Ibaraki
Chiba
Saitama
Kanagawa
Shizuoka
Aomori
Iwate
Akita
Yamagata
Fukushima
Miyagi
Hokkaido
Sakhalin
Kamchatka
Vladivostok
Khabarovsk
Amur
Yakutia
Irkutsk
Buryatia
Chita
Krasnoyarsk
Tuva
Khakassia
Altai
Novosibirsk
Omsk
Tyumen
Sverdlovsk
Chelyabinsk
Kurgan
Perm
Kirov
Nizhny Novgorod
Moscow
Tula
Ryazan
Tambov
Voronezh
Belgorod
Kursk
Bryansk
Smolensk
Kaluga
Tver
Yaroslavl
Vologda
Arkhangelsk
Murmansk
Karelia
Leningrad
Pskov
Novgorod
Kaliningrad
Lithuania
Latvia
Estonia
Belarus
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Poland
Czech Republic
Germany
Austria
Switzerland
Italy
France
Spain
Portugal
Ireland
United Kingdom
Iceland
Norway
Sweden
Finland
Denmark
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Belgium
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Croatia
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Montenegro
Albania
Macedonia
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Greece
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Republic of the Congo
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Benin
Togo
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Ivory Coast
Liberia
Sierra Leone
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Guinea-Bissau
Gambia
Senegal
Mauritania
Mali
Burkina Faso
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Canary Islands
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Greenland
Canada
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El Salvador
Honduras
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Costa Rica
Panama
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Singapore
Brunei
East Timor
Taiwan
Mongolia
North Korea
South Korea
Japan
Russia
Kazakhstan
Uzbekistan
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Afghanistan
Iran
Iraq
Kuwait
Saudi Arabia
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Oman
United Arab Emirates
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Kyrgyzstan
Tajikistan
Afghanistan
Iran
Iraq
Kuwait
Saudi Arabia
Yemen
Oman
United Arab Emirates
Qatar
Bahrain
Jordan
Syria
Lebanon
Israel
Palestine
Armenia
Azerbaijan
Georgia
Kosovo
Andorra
Monaco
San Marino
Vatican City
Liechtenstein
200 km
600 km
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**Pinned specimens of *Samia cynthia* (Drury)**

1. *Samia cynthia* ♂, lectotype of *Phalaena Attacus Cynthia*, China, from the collection of Dru Drury (AM).

2. *Samia cynthia* ♂, lectotype of *Attacus Walkeri*, Ningbo, Zhejiang Province, China (BMNH).

3. *Samia cynthia* ♂, Beijing, China, *ex* pupa 12 May 1863, leg. Simon, from the collection of F.-É. Guérin-Méneville (MNHN).

4. *Samia cynthia* ♂, Ningbo, Zhejiang Province, China, 1922, leg. A. Buch (MNHN).

5. *Samia cynthia* ♂, Shanghai, cocoon collected in 1917 by G. M. Franck, reared from cocoon June 1918 at Withington, England, by J. H. Watson (BMNH).

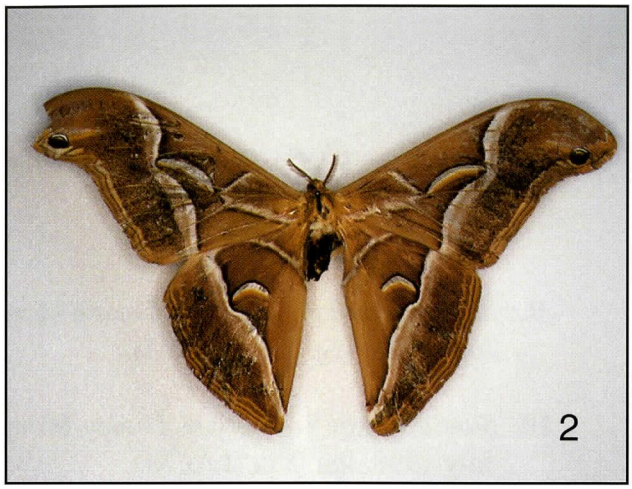
6. *Samia cynthia* ♂, Yanagawa-machi, Date-gun, Fukushima Prefecture, Japan, reared *ex ovo* on *Ailanthus altissima* in 1996 in Colorado by R. S. Peigler (SN).

7. *Samia cynthia* ♀, Rovereto, Trento, Italy, emerged 29 May 1997 from cocoon collected on *Ailanthus altissima* by Uberto Nardelli (SN).

8. *Samia cynthia* ♀, United States stock, reared June 1994 from cocoon by R. S. Peigler, reared *ex ovo* by Jeff Frey in Pennsylvania. Unfaded specimen showing olive green color.

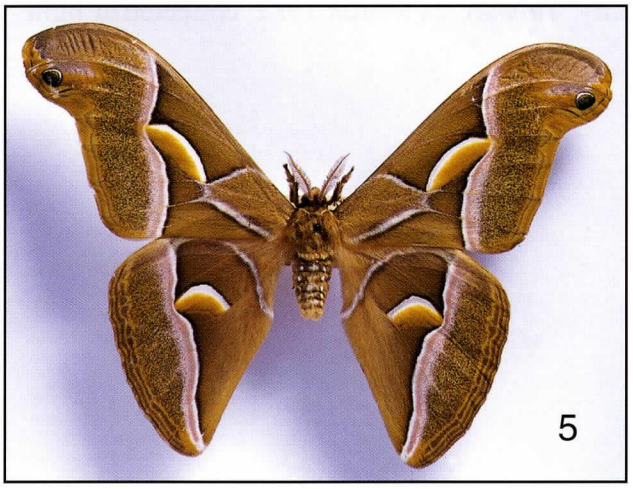
**Abbreviations used for the figures:**
leg. = collected by
m = meters above sea level
SN = collection of Stefan Naumann (Berlin)
RSP = collection of Richard S. Peigler (San Antonio)
The following acronyms for museums are given on pages 35-36: AM, BMNH, CMNH, DMNS, LACM, MNHN, MNHL, MZB, NHMW, SEHU, SMFL, TM, TNM, ZMHB, ZMUC.


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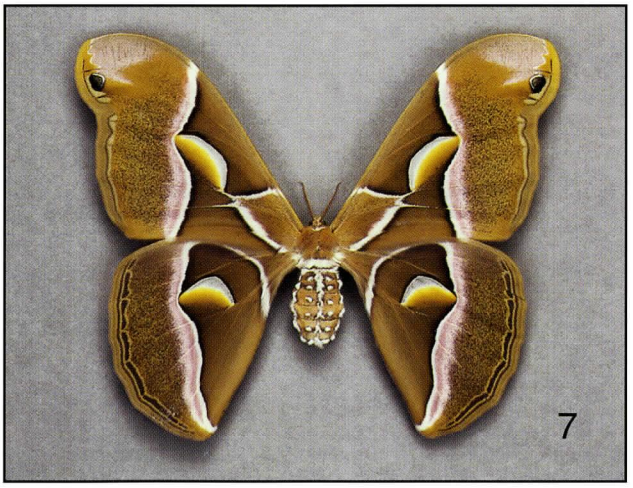

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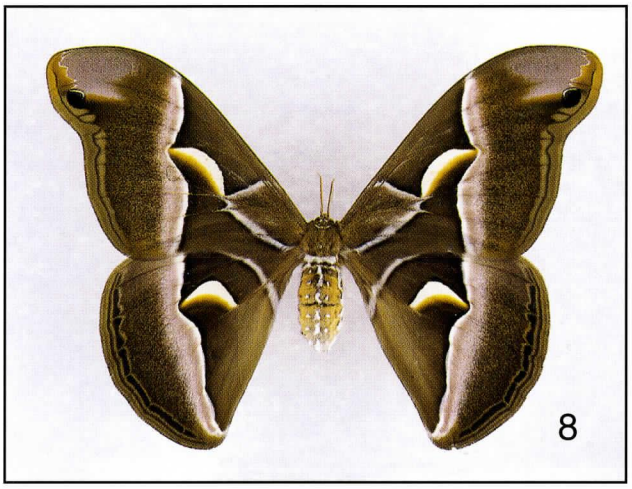

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8

## *Samia wangi* Naumann & Peigler

9. *Samia wangi* ♂, holotype, Duang Mountain, 1500 m, Huiji, Guangdong Province, China, July 1998, leg. Yin (LACM).

10. *Samia wangi* ♀, allotype, Duang Mountain, 1500 m, Huiji, Guangdong Province, China, July 1998, leg. Yin (LACM).

11. *Samia wangi* ♂, paratype, Jingang Mountains, 400-500 m, Jiangxi Province, China, July 1994, leg. Wang (SN).

12. *Samia wangi* ♂, Huai Hua, Hunan Province, China, 2-13 May 1996, leg. Y. Wu (SN).

13. *Samia wangi* ♂, Mount Emei, 1600 m, Sichuan Province, China, 2-15 May 1996, leg. Y. Wu (SN).

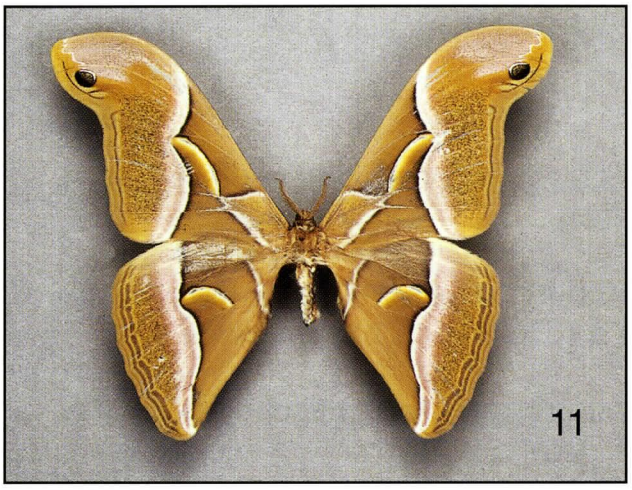
14. *Samia wangi* ♂, paratype, Wulai, Taipei County, Taiwan, 16 July 1968, leg. S. Suzuki (SN).

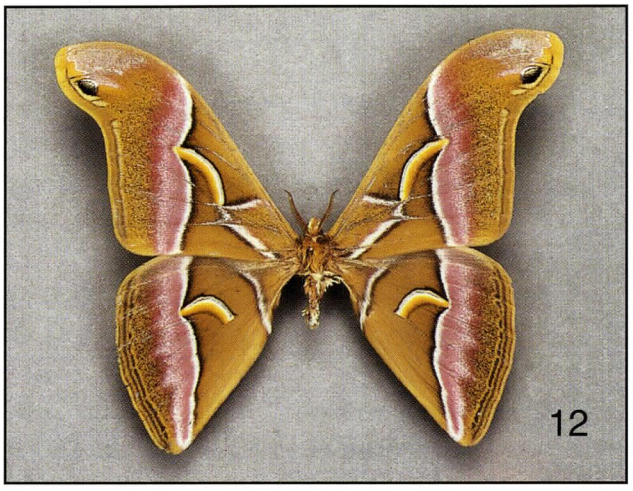
15. *Samia wangi* ♂, Chapa, 1600 m, primary forest on northern slope of Mount Fan Si Pan, northern Vietnam, April 1995 (SMFL).

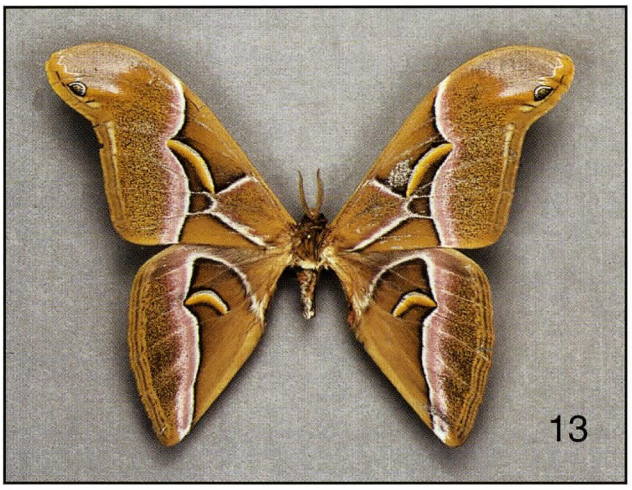
16. *Samia wangi* ♀, paratype, Wushe, Nantou County, Taiwan, 31 March 1987, collected at light by Hsiau Yue Wang (TM).

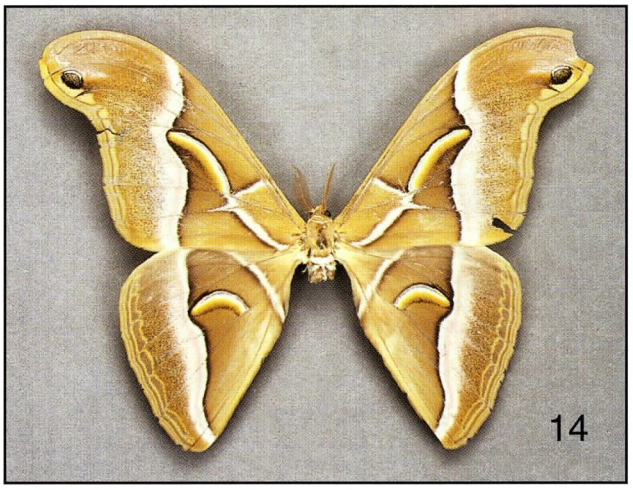

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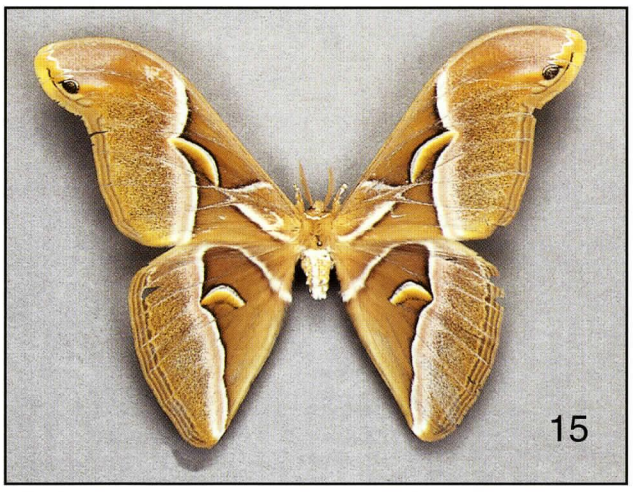

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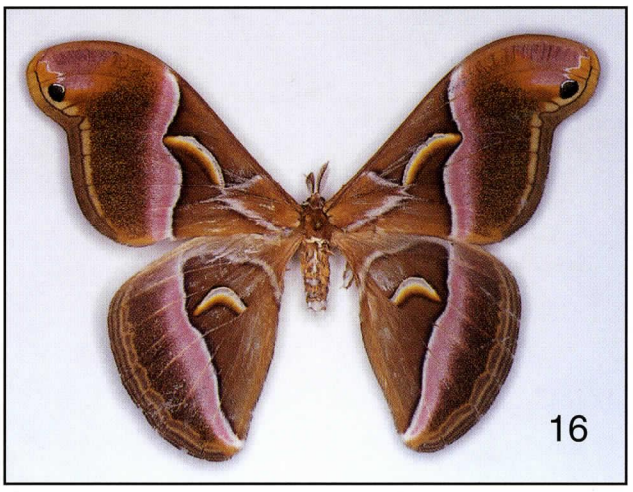

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16

## *Samia pryeri* (Butler) and *Samia canningi* (Hutton)

**17.** *Samia pryeri* ♂, lectotype of *Attacus pryeri*, Yokohama, Japan, leg. F. M. Jonas (BMNH).

**18.** *Samia pryeri* ♀, paralectotype of *Attacus pryeri*, Yokohama, Japan, September 1877, leg. F. M. Jonas (BMNH).

**19.** *Samia pryeri* ♀, Yona, Okinawa, Ryukyu Islands, Japan, 4 September 1970, leg. M. Chujo (SN).

**20.** *Samia pryeri* ♀, underside of same specimen.

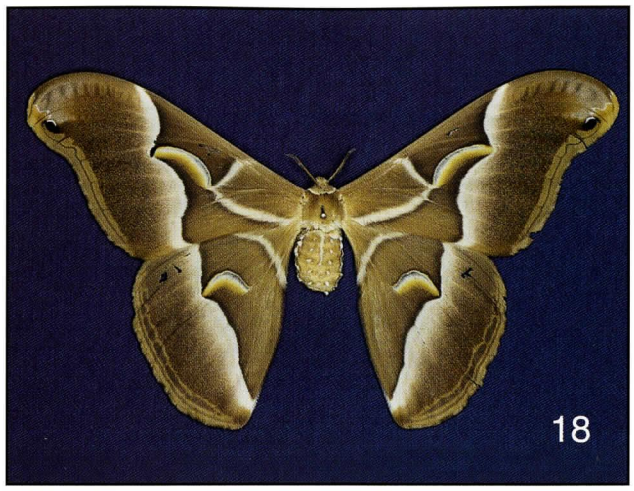
**21.** *Samia canningi* ♂, road from Shillong to Mawphlag, 600-1000 m, Khasi Hills, Meghalaya, India, May 1996, received from L. del Corona (SN).

**22.** *Samia canningi* ♂, Pir Sowaha, 600 m, Margalla Hills, 20 km north of Islamabad, Pakistan, 29-31 July 1994, leg. B. Herczig, G. M. László & G. Ronkay (T. Witt collection).

**23.** *Samia canningi* ♂, Yigong, 2300-2400 m, Xizang [=Tibet], China, collected between May and September 1996, leg. Wang (SN).

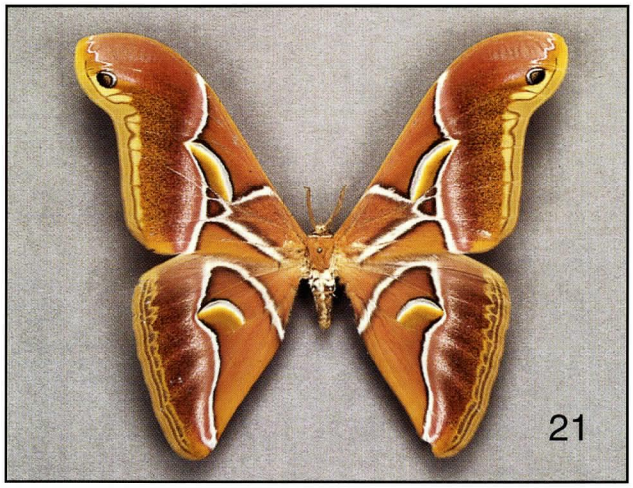
**24.** *Samia canningi* ♂, Ranong, southern Thailand, March-April 1999, leg. Sabine Steinke & H. Lehmann (SN).


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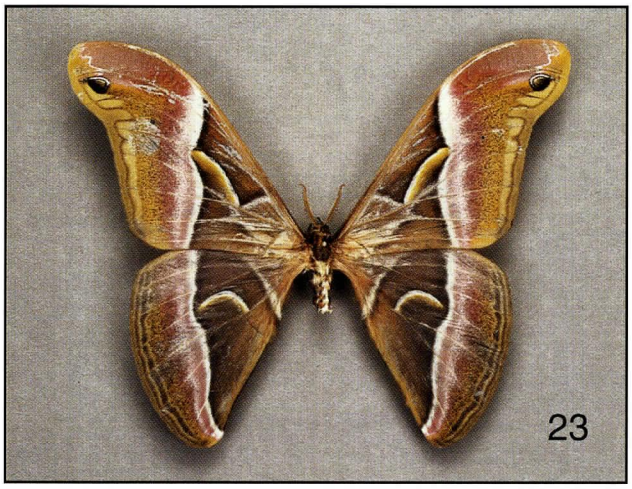

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## *Samia canningi* (Hutton) and *Samia ricini* (Anonymous)

**25.** *Samia canningi* ♂, Maetaeng, Chiangmai Province, northern Thailand, 6 October 1998, leg. Sabine Steinke (RSP).

**26.** *Samia canningi* ♀, Pailin, 300 m, southwestern Cambodia, 5-8 June 1999, leg. S. Steinke & H. Lehmann (SN).

**27.** *Samia canningi* ♀, Xiaoxinganling, 1300 m, Tieli, Heilongjiang Province, China, August 1999, leg. Zhu (SN).

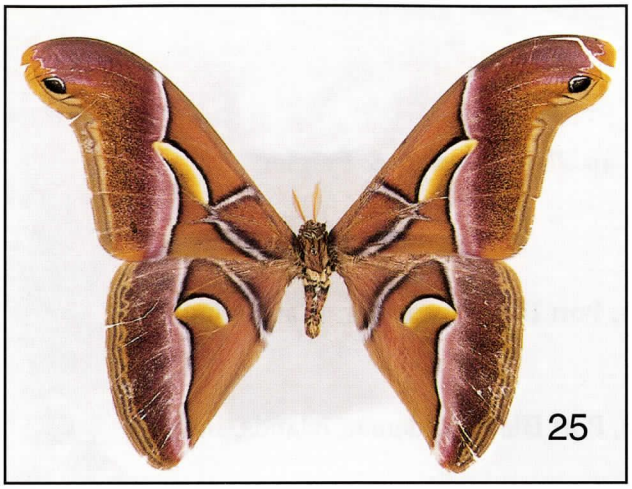
**28.** *Samia canningi* ♀, Tenasserim Peninsula, southeastern Myanmar [=Burma], 18 September 1996, leg. S. Steinke (SN).

**29.** *Samia canningi* ♀, India, emerged May 1975 from cocoon bought by R. S. Peigler from Worldwide Butterflies Ltd., England (LACM).

**30.** *Samia ricini* ♀, Sichuan Province, China, April 1999, reared *ex ovo* on castor (*Ricinus communis*) and Arizona ash (*Fraxinus velutina*) in Texas by R. S. Peigler (SN).

**31.** *Samia ricini* ♂, Darjeeling, West Bengal, India, reared 17 October 1994 in Czech Republic (SN).

**32.** *Samia ricini* ♂, Beirut, Lebanon, emerged 26 November 1974 (SN).


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## *Samia fulva* Jordan and *Samia kohlli* Naumann & Peigler

**33.** *Samia fulva* ♂, lectotype of *Samia lunula fulva*, Port Blair, Andaman Islands, India (BMNH).

**34.** *Samia fulva* ♀, paralectotype of *S. lunula fulva*, Port Blair, Andaman Islands, India (BMNH).

**35.** *Samia fulva* ♂, Port Blair, Andaman Islands, India, Oct. 1992, leg. Rautenstrauch (MHNL).

**36.** *Samia kohlli* ♂, holotype, Tanah Rata, Cameron Highlands, Pahang, West Malaysia, 18 January 1998, received from Steve Kohll (ZMHB).

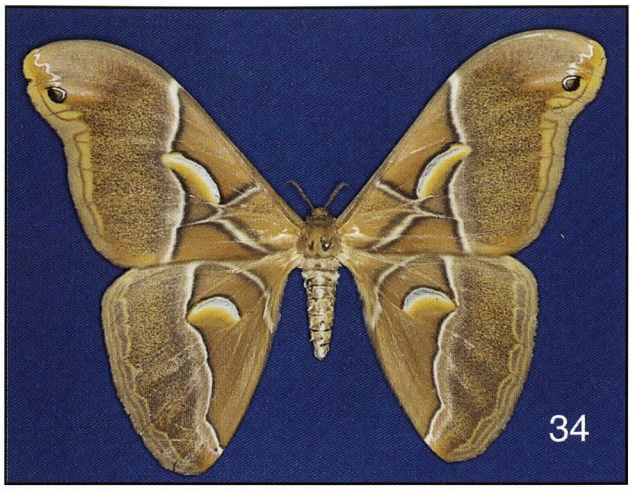
**37.** *Samia kohlli* ♀, allotype, 3 km north of Brinchang, 1350 m, Cameron Highlands, Pahang, West Malaysia, 14 July 1998, reared on *Ligustrum ovalifolium* in Germany by S. Naumann (ZMHB).

**38.** *Samia kohlli* ♂, Dawna, northeast of Moulmein, ca. 1300 m, southeastern Myanmar, 21 July 1995 (SMFL).

**39.** *Samia kohlli* ♂, Dexin, ca. 4500 m, Baimaxue Mountains, northwestern Yunnan Province, China, June 1999, leg. Wang & Li (SN).

**40.** *Samia kohlli* ♂, Tam Dao, ca. 1000 m, northern Vietnam, 24-26 June 1999, leg. A. Kallies, Yutaka Arita, and others (SN).


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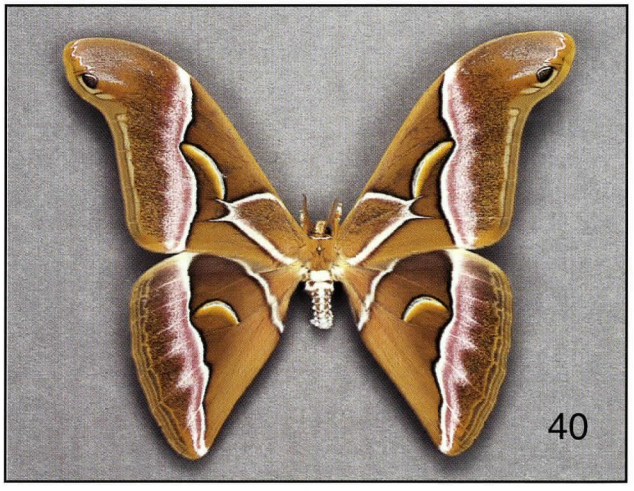

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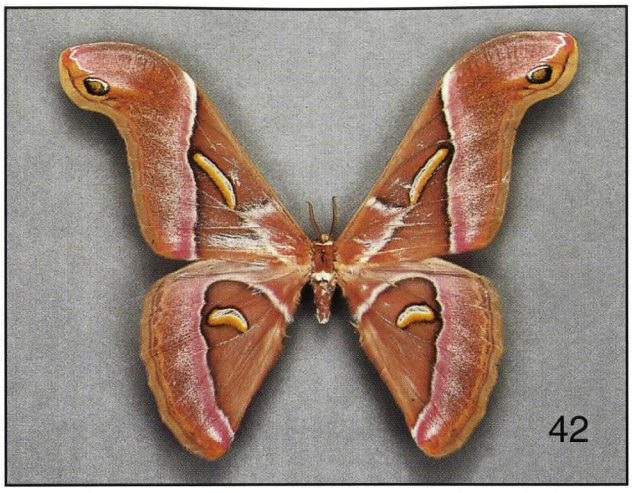

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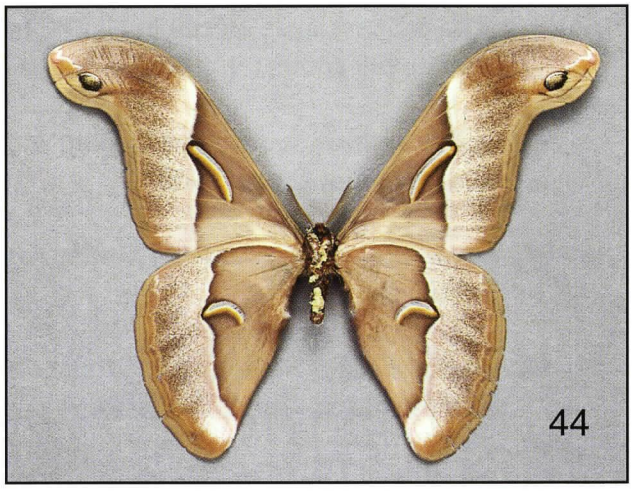

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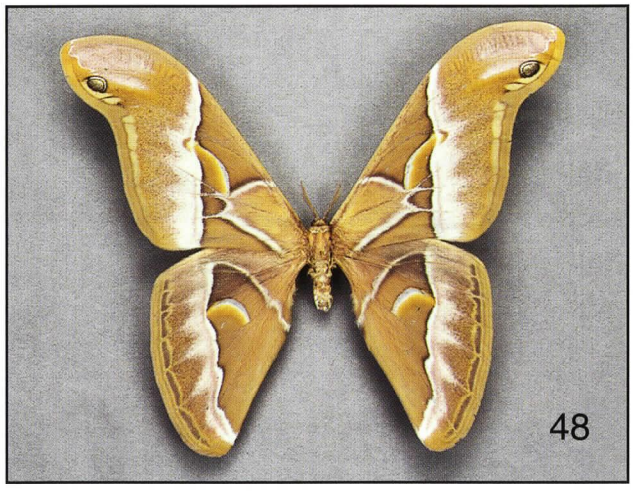

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***Samia insularis* (Snellen van Vollenhoven); *Samia abrerai* Naumann & Peigler; and *Samia yayukae* U. Paukstadt, Peigler & L. Paukstadt**

**49.** *Samia insularis* ♀, Mount Salak, western Java, Indonesia, emerged from cocoon May 1993, leg. Ulrich Paukstadt (SN).

**50.** *Samia abrerai* ♂, holotype, West Bali National Park, 650 m, road from Pucaksari to Sepang, Bali, Indonesia, 25 December 1998, to light at 01:10 hours, secondary forest and coffee and nutmeg plantations, leg. Stefan Naumann (BMNH).

**51.** *Samia abrerai* ♀, paratype, Mount Argopuro, eastern Java, Indonesia, December 1997, received from Detani (SN).

**52.** *Samia abrerai* ♂, paratype, Mount Argopuro, eastern Java, Indonesia, received 1998 from Detani (SN).

**53.** *Samia yayukae* ♂, holotype, Mount Golo Lusang, near Ruteng, Flores Island, Indonesia, 25 July 1991, leg. Ulrich Paukstadt & Laela Hayati Paukstadt (MZB).

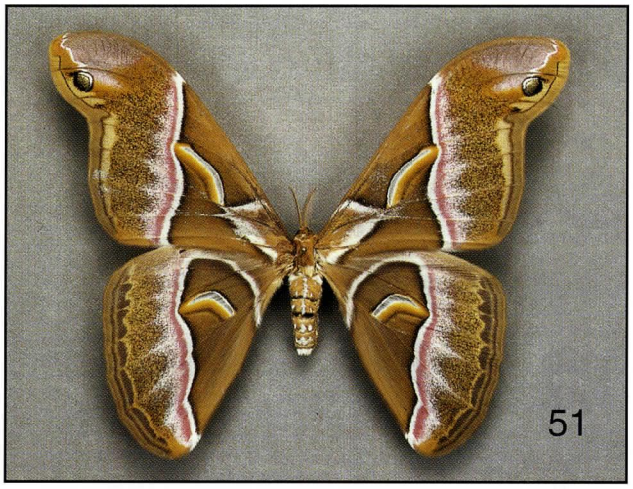
**54.** *Samia yayukae* ♂, Mount Mutis, 1000 m, near Kapan, western Timor Island, Indonesia, April 1993, leg. M. Amin (RSP).

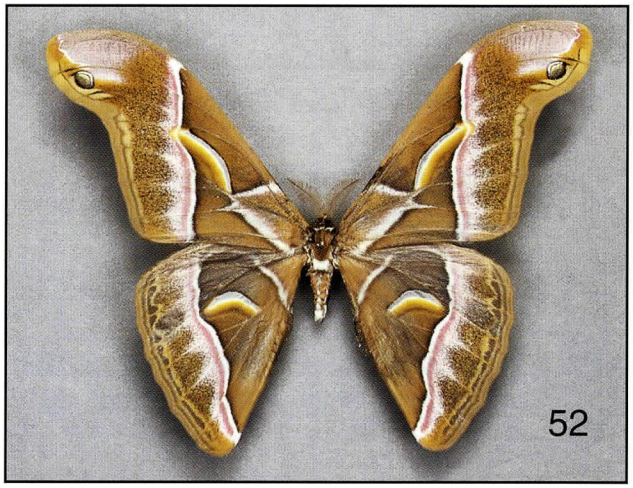
**55.** *Samia yayukae* ♀, Mount Mutis, 1000 m, near Kapan, western Timor Island, Indonesia, April 1993, leg. M. Amin (LACM).

**56.** *Samia yayukae* ♀, Mount Mutis, 1000 m, near Eban, western Timor Island, Indonesia, emerged 11 January 1994, reared *ex ovo* in Germany by Laela H. Paukstadt (SN).

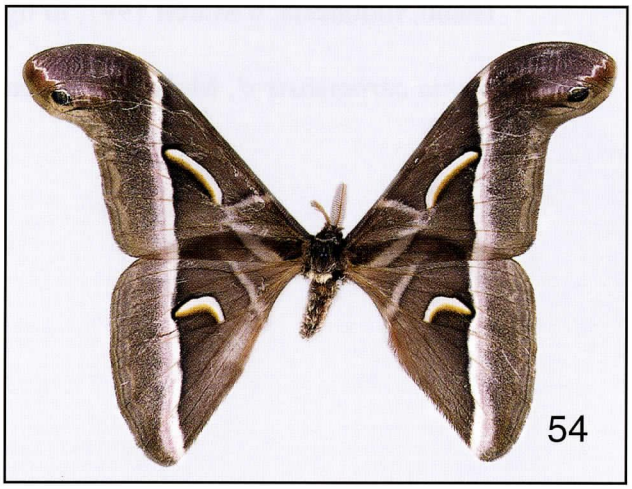

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***Samia vandenberghi* Watson; *Samia naumanni* U. Paukstadt, Peigler & L. Paukstadt; *Samia naessigi* Naumann & Peigler; and *Samia ceramensis* (Bouvier)**

**57.** *Samia vandenberghi* ♂, Puncak Palopo, 1300 m, South Sulawesi Province, Indonesia, emerged 30 June 1996, reared *ex ovo* in Germany by S. Naumann (SN).

**58.** *Samia vandenberghi* ♂, paralectotype of *Philosamia insularis vandenberghi*, Gorontalo, North Sulawesi Province, Indonesia, 1914, leg. P. J. van den Bergh (BMNH).

**59.** *Samia vandenberghi* ♀, Puncak Palopo, 1300 m, South Sulawesi Province, Indonesia, August 1995, leg. Gala (SN).

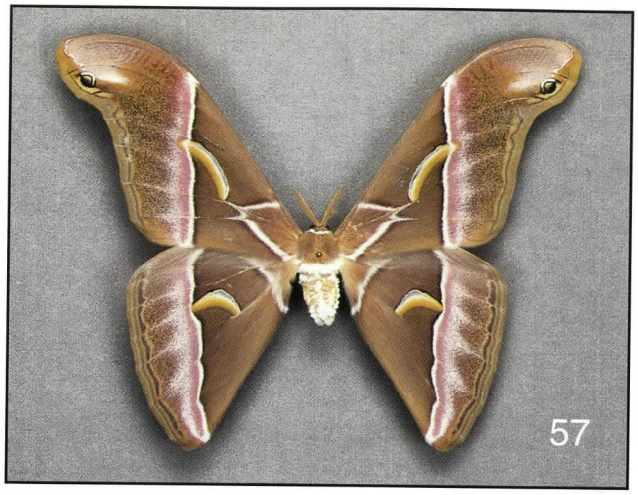
**60.** *Samia naumanni* ♂, paratype, Waibau, ca. 250 m, Sanana Island, Indonesia, 4 August 1995, leg. S. Naumann & U. Paukstadt (SN).

**61.** *Samia naumanni* ♀, Peleng Island, Indonesia, September 1998 (SN).

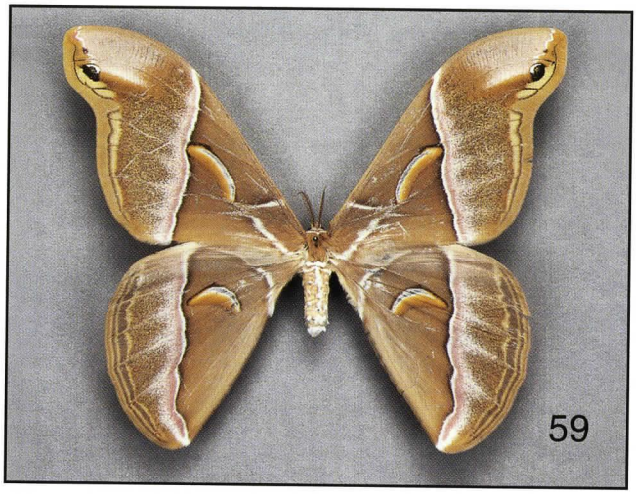
**62.** *Samia naessigi* ♂, holotype, road from Baru to Basale, 500 m, northwestern Halmahera Island, Indonesia, 6 March 1997, to light at 03:00 hours, leg. S. Naumann (ZMHB).

**63.** *Samia naessigi* ♀, allotype, road from Baru to Basale, 500 m, northwestern Halmahera Island, Indonesia, 6 March 1997, to light at 00:55 hours, leg. S. Naumann (ZMHB).

**64.** *Samia ceramensis* ♂, Moluccas, Indonesia, 1945, leg. J. E. Tesner (CMNH).

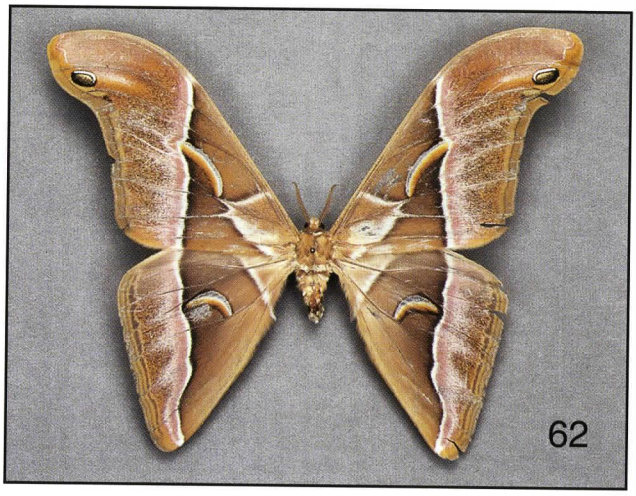

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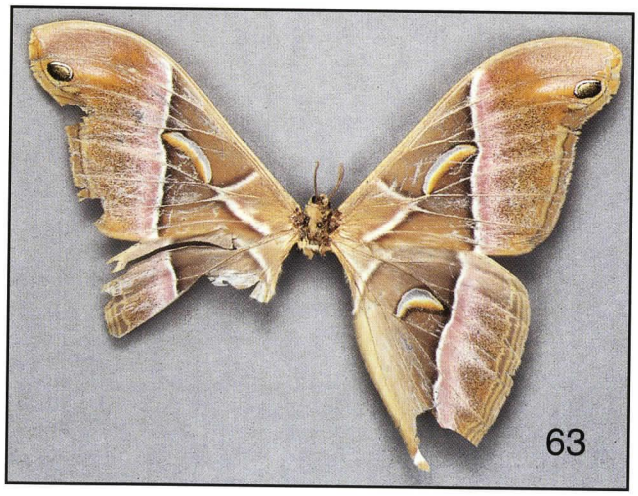

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***Samia ceramensis* (Bouvier), *Samia tetrica* (Rebel), and *Samia treadawayi* Naumann**

**65.** *Samia ceramensis* ♂, holotype of *Philosamia cynthia ceramensis*, Manusela, 1828 m, central Ceram Island [=Seram], Indonesia, October-November 1919, C., F. & J. Pratt (BMNH).

**66.** *Samia tetrica* ♂, lectotype of *Philosamia cynthia tetrica*, Singapore, 1900, leg. Löbell (NHMW).

**67.** *Samia tetrica* ♂, Tanah Rata, 1500 m, Cameron Highlands, West Malaysia, December 1993-February 1994, leg. Wong Tet Fatt (SN).

**68.** *Samia tetrica* ♂, Sungai Burong, Brunei, 30 November 1997, leg. Glen R. Ping (RSP).

**69.** *Samia tetrica* ♀, holotype of *Philosamia cynthia borneensis*, Mount Kinabalu, Sabah, East Malaysia, May-June 1903, leg. J. Waterstradt (NHMW).

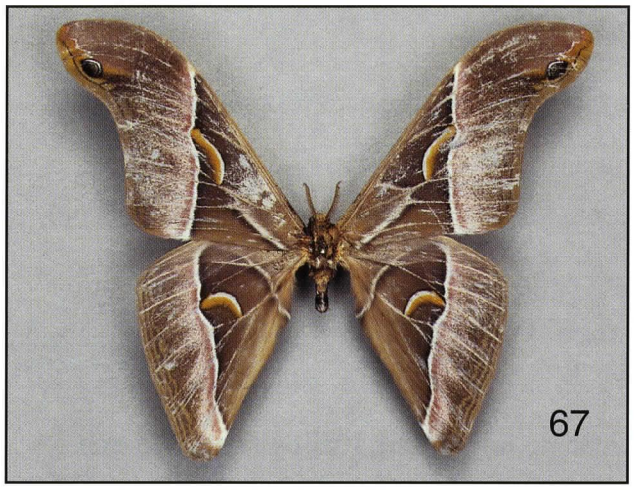
**70.** *Samia treadawayi* ♂, holotype, Mount Salakot, 350 m, central Palawan Island, Philippines, March 1996, leg. Colin G. Treadaway (SMFL).

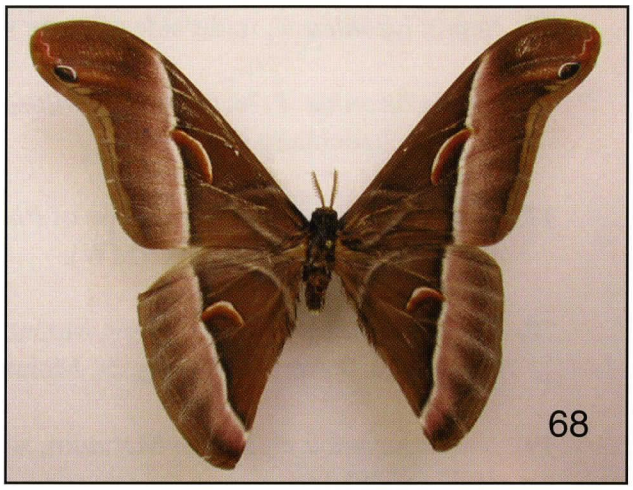
**71.** *Samia treadawayi* ♂, underside of same specimen.

**72.** *Samia treadawayi* ♀, paratype, Mount Bayog, 305 m, southern Palawan Island, Philippines, August 1994, received from C. G. Treadaway (SN).


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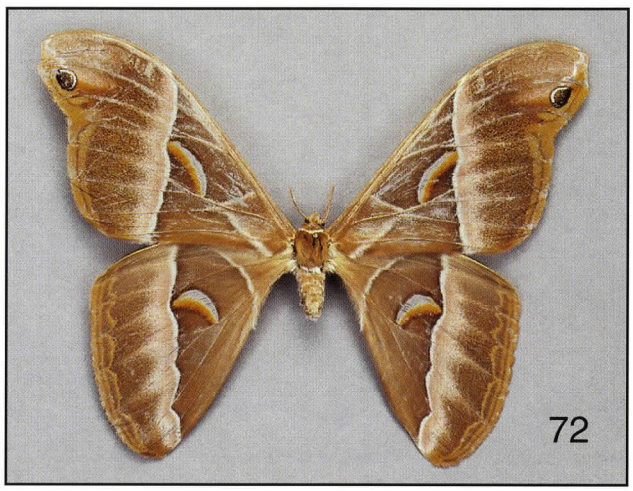

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## *Samia luzonica* (Watson)

**73.** *Samia luzonica* ♂, lectotype of *Philosamia insularis luzonica*, Polangui Albay, Luzon, Philippines, leg. Salting (BMNH).

**74.** *Samia luzonica* ♂, Borocay Island, Panay Province, Philippines, *ex*-larva 30 October 1991 (SN).

**75.** *Samia luzonica* ♂, underside of same specimen.

**76.** *Samia luzonica* ♂, lectotype of *Philosamia mindanaënsis*, Mindanao, Philippines, 1890, leg. A. V. Schadenberg (NHMW).

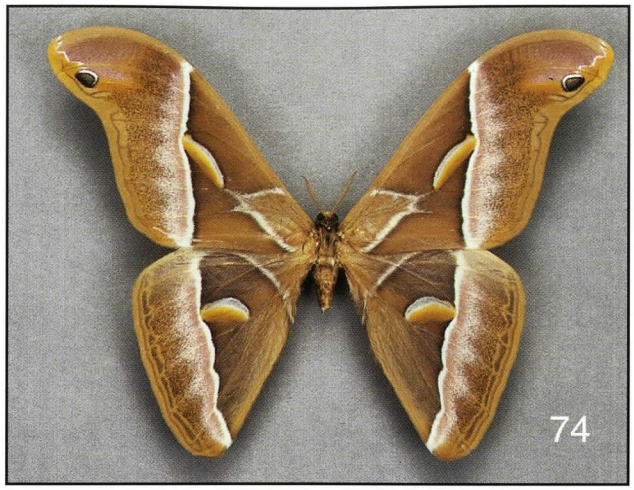
**77.** *Samia luzonica* ♀, paralectotype of *Philosamia mindanaënsis,* Mindanao, Philippines, 1890, leg. A. V. Schadenberg (NHMW).

**78.** *Samia luzonica* ♀, Dalongdong Mountain, 800 m, 40 km north-northwest of Maramag, Mindanao, 9 April 2000, leg. N. Mohagan (SN).

**79.** *Samia luzonica* ♂, Mount Matutum, south of Cotabato, Mindanao, Philippines, 15 March 1977 (SMFL).

**80.** *Samia luzonica* ♂, Calyasan, Mindanao, Philippines, September 2000, leg. N. Mohagan (SN).

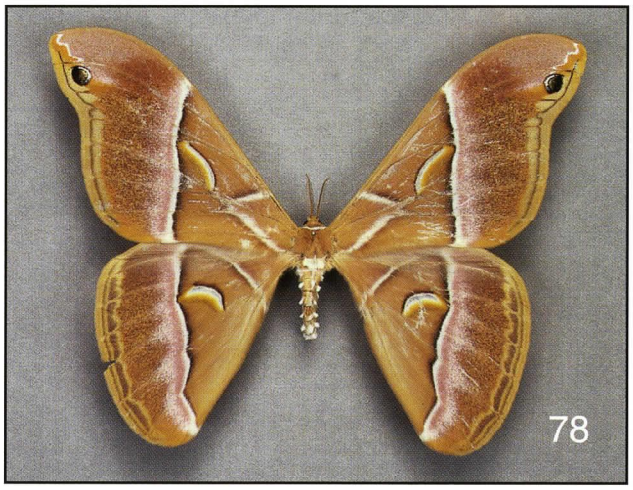

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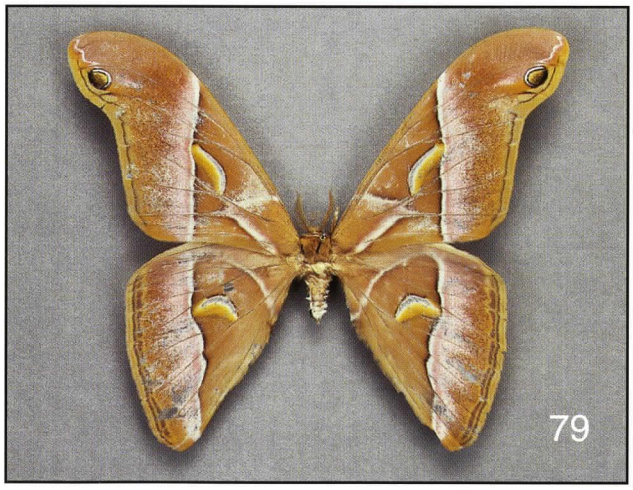

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***Samia watsoni* (Oberthür)**

**81.** *Samia watsoni* ♂, lectotype of *Desgodinsia Watsoni,* Kangding, Sichuan Province, China (BMNH).

**82.** *Samia watsoni* ♂, lectotype of *Samia formosana*, Horisha, Taiwan, August 1924 (SEHU).

**83.** *Samia watsoni* ♂, Yangjialing, 1500 m, Wuyi Mountains, eastern Jiangxi Province, China, August 2000, leg. Yin (SN).

**84.** *Samia watsoni* ♂, underside of same specimen.

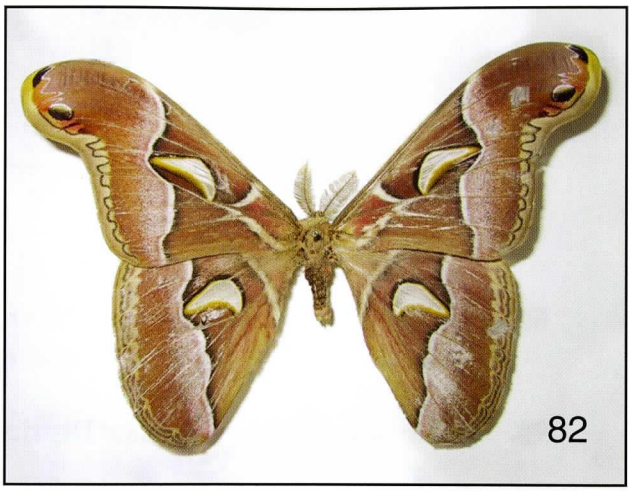
**85.** *Samia watsoni* ♀, Shou-Man, 1800 m, Daba Mountains, southern Shaanxi Province, China, 25 May-14 June 2000 (SN).

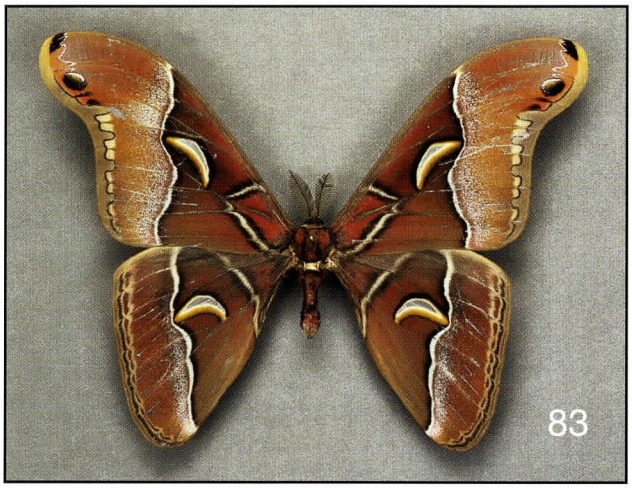
**86.** *Samia watsoni* ♂, Mount Shikengkong, 1600 m, near Ruyuan, northern Guangdong Province, China, end of March 2002, leg. Li (SN).

**87.** *Samia watsoni* ♀, Mount Emei, Sichuan Province, cocoon collected summer 1921 by G. M. Franck, emerged 30 April 1922 at Chengdu (BMNH).

**88.** *Samia watsoni* ♂, Kuatan, 2300 m, northern Fujian Province, China, 28 May 1938, leg. J. Klapperich (RSP).

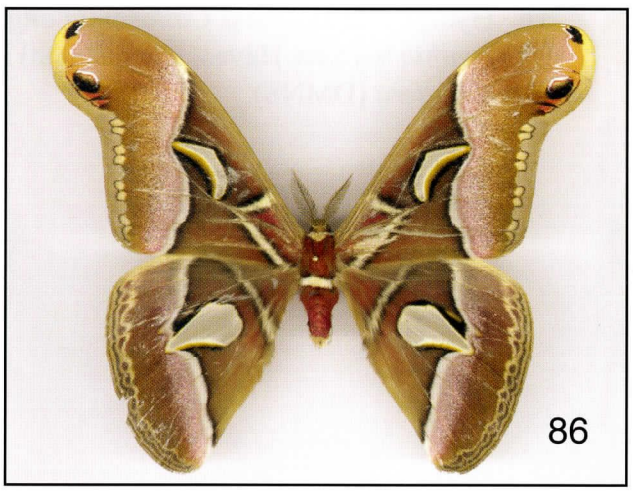

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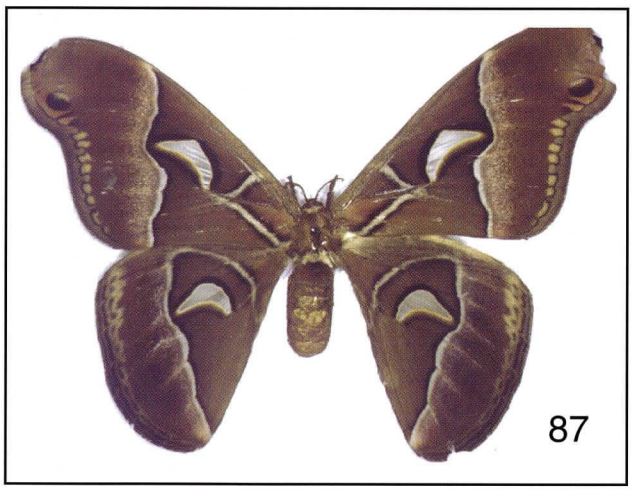

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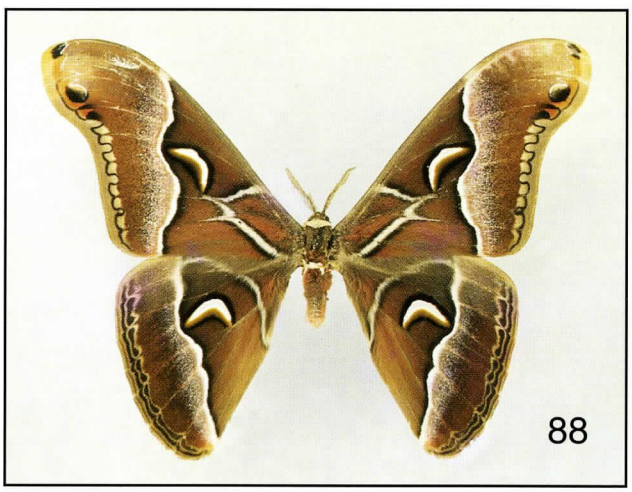

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## Genera Related to *Samia*

**89.** *Archaeoattacus edwardsii* ♂, Zi Yar Dam, 1250 m, 65 km north of Putao, northern Myanmar, May 1998, leg. S. Murzin & V. Sinjaev (SN).

**90.** *Epiphora antinorii* ♂, Njombe District, 800 m, southern Tanzania, November 1996 (SN).

**91.** *Epiphora vacuna* ♂, Department of Nyong and So'o, central Cameroon, June-July 1996 (SN).

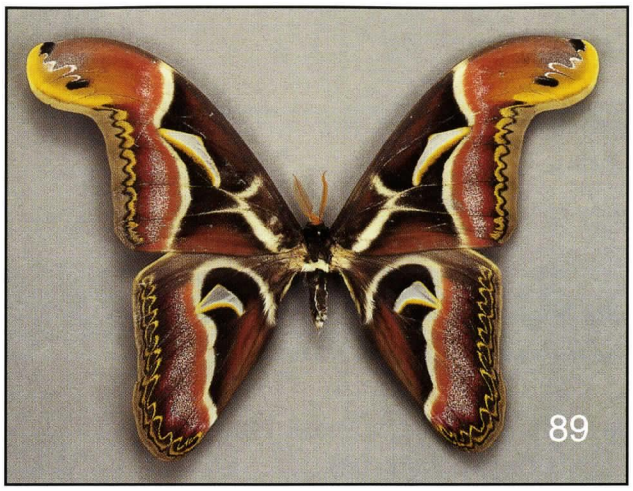
**92.** *Epiphora vacuna* ♂, underside of same specimen.

**93.** *Epiphora vacuna* ♀, Bukonde, Kasai Occidental Province, southern Congo, April 1991, leg. M. De Ridder (SN).

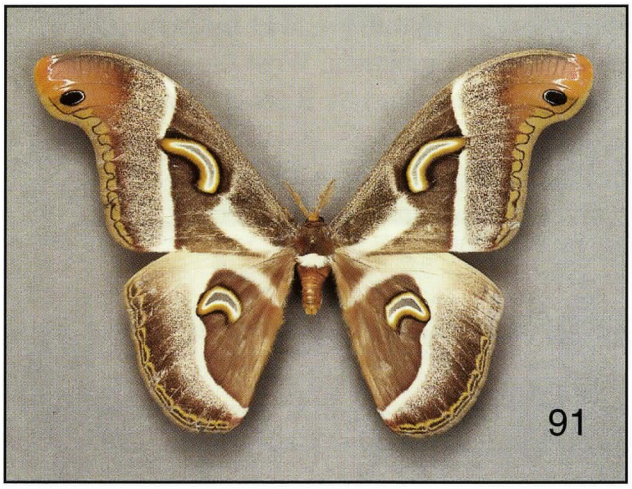
**94.** *Epiphora rectifascia* ♂, Mont de Cristal, Gabon, November 1990 (SN).

**95.** *Callosamia angulifera* ♂, 6 km east of Timberville, Rockingham County, Virginia, reared *ex ovo* in 1984 on tuliptree (*Liriodendron tulipifera*) in South Carolina by R. S. Peigler, emerged 3 May 1985 (DMNS).

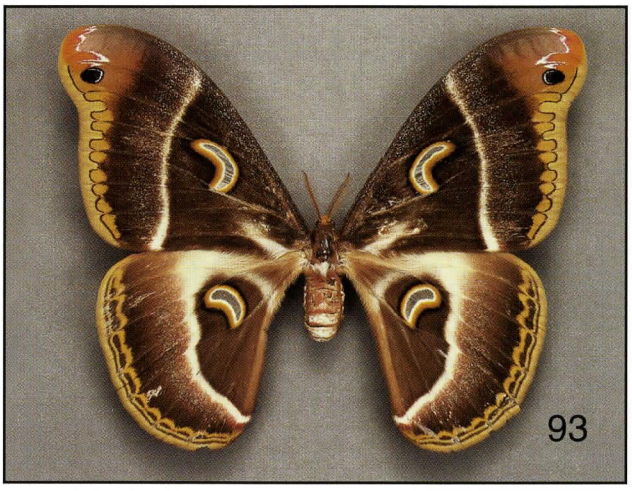
**96.** Hybrid ♂ of the cross *Callosamia angulifera* ♂ (Clemson, South Carolina) × *Samia cynthia* ♀ (New Haven, Connecticut) reared in 1975 by R. S. Peigler on *Liriodendron tulipifera* (DMNS).

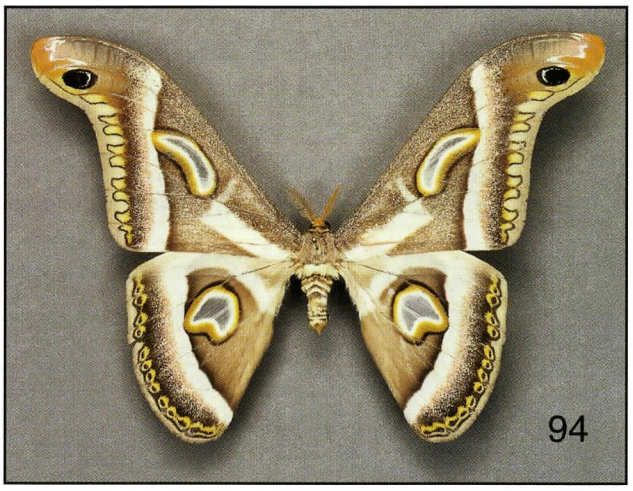

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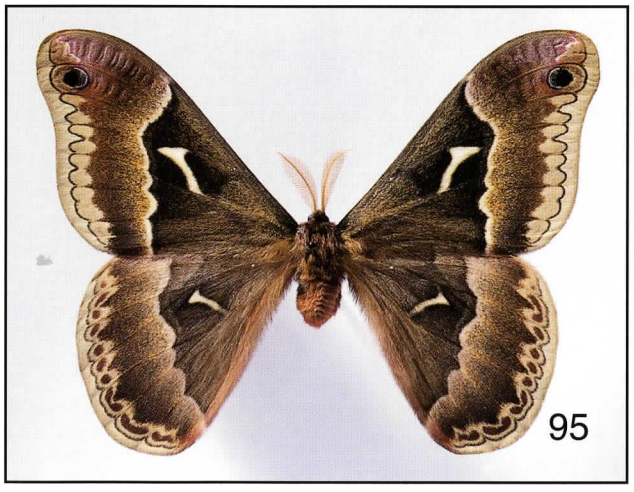

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## Larvae of *Samia*

**97-101.** *Samia kohlli*, all five instars, from Cameron Highlands, West Malaysia, reared in Germany in 1998 on privet (*Ligustrum ovalifolium*) by Stefan Naumann.

**102-106.** *Samia yayukae*, all five instars, from Kapan, Mount Mutis, western Timor, Indonesia, reared in Germany in 1994 by Laela Hayati Paukstadt.

**107-111.** *Samia tetrica*, all instars, except last, which resembles that in Fig. 111 but without waxy covering, and scoli are yellow. From Cameron Highlands, West Malaysia, reared in Germany in 1988 on ailanthus (*Ailanthus altissima*) by Rudolf Lampe.

**112-116.** *Samia vandenberghi,* all five instars, from Puncak Palopo, South Sulawesi, Indonesia, reared in Germany in 1995 on privet (*Ligustrum japonicum*) by S. Naumann.

**117.** *Samia cynthia*, 5th instar, Fukushima Prefecture, Japan, reared in Colorado in 1996 on ailanthus by R. S. Peigler.

**118.** *Samia ricini*, 5th instar, Assam, India, bluish form, mottled, reared in California in 1995 on castor (*Ricinus communis*) by Kirby L. Wolfe.

**119.** *Samia ricini*, 5th instar, Philippines, yellowish white form and bluish form, both unmottled; reared in Colorado in 1995 on lilac (*Syringa vulgaris*) by R. S. Peigler.

**120.** *Samia luzonica*, 5th instar, Bukidnon Province, Mindanao, Philippines, reared in California in 2001 on camphor (*Cinnamomum camphora*) by Christopher A. Conlan.

**121.** *Samia vandenberghi*, 5th instar, South Sulawesi, Indonesia, form with yellowish scoli, from same brood as those shown in Figs. 112-116.


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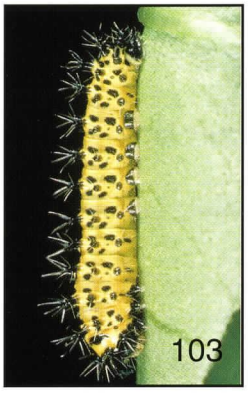

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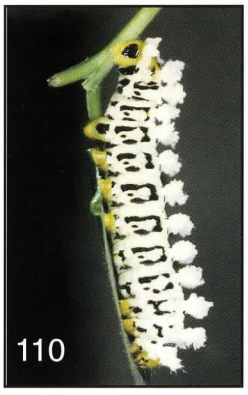

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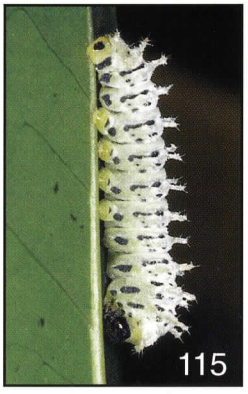

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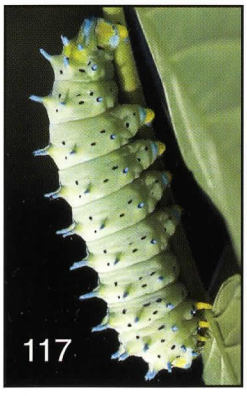

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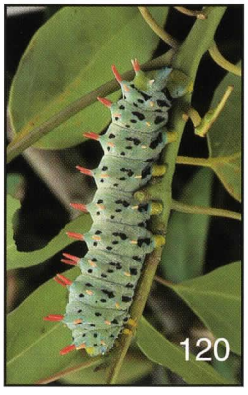

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**Larvae of Genera Related to *Samia*; Eggs, Cocoons, Hostplants of *Samia***

**122.** *Coscinocera hercules*, Morobe Province, Papua New Guinea, mature larva (6th instar), 3 December 1990, reared on *Ligustrum* (but shown on ailanthus) by Kirby L. Wolfe.

**123.** *Hyalophora euryalus*, Cataviña, Baja California Norte, Mexico, mature larva, May 1994, reared on *Ceanothus verrucosus* by Kirby L. Wolfe.

**124.** *Epiphora boolana*, Ghana, 4th instar larva, September 1996, reared on *Ziziphus jujube* by Kirby L. Wolfe.

**125.** *Epiphora manowensis*, Vumba Mountains, Zimbabwe, mature larva, October 1990, reared on *Ziziphus mucronata* by Rolf Oberprieler.

**126.** *Epiphora bauhiniae*, Windhoek, Namibia, March 1990, mature larva on *Ziziphus mucronata*, reared by Rolf Oberprieler.

**127-130.** Hybrid larvae of *Callosamia angulifera* ♂ × *Samia cynthia* ♀, reared in South Carolina in 1975 by R. S. Peigler on *Liriodendron tulipifera.* See also Figure 96.
**127.** 2nd instar. **128.** 3rd instar. **129.** 4th instar, ready to molt. **130.** 5th (last) instar.

**131.** *Callosamia angulifera*, Carbondale, Whitfield County, Georgia, mature larva, September 2002, reared in Texas by R. S. Peigler on *Liriodendron tulipifera*.

**132.** *Samia vandenberghi*, eggs, South Sulawesi, April 1999, lab culture in Germany reared by S. Naumann.

**133.** *Samia ricini*, eggs, Assam, India, 1994, lab culture in Colorado reared by R. S. Peigler.

**134.** *Samia ricini*, cocoons, Jorhat, Assam, India, received 1991 from S. N. Chowdhury. Pure white and brick red forms.

**135.** *Samia canningi*, cocoons, India, received 1975 from Worldwide Butterflies, Ltd.

**136.** *Samia yayukae*, cocoons, Kapan, Timor, Indonesia, from U. & L. Paukstadt (LACM).

**137.** *Ailanthus lesquereuxi*, fossil seed from Green River formation in southwestern Wyoming, of Middle Eocene age, about 45 million years old (RSP).

**138.** Tree-of-heaven (*Ailanthus altissima*), dried seeds, Denver, Colorado, autumn 1992.

**139.** *Ailanthus altissima*, San Antonio, Texas, September 2002.

**140.** Castor (*Ricinus communis*), foliage and fruit, grown in San Antonio, Texas, autumn 1999.

**141.** Avocado trees (*Persea americana*), Chin State, Myanmar, May 2001, defoliated by larvae of *Samia canningi.*

Photos 122-124, 137 by K. L. Wolfe; 125-126 by R. G. Oberprieler; 127-130 by G. R. Carner; 131, 139 by R. S. Peigler; 133-136, 138 by Rick Wicker; 132, 140-141 by S. Naumann.

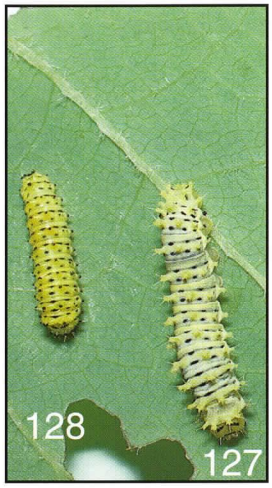

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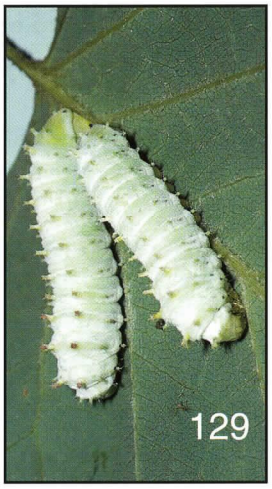

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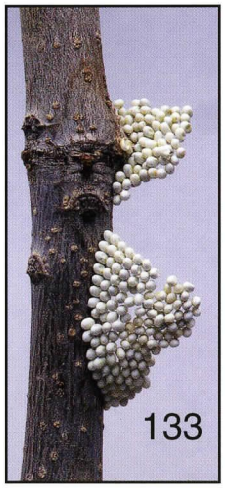

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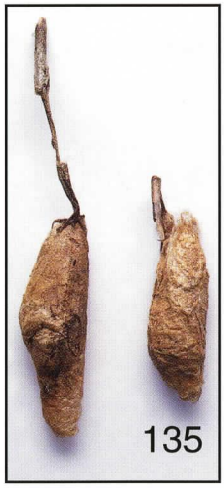

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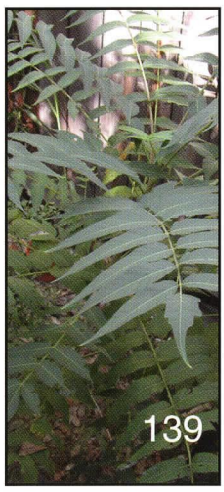

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## Textiles Composed of Eri Silk from *Samia ricini*

**142.** Blue scarf and white dishcloth, silk grown inVietnam and finished products made in Japan; natural colored white, handwoven cloth in background from Jorhat, Assam; white eri cocoon; skein of handspun eri yarn from Assam (DMNS).

**143.** Woman's dress from Manipur, with cotton embroidered top and bottom edges (DMNS).

**144.** Peasant's kabné from Bhutan, composed of two panels of natural colored beige silk made from brick red cocoons (DMNS).

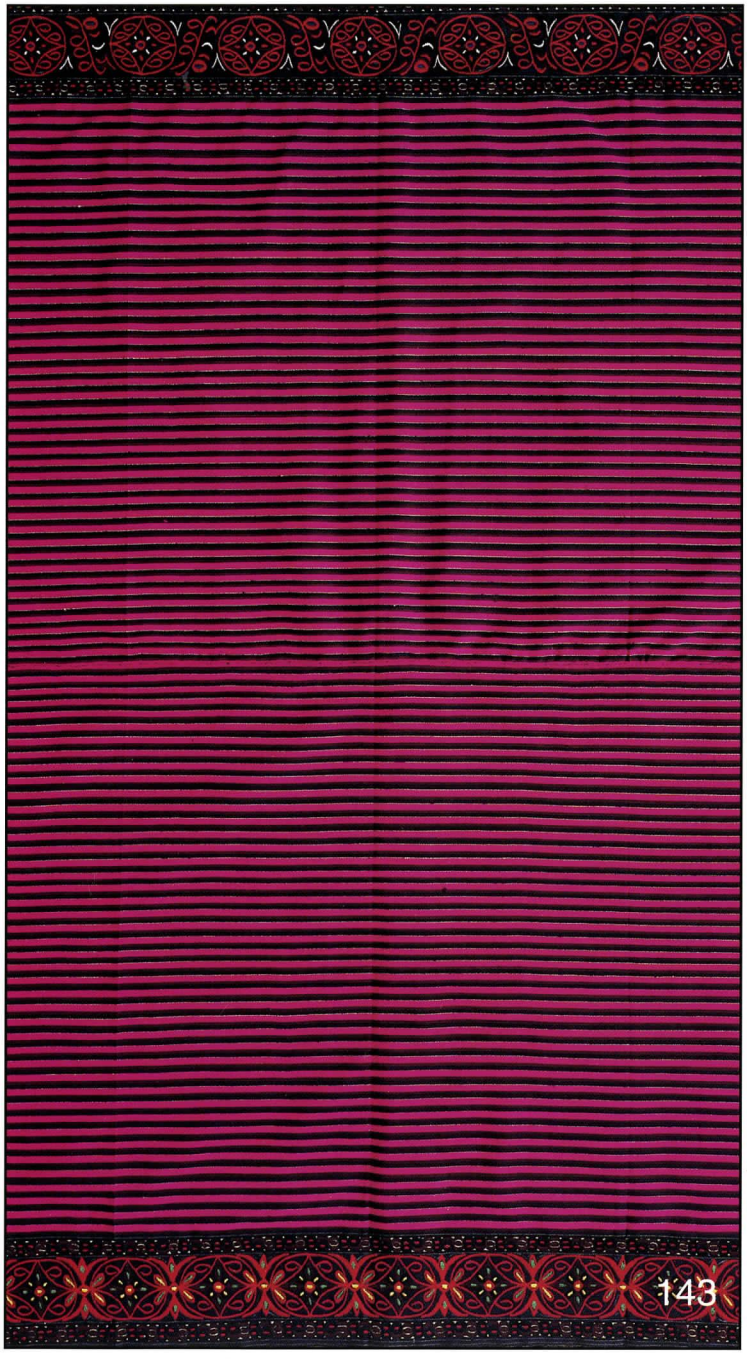
**145.** Khamar kabné from Bhutan; central panel is natural colored white silk made from white cocoons, and side panels dyed red (RSP).

**146.** Handwoven panel from Bhutan, natural colored beige silk made from brick red cocoons (SN).

See page 70 for details.

Photos 142-144 by Rick Wicker; 145 by R. S. Peigler; 146 by S. Naumann.


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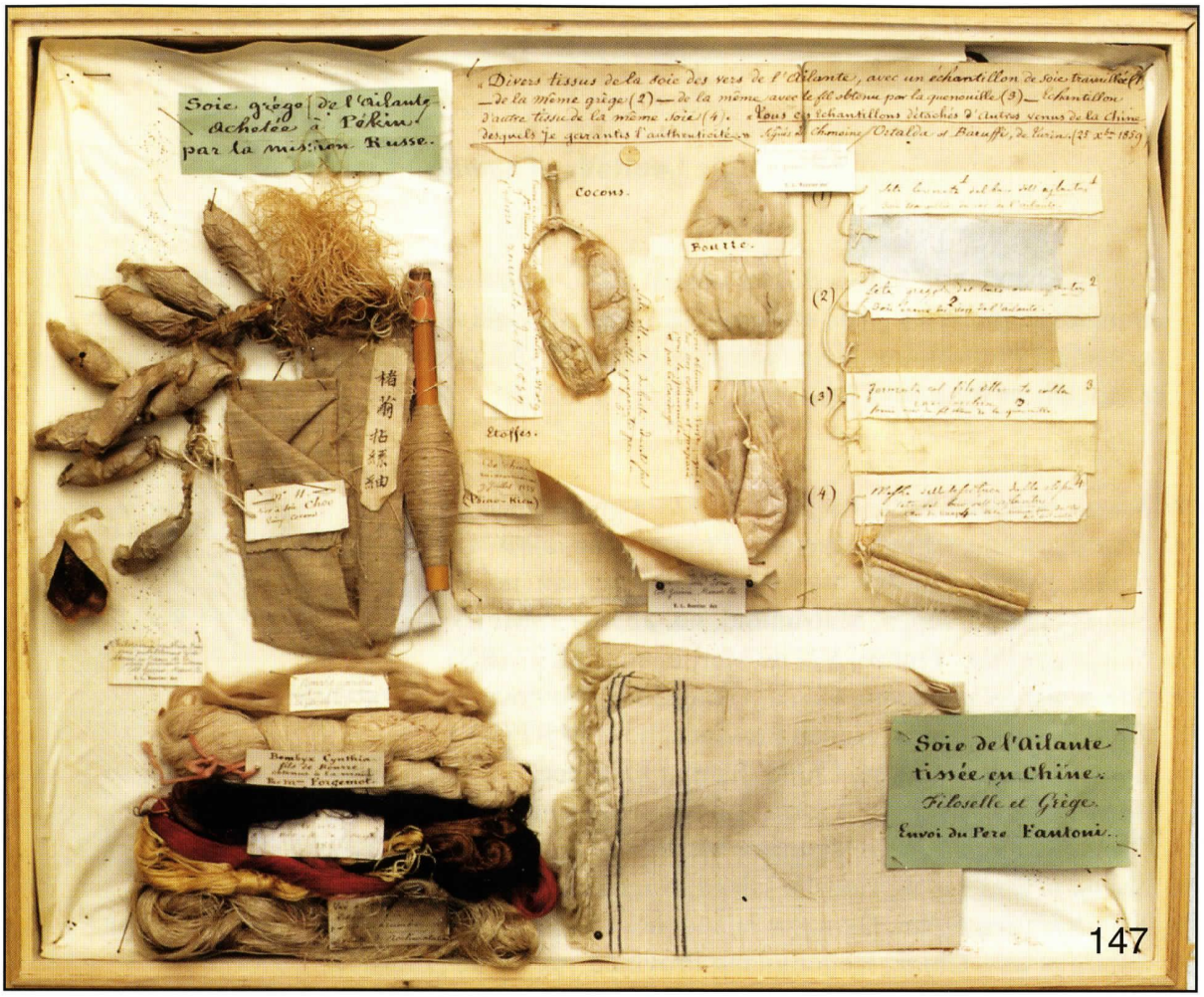

146

**Historical Samples of Silk of *Samia cynthia***

**147.** Examples of silk from China of *Samia cynthia* produced in the mid-1800s, including combed floss, handspun yarns, and hand woven fabrics. The folded piece in the lower right was sent to Europe by Father Annibale Fantoni, the Italian priest who introduced *S. cynthia* from Shandong to Turin in 1856. Shown also in the center left is a darker brown sample obtained from the Russian mission in Beijing.

**148.** Pinned specimens of some of the first moths of *Samia cynthia* introduced from Italy to France in 1858, shown on the left. To the right are empty cocoons of *S. cynthia* and *S. ricini*, and some of the parasitoids that emerged from them. A small sample of silk from *S. cynthia* is seen in the lower center.

Both storage cases are in the entomological collections at the Muséum National d'Histoire naturelle in Paris. Photos by S. Naumann.

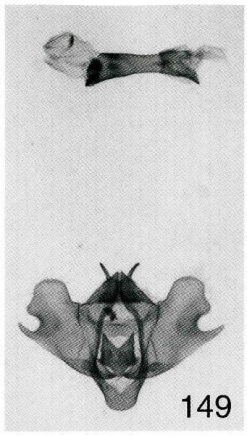

Soie grège de l'Ailante achetée à Pékin par la mission Russe.
Divers tissus de la soie des vers de l'Ailante, avec un échantillon de soie grège (1) — de la même grège (2) — de la même avec le fil obtenu par la quenouille (3) — échantillon d'autre tissu de la même soie (4). Tous ces échantillons détachés d'autres venus de la Chine desquels je garantis l'authenticité. Signé M. Thomine Desmazures et Baruffi, de Turin (23 Xbre 1859)
Cocons.
Poupe.
Etoffes.
(1)
(2)
(3)
(4)
Soie de l'Ailante tissée en Chine. Filoselle et Grège. Envoi du Pere Fantoni.
147

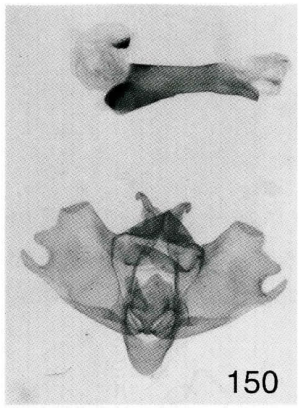

Ver à soie de l'Ailante, Bombyx Cynthia, et Ver du Ricin, Bombyx arrinicia, Premiers cocons obtenus en France Par M. Guérin-Méneville en 1858. — Il a donné ce ver à soie aux divers états de l'Europe, à l'Afrique, à l'Amérique, à l'Australie.
Il a été encouragé dans cette œuvre de dévouement aux intérêts publics par les société Imp. d'agriculture de France, d'Encouragement, d'acclimatation, et par la plupart des autres sociétés scientifiques et agricoles de la France et de l'étranger.
Aujourd'hui l'élevage de ce ver à soie, si profitable en Chine, est pratiqué ou essayé partout. Au lieu de n'être qu'Acclimaté, comme le ver à soie ordinaire, il est Naturalisé en France.
Le croisement du ver de l'Ailante avec celui du Ricin a été obtenu par M. Guérin-Méneville le premier. Ses métis sont féconds et peuvent être nourris indifféremment avec l'Ailante ou le Ricin. — Leur élevage sur le Ricin se développe rapidement dans la Confédération Argentine, au Paraguay et autres contrées de l'Amérique. — Voir la Revue de Sériciculture comparée et les autres ouvrages de Guérin-Méneville, ainsi que leurs traductions, et ceux de ses élèves et, entr'autres celui de M. Givelet sur l'Ailante et son [illegible] est [illegible] le plus récent et le plus complet publié sur cette matière.
ÉTOFFE
148

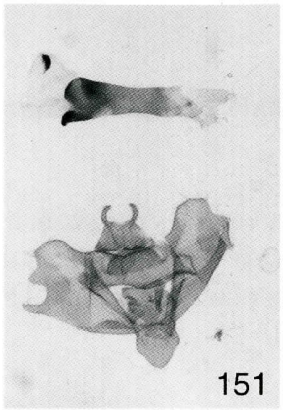
## Male Genitalia of *Samia*

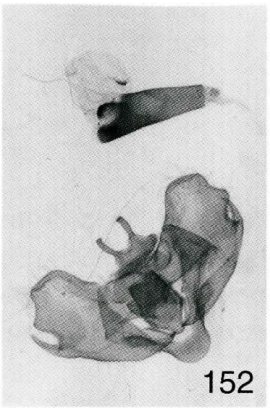
Each preparation is shown from a ventral view, with the valves opened, and mounted on microscope slides. The aedeagus was removed and is shown in lateral view. The permanent preparations were then photographed. All preparations by S. Naumann except where otherwise indicated.

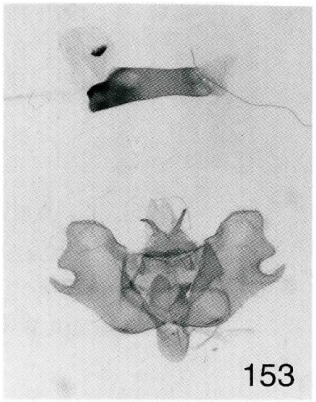
**149.** *Samia cynthia*, China, Beijing, no. 225/97 (MNHN).
**150.** *Samia cynthia*, China, Zhejiang Province, no. 50/97 (ZFMK).
**151.** *Samia cynthia*, North Korea, Mt. Myohyang-san, no. 72/97 (T. Witt).
**152.** *Samia cynthia*, Japan, Matsumoto, no. 153/97 (SMFL).
**153.** *Samia cynthia*, France, Val de Marne, no. 131/97 (SN).
**154.** *Samia wangi*, paratype, China, Guangdong Province, no. 366/99 (SN).
**155.** *Samia wangi*, China, Hunan Province, no. 144/97 (SN).
**156.** *Samia wangi*, paratype, China, Jiangxi Province, no. 16/96 (SN).
**157.** *Samia wangi*, paratype, China, Taiwan, Kaohsiung County, no.274/98 (TNM).
**158.** *Samia wangi*, northern Vietnam, Mt. Fan Si Pan, no. 947/96 Nässig (SMFL).
**159**. *Samia pryeri*, Japan, Honshu Island, Nagoya, no. 74/97 (T. Witt).
**160.** *Samia pryeri*, Japan, Okinawa Island, no. 173/97 (BMNH).
**161.** *Samia pryeri*, China, Heilongjiang Province, no. 49/96 (ZFMK).
**162.** *Samia canningi*, India, Assam State, no. 90/97 (RMNH).
**163.** *Samia canningi*, Pakistan, no. 81/97 Naumann = 4235 Witt (T. Witt).
**164.** *Samia canningi*, Nepal, no. 27/96 Witt (T. Witt).
**165.** *Samia canningi*, China, Xizang, no. 294/98 (SN).
**166.** *Samia canningi*, Myanmar, Dawna, no. 106/97 (SMFL).
**167.** *Samia ricini*, northern Thailand, Chiangmai, no. 9/96 (SN).
**168.** *Samia canningi* northern Vietnam, Mt. Fan Si Pan, no. 216/97 (SMFL).
**169.** *Samia ricini*, India, Assam State, no. 68/97 (SN)
**170.** *Samia fulva*, India, Andaman Islands, no. 123/97 (SN).
**171.** *Samia kohlli*, paratype, West Malaysia, Cameron Highlands, no. 297/98 (SN).
**172.** *Samia kohlli*, northern Thailand, Chiangmai, no. 111/97 (SMFL).
**173.** *Samia kohlli*, southern Myanmar, Dawna, no. 75/97 (SMFL).

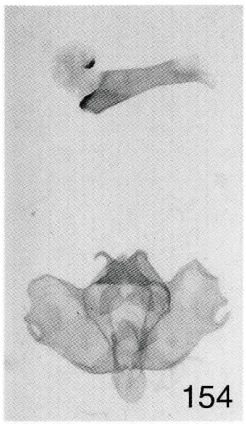

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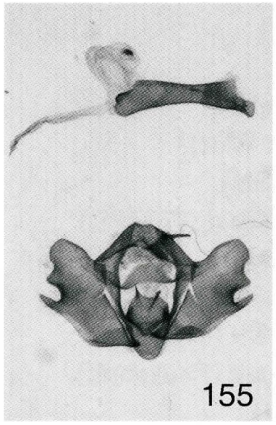

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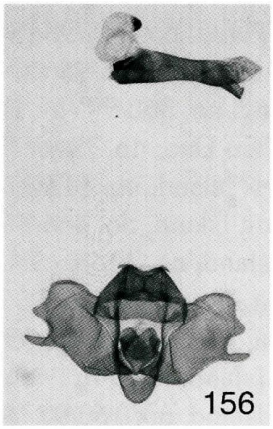

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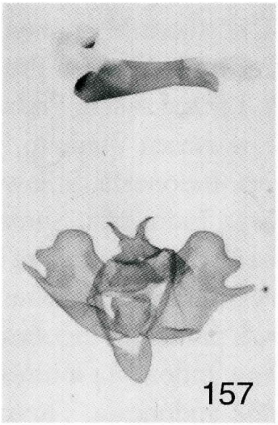

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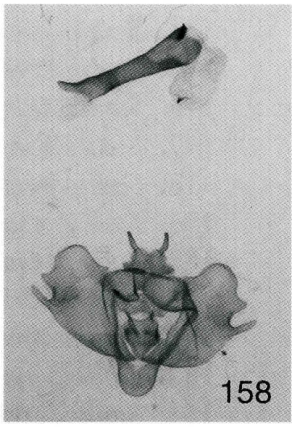

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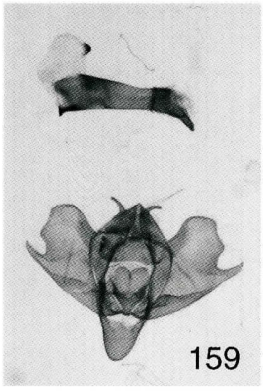

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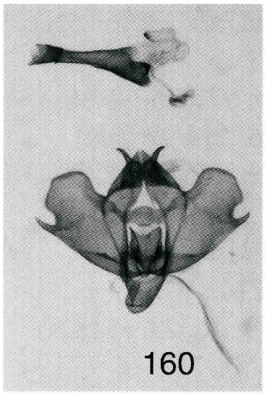

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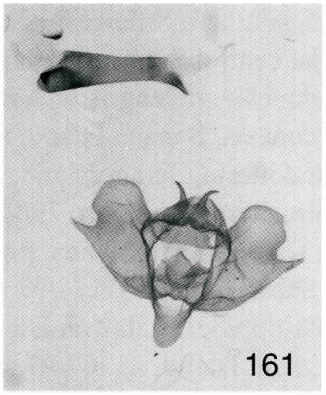

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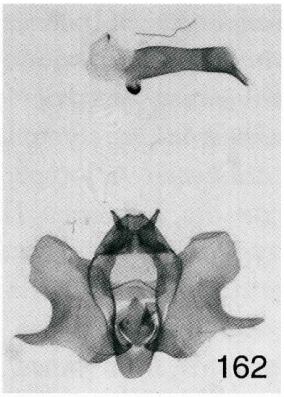

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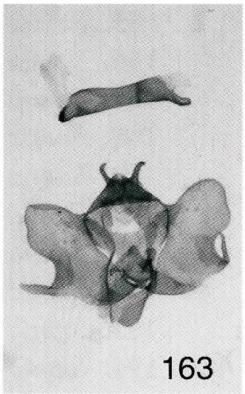

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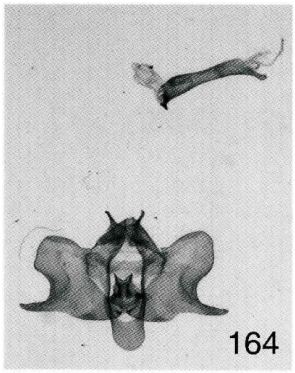

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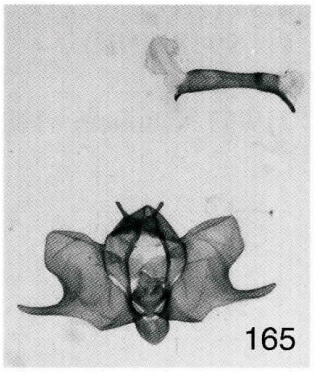

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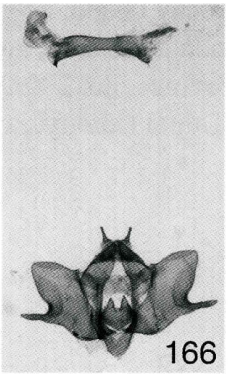

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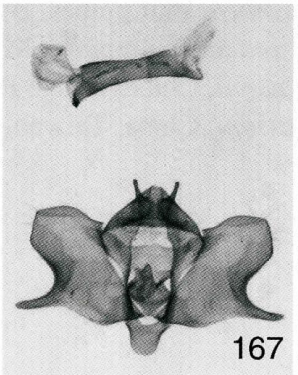

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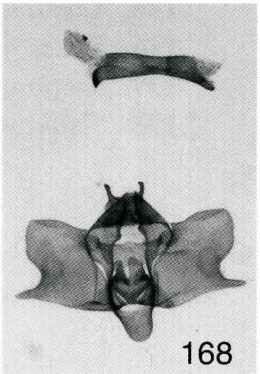

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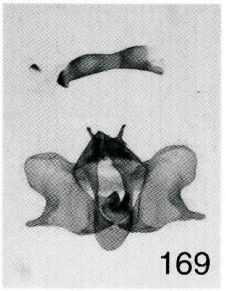

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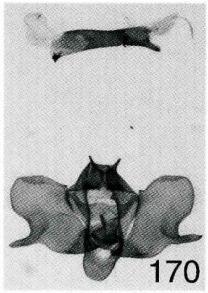

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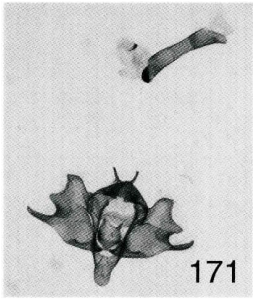

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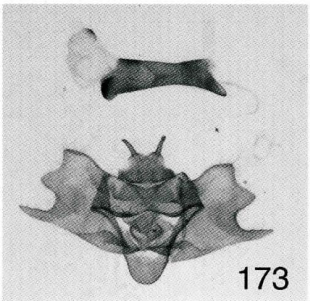

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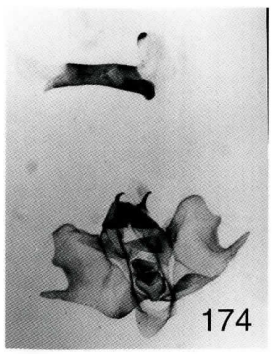

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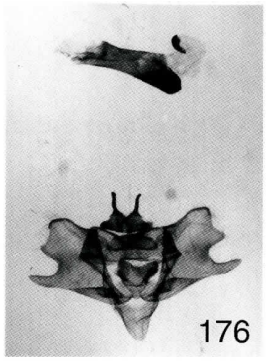
## Male Genitalia of *Samia*

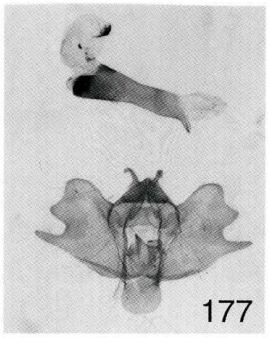
Each preparation is shown from a ventral view, with the valves opened, and mounted on microscope slides. The aedeagus was removed and is shown in lateral view. The permanent preparations were then photographed. All preparations by S. Naumann except where otherwise indicated.

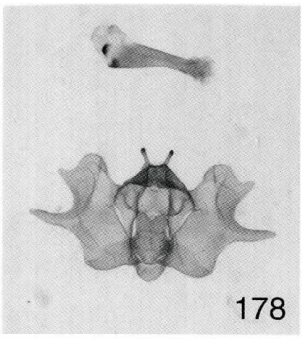
**174.** *Samia kohlli*, northern Myanmar, Putao, no. 318/98 (SN).
**175.** *Samia kohlli*, China, Yunnan Province, no. 295/98 (SN).
**176.** *Samia kohlli*, Laos, Louang Prabang, no. 360/99 (M. Beeke).
**177.** *Samia kohlli*, northern Vietnam, Tam Dao, no. 73/97 (T. Witt).
**178.** *Samia peigleri*, Indonesia, Sulawesi Island, no. 113/97 (SN).
**179.** *Samia insularis*, Indonesia, Sumatra Island, no. 466/86 Nässig (SMFL).
**180.** *Samia insularis*, Indonesia, Java Island, no. 13/96 (SN).
**181.** *Samia abrerai*, paratype, Indonesia, Java Island, no. 358/99 (SN).
**182.** *Samia abrerai*, paratype, Indonesia, Bali Island, no. 357/99 (SN).
**183.** *Samia yayukae*, Indonesia, Flores Island, no. 346 Paukstadt (Paukstadt).
**184.** *Samia yayukae*, Indonesia, Timor island, no. 160/97 (SN).
**185.** *Samia vandenberghi* Indonesia, southern Sulawesi Island, no. 14/96 (SN).
**186.** *Samia vandenberghi*, Indonesia, central Sulawesi Island, no. 161/97 (SN).
**187.** *Samia naumanni*, paratype, Indonesia, Peleng Island, no. 927/95 Nässig (SN).
**188.** *Samia naumanni*, paratype, Indonesia, Sanana Island, no. 114/97 (SN).
**189.** *Samia ceramensis*, holotype, Indonesia, Seram Island, no. B.M. 682 (BMNH).
**190.** *Samia naessigi*, Indonesia, Halmahera Island, no. 79/97 (SN).
**191.** *Samia tetrica,* West Malaysia, Cameron Highlands, no. 31/96 (SN).
**192.** *Samia tetrica,* East Malaysia, Sabah State, no. 178/97 (ZMHB).
**193.** *Samia treadawayi*, paratype, Philippines, Palawan Island, no. 29/96 (SN).
**194.** *Samia luzonica*, Philippines, Luzon Island, no. 67/97 (SN).
**195.** *Samia luzonica*, Philippines, Borocay Island, no. 159/97 (SN).
**196.** *Samia luzonica*, Philippines, Mindanao Island, no. 411/99 (RMNH).
**197.** *Samia watsoni*, China, Fujian Province, no. 209/97 (SN).
**198.** *Samia watsoni*, China, Taiwan, Taipei County, no. 219/97 Naumann =1180/97 (SMFL).

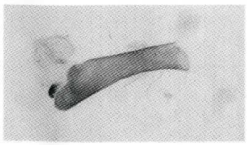

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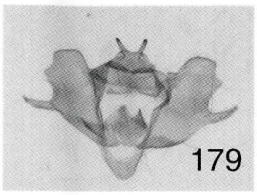

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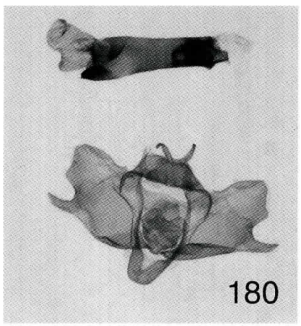

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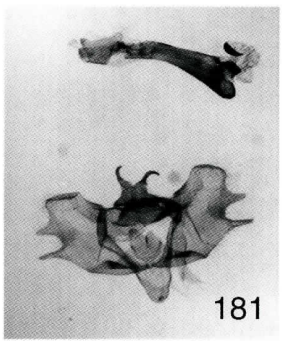

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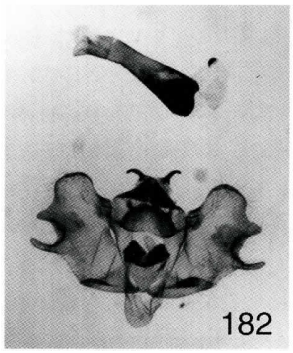

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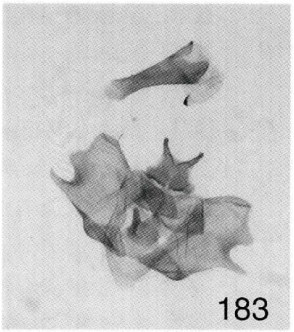


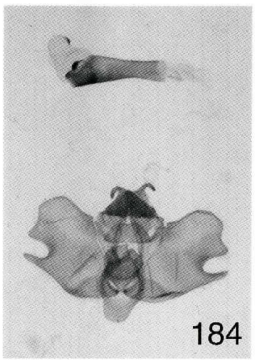

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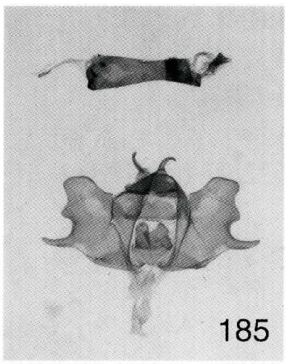

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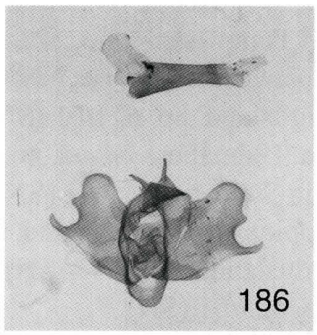

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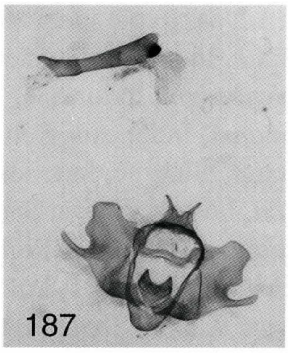

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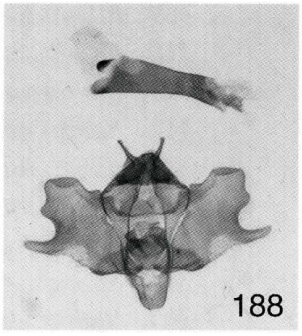

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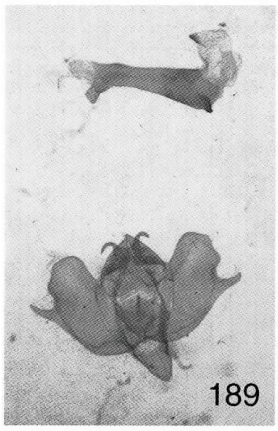

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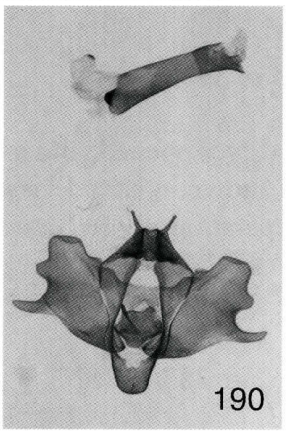

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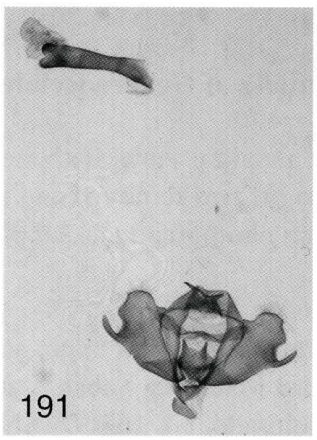

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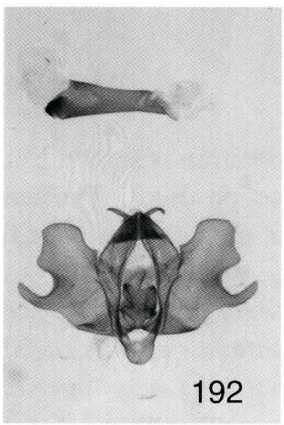

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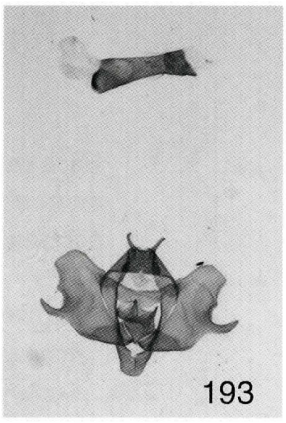

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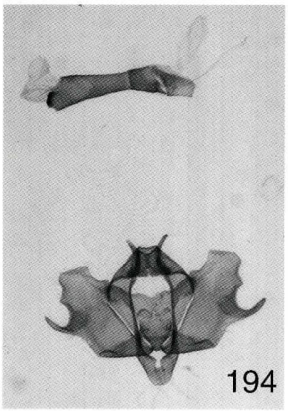

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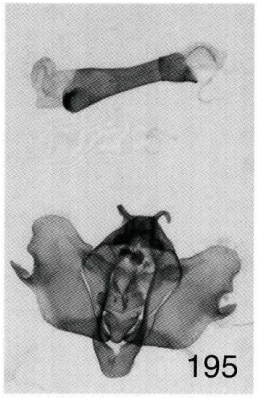

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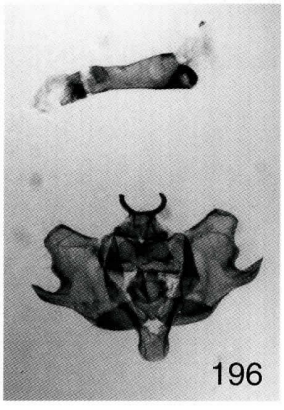

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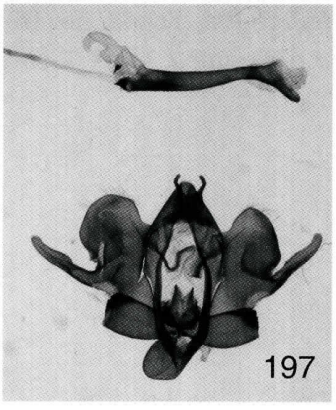

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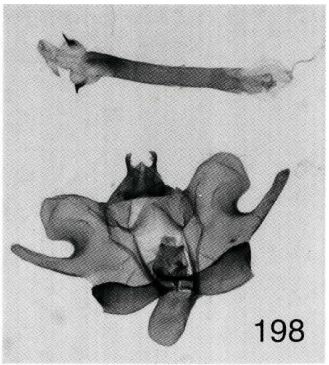

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## Female Genitalia of *Samia*

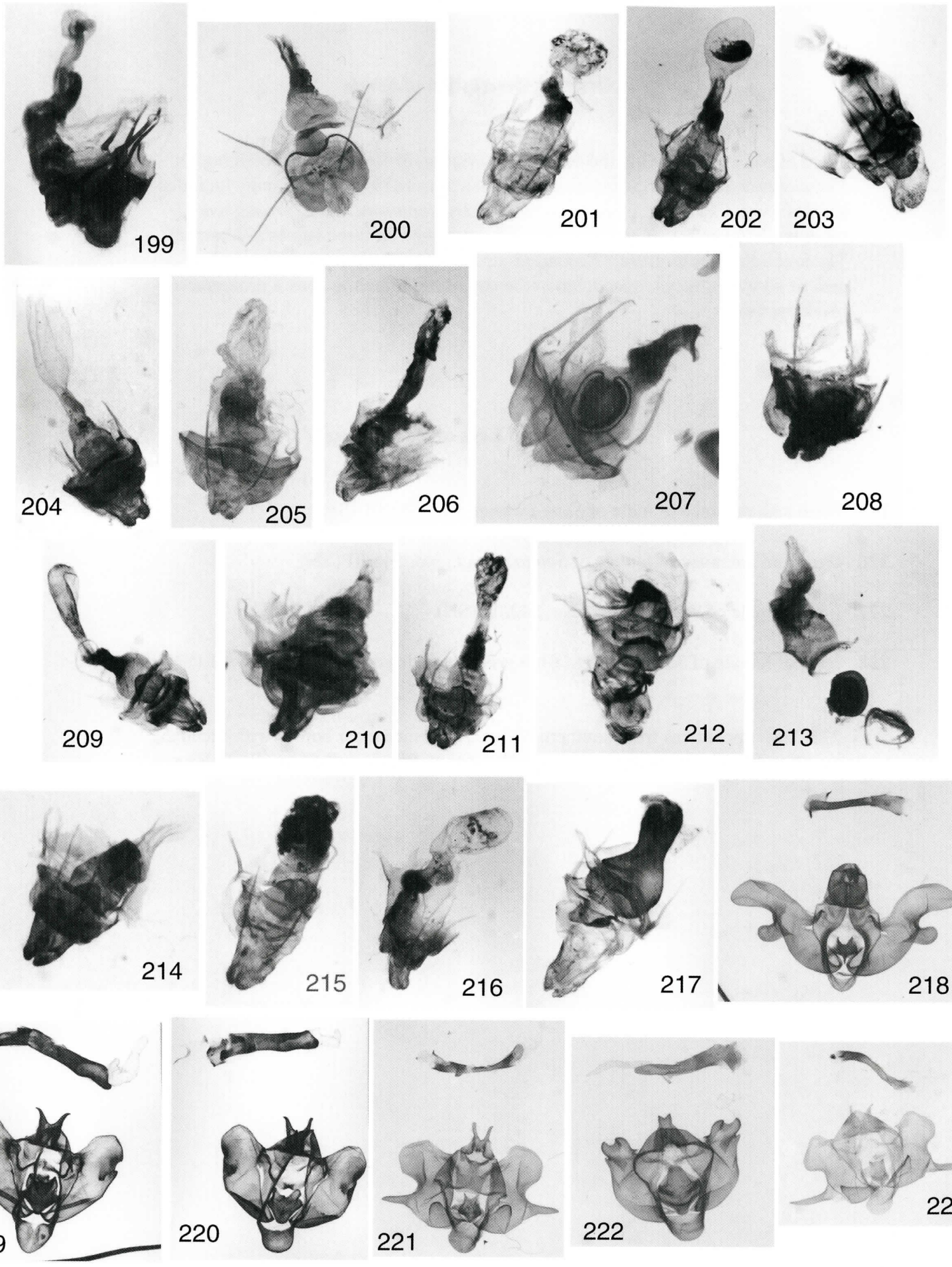
These were photographed in alcohol before being made into permanent slide mounts. All preparations by S. Naumann.

**199.** *Samia cynthia*, Japan, Honshu Island, no. 54/97 (SN).
**200.** *Samia wangi*, China, Guizhou, no. 147/97 (SN).
**201**. *Samia wangi*, China, Jiangxi, no. 632/01 (SN).
**202.** *Samia pryeri*, Japan, Okinawa Island, no. 624/01 (SN).
**203.** *Samia canningi*, India, Meghalaya, no. 631/01 (SN).
**204.** *Samia ricini*, India, Assam, no. 71/97 (SN).
**205.** *Samia fulva*, India, Andaman Islands, no. 126/97 (SN).
**206.** *Samia kohlli*, paratype, West Malaysia, no. 630/01 (SN).
**207.** *Samia peigleri*, Indonesia, Sulawesi Island, no. 150/97 (U. Brosch).
**208.** *Samia insularis*, Indonesia, Java Island, no. 626/01 (SN).
**209.** *Samia abrerai*, paratype, Indonesia, Java Island, no. 620/01 (SN).
**210.** *Samia yayukae*, Indonesia, western Timor Island, no. 628/01 (SN).
**211.** *Samia vandenberghi*, Indonesia, Sulawesi Island, no. 629/01 (SN).
**212.** *Samia naumanni*, Indonesia, Peleng Island, no. 621/01 (SN).
**213.** *Samia naessigi*, allotype, Indonesia, Halmahera Island, no. 622/01 (ZMHB).
**214.** *Samia tetrica*, East Malaysia, Sabah State, no. 619/01 (SN).
**215.** *Samia treadawayi*, paratype, Philippines, Palawan Island, no. 185/97 (SMFL).
**216.** *Samia luzonica*, Philippines, Luzon Island, no. 70/97 (SN).
**217.** *Samia watsoni*, China, Shaanxi, no. 625/01 (SN).

## Male Genitalia of Genera Related to *Samia*

Each preparation is shown from a ventral view, with the valves opened, and mounted on microscope slides. The aedeagus was removed and is shown in lateral view. The permanent preparations were then photographed. All preparations by S. Naumann.

**218.** *Rothschildia orizaba*, Mexico City, no. 164/97 (SN).
**219.** *Archaeoattacus edwardsii*, Myanmar, Kachin State, no. 377/99 (SN).
**220.** *Archaeoattacus staudingeri*, East Malaysia, Sabah State, no. 383/99 (SN).
**221**. *Hyalophora cecropia*, USA, Colorado, no. 163/97 (SN).
**222.** *Epiphora bauhiniae*, Tchad, no. 169/97 (SN).
**223.** *Callosamia promethea*, USA, Georgia, no. 165/97 (SN).


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## Original Description of *Samia*

**224.** Scan of page 156 showing the original description of *Samia* in Jakob Hübner's *Verzeichniss Bekannter Schmettlinge*, published in 1819. The originally included species were *S. cynthia*, *S. cecropia* (now in *Hyalophora*), and *S. promethea* (now in *Callosamia*). Hübner erroneously attributed all three names to Cramer. The text translates to mean: "Second group: *Samia*. The pattern in the central area of all wings very reduced, but at the end of the forewing apex a pronounced black eyespot."

## Antennae and Legs of *Samia wangi*

**225.** Head and antennae of male of *Samia wangi*. No. 542/01 (SN).

**226.** Head and antennae of female of *Samia wangi*. No. 543/01 (SN).

**227.** Legs of male of *Samia wangi*. No. 542/01 (SN).

**228.** Legs of female of *Samia wangi*. Both prothoracic legs shown. No. 543/01 (SN).

Figs. 225-228. Specimens from southern Shaanxi Province, near border with Sichuan. Slide mounts prepared by S. Naumann. Photographed by Ulrich Brosch.

1625. Attacus Atlas Linn. Syst. Phal. 1. Cram. 381. C. 382. A.

1626. A. Talas. Atlas Cram. 9. A.

1627. A. Aurota Cram. 8. A.

1628. A. Hesperus Linn. Syst. Phal. 2. Cram. 68. A.

### 2. Verein, Coitus 2.

### Samien, Samiae.

Die Mittezierde aller Flügel sehr nachläßig, aber am Ende der Schwingen ein deutliches schwarzes Augenfleckgen.

1629. Samia Cynthia Cram. 39. A.

1630. S. Cecropia Cram. 42. A. B.

1631. S. Promethea Cram. 76. A. B. & 75. A. B.

### 3. Verein, Coitus 3.

### Rhescynten, Rhescyntes.

Die Schwingen nur am Ende zierlich zackenstriemig.

1632. Rhescyntis Erythrinae Fabr. Spec. Bom. 9. Armida Cram. 197. A.

1633. R. Cassandra Cram. 197. B.

1634. R. Sylla Cram. 240. A.

1635. R. Hippodamia Cram. 126. B.

## Zweyte Rotte, Tribus secunda.

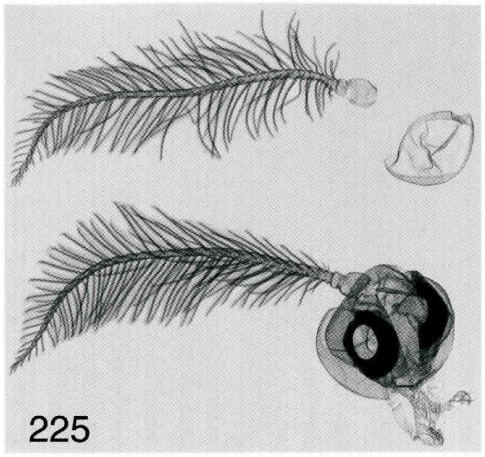
## Wahre, Verae.

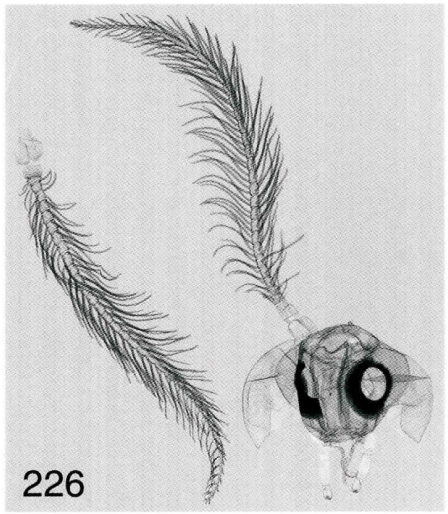
Der Kopf und der Rumpf sehr weich und artig behaart; die Schwingen kaum bunter als die Senken.

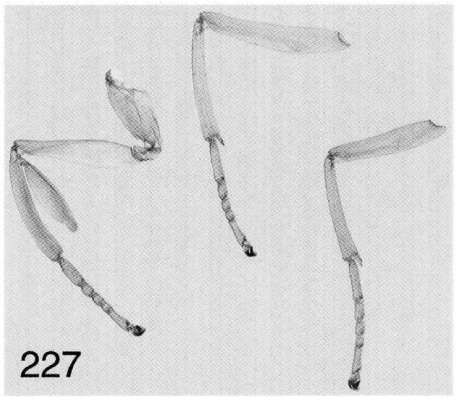
### 1. Stamm, Stirps I.

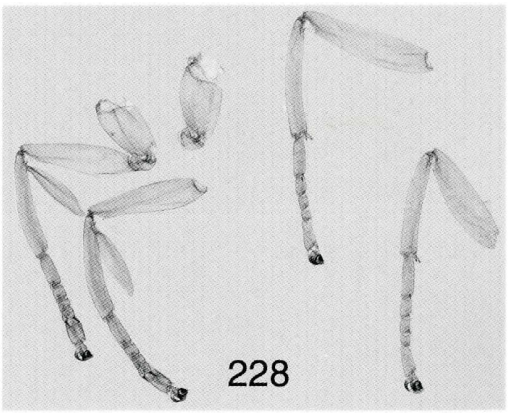
### Heräen, Heraeae.

Der Hals weißlich gefärbt; die Flügel mit großen zierlichen Flecken besezt.


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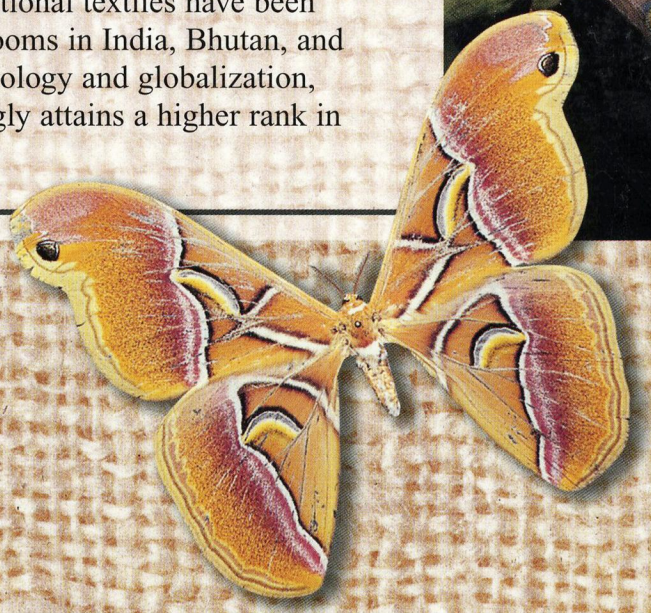

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The authors have collaborated to produce this taxonomic revision and compilation on the splendid moths and caterpillars of the genus *Samia*, of which 19 species are now known to science. All species are shown in full color. For centuries, colorful and traditional textiles have been woven from their silk on handlooms in India, Bhutan, and China, but with improved technology and globalization, this form of wild silk increasingly attains a higher rank in the world market.



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