

A review of selected species of **LYMANTRIA HÜBNER [1819]**

Including three new species (Lepidoptera: Noctuidae: Lymantriinae)

from
subtropical
and temperate
regions of Asia,
some
potentially
invasive to
North America

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Forest Health Technology Enterprise Team
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A review of selected species of *Lymantria* Hübner [1819]
Including three new species

Pogue and Schaefer



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Cover design by J. Marie Metz and Chuck Benedict. Photo of *Lymantria* (*Nyctria*) *flavida* by Paul W. Schaefer.

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A REVIEW OF SELECTED SPECIES OF *LYMANTRIA* HÜBNER [1819]
(LEPIDOPTERA: NOCTUIDAE: LYMANTRIINAE)
FROM SUBTROPICAL AND TEMPERATE REGIONS OF ASIA,
INCLUDING THE DESCRIPTIONS OF THREE NEW SPECIES,
SOME POTENTIALLY INVASIVE TO NORTH AMERICA

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ABSTRACT

The genus *Lymantria* Hübner [1819] contains some of the most destructive forest pests in the world. Potential invasive species of *Lymantria* from temperate and subtropical Asia are a threat to the forests of North America. Treated here are 31 species and three subspecies of *Lymantria* that, if accidentally introduced into North America, could result in severe damage to native forests and economic losses. Three species are described as new: *Lymantria* (*Porthetria*) *brunneoloma*, n. sp. from China, *Lymantria* (*Lymantria*) *pulverea*, n. sp. from Taiwan, and *Lymantria* (*Nyctria*) *flavida*, n. sp. from Okinawa, Japan. *Lymantria* (*Porthetria*) *dispar asiatica* Vnukovskij, **revised status**, is considered a valid subspecies. *Lymantria* (*Porthetria*) *umbrosa* (Butler), **revised status**, is considered a valid species and a **lectotype** was designated to establish nomenclatural stability. *Lymantria* (*Porthetria*) *albescens* Hori and Umeno and *Lymantria* (*Porthetria*) *postalba* Inoue, **revised status**, are considered valid species. *Lymantria* (*Porthetria*) *xylina nobunaga* Nagano, **revised synonymy**, is considered a synonym of *L.* (*Porthetria*) *xylina* Swinhoe. *Lymantria* (*Porthetria*) *lunata curvifera* (Walker) is a **new synonym** of *Lymantria* (*Porthetria*) *lunata* (Stoll). The following are treated as **new synonymies** of *Lymantria* (*Porthetria*) *brotea* (Stoll): *Lymantria* (*Porthetria*) *brotea lepcha* (Moore) and *Lymantria* (*Porthetria*) *brotea rudloffii* Schintlmeister. *Lymantria* *minomonis okinawaensis* Kishida is a **revised synonym** of *Lymantria* (*Lymantria*) *minomonis* Matsumura. *Lymantria* (*Lymantria*) *concolor septentrionalis* Schintlmeister is a **new synonym** of *Lymantria* (*Lymantria*) *concolor* Walker. *Lymantria* (*Lymantria*) *sinica albida* Schintlmeister is a **new synonym** of *Lymantria* (*Lymantria*) *sinica* Moore. *Lymantria* *aurora* Butler is a **revised synonym** of *Lymantria* (*Nyctria*) *mathura* Moore. The following are considered **new synonymies** of *Lymantria* (*Collentria*) *grisea* Moore: *Lymantria* *servula* Collenette, *Lymantria* *grisea servula* Collenette. *Lymantria* (*Spinotria*) *ban-taizana* Matsumura, **revised status**, is considered a valid species. Descriptions, distributions, and illustrations of adults are included. Larvae of 13 species and two subspecies are described and illustrated. Sections provide information on oviposition, biology and behavior, food plants, pheromonal communication, flight and pheromone periodicity, and seasonality.

DEDICATION

This review of selected, potentially invasive species of *Lymantria* is dedicated to the late Dr. Douglas C. Ferguson, formerly of the Systematic Entomology Laboratory, U. S. Department of Agriculture, Smithsonian Institution, Washington, D.C. Known affectionately as “Doug” by lepidopterists worldwide, he began this review in 1993. He was initially responsible for some of the early taxonomy decisions and for the preparation of many of the drawings of genitalia contained herein. Doug passed away in 2002 before this text was outlined and written. The authors trust that the final document would have had Doug’s full approval.

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1 INTRODUCTION

Invasive species are non-native species that have been introduced into an area either on purpose or by accident. Purposeful introductions of insects and weed species into the United States are most often done for biological control of other pest species. These would be considered beneficial introductions. Most often, invasive species are accidentally introduced and can become pests. Introduced insect pests cost United States agriculture approximately \$13.5 billion per year. In addition, the loss of forest products to invasive species amounts to \$2.1 billion per year (Pimentel et al. 2005).

CLASSIC CASE: AN INVASIVE TUSSOCK MOTH

The gypsy moth (*Lymantria dispar* Linnaeus) is one of the most recognized pests of forests and ornamental trees in the United States. Each year approximately \$11 million is spent on gypsy moth control (Pimentel et al. 2005).

The gypsy moth was intentionally brought into the United States by the French artist Étienne Léopold Trouvelot to be used in hybridization experiments with native silk producing moths, the goal being to develop a strain resistant to the protozoan disease, *Nosema bombycis*, which devastated the European silk industry. In 1868 or 1869 several moths escaped from Trouvelot's home in Medford, Massachusetts. He was aware of the pest potential of the gypsy moth and "publicly" announced it; however, there is no confirmation that he contacted any government officials. Within a year of the escape many prominent entomologists, including Charles Valentine Riley, had been informed (Liebhold et al. 1989).

By 1879, the gypsy moth had reached defoliating populations in Trouvelot's neighborhood. By this time, Trouvelot had returned to France. Ferguson (1978) recounts the interviews of the residents of Medford and Malden, Massachusetts, conducted by Forbush and Fernald (1896). Entire fronts of houses were covered with caterpillars and the ground was so thick with them that residents could not walk down the sidewalks without crushing them under foot and having them rain down upon them. All of the trees were defoliated and thousands of male moths flew about in the evenings. Egg masses were found on tree trunks, stone walls, fences, and buildings, often nearly covering some structures. A large-scale eradication program was begun in 1890, but it failed and the gypsy moth has continued to spread (Liebhold et al. 1989).

The gypsy moth now occurs in eastern North America and is a major pest of forest trees from Nova Scotia, New Brunswick and Maine, south to North Carolina, and northwest into Wisconsin (Fig. 1). Isolated populations have occurred in many other states in the South, Midwest, and far West; in general, these populations have been eradicated by aerial spraying and intensive trapping technology. Since 1991, the added threat of invasion has been that of incursions of material typed as "Asian gypsy moth" (AGM). In 2005, there were 14 confirmed detections of AGM material in North Carolina, Washington, Oregon, and Idaho; in 2006 there were confirmed detections in two locations in California, one in Texas, and one in Oregon. Incursions have occurred repeatedly in the Vancouver area of Canada (1992–1995,

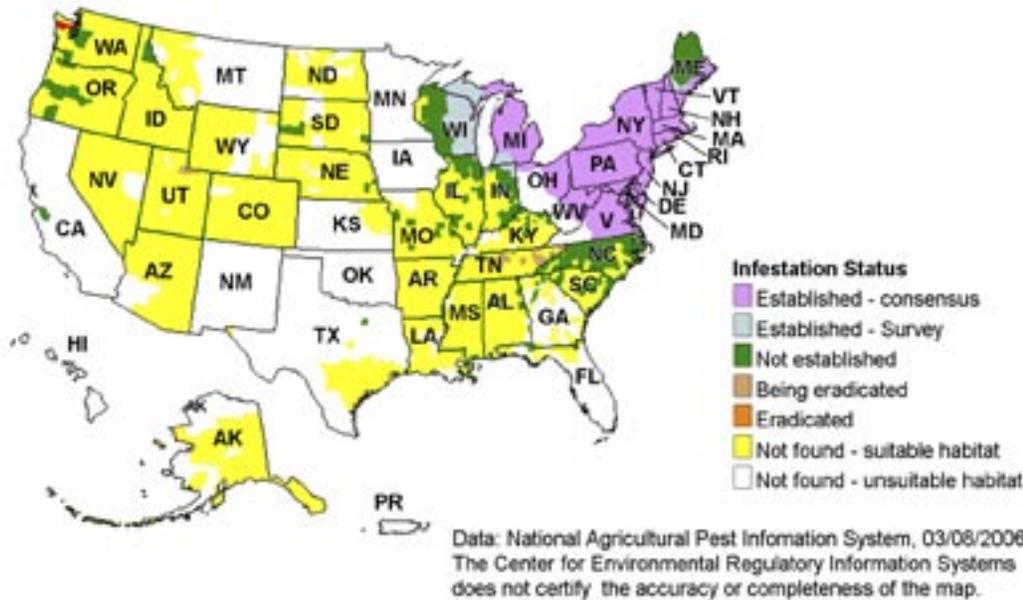


Figure 1. Distribution and status of *Lymantria dispar dispar* in the United States and Puerto Rico. Data: National Agricultural Pest Information System, 03/08/2006. The Center for Environmental Regulatory Information Systems does not certify the accuracy or completeness of the map.

2004). As well, there have been several years of detections of Asian-type males and a series of interceptions of suspected Asian-type egg masses (Marie-José Côté, pers. comm.). Each of these incursions has been met with a varying degree of control application, based on the available evidence and on the likelihood of population establishment. Generally, these potential threats have resulted in combined state and federal emergency suppression efforts costing many millions of dollars.

The already established North American gypsy moth and the potential threat of invasion by the various forms of gypsy moth detailed in this study give us ample reason to be most vigilant and responsive to still more incursions of potentially invasive forms into North America. The various forms of gypsy moths we discuss in this study represent both new and renewed threats to North American forests. The gypsy moth and all its various forms represent the most costly forest pest species, ever. We hope that this study will better inform and prepare forest entomologists for the time when new invasive species arrive in North America. Guidelines for proper response and control strategies for use on future, similar incursions of Lymantriidae (now more properly referred to as Lymantriinae within the Noctuidae), have been addressed (Stibick 2000); we hope they will be adequate to prevent future establishment of any invasive moth.

TAXONOMY

Linnaeus (1758) was the first to describe both the gypsy moth and the nun moth, *L. monacha* (Linnaeus), which are important pest species in Europe and Asia. As collections from various parts of the world became available to taxonomists working at major European museums, more species of *Lymantria* were described. *Lymantria* from the collections of the British

Museum were described by Stephens (1829), Walker (1855a, b, 1865), Butler (1878, 1889), and Swinhoe (1903). Many *Lymantria* were described in faunal studies, including some conducted in Japan (Butler 1877, 1881; Inoue 1957; Inoue et al. 1982a, b; Leech 1888, 1899; Matsumura 1911, 1921, 1927, 1931, 1933), India (Butler 1883, Forsayeth 1884, Hampson 1892, Swinhoe 1886), Malaysia (Collenette 1932), Borneo (Holloway 1999), and the Indo-Australian region (Collenette 1938; Strand 1915, 1923). Schintlmeister (2004) was the first to do a complete revision of the genus and to adopt subgeneric taxa. *Lymantria* larvae from India were described by Gardner (1938, 1941) and from North America by Ferguson (1978).

Recent classifications using both morphological (Fibiger and Lafontaine 2005, Lafontaine and Fibiger 2006) and molecular characters (Mitchell et al. 2005) have resulted in the Arctiidae and Lymantriidae being included within the quadrifine Noctuidae. The quadrifine Noctuidae is defined as a group in which hindwing vein M2 originates in the lower 1/3 of the discal cell and is as strong as vein M3: Thus, the cubital vein (Cu) appears to have four branches. In the primitive groups of quadrifine Noctuidae (Rivuliinae, Boletobiinae, Hypenodinae, Araeopteroninae, Eublemminae, Herminiinae, Scolecocampinae, Hypeninae, Phytometrinae, Aventiinae) vein M2 is in the lower 1/3 of the discal cell. In derived groups, vein M2 is adjacent to M3 and these are referred to as having a true quadrifine hindwing. The families Nolidae, Strepsimanidae, Arctiidae, and Lymantriidae belong to the true quadrifine Noctuidae. The more derived trifine Noctuidae refers to the subfamilies in which hindwing vein M2 is vestigial or absent, so the cubital vein appears three-branched.

The classification of Mitchell et al. (2005) resulted in a close relationship of the clade comprising the Arctiidae and Lymantriidae and a clade containing four subfamilies of quadrifine Noctuidae (Calpinae, Catocalinae, Strepsimaninae [on the basis of *Phobolusia* Dyar, which was treated as Scolecocampinae in Fibiger and Lafontaine (2005)], Rivulinae [on the basis of *Mycterophora* Hulst, which was treated as Boletobiinae in Fibiger and Lafontaine (2005)], and Eublemmini [Eublemminae in Fibiger and Lafontaine (2005)]). To preserve the family rank of the Arctiidae and Lymantriidae, Mitchell et al. (2005) had to raise six subfamilies to family status (Stictopteridae, Euteliidae, Aganaidae, Herminiidae, Hypenidae, and Catocalidae), thereby restricting the family Noctuidae to the trifine noctuids.

Using morphological characters, Lafontaine and Fibiger (2006) agreed with Mitchell et al. (2005) that the Arctiidae and Lymantriidae belong within the quadrifine Noctuidae. However, they disagreed to the ranking of the Arctiidae and Lymantriidae treating them as subfamilies of the Noctuidae. Lafontaine and Fibiger (2006) define the Noctuidae as having a quadrifid forewing, where vein M2 is in the lower portion of the discal cell, so the cubital vein appears four-branched. The other families in the superfamily Noctuoidea (Oenosandridae, Notodontidae, Doidae) have a trifid forewing, where vein M2 originates near the middle of the discal cell and the cubital vein appears three-branched. By treating the Arctiidae and Lymantriidae as subfamilies of the Noctuidae, fewer higher-level taxonomic changes are required to maintain the Noctuidae as a monophyletic group. We follow Lafontaine and Fibiger (2006) in treating the Lymantriidae as a subfamily of the Noctuidae. (See above.)

Little has been published on the eggs and pupae of Lymantriinae. Eggs of *L. dispar dispar* (Linnaeus) and *L. monacha* were described and illustrated by Döring (1955). Pupae of *L. dispar dispar* and *L. monacha* were described and illustrated by Nakamura (1976) and Patocka and Turcáni (2005a, b). Nakamura (1976) also described and illustrated *L. fumida* Butler and *L. mathura* Moore.

The genus *Lymantria* reaches its greatest diversity in Asia. Treated here are 31 species, including three new species, and three subspecies. These species represent potential invasive species from mostly temperate and subtropical Asia, and species that resemble the gypsy moth from subtropical Asia. If known, detailed descriptions are given of the adults and larvae, life histories, host plants, pheromones, and distributions.

FEMALE FLIGHT AND PHENOLOGY

In flight behavior of *Lymantria* species, two distinct strategies have evolved. One is the diurnal approach exhibited by all known *L. dispar sensu lato*, which are easily recognized by a very much reduced compound eye size. All other species covered in this review, as well as almost all of the many tropical species (see Holloway's (1999), *Moths of Borneo*), are strictly nocturnal. From what we now know, these nocturnal species have stratified the scotophase into

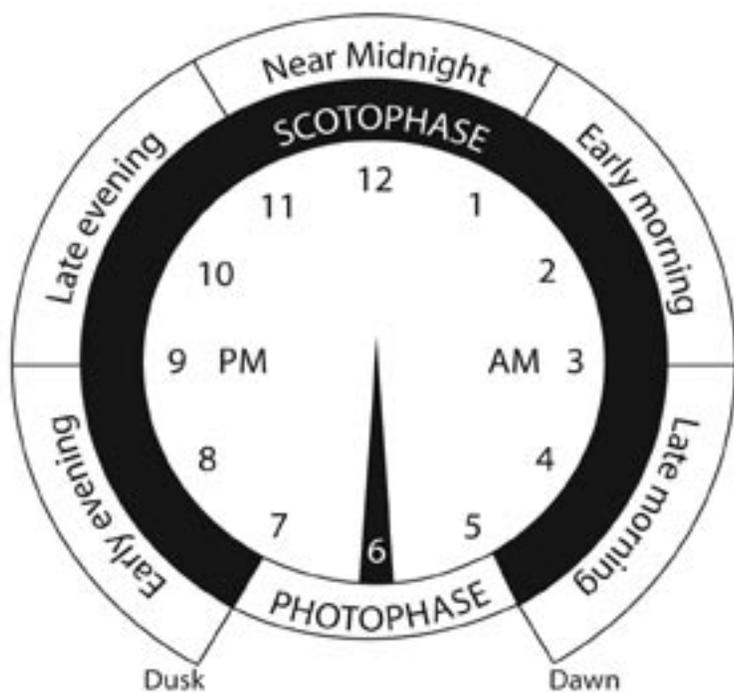


Figure 2. Partitioning of the night (Scotophase) into five equal biologically active periods used in referring to moth nocturnal behavior. Note: these time periods vary relative to the local clock time due to geographical location, local time zones, and seasons.

distinct activity periods (Fig. 2). In brief, we recognize five sequential nocturnal periods; Early Evening (7 to 9 PM), Late Evening (9 to 11 PM), Near Midnight (11pm to 1 AM), Early Morning (1 to 3 AM), and Late Morning (3 to 5 AM). These times are more appropriately celestial times, as they vary with regions or countries and international time zones. The activities of these nocturnal moths tend to be restricted to periods mostly defined by one or two of these periods. Two examples well illustrate the importance of these behaviors. In collaboration with Dr. Gerhard Gries (Simon Fraser University, Burnaby, B.C., Canada), we have detected that in Europe *L. monacha* males respond mostly during the late evening period, while in Japan males respond in the late morning hours. We have proposed that this is a case of character displacement in response to other sympatric species in Japan (e.g. *L. fumida* Butler) (Gries et al. 2001).

In Thailand, two tropical sympatric species have clearly partitioned the night into their own activity periods. *Lymantria atemeles* Collenette responds to (7R,8S)-*cis*-7,8-epoxy-2-methyloctadec-17-ene [(+)-disparlure] in the late evening while in the same habitat, but not competing for the same food sources, *L. plumbalis* Hampson (not covered in this review) responds to *cis*-7,8-epoxy-2-methyleicosane (xylylure) in the late morning hours. Clearly, both temporal and chemical separation have resulted in sympatric species maintaining clear communication channels. We (G. Gries and PWS) hypothesize that this principle is maintained wherever we encounter sympatric species of *Lymantria* (and likely other closely related

moths). This feature of these moths will become more evident as we review what is known about each species. Much of this information would not be possible without the synthetic lures to which males respond, and in doing so, demonstrate their preferred flight activity.

FOOD PLANTS

Unless indicated otherwise, when considering all food plants of these moths we followed the nomenclature and family placement presented in Mabberley's (1987) *The Plant-book*. In addition, we found *A checklist of names of 3,000 vascular plants of economic importance* (Terrell et al. 1986) most useful as a reference. Finally, we consulted the USDA Forest Service, Forest Products Laboratory Center for Wood Anatomy Research website (<http://www2.fpl.fs.fed.us/>) for many botanical synonymies and author's names.

COMMON NAMES

The common names given are in English unless indicated otherwise. Many others are transliterations. In one case, we distinguish the differences between American and English (Great Britain) spellings. A few of the Russian names come from Baranchikov and Kucerea (2002). In this text, use of "*L. dispar sensu lato*" refers to all the taxa that are very similar and have been generally referred to as "gypsy moths." This includes the Indian gypsy moth, *L. obfus-cata* Walker, and the several Asian and Japanese forms that traditionally have been referred to as "gypsy moths." Herein, we have separated out various taxa of this species complex and have attempted to clarify useful, functional taxa with clear biological distinctiveness. For the most part, the decisions to do this are based on morphological evidence, but also functional dimorphism (flight capability of females) and geographical isolation were taken into account. Some of these taxa are known to interbreed in the laboratory, i.e. *L. obfus-cata* X *L. dispar* (of North America); but of course, populations of these two species are allopatric in nature.

For regulatory purposes, the U. S. Department of Agriculture has defined the Asian Gypsy Moth as "any biotype of *Lymantria dispar (sensu lato)* possessing female flight capability." We have added to that definition, the *sensu lato*, in light of the numerous changes in nomenclature and our current interpretation of the taxonomy of this group, specifically the recent revision of the genus *Lymantria* by Schintlmeister (2004) and our current study and intensive revision of the various taxa of potentially invasive species. At the very heart of this revisionary study is the so-called "Asian Gypsy Moth," which previously has been considered a complex of species or subspecies (Inoue 1957; Goldschmidt 1940). We propose these names and their descriptions in the body of the text and, for convenience, in Tables 1 and 2. Although our concept of Asian Gypsy Moth remains, that it is comprised of those forms with females capable of flight, we recognize the changes we propose to nomenclature will lead to significant changes to the species names. Still, we're confident the following discussion will validate our interpretation of the many names ascribed to "Asian Gypsy Moth" and other forms of "Gypsy Moth."

MATERIALS AND METHODS

Much of the information gained about *Lymantria* began with the overseas assignment of Paul W. Schaefer (PWS) as location leader and sole American at the U. S. Department of Agriculture, Agricultural Research Service, Asian Parasite Laboratory, in Sapporo, Hokkaido, Japan, from May 1975 through August 1979. Since then, PWS has made repeated visits to various locations in Asia, especially Japan, even after his retirement from the U. S. Department of Agriculture in April, 2006. Without the experiences of field work in Japan, China, Mongolia, Korea, Taiwan, and Thailand (and other tropical areas), and the ability to rear liv-

Table 1. Gypsy Moth (non-Asian or Indian). Nearly wingless and/or flightless females.

Common Name(s)	<i>Lymantria</i> Species or Subspecies (Subgenus: <i>Porthetria</i>)	Latest authoritative reference for name	Brief Distribution	Field ID Characteristics
North American Gypsy Moth (NAGM)	<i>dispar dispar</i>	Present Study	Eastern North America	Females winged but flightless
European Gypsy Moth (EGM)	<i>dispar dispar</i>	Present Study	Europe, western Asia and North Africa	Females winged but flightless
Indian Gypsy Moth (IGM)	<i>obfuscata</i>	Beeson, 1941 Roonwal, 1954	Northern India, Pakistan & Afghanistan	Small males, females with highly reduced wings

Table 2. Asian Gypsy Moth. Winged and flight-capable females.

Common Name(s)	<i>Lymantria</i> Species or Subspecies (Subgenus: <i>Porthetria</i>)	Latest authoritative reference for name	Brief Distribution	Field ID Characteristics
Asian Gypsy Moth (AGM)	<i>dispar asiatica</i>	Present Study	Asia mostly east of Urals, China Korea	Females fly to lights, often en masse
Japanese Gypsy Moth (JGM)	<i>dispar japonica</i>	Schintlmeister, 2004; Present Study	All main islands in Japan; limited in Hokkaido	Large males, very dark brown color
Okinawan Gypsy Moth (OGM)	<i>albescens</i>	Schintlmeister, 2004; Present Study	Okinawa, southern Ryukyu Islands	Males with white hind wings, more southerly
Hokkaido Gypsy Moth (HGM)	<i>umbrosa</i>	Present Study	Hokkaido, esp. eastern part	Smaller males, light in color
Tsushima Gypsy Moth (TGM)	<i>postalba</i>	Present Study	S. Kyushu & N. Ryukyu Islands	Male with white hind wing, more northerly

ing material in the containment facility at the Beneficial Insects Introduction Research Unit, Newark, Delaware, first-hand knowledge and understanding of these moths would not have been possible.

Figures describing behavior, interesting life forms, and economic damage are imbedded within the text. Figures illustrating taxa descriptions are arranged in individual plates at the end of the text.

Genitalic dissections were prepared as outlined in Pogue (2002) and both Canada Balsam and Euparal were used as mounting media. Photographs of adults were either taken with a 35-mm camera using Kodak Kodachrome® slide film or a Nikon D1X digital camera using a Microptics® ML-1000 Flash Fiber Optic Illumination System. Images of habitats and life stages (larvae and adults) in nature were taken with either a Asahi Pentax H2, Nikon N70, or Nikon 8008S camera often using a Nikon AS-14 or Nikon Macro Speedlight SB-29S ringflash and 35-mm Kodak Ektachrome® and Kodachrome® slide film. Digital scanning was done with an Epson Stylus Photo RX600® scanner. All scanned images were manipulated and plates prepared using Adobe® Photoshop CS.

To prepare larvae for scanning electron microscopy (SEM), the first and last instars were boiled in water and placed in 409® detergent for cleaning. After several rinses in water, larvae were dehydrated in EtOH incrementally (20%, 50%, 75%, 95%) to 100% EtOH prior

to chemical drying in Hexamethyldisilazane (HMDS), as described by Oshel (1997). After chemical drying, specimens were mounted on SEM stubs and coated with gold-palladium (40–60%) using a Cressington sputter coater. The ultrastructure of all larvae was studied with an Amray 1810 scanning electron microscope.

Prior to SEM study, gross morphological observations and measurements of all larvae were made using a dissecting microscope (reflected light) with a calibrated micrometer. Terminology for chaetotaxy follows Stehr (1987). All vouchers of larvae are deposited in the collection of Paul W. Schaefer (PWS).

Adult specimens were obtained by collecting with sticky traps or so-called “USDA milk carton traps” (with enclosed Hercon® Vaportape™ Insecticidal strips (Hercon Environmental Co, Emigsville, Pennsylvania)) baited with pheromones, at lights, and by rearing from eggs and larvae. Many samples were obtained through cooperators or collectors and all living exotic material was imported under USDA importation permits (#36668 or #66309). Nearly all laboratory rearing was done at the containment facilities at the USDA, ARS, Beneficial Insects Introduction Research facility at Newark, Delaware. Culture of European *L. monacha* continues at the USDA, Forest Service quarantine facility at Ansonia, Connecticut, under the direction of Melody Keena, who provided us with samples.

Pheromones were obtained by acquiring virgin females through collection or rearing. The abdominal tip was severed (containing the pheromone gland) and extracted in HPLC grade hexane for 10 to 30 minutes. Frequently in the rearing process, since males usually develop and eclose before females, male pupae were retarded in their development by holding them at 13° C (55° F). This permitted females to be processed as needed upon normal eclosion, and made males available after sampling the females (i.e., reversing the normal eclosion sequence). Extraction samples and male pupae were shipped to Dr. Gerhard Gries, Simon Fraser University, Burnaby, B.C. Canada, for analysis by coupled gas chromatographic-electroantennographic detection (GC-EAD). Details for each analysis varied (e.g., Gries, R. et al. 2005 and citations therein); ultimately a candidate pheromone was field tested on location where the original sample was collected. Field tests of our synthetic pheromone candidates have occurred in the United States (Roth Rock State Park, near State College, Pennsylvania, and North East, Maryland), Japan (Bibai, Hokkaido; Morioka and Toyota, Honshu; and Okinawa), Taiwan (FuShan, Kuanyin and Taoyuan), Korea (Soraksan National Park, Wontong and Yongdae-ri), and Thailand (Kampeng Saen and Cheng Mai).

Literature acquisition was facilitated by several available bibliographies, especially that of Schaefer et al. (1988) for relevant Japanese literature and food-plant compilations, and that of Baranchikov et al. (1998) for literature in Russian. Acronyms of museum and private collections include the following:

ASD – Alexander Schintlmeister private collection, Dresden, Germany

BMNH – The Natural History Museum, London, England

CMP – Carnegie Museum of Natural History, Pittsburgh, Pennsylvania

DEI – Deutsches Entomologisches Institut, Kleinmachnow, Eberswalde, Germany

HUS – Entomological Institute, Hokkaido University, Sapporo, Japan

MAKB – Zoologisches Forschungsinstitut und Museum “Alexander Koenig,”
Bonn, Germany

NRS – Naturhistoriska Riksmuseet, Stockholm, Sweden

PWS – Paul W. Schaefer, Beneficial Insects Introduction Research Laboratory, Agricultural Research Service, USDA, Newark, Delaware

SMF – Senckenberg Museum, Frankfurt-am-Main, Germany

ZMHB – Zoologisches Museum, Humboldt University, Berlin, Germany

ZMUC – Zoologisk Museum, Universitets Copenhagen, Copenhagen, Denmark

2 KEYS

KEY TO FIRST INSTAR LARVAE OF SELECTED *LYMANTRIA* SPECIES

First instar larvae of *Lymantria* can be distinguished by all dorsal, subdorsal, and lateral verrucae having spine-like setae with a subbasal bulbous process and barbed setae with an elongate socket base (Pl. 33, Figs. 2, 4–5; Pl. 36, Fig. 4; Pl. 37, Figs. 2–4; Pl. 38, Figs. 1–3).

1. Pinaculum bearing SD1–2 on T1 separate from prothoracic shield (Pl. 38, Figs. 1–3); stemma 3 and 4 smooth; five crochets on A3–6.2
- 1'. Pinaculum bearing SD1–2 on T1 approximate to prothoracic shield (Pl. 38, Fig. 4); Stemma 3 and 4 rough and tripartite (Pl. 38, Fig. 5); six crochets on A3–6 (Pl. 38, Fig. 6) *obfuscata*
2. SD2 on T1 lacking microbarbules (Pl. 38, Fig. 1).....3
- 2'. SD2 on T1 with short microbarbules, spine-like, and half the length of SD1 (Pl. 38, Fig. 3) *monacha*
3. SD2 on T1 greater than two-thirds length of SD1 (Pl. 38, Fig. 1) *dispar*
- 3'. SD2 on T1 less than half length of SD1 (Pl. 38, Fig. 3)..... *mathura*

KEY TO LAST INSTAR LARVAE OF SELECTED *LYMANTRIA* SPECIES

Ferguson (1978) includes a key to the last instar larvae of North American Lymantriinae genera.

1. Head capsule with distinct black stripes adjacent to frons (Pl. 32, Figs. 1–4, 6–7). . 2
- 1'. Head capsule lacking distinct black stripes adjacent to frons (Pl. 32, Figs. 5, 8–9).. 9
2. Black stripes on head capsule extend below frons (Pl. 32, Figs. 1–2, 6) 3
- 2'. Black stripes on head capsule extends to or just below F1 (Pl. 32, Figs. 3–4, 7) 4
3. Head capsule lacking large dorsal and lateral black spots (Pl. 32, Figs. 1–2) ... *dispar*
- 3'. Head capsule with six large dorsal and lateral black spots (Pl. 32, Fig. 6) *lucescens*
4. Black stripes on head capsule adjacent to coronal suture (Pl. 32, Fig. 7); T1 with short, red bushy setae (Pl. 31, Fig. 1; Pl. 50, Figs. 5–6)..... *atemeles*
- 4'. Black stripes on head capsule separate from coronal suture (Pl. 32, Figs. 3–4); T1 lacking short, red, bushy setae..... 5

5. Head capsule with small dark brown or black spots (Pl. 32, Figs. 4–6) 6
- 5'. Head capsule lacking small dark brown or black spots (Pl. 32, Figs. 3–4) 8
6. D verrucae dark brown to yellowish-brown on at least one segment of thorax
(Pl. 29, Fig. 6; Pl. 30, Fig. 1) 7
- 6'. D verrucae blue on at least one segment of thorax (Pl. 30, Figs. 2–4) *xylina*
7. D verrucae blue on T1–A3; D verrucae red on A4–A9 (Pl. 29, Fig. 6) *obfuscata*
- 7'. D verrucae brown to yellowish brown on T1–A2; D verrucae yellowish brown on
A3–A9 (Pl. 30, Fig. 1) *albescens*
8. D and L verrucae on T1–A9 reddish-brown (Pl. 31, Fig. 4) *fumida*
- 8'. D verrucae on T1 and A3–9 light brown, T2–3 and A1–2 brown; L verrucae
on T1–A9 pale brown to near white *umbrosa*
9. Head capsule concolorous, contrasting spots lacking or very faint
(Pl. 32, Figs. 13–14) 10
- 9'. Head capsule with contrasting spots (Pl. 32, Figs. 7–8, 11) 11
10. Head capsule black (Pl. 32, Fig. 13) *serva*
- 10'. Head capsule amber with slightly darker spots (Pl. 32, Fig. 14) *bantaizana*
11. Head capsule gray with small dark gray spots (Pl. 32, Fig. 11) *mathura*
- 11'. Head capsule light brown with small dark brown to black spots
(Pl. 32, Figs. 7–8) 12
12. All abdominal D verrucae, except A5, blue (Pl. 30, Fig. 5) *monacha*
- 12'. All abdominal D verrucae, except A5, pale orange (Pl. 30, Fig. 6) *minomonis*

3 DESCRIPTIONS OF SPECIES

SUBGENUS *PORTHETRIA* HÜBNER

Porthetria Hübner, [1819]:160. Type species: *Phalaena dispar* Linnaeus, 1758:501; designated by Kirby, 1892:475.

Sericaria Berthold, 1827:480. Type species: *Phalaena dispar* Linnaeus, 1758:501; designated by Blanchard [1846]: pl. 152.

Enome Walker, 1855b:883. Type species: *Enome ampla* Walker; by monotypy.

Pegella Walker, 1866:1922. Type species: *Pegella curvifera* Walker; by monotypy.

Barbona Moore, 1879b:55. Type species: *Barbona carneola* Moore; by monotypy.

As in most species, the forewing ground color in males is brown or white, with a full complement of lines consisting of the basal, antemedial, median, postmedial, and subterminal. These lines usually are a series of connected chevrons or curved spots that can vary with intensity and with shading between them. All species are sexually dimorphic, and females are larger than males. In females, forewing ground color is white and the shape is more of an elongate triangle than triangulate as in the male. The forewing lines are solid and can be reduced in number or nearly absent. The valve in the male genitalia is characteristic of *Porthetria*, having an elongate arm that is either an extension of the costa (Pls. 7–12) or can extend from the middle of the valve (Pl. 13, Fig. 2). Tymbals are absent on the third abdominal sternite. Female ovipositor is not telescopic.

LYMANTRIA (*PORTHETRIA*) *DISPAR DISPAR* (LINNAEUS)

(Figs. 4–8; Pl. 1, Figs. 1,4; Pl. 7; Pl. 25, Fig. 1; Pl. 29, Fig. 1; Pl. 32, Fig. 1; Pls. 33–37; Pls. 39–43).

Phalaena (Bombyx) dispar Linnaeus, 1758:501. ST: Not given (probably Europe) (probably lost, not examined).

Bombyx dispar Thunberg, 1784:1. LT: SWEDEN: Uppland (UZIÜ, Uppsala, Sweden, not examined). Note: *Bombyx dispar* Thunberg is a junior objective synonym of *Phalaena (Bombyx) dispar* Linnaeus (Karsholt and Nielsen 1985).

Bombyx dispar f. *disparina* Müller, 1802:pl.3, Fig. 1. ST: POLAND: Silesia (probably lost, not examined).

Lymantria dispar var. *nigra* de Selys-Longchamps, 1857:52. ST: BELGIUM (unknown type depository, not examined).

Lymantria dispar f. *burdigalensis* Mabille, 1876:ix. ST: FRANCE: Bordeaux (unknown type depository, not examined).

- Lymantria dispar* var. *disparoides* Gaschet, 1876:521. ST: FRANCE: Bordeaux (unknown type depository, not examined)
- Ocneria dispar* Staudinger, 1871:67.
- Ocneria dispar* f. *erebus* Thierry-Mieg, 1886:237. ST: ENGLAND: (unknown type depository, not examined).
- Porthetria dispar* Kirby, 1892:475; Rothschild, 1917:358.
- Ocneria dispar* f. *major* Fuchs, 1899:130. ST: GERMANY: (unknown type depository, not examined).
- Lymantria dispar* f. *brunnea* Schulze, 1910:36. ST: GERMANY: vicinity of Berlin (unknown type depository, not examined); Gaede, 1932:100.
- Lymantria dispar* f. *suffusa* Schulze, 1912:263. ST: GERMANY: vicinity of Berlin (unknown type depository, not examined)
- Lymantria dispar* f. *alba* Stauder, 1914:16. ST: ITALY: Trieste “Österreichischen Litorale” (unknown type depository, not examined)
- Lymantria dispar* f. *atra* Heinrich, 1916:511. ST: GERMANY: Charlottenburg (unknown type depository, not examined)
- Lymantria dispar* f. *fasciatella* Strand, 1934, *In Bryk*, *Lepidoptorum Catalogus*, 62:148. Note: Proposed as a replacement name for *fasciata* Rebel, 1910, which is a junior homonym of *fasciata* Lambillion, 1907. It has the same type and type locality as the Rebel name.
- Lymantria dispar andalusiaca* Reinig, 1938:109. ST: SPAIN (unknown type depository, not examined)
- Lymantria dispar mediterranea* Goldschmidt, 1940:59. ST: Southern Europe (unknown type depository, not examined)
- Lymantria dispar bocharae* Goldschmidt, 1940:59. ST: Turkestan (unknown type depository, not examined)
- Lymantria dispar*; Spuler, 1908:131; Rebel, 1910:117; Vorbrodt, 1911:232; Eckstein, 1915:47; Marschner, 1932:246; Swinhoe, 1923:426; Matsumura, 1933:135.
- Lymantria dispar dispar*; de Freina, 1999:223; Schintlmeister, 2004:22.

COMMON NAMES

Gypsy Moth (GM); Gipsy (in England); European Gypsy Moth (EGM); North American Gypsy Moth (NAGM); Schwammspinner or Zigeunermotte (in German); Le Bombyx Disparate or Spongieuse (in French); Lehtinunna (in Finnish); Zig-zag or Lagarta peluda de los encinares (larva) (in Spanish); Mariposa de Cigano (in Portuguese); Shelkopryad neparniy (in Russian); Lövs kogsnunna (in Swedish); Løvstraesnonne or Sigsyner moth (in Norwegian); Zigeuner mot (in Dutch); Løvstraesnonne (in Danish); Mniska vel'kohlava (in Slovakian); Limantria (in Italian); Gubar (in Roumanian); Erdei gyapjaslepke (in Hungarian); Neparniy shovkopryad (in Ukrainian); Gubarevih (in Croatian) and Gubareve or Gubara (in Bosnian or Serbian).

DIAGNOSIS

Males are generally smaller in *L. d. dispar* with a forewing length of 14.5–22 mm, whereas in *L. d. asiatica* Vnukovskij the forewing length is 23–28 mm. Females of *L. d. dispar* are also smaller, with a forewing length of 20–30 mm, but they are not able to fly as in *L. d. asiatica* with a forewing length of 28–41 mm. *L. d. dispar* is a classic example of extreme sexual dimorphism and is best illustrated by an extremely rare specimen (the only one ever found in nature in nearly forty years of field experience PWS) exhibiting bilateral gynandromorphy, in which the left side is male and the right side is female (Fig. 3).

The area between the D verrucae on the abdomen of *L. d. dispar* has a prominent white pattern on a less-evident solid color, whereas in *L. d. asiatica*, the solid color is prominent and the white pattern less evident. In *L. d. asiatica*, there is a pair of irregularly shaped white spots with gray centers along the anterior margin of abdominal segments 1–7. These spots are absent in *L. d. dispar*. The small D1 verruca has a black primary seta in *L. d. dispar* and this seta is white in *L. d. asiatica*. Variation among larvae occurs throughout the range of *L. d. dispar*. In June 1981 in present day Ukraine, we detected 1.8% frequency of the black form where the normal integument background color is replaced with a solid black stripe down the entire length of the caterpillar (Schaefer et al. 1984a).



Figure 3. Exceedingly rare *L. d. dispar* bilateral gynandromorph. Specimen encountered on day of emergence (June 19, 2000) at Elk Neck State Forest, North East, Cecil Co., Maryland, and is the only such specimen ever found in nature in nearly 40 years of experience with these moths (photo by Paul W. Schaefer).

REDESCRIPTION

MALE

- *Head* Front and vertex pale gray to light brown; scape pale gray to light brown; antenna bipectinate, shaft completely scaled, light brown with some fuscous scales apically; labial palp porrect, white to light brown, apex gray.

- *Thorax* Tegula, mesothorax, and metathorax pale gray to light brown; forefemur dark gray dorsally and medially, white laterally, tibia white with dark gray proximal apex, tarsal segments 1–2 and 5 white, 3–4 gray; middle and hind legs similar to prolegs; underside white, slightly darker under wings.
- *Forewing* (Pl. 1, Fig. 1): Length 14.5–22 mm; ground color brown; basal band black, extends to A vein; antemedial line black, costal portions distinct, remainder of line less distinct and extends to posterior margin; reniform spot crescent-shaped, at end of discal cell; postmedial line consists of a black spot at the costa with a broad, indistinct dark brown band to posterior margin; subterminal line with a black spot at costa and a crenulate dark brown line that becomes less distinct as it nears posterior margin; brown to brownish-gray between subterminal line and outer margin; fringe tan with brown spots between veins.
- *Hindwing* Ground color reddish-brown with dark brown marginal band; fringe light brown.
- *Abdomen* Dorsally reddish-brown, concolorous with hindwing, indistinct dark brown spots, white ventrally; tymbals absent on third sternite.
- *Genitalia* (Pl. 7) Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a square plate with dorsal margin heavily sclerotized and convex, ventral margin with broad excavation; sacculus apex broadly rounded; saccus variable, from V-shaped to narrow U-shaped; aedoeagus 0.75–0.85x height of genital capsule, straight, slightly curved distal to opening for ductus ejaculatorius; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape speckled white and brown, antenna with short pectinations, shaft and pectinations fuscous, apex white; labial palp light brown.
- *Thorax* White; forefemur fuscous, white basally, long fringe scales white, tibia fuscous, tarsi fuscous; middle femur white, distal apex fuscous, tibia white, proximal apex fuscous, tarsi fuscous; hind femur white, tibia fuscous distally and apically, long white fringe scales and white ventrally, tarsi fuscous; underside white.
- *Forewing* (Pl. 1; Fig. 4): Length: 20–30 mm; ground color white; basal band a prominent black bar from costa to R vein, becomes faint to absent below R vein to posterior margin; antemedial line a black spot at costa and in well marked specimens a sinuate line to posterior margin; orbicular spot a small, black dot in middle of discal cell; reniform spot crescent-shaped, at end of discal cell; postmedial line brown, distinct at costa, curved, crenulate, less distinct below reniform to posterior margin; subterminal line brown, distinct at costa, crenulate to posterior margin; fringe white with brown spots between veins.
- *Hindwing* Ground color white; discal spot faint, V-shaped at end of discal cell; faint fuscous submarginal band; fringe white with fuscous spots between veins.
- *Abdomen* Tergites light brown becoming brown toward apex; sternites white in basal quarter, remainder light brown.
- *Genitalia* (Pl. 25, Fig. 1): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae broad, U-shaped, with vertical indentations or medial pockets, apices of these

pockets merge medially; ductus bursae membranous to lightly sclerotized, shorter than corpus bursae; corpus bursae oblong.

LARVA

FIRST INSTAR (PLS. 33-37)

- *Length* 3.70–3.93 mm (n=20). All dorsal, subdorsal, and lateral verrucae have spine-like setae with subbasal bulbous process and barbed setae with an elongate socket base.
- *Head* Hypognathous: width at widest point 0.53–0.60 mm (n=20); epicranium smooth; adfrontal sclerites and short epicranial suture faint; setae barbed; (Pl. 34, Fig. 4) distance between AF2 setae about 1/3 distance between AF1 setae; AF2 about 1/3 longer than AF1 and F1; vertical distance between AF2, AF1, and F1 equal; C2 at least twice length of C1; P2 equal in length to P1, on vertex between AF2 and P1; P1 ventrolateral to AF2 and above and between A2 and L1; A2 closer to A1 than A3; A3 above and adjacent to stemma 2; A1 directly below A2; S3 ventrolateral to stemma 1; S2 lateral to stemma 4; S1 slightly beneath and between stemmata 5 and 6; stemmata smooth; stemmata 1–4 in arc above and lateral to antenna, 3 and 4 nearly touching, 5 and 6 separated from 1–4 by greater than stemma width, distance between 5 and 6 less than stemma width; SS3 ventrolateral to SS1; SS1 ventrolateral to mandibular condyle; SS2 about equal in distance to SS1 and SS3; clypeus with six pairs of barbless setae; mandibles with two subequal setae; sensilla of antenna as in Pl. 34, Fig. 5; sensilla of maxillary palpus as in Pl. 34, Fig. 6; spinneret short and conical.
- *Thorax* T1: prothoracic shield smooth, anterior wider than posterior margin, XD2 verruca with three spine-like setae, XD1 verruca large with many spine-like setae, D1 and D2 equal in length and barbed, D2 on posterolateral margin between XD1 and XD2, D1 on posterior margin caudal to XD1; SD1 and SD2 on same pinnaculum, near laterocaudal margin of prothoracic shield and above spiracle, SD1 slightly longer than SD2, SD1 seta with elongate barbs (Pl. 35, Fig. 3), barbless SD2 seta (Pl. 35, Fig. 3); L verruca large with many spine-like setae; SV verruca with many barbed setae. T2 and T3: D1 seta barbed distad and adjacent to D2 verruca (Pl. 35, Fig. 4); D2 verruca with spine-like setae; SD verruca small, adjacent to D2 with a long-barbed seta on dorsoposterior margin and spine-like setae (Pl. 35, Fig. 5); SV verruca small with barbed setae (Pl. 36, Fig. 2); median dorsal gland on posterior margin of T2 (Pl. 36, Fig. 1); thoracic legs having two flattened setae with apical pad-like process on outer surface at base of claw (Pl. 36, Fig. 3).
- *Abdomen* D1 seta slightly barbed and just anterior to D2 verruca; SD verruca semi-circular, adjacent to L verruca with several spine-like setae and a single large slightly barbed seta (Pl. 36, Fig. 5); L verruca with two sizes of setae, the large diameter seta in middle of verruca and smaller diameter seta along margin with slightly longer barbs (Pl. 36, Fig. 5); SV verruca as on thorax (Pl. 36, Fig. 6); spiracle on anterior margin of L verruca (Pl. 36, Fig. 5); small SV verrucae on A8–9 (Pl. 37, Fig. 1); dorsal glands between D2 verrucae on A6–7 (Pl. 37, Fig. 2); D verruca on A9 with spine-like and barbed setae (Pl. 37, Fig. 3); anal plate with SD1 closer to D1 than to SD2, SD2 along anterolateral margin (Pl. 37, Fig. 4); prolegs on A3–6 with three anterior and two posterior crochets (Pl. 37, Fig. 5); anal prolegs with three anterior and three posterior crochets (Pl. 37, Fig. 6).

LAST INSTAR, LIVE SPECIMENS (PL. 29, FIG. 1; PL. 32, FIG. 1; PLS. 39–43)

- *Length* 30–60 mm (n=6)
- *Head* Light brown speckled with black, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 1); area of head from apex of frons along lateral margin of adfrontal sclerites to midgenal area including stemmata 3–5 to back and bottom of head smooth, rest of head covered in spiculi (Pl. 39, Figs. 5–6); adfrontals narrow from apex to dorsolateral margin of clypeus; AF2 just below coronal suture; AF1 1/3 distance from apex of frons to base of clypeus; numerous secondary setae on adfrontal sclerite or margin of frons, from slightly beneath AF1 extending beyond AF2; F1 midway between dorsal margin of clypeus and apex of frons; clypeus with two pairs of vertical folds; C2 lateral to outer fold; C1 between folds on dorsal margin; all primary setae of other setal groups are indistinguishable due to numerous secondary setae; stemmata smooth, 1–4 separate from 5–6; clypeus deeply clefted, six pairs of setae; labrum deeply clefted; mandibles with two subequal setae apically (Pl. 40, Fig. 3); antenna elongate, number and pattern of sensilla similar to first instar (Pl. 40, Fig. 5); maxillary palpus with sensilla in a round apical concavity (Pl. 40, Fig. 6); spinneret opening ventral, conical, twice as long as labial palps (Pl. 40, Fig. 4).
- *Thorax* D2 verrucae on the thorax blue; prothoracic shield with anterior verrucae raised, XD2 verruca smaller than XD1 with large spine-like setae, XD1 verruca large with spine-like setae, sparse hair-like setae along margins of XD1 and XD2, D2 and D1 verrucae posterior to XD1 verruca, D2 smaller than D1 with four spine-like setae, D1 with two spine-like setae including sparse hair-like setae along margin; SD1 hair-like with long barbs on margin of SD2 verruca; SD2 verruca with five spine-like setae with marginal sparse hair-like setae (Pl. 41, Fig. 2); spiracle large and elliptical (Pl. 41, Fig. 2); L1 verruca with long slightly barbed setae (Pl. 41, Fig. 3); T1 with V1s approximate; T2–3 with V1s at least twice the distance apart than on T1; V1s with two pairs on T3; T1 with coxae adjacent anteriorly and divergent posteriorly; T2–3 with coxae separate; legs yellowish-brown; tarsus with flat setae, one seta ventrolateral to claw and one ventral pair (Pl. 41, Fig. 4).
- *Abdomen* Ground color black to gray irrorated with an irregular pattern of white to pale yellow; dorsal stripe indistinct, white to yellow; lateral stripe indistinct, white to yellow; D2 verrucae on A1–2 blue, on A 3–8 red; D1 verruca small, with a large black central spine-like primary seta surrounded by several smaller white marginal secondary setae (Pl. 41, Figs. 5–6); D1 verrucae closer together than D2 verrucae; pair of small glands posterior to D1 verruca, in line with anterior margin of D2 verrucae (Pl. 41, Figs. 5–6); D2 verruca prominent with many black spine-like primary setae surrounded by smaller white marginal secondary setae; primary setae on D2 verruca shorter than those on L verruca; SD verruca reddish-brown and L1 white, contiguous, dorsocaudal to spiracle; A2–10 with microbarbules on setae of L verruca (Pl. 42, Fig. 1) less prominent than those on SD verruca (Pl. 42, Fig. 2), SD and L verrucae with long black and pale yellow setae; A6–7 with red dorsal medial eversible gland between D2 verrucae (Pl. 29, Fig. 1); A1–2 and A7 with three SV verrucae, setae white, SV3 largest and directly ventrad to SD and L, SV1 smallest and ventrocaudal to SV3, SV2 verruca intermediate in size, directly ventrad to SV3, and closest to V verruca; A1–2 and A7 with V verruca smaller than SV2 and slightly posterior; A3–6 with two SV verrucae, SV3 and SV1 in same position as in A1–2 and A7; A3–6 with V1 minute and anterior to proleg base; A8 with two SV verrucae, SV3 largest directly ventrad to SD and L, SV1 absent, SV2 ventrad to SV3; A8 with V1; A9 with D, SD, and L ver-

rucae, SD and L not adjacent as in other abdominal segments, only SV2 present, VI setaceous; anal plate with D1 and SD2 verrucae with a single primary seta surrounded by several secondary setae, D2 and SD1 on same verruca, surrounded by secondary setae; spiracles on A1 and A8 more vertically oriented and slightly larger than the diagonally oriented spiracles on A2–7; ventral broad black stripe between prolegs, remainder of underside a solid yellowish-brown with little or no pattern; prolegs pale with well developed lateral sclerotized plates; crochets in a homoideous mesoserries. Females tend to be larger and grayer than the blacker males.

There are five recognized color forms of *L. dispar sensu lato*: bright yellow, yellow, black, yellow-gray, and gray. Characters used to recognize these forms are size and arrangement of the dorsal median spots, width of the lateral stripes, and dorsal ground color. These color forms can be recognized only in the fourth or early fifth instar. In early instars most of the color forms appear black and in later instars the dorsal spot pattern is not recognizable (Keena 2004).

In the NAGM, the gray form is most common, with a few yellow-gray individuals from Southern areas. All color forms are present in AGM larvae. In the Russian Far East larvae are of the bright yellow and yellow forms. Larvae from Central Siberia are predominantly of the gray form. All color forms are present in the areas in Europe where the AGM and EGM have hybridized (Germany). In other parts of Europe where no hybridization has occurred (Austria), larval color forms include black, yellow, and yellow-gray (Keena 2004).

DISTRIBUTION

Occurs throughout Europe, nearly to the Ural Mountains in the east, parts of the Middle East, the Mediterranean islands of Corsica and Sardinia, North Africa, and introduced into North America in 1868 or 1869.

In North America, the gypsy moth has become established as far north as Quebec, Ontario, New Brunswick, Maine, and Nova Scotia, south to North Carolina, and westward to parts of West Virginia, Ohio, Indiana, Illinois, Michigan, and Wisconsin (Fig. 1). As a result of transportation of household effects, recreational campers and other vehicles or commerce, isolated small populations have erupted in Missouri, Colorado, Utah, California, Oregon, Washington, British Columbia and elsewhere (Fig. 1). These population foci have been eradicated through the use of effective spray programs and multi-year population monitoring using pheromone trapping techniques.

SPECIMENS EXAMINED

BELGIUM: Papignies, J. C. Fontaine (1m) (CMP). CZECH REPUBLIC: Moravia, Klentnitz (Pollauer Bg.), Aug. 1978 (1m) (CMP). ENGLAND: New Forest (1m) (CMP). FRANCE: Paris (1f), genitalia slide USNM 59102 (USNM). GERMANY: No specific locality (2m) (CMP); Pomerania (1m) (CMP). HUNGARY: Doboz (Bekes), 20 June 1927 (1m), genitalia slide USNM 59101 (USNM). IRAN: Mazandaran Province, 30 km S of Sari, 21 June 1965, J.W. Neal (4m), genitalia slide USNM 59103 (USNM). IRAQ: Kurdistan, Haji Omran, 1760 m, 26 July 1954, E. P. Wiltshire (1m) (BMNH). ITALY: Settentrionale, Alto Adige, (1m, 1f) (CMP); Sardinia, (2m) genitalia slides USNM 59164, 59165 (USNM). LEBANON: Shweir, 10 July 1933 (1m), 20 July 1933 (1f), 1 Aug. 1934 (1f), E. P. Wiltshire (BMNH). MOROCCO: Pt. Lyautey, 13 June 1952 (8m), C. L. Jackson (CMP). RUSSIA:

Nakhodky, 2 Aug. 1992 (1m, 1f), male genitalia slide USNM 59150, female genitalia slide USNM 59149 (USNM); Krasnoyarsk, region of Krasnoturansk, 8 Aug. 1994 (18m, 1f) (Barranchikov). SPAIN: (1m) (CMP). U.S.A.: Maryland: Montgomery Co., Colesville, 1 July 1984 (1m), genitalia slide USNM 59095, 1 Aug. 1984 (1m), genitalia slide USNM 59088, D. C. Ferguson (USNM); Massachusetts: Otis Air National Guard Base, 1990 (4m), genitalia slides USNM 59082, 59094, 59098, 59100, Ronberg (USNM); Medford, June 1894 (1f), Dyar, genitalia slide USNM 59443 (USNM); Sandwich, July 1935 (1m, 1f), male genitalia slide USNM 59092, female genitalia slide USNM 59093 (USNM); Sturbridge, 11 July 1981 (4m), D. C. Ferguson, genitalia slides USNM 59089, 59090, 59091, 59096, 12 July 1981 (2f), D. C. Ferguson, genitalia slides USNM 59083, 59094. New Hampshire: Portsmouth, July (1m), D. C. Ferguson, genitalia slides USNM 59097. Pennsylvania: Westmoreland Co., Rector, 5 km SSE, Linn Run Bog, 25 July 1986 (2m), J. E. Rawlins (CMP).

OVIPOSITION

Females are nearly fully winged but functionally flightless and usually oviposit within a short distance from the site of pupation. In North America, females often descend tree trunks to oviposit low on tree trunks or on lower surfaces of horizontal branches. Otherwise, females deposit egg masses on stones, walls, or other man-made objects, including objects associated with commerce, such as vehicles, shipping containers, packing crates, etc. However, because true flight is not involved, the eggs can be deposited only so far away as the caterpillar or the adult moth can crawl. Eggs are deposited in a single mass covered with a thick matting of abdominal hairs which, upon microscopic examination, are long, straight and generally tapered at both ends as illustrated by Roonwal (1954). Egg masses appear teardrop-shaped, yellowish to brownish, felt-like in appearance, and turn lighter in color with age (Fig. 4). Normally, all individual eggs are obscured from view by the hairs from the female abdomen (Fig. 5).



Figure 4. Variation in *L. d. dispar* egg mass color during population outbreak. Photo taken at Elk Neck State Forest, North East, Cecil Co., Maryland, July 7, 1999 (photo by Paul W. Schaefer).

In eastern Eurasia, oviposition is generally the same as in North America. Reports from the Caucasus Mountain area indicated egg masses are found on tree trunks, in hollows (cavities within the trees) and on or under stones (Zharkov and Tvaradze 1988). In Europe, oviposition tends to be mostly on tree trunks. Near Klausnitz, Germany (ca 150 km south of Berlin) in 2006, we observed newly deposited charcoal black colored egg masses. The extent of this unusually dark color form is unknown. In North Africa, where populations often feed on commercial cork oak, *Quercus suber* L., about half of all egg masses are deposited on the tree bole 1–4 m high with fewer egg masses on the lower portions that have been stripped of useful cork (Fralval et al. 1978). In 1966 in Slovakia, Marek Turcani and Mike Montgomery noted that in low population levels, egg masses were nearly always located on the boles of trees at heights less than 2 m. They searched all possible field locations and found a limited number of masses on the trees (Mike Montgomery, pers. comm. July 2006).



Figure 5. Female *L. d. dispar* ovipositing on trunk of white birch. Photo taken at Newark, Newcastle Co., Delaware, August 10, 2002 (photo by Paul W. Schaefer).

BIOLOGY AND BEHAVIOR

Forbush and Fernald (1896), Leonard (1974, 1981), Montgomery and Wallner (1988) and Liebhold et al. (1995b) all reviewed much on the Biology and behavior of the invasive *L. d. dispar* in North America. Wellenstein and Schwenke (1978) and Grijpma (1989) provided insight into this same insect in European populations. Davidson et al. (2001) reviewed the overall impact of populations of *L. d. dispar* on individual trees and on the forests of the northeastern United States. Aspects of flight and mating behavior have been reviewed by Doane (1976).

Important behavioral factors in *L. d. dispar* (and several other closely related species of the subgenus *Porthetria*) are diurnal activity of male flight (with compensatory reduced dimensions in their compound eyes), and natural population dispersal occurs via “ballooning” of



Figure 6. Example of *L. d. dispar* larval daytime aggregation behavior on a smooth barked poplar tree providing no niches or recesses in which larvae prefer to rest. Photo taken at Blackbird State Forest, Blackbird, Newcastle Co., Delaware, June 1992 (photo by Paul W. Schaefer).

neonate larvae and not through any flight by females.

All populations are univoltine, with obligate diapause in larvae developed within the egg chorion. Eggs hatch in spring, about late-May in the Mid-Atlantic States, and feeding commences following dispersal by ballooning by the neonate larvae. Landing on trees, larvae choose whether or not to feed on that tree species. If acceptable, they settle down and feed. Gaining in size, individuals begin to descend trees during day and either rest in sheltered spots or aggregate together (Fig. 6). They ascend the tree late in the day to feed, mostly at night. Often, pupation

occurs in the same refuge as used earlier by larvae. Oviposition may occur in the same location, but if not, it will occur within walking distance, but generally on the shady or cooler sides of the trees where the moths will accumulate in appreciable numbers (Fig. 7). Newly emerged females are capable of mating and can be found *in copula* before wings are fully inflated (Fig. 8, page 22).

FOOD PLANTS

The gypsy moth is highly polyphagous. Mosher (1915), Lechowiza and Mauffette (1986) and Liebhold et al. (1995a) gave details on hosts and levels of tree susceptibility or preference in North America. Liebhold et al. (1995a) attempted to summarize and combine all related studies; they tabulated 449 tree species as susceptible (Categories 1 and 2) and recorded 148 tree species as most susceptible (Category 1). Half of all tree species tabulated in this category are contained in the genera *Quercus* (Fagaceae) (N=51) and *Salix* (Salicaceae) (N=23). The other half (N=74) are distributed among 28 other tree genera, reflecting the polyphagous nature of this moth. Lechowiza and Mauffette (1986) compared the host plant preferences in North America and Europe. Grijpma (1989) summarized the host plants in Europe and indicated that over 300 food plants are recorded there. It seems that throughout its native and invasive range, *Quercus* spp. (Fagaceae) are regarded as the most preferred food plant group, followed by *Salix* (Salicaceae) and *Crataegus* (Rosaceae).

In more general terms, larval host plants include most trees and shrubs, with a preference for species of oak, birch, alder, poplar, willow, sumac, basswood, larch, apple, hawthorn, shadbush, mountain ash, rose, box-elder, hazelnut, and witch hazel. Later instars are not as particular and will feed on beech, chestnut, and conifers, such as pine, spruce, and hemlock. Species that they tend to avoid, except when favored hosts are not available or when these species are mixed with favorable hosts, include elm, hickory, cherry, maple, sassafras, black gum, blue beech, and hop hornbeam. Trees and shrubs they usually avoid entirely include, ash, azalea, balsam fir, black walnut, dogwood, bald cypress, grape, greenbrier, hackberry,

holly, honeysuckle, black locust, honey locust, mulberry, persimmon, sycamore, tulip tree, and *Viburnum* species (Ferguson 1978).

PHEROMONAL COMMUNICATIONS

Following an earlier report, which later proved to be inaccurate (Jacobson et al. 1960) and was retracted and reinvestigated (see summary story in Mayer and McLaughlin 1991), *cis*-7,8-epoxy-2-methyloctadecane (disparlure) was ultimately identified as the sex pheromone of North American *L. d. dispar* (Bierl et al. 1970). Subsequently, the plus enantiomer or (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] was shown to possess exclusive attractiveness to male *L. d. dispar* (Plimmer et al. 1977, Cardé et al. 1977). Since those discoveries, (+)-disparlure has been studied intensively and used exhaustively in survey, detection and delimitation of *L. dispar sensu lato*. Recently, (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadec-17-ene has been identified as a trace component in pheromone gland extracts of *L. d. dispar*. By itself, this component is 1/10th as effective as (+)-disparlure in attracting male *L. d. dispar* (Gries et al. 2005b).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Diurnal in their flight activity, males can be found flying from mid- to late morning into late afternoon. During this period, males are attracted to pheromone baited traps. Periodicity studies on 16–17 July 2002 in Rothrock State Park, near State College, Pennsylvania, illustrated that among 426 males captured in 40 synthetic (+)-disparlure-baited sticky traps (constructed of milk carton material), 53, 10, 3, 37% were captured during the periods 3:45 to 5:45 PM; 5:45 to 8:45 PM; 8:45 PM to 6:00 AM; and 6:00 AM to 2:00 PM, respectively (Schaefer, unpubl. data). Overall, of those captured 97% responded during daylight while 3% did respond during hours of darkness. True nocturnal flight cannot be ruled out completely in *L. d. dispar*, but it is uncommon. Seasonally, in North America, adults appear in late June and early July in the Mid-Atlantic region and progressively later in the season further north. They normally appear in late August to early September in eastern Maine and New Brunswick.



Figure 7. Cluster of ovipositing *L. d. dispar* females near base of oak tree. Behavior of individual females often causes them to walk down the tree surface and seek out the shady or cooler sites for oviposition. This leads to the low stratification of large numbers of egg masses. Photo taken near Elkton, Cecil Co., Maryland, June 19, 2002 (photo by Paul W. Schaefer).

DISCUSSION

We are recognizing three subspecies of *L. dispar* due to their economic importance throughout the temperate part of the world. Nominate *L. d. dispar* is the western Eurasian form with a winged, but flightless, female. To other subspecies are *L. d. asiatica* Vnukovskij and *L. d. japonica* (Motschulsky).

Lymantria dispar dispar was introduced into North America around 1868 or 1869 by a French artist and naturalist Étienne Léopold Trouvelot, who lived in Medford, Massachusetts, near Boston.

He was interested in silk production by native moth species and imported the gypsy moth from Europe for his experiments. Consequently the species escaped and became established. In about 10 years the moth became extremely abundant and had completely stripped the trees in a 359-square-mile area around Boston (Forbush and Fernald 1896, Ferguson 1978, Liebhold et al. 1989).

The North American Gypsy Moth (NAGM) represents the epitome of a successful invasive species and the destructive aftermath and consequences of successful establishment on a new continent has proven to be the most costly invasive forest defoliator of all time. As a result of this introduction, more has been written on NAGM than any other forest insect pest. See, for example, the so called “gypsy moth compendium” edited by Doane and McManus (1981) and a more recent book chapter (Montgomery and Wallner 1988). The impact of NAGM on the forest trees through mortality and reduced tree growth is substantial (Davidson et al. 2001). It is clearly the overall goal of all forest managers in the future to prevent this sort of destructive invasion by all means possible. This has been a classic example of what not to do and hopes are that it would never happen again.



Figure 8. Newly emerged female of *L. d. dispar* with wings not fully expanded and hardened and yet already in copula with male. Photo taken at Elk Neck State Forest, North East, Cecil Co., Maryland, July 7, 1999 (photo by Paul W. Schaefer).

LYMANTRIA (PORTHETRIA) DISPAR ASIATICA VNUKOVSKIJ, REVISED STATUS

(Figs. 9–12; Pl. 1, Figs. 2, 5; Pl. 8, Figs. 1–7; Pl. 29, Fig. 5; Pl. 32, Fig. 2; Pl. 38, Fig. 1; Pl. 44, Figs. 1–4)

Lymantria dispar asiatica Vnukovskij, 1926:79. ST: RUSSIA: Siberia meridionales, Altaj et Sajan occidentales, Prov. Semiplatinsk (Tomsk Polytechnic University, Tomsk, not examined); Gaede, 1932:100; Witt, 1985:187; Schintlmeister, 2004:22. **Revised status**

Lymantria dispar chosenensis Goldschmidt 1940:60. ST: KOREA: (unknown type depository, not examined)

Lymantria dispar koreiba Bryk 1948:15. HT male: KOREA: Motojondo (NMS, Stockholm, not examined)

Lymantria dispar kolthoffi Bryk 1948:16. HT male: CHINA: Kiangsu (NMS, Stockholm, not examined)

COMMON NAMES

Asian Gypsy Moth (AGM); Maemi-Nabang or Gypsy-Nabam (in Korean); Ya-zhou-do-er (in Chinese), also translations refer to Persimmon caterpillar or Persimmon tussock moth (in China); Shelkopryad neparnyy (in Russian); Neparniy shovkopryad (in Ukrainian); Uruusgul hur ervechei (in Mongolian).

DIAGNOSIS

The males of *L. d. asiatica* differ from those of *L. d. dispar* in the ground color of the forewing, which is either a lighter or darker brown in *L. d. asiatica*. In *L. d. dispar*, there is a grayish cast to the light brown ground color. The females of *L. d. asiatica* have a more prominent postmedial band than in *L. d. dispar*. Among late stage larvae, the black form is found to a limited extent in China (Fig. 9) (Schaefer et al. 1984b).



Figure 9. Unusual black larval form of *L. d. asiatica* with tachinid eggs (white spots on dorsum) probably of *Parasetigena* sp. (Diptera: Tachinidae). Photo taken in Mengjiagang, Heilongjiang Province, China, July 1983 (photo by Paul W. Schaefer).

REDESCRIPTION

MALE

- *Head* Front and vertex light brown; scape and antenna light brown, bipectinate; labial palpus cream-colored basally and ventrally, gray apically.
- *Thorax* Tegula, mesothorax and metathorax slightly darker brown than head and vertex; forefemur cream-colored basally, gray apically, tibia and tarsi cream-colored to

light brown, segments 2–3 dark gray to black; middle and hind legs cream-colored to light brown, tarsi concolorous with legs, segments 2–3 gray to black; underside cream-colored.

- *Forewing* (Pl. 1, Fig. 2): Length 23–28 mm (n=10); ground color light brown to brown; basal area with black dots above and below M vein; antemedial line brown, crenulate from costa to posterior margin, slightly more distinct between costa and R vein; orbicular spot black, in middle of discal cell; reniform spot black, angulate, along vein at end of discal cell; postmedial line a broad brown band, darker at costa, extends to posterior margin; subterminal line brown, crenulate, dark brown spot at costa, line extends to posterior margin; outer margin brown to dark brown and contrasting with ground color; fringe cream-colored to brown, dark brown spots can be present between veins.
- *Hindwing* Ground color brown; discal spot can be absent, but if present, dark brown, crescent-shaped, at end of discal cell; marginal band dark brown; fringe white to light brown.
- *Abdomen* Light brown with median dorsal dark brown patches, light brown ventrally; tymbals absent on third sternite.
- *Genitalia* (Pl. 8): Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a square plate with dorsal margin concave to slightly convex, ventral margin with broad excavation; sacculus apex broadly rounded; saccus variable, V-shaped to narrow U-shaped; aedoeagus 0.70–0.84x height of genital capsule, straight, slightly curved proximal to opening of ductus ejaculatorius; vesica an ovate, dorsally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape white, antenna dark brown and bipectinate; labial palps dark brown to black.
- *Thorax* White; forefemur fuscous, white basally, long fringe scales white, tibia fuscous, tarsi fuscous; middle femur white, distal apex fuscous, tibia white, proximal apex fuscous, tarsi fuscous; hind femur white, tibia fuscous distally and apically, long white fringe scales and white ventrally, tarsi fuscous; underside white.
- *Forewing* (Pl. 1, Fig. 5) Length 28–41mm (n=10); ground color white; all wing markings fuscous; basal spot; antemedial line a short dash from costa to R vein, becomes a variably distinct sinuate line to posterior margin; orbicular spot small at middle of discal cell; reniform spot V-shaped along veins at end of discal cell; postmedial line a dark spot at costa, becomes a variably distinct broad angular band to posterior margin; subterminal band crenulate, from costa to posterior margin; fringe white with fuscous spots between veins.
- *Hindwing* Ground color white; discal spot faint, V-shaped at end of discal cell; faint fuscous submarginal band; fringe white with fuscous spots between veins.
- *Abdomen* Tergites white, gradually becoming browner dorsally, apex dark brown; sternites white in basal half, brown in distal half.
- *Genitalia* Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae with sclerotized

strap-like process merging to form a circular opening; ductus bursae shorter than in or *L. d. japonica*; corpus bursae ovate.

LARVA

PRESERVED SPECIMENS (PL. 29, FIG. 5; PL. 32, FIG. 2; PL. 44, FIGS. 1–4)

- *Length* Full grown larvae 50–55 mm.
- *Head* Cream-colored speckled with light brown, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 2); setae twisted (Pl. 44, Fig. 2); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a wrinkled surface and a raised rim margin (Pl. 44, Fig. 3).
- *Thorax* D2 verruca on T1–3 blue; legs yellowish-brown
- *Abdomen* Ground color gray, irrorated with an irregular pattern of white, laterally; dorsal stripe distinct, white; lateral stripe indistinct, white; anterior margin of A1–7 with a pair of irregularly shaped white spots with gray centers; D2 verrucae blue on A1–2, red on A3–8; D1 verrucae small with a large white primary seta and several white secondary setae; SD verrucae reddish-brown and L white, contiguous; SV verruca white; primary setae on D2 verruca black, secondary setae white; primary setae on D2 verruca shorter than those on L; L verruca with long black and white setae; long setae, both black and white on SD and L with microbarbules; eversible glands on A6–7 red; ventral broad black stripe between prolegs faint to absent, remainder of underside a solid pale gray with little or no pattern; prolegs pale with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries.

FIRST INSTAR (PL. 38, FIG. 1)

Differences from *L. d. dispar*: SD1 seta on T1 with elongate barbs, SD2 seta with fewer and shorter barbs than SD1 (Pl. 38, Fig. 1).

DISTRIBUTION

Throughout temperate Asia, generally east of the Ural Mountains into the Russian Far East, the northern 2/3 of China, and the Korean Peninsula. In Central Asia, it is not found south of the Himalayan range in India (Bhardwaj 1987, Gupta 1992).

SPECIMENS EXAMINED

CHINA: Liaoning Prov., Shenyang, 12 Feb. 1999 (3f), Y. Dekang (PWS); Beijing, Tongxian, 1998 (2f), P.W. Schaefer (PWS); Manchuria, Luta (Dairen), 22–31 July (1m), 30 July (1f), 8–14 Aug. (1m), Weymarn (CMP); Djalantun, Gr. Kingan Mts., 22–31 July (2m), 30 July 1, 25 July (1m), 26 July (1m), Weymarn (CMP); Sichuan: junction of Min & Yangtze rivers (1f), Suifu (CMP), K'angting (Taatsienlu), 1906 (1m), (BMNH); Mo Sy Mein, 1894 (2m), genitalia slide USNM 59169 (BMNH); Taekou, Th. Monbeig, 1909 (1m) (BMNH); Tsing Tao, 15–21 July (1m), 1–7 Aug. (1f), Weymarn (CMP). MONGOLIA: Ulaanba-atar, 2004 (3f), P.W. Schaefer (PWS). RUSSIA: Kongaus, 10 Aug. 1923 (1f), Cockerell (CMP).

OVIPOSITION

Ovipositional behavior is most variable over the wide distribution of this subspecies. Oviposition is similar to that in *L. d. dispar*, but egg mass color is lighter and more consistently yellow, less frequently darkening only to light brown.

In China (Schaefer et al. 1984b) and Korea (Schaefer unpubl. data), egg masses are frequently placed high up on the undersurfaces of branches of large pine trees, *Pinus tabulaeformis* Carriere (Pinaceae). In Russia and Mongolia, females oviposit in cracks or crevices on rock outcrops or occasionally directly on the soil under individual boulders. There, egg masses are so concentrated that they are laid on top of other egg masses or on the remains of previous years' egg masses, and the remains of the expired females remain evident from season to season (Fig. 10). Benkevich (1956) states that in the Altay (or Altai) Mountain region of Siberia and Mongolia the behavior changes from ovipositing on trees in the west to rocks in the east. In the Russian Far East, egg masses are laid on undersides of leaves of deciduous trees (Yurchenko and Turova 1984), which assures the egg masses will fall to the ground and be covered by accumulating snow, and thus be protected from extreme cold temperatures and desiccating winds known to cause significant egg mortality.



Figure 10. Egg mass remains of *L. d. asiatica* deposited on the undersurface of a stone (rolled over) and showing partly preserved remains of the expired females. These female remains represent the previous year's individuals as this picture was taken at Hatgal, Hövsgöl, Mongolia, on July 12, 2003, at a time when the current generation was feeding in nearby Siberian larch trees (photo by Paul W. Schaefer).

BIOLOGY AND BEHAVIOR

Populations are univoltine throughout its range, as in *L. d. dispar*, and all overwinter as eggs deposited in a variety of locations. Populations everywhere may reach destructive outbreak levels. In central Asia, where egg masses are concentrated on rocks, ridges or outcrops, upon

hatching larvae must spin copious amounts of silk (Fig. 11) and balloon off the ridges in order to passively encounter acceptable food trees. In the Siberian larch forests and riparian habitats of Mongolia, dispersal by ballooning from either rock faces, pine trees or manmade object, is essential for the larvae to reach food plants in. Often, and depending on the prevailing breezes at the time of the spring egg hatch, the distances involved are appreciable, ranging from several hundred meters to a kilometer or two. In Korea, larvae on pines disperse to suitable tree species such as *Carpinus*, *Quercus* or *Rhododendron* (*Azalia*) (Lee et al. 2002) to feed, but adults fly back to the large pines for oviposition. Much the same occurs in China (Schaefer et al. 1984b). In all these cases, an annual host-utilization cycle exists between the oviposition site (rock outcrop or non-food source pine tree) and the food source (preferred forest trees).

Throughout the range of this subspecies, females are capable of either sustained level or ascending flight and in some areas even show evidence suggesting nocturnal mass migrations of variable, including unknown, distances (Gornostaev 1962, Kondakov 1961, Meyngard 1909, Rozhkov and Vasil'eva 1982, Epova and Pleshanov 1988). We provide one such example of a mass flight, which occurred on 17 August, 2003 at Mörön, Hövsgöl, Mongolia, where many thousands of mostly female moths descended on parking lot lights between 10:30 PM and midnight.

Baranchikov (1989) compared the ovipositional strategy of Eurasian populations of flight-capable females to those of flightless females of gypsy moths. A complicating issue is that Baranchikov's (1989) records and maps of the distribution illustrate a sizable area of overlap, presumably signifying an area of functional polymorphism or of sympatry of two distinct species. According to Baranchikov (1989), this location, centered on Tataria with a



Figure 11. Silk deposited from the concentration of hatching *L. d. asiatica* larvae on a Siberian larch tree in close proximity to a rock outcropping where tremendous numbers of egg masses were concentrated. Photo taken at Dalbay Valley, Hövsgöl, Mongolia, on July 13, 2003 (photo by Paul W. Schaefer).

regional city of Kazanj, is a transition zone, wherein females can fly well but flights are short. (Interestingly, this area lies just to the west of the Ural Mountains and might involve both the subspecies *L. d. dispar* and the flighted females, which by our definition are *L. d. asiatica*.) Schaefer and Tuulaikhuu (in Prep.) confirmed that 97% of the AGMs in the mass flight to lights in the city of Mörön, Mongolia, were females, and that all of those females were virgin. In the morning after this flight, all of the males were *in copulo*, while the remaining myriads of other females rested on fence posts, having been inactive during the cool night (Fig. 12). They began to get active as they warmed up and eventually flew upwards, appearing headed for the surrounding higher mountains. Only after their arrival at the higher mountain outcrops, would they chance to call a male. Based on observations at other locations, at which



Figure 12. Females of *L. d. asiatica* rest on a fence at a hotel in the center of Mörön, Hövsgöl, Mongolia, August 18, 2003. After warming up in the mid- to late-morning hours, individuals took off and flew upwards and appeared headed for the higher mountains (photo by Paul W. Schaefer).

we found numerous dead males captured in spider webbing, we know that males do frequent such locations. In the final analysis, presence of suitable males for successful mating at these sites of concentrated females seemed to be a limiting factor and in this Mongolian population, many successfully laid egg masses appeared to be infertile.

In other areas of China and Korea, in hours of darkness, females often respond to outdoor lighting, such as street lamps or illuminated store fronts (Belova 1988), and often deposit their egg mass at the site of landings near the lighting (Schaefer et al. 1984b).

FOOD PLANTS

Polyphagous. Found on many of the same food plants used by both *L. d. dispar* and *L. umbrosa*, as tabulated in Schaefer et al. (1988). Siberian larch, *Larix sibirica* Ledeb. (Pineaceae) is a dominant food tree in much of the northern part of the native range (eastern Siberia and Mongolia). In more southern regions, as in central China, it is often associated with persim-

mon (consequently its alternate local names), *Diospyros kaki* Thunberg (Ebenaceae) (Schaefer et al. 1984). Various species of *Quercus* (Fagaceae) are preferred in all areas within the range of *L. dispar sensu lato*. Otherwise, the following families and genera serve as major food sources: Aceraceae (*Acer*); Betulaceae (*Alnus*, *Betula*, *Carpinus*, *Corylus*); Ebenaceae (*Diospyros*); Fagaceae (*Castanea*, *Castanopsis*, *Fagus*, *Quercus*); Flacourtiaceae (*Xylosma*); Hamamelidaceae (*Hamamelis Liquidambar*); Juglandaceae (*Juglans*); Leguminosae (*Robina*, *Wisteria*, *Lespedeza*); Moraceae (*Morus*); Oleaceae (*Fraxinus*); Pinaceae (*Larix*, *Pinus*, *Picea*); Rosaceae (*Cydonia*, *Cerasis Eriobotrya*, *Malus*, *Prunus*, *Pyrus*, *Rosa*, *Rubus*); Salicaceae (*Populus*, *Salix*); Theaceae (*Eurya*); Tiliaceae (*Tilia*); and Ulmaceae (*Celtis*, *Ulmus*, *Zelkova*) (Kozhanskikov 1950, Kim et al. 1982, Schaefer et al. 1988).

PHEROMONAL COMMUNICATIONS

As in *L. dispar sensu lato*, (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] has been confirmed as the major pheromone in *L. d. asiatica*.

In China, earlier work revealed that the racemic mixture and the addition of olefin (2-methyl-*Z*-7-octadecane) generally reduced male captures, (Wallner et al. 1984, O'Dell et al. 1992), but one trapping effort at two test locations produced conflicting results (Wallner et al. 1984).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Males are almost exclusively diurnal and gravid females are fully capable of normal sustained level or ascending flight.

As with both *L. mathura* and *L. monacha*, in the Russia Far East, Wallner et al. (1995) showed the pattern of nocturnal attraction of adult *L. d. asiatica* to ultraviolet lamps, with peak activity from 11:00 PM to 1:00 AM (i.e. Near Midnight), and a male-to-female sex ratio of 11:1. Also in Russia, female flight is described as strong and mention is made that unfertilized females fly better than fertilized females (Benkevich 1966).

DISCUSSION

Lymantria dispar asiatica was originally described as a subspecies of *L. dispar* by Vnukovskij (1926). Schintlmeister (2004) synonymized *L. d. asiatica* with *L. d. dispar*. Because of the importance in formally recognizing the Asian population of *L. dispar*, we treat *L. d. asiatica* as a valid subspecies. However, based on results from the analysis of the COI mitochondrial gene by Ball and Armstrong (2006), because some specimens from Korea, Russia, and Japan showed no sequence divergence, and even though some recognized coloration differences are evident in certain populations, we are treating both *L. d. asiatica* and *L. d. japonica* as subspecies. Ball and Armstrong (2006) analyzed 21 specimens of *L. dispar sensu lato*. (For purposes of clarity we divide these specimens into three groups.) There was no sequence divergence among the five specimens of *L. d. dispar* from North America in Group 1, or among the 13 specimens of *L. d. asiatica* from Korea and Russia, and *L. d. japonica* from Japan, in Group 2. However, there was a slight sequence divergence between Groups 1 and 2. There was sequence divergence among the three specimens, one each from Russia (near Sakhalin Island, GP2), Korea (Wontong, Ly219), and Japan (Iwate Prefecture, Ly323), in Group 3, and be-

tween Group 3 and Groups 1 and 2. Overall, the mean sequence divergence was only 0.44% for all specimens of *L. dispar sensu lato* analyzed (Ball and Armstrong 2006).

Throughout its range, there is considerable variation in adult forewing color and pattern of *L. d. asiatica*. There are dark brown males from Korea and China and light brown males from Krasnoyarsk in central Russia. Female forewing ground color is white for most, but some specimens from China can have a very slight brownish cast.

Larvae show considerable variation in color and patterning. The black form is more common in *L. d. japonica* (Fig. 9), but occurs rarely in China (Schaefer et al. 1984b) and Korea (Lee and Chung 1997).

As with *L. d. dispar*, *L. d. asiatica* is highly polyphagous. However, whereas *L. d. dispar* females are flightless, *L. d. asiatica* females are fully capable of level or ascending flight, with some showing evidence of migratory flights. Furthermore, the female's ability to fly to lights at night makes for a high potential for female movement to dock areas, shipping containers, or vessels, where they may readily lay their complement of eggs. Hence, the potential for invasion to other countries or continents is very real. Indeed, it accounts for why males and egg masses of Asian-type gypsy moths have been intercepted and collected in western North America. As an endemic species in central Asia, it feeds almost exclusively on Siberian Larch. Although North America does not have extensive larch forests, this moth is highly polyphagous and if introduced will likely find adequate alternative food sources. Maritime commerce with coastal Asian countries, specifically, Korea, China, and Russia, is significant and could result in *L. d. asiatica* invading North America. Clearly, every effort should be made to prevent such an invasion.

LYMANTRIA (PORTHETRIA) DISPAR JAPONICA (MOTSCHULSKY)

(Pl. 1, Figs. 6, 10; Pl. 9, Figs. 7–12; Pl. 25, Figs. 2–4; Pl. 29, Figs. 2–4)

Liparis dispar var. *japonica* Motschulsky, 1860:31. HT male: JAPAN (unknown type depository, not examined).

Porthetria hadina Butler, 1881:11. HT male: JAPAN: Honshu, Yokohama (BMNH, examined); Kirby, 1892:475; Schintlmeister, 2004:22.

Porthetria japonica; Kirby, 1892:475.

Lymantria japonica; Swinhoe, 1903:483.

Lymantria dispar japonica; Strand, 1911:127; Strand, 1923:322; Matsumura, 1933:135; Bryk, 1934:150; Inoue, 1956a:398; Ferguson, 1978:90; Schintlmeister, 2004:22.

Liparis japonica; Swinhoe, 1923:426.

Lymantria dispar hadina; Matsumura, 1933:135.

Lymantria dispar obscura Goldschmidt, 1940:60. ST: JAPAN: Lake Biwa and Gifu regions (unknown type depository, not examined); Schintlmeister, 2004:22.

Lymantria dispar nesiobia Bryk 1942:25. HT male: JAPAN: Kuril Islands (NMS, Stockholm, not examined); Schintlmeister, 2004:22.

COMMON NAMES

Japanese Gypsy Moth (JGM); Maimaiga or Shiroshita-maimai (in Japanese).

DIAGNOSIS

The males of *L. d. japonica* are very similar to *L. d. dispar*, but *L. d. japonica* has a larger forewing length in both the male (25–32 mm) and female (34–41 mm) than in the smaller *L. d. dispar* with forewing length of 14–22 mm for males and 20–30 mm for females. Genitalia among the males of the three subspecies are virtually identical, as are those of the females. The female wings of *L. d. japonica* have a distinct brown cast, whereas they are distinctly white in *L. d. dispar* and *L. d. asiatica*. The black form in late stage larvae can be found, but it is very limited in its percentage of the total population (Schaefer and Furuta, 1979(81)) (Fig. 9).

REDESCRIPTION

MALE

- *Head* Front and vertex light brown; scape and antenna light brown, bipectinate; labial palpus cream-colored basally and ventrally, brown to gray apically.
- *Thorax* Tegula, mesothorax and metathorax slightly darker brown than head and vertex; forefemur cream-colored basally, brown apically, tibia brown, tarsi cream-colored segments 2–3 dark brown; middle and hind legs cream-colored to light brown, tarsi concolorous with legs, segments 2–3 dark brown; underside cream-colored.
- *Forewing* (Pl. 1, Fig. 6) Length 25–32 mm (n=10); ground color light brown to brown; basal area with brown dots above and below M vein; antemedial line brown,

crenulate from costa to posterior margin, slightly more distinct between costa and R vein; orbicular spot black, in middle of discal cell; reniform spot black, angulate, along vein at end of discal cell; postmedial line a broad brown band, darker at costa, extends to posterior margin; subterminal line brown, crenulate, dark brown spot at costa, line extends to posterior margin; outer margin brown to dark brown and contrasting with ground color; fringe light brown to brown, dark brown spots can be present between veins.

- *Hindwing* Ground color brown; discal spot can be absent or, if present, dark brown, crescent-shaped, at end of discal cell; marginal band dark brown; fringe white to light brown.
- *Genitalia* (Pl. 9, Figs. 7–12) Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a square plate with dorsal margin concave to slightly convex, ventral margin with broad excavation; sacculus apex broadly rounded; saccus variable, V-shaped to narrow U-shaped; aedoeagus 0.75–0.79x height of genital capsule, straight, slightly curved proximal to opening of ductus ejaculatorius; vesica an ovate, dorsally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex dirty white; scape dirty white, antenna fuscous and bipectinate; labial palps dark brown.
- *Thorax* White; forefemur fuscous, white basally, long fringe scales white, tibia fuscous, tarsi fuscous; middle femur white, distal apex fuscous, tibia white, proximal apex fuscous, tarsi fuscous; hind femur white, tibia fuscous distally and apically, long white fringe scales and white ventrally, tarsi fuscous; underside white.
- *Forewing* (Pl. 1, Fig. 10): Length 34–41mm (n=10); ground color brownish-white; all wing markings fuscous; basal spot; antemedial line a short dash from costa to M vein, very faint or absent below M vein; orbicular spot small at middle of discal cell; reniform spot V-shaped along veins at end of discal cell; postmedial line a dark spot at costa, becomes a variably distinct broad angular band to posterior margin; subterminal band faint and crenulate from costa to posterior margin; fringe dirty white with fuscous spots between veins.
- *Hindwing* Ground color brownish-white; discal spot faint, V-shaped at end of discal cell; faint fuscous submarginal band; fringe dirty white with fuscous spots between veins.
- *Abdomen* Tergites white, gradually becoming browner dorsally, apex dark brown; sternites white in basal half, brown in distal half.
- *Genitalia* (Pl. 25, Figs. 2–4): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae with sclerotized, strap-like processes merging medially to form a triangulate opening; ductus bursae longer than in *L. obfuscata* or *L. d. dispar*; corpus bursae ovate.

LARVA

PRESERVED SPECIMENS (PL. 29, FIGS. 2–4)

- *Length* 35–40 mm.

- *Head* Cream speckled with light brown, a pair of broad black coronal stripes from above frons paralleling ecdysial line.
- *Thorax* D2 verruca on the thorax dark brown; legs yellowish-brown.
- *Abdomen* Ground color brown to black irrorated with an irregular pattern of white laterally; dorsal stripe white, variable, with either a distinct narrow stripe or with broad white patches between the D2 verrucae; lateral stripe white, indistinct; anterior margin of A3–8 with a pair of irregular shaped white spots in specimens with narrow dorsal stripe; D2 verruca on A1–2 dark brown, on A3–8 light brown; D1 verruca small with a large dark brown primary seta and several white secondary setae; primary setae on D2 verruca dark brown to black, secondary setae white; primary setae on D2 verruca shorter than those on L verruca; L verruca with long dark brown and white setae; SD verruca light brown and L verruca white, contiguous; long setae, both dark brown and white on SD and L with microbarbules; SV verrucae white; eversible glands on A6–7 light brown; underside with non-contiguous broad brown patches between prolegs, remainder of underside a solid yellowish-brown with little or no pattern; prolegs pale with well-developed lateral sclerotized plates; crochets in a uniordinal mesoserries.

DISTRIBUTION

In Japan from Honshu, Shikoku and Kyushu and is locally established on parts of southern and western Hokkaido.

SPECIMENS EXAMINED

JAPAN: No specific locality, (1m, 1f), male genitalia slide USNM 59118, female genitalia slide USNM 59182 (USNM), June 1910 (1m), (1m, 1f) (CMP). HONSHU: Lifu, (1f), genitalia slide USNM 59183; Kukisaki, Ibaraki, 21 Aug. 1992 (4m), genitalia slides USNM 59155–59158; Mitsukuri (1f), USNM genitalia slide 59120; Yizo, Aug. 1888 (1m), genitalia slide USNM 59119; Yokohama, 23 June 1910 (1f), 1 July 1910 (1f) (MAKB), no date (3m) (CMP); Narita, Temple Park, 11 Aug. 2003 (1m), P.W. Schaefer (PWS); Chuo exprw., Suwako Rest Area, 1998 (1m, 2f), P.W. Schaefer (PWS); Chuo exprw., Zakoji Rest Area, 1998 (3f), P.W. Schaefer (PWS); Tohoku Expr., Sano Rest Area, Aug. 1998 (3m), P.W. Schaefer (PWS); Gumma Pref., Gumma, 24 Aug. 1998 (1m), P.W. Schaefer (PWS); Shitama Pref., Hasuda R.A., 10 July 1994 (1m), P.W. Schaefer (CMP); Sekiya, 2 July 1994 (1m), P.W. Schaefer (CMP); Kumomoto Pref., Kumomoto, 2 July 1994 (1m), P.W. Schaefer (CMP); Kumomoto Pref., Ueki, 15 km N. Kumomoto, 1 July 1994 (1m), P.W. Schaefer (CMP); Shitama Pref., Kamisato, R.A., 10 July 1994 (1m), P.W. Schaefer (CMP); Tochigi Pref., Hanyu R.A., 4 July 1994 (1m), P.W. Schaefer (CMP); Fukui Pref., 10 km S of Fukui Suehiro, 4 July 1994 (1m), P.W. Schaefer (CMP). KYUSHU: Fukuoka Pref., Fukuoka, 2 July 1994 (1m), P.W. Schaefer (CMP); Fukuoka City, spring 1999 (2m, 3f), H. Shima (PWS). Tshushima Island, spring 1999 (2m, 2f), H. Shima (PWS). SHIKOKU: Naruto City, (2m, 4f), C. Koshio (PWS).

OVIPOSITION

Oviposition is similar to that in *L. d. dispar*, but egg mass color is inclined to be darker in Japan, ranging from light yellow to dark brown, and in some instances chocolate brown. In northern Japan, specifically the Tohoku region (northern portion of Honshu Island), where

the moths and white birches coexist, females do show a propensity to oviposit on white birch, as does the closely related *L. umbrosa* in Hokkaido, where white birches are more prevalent. In Nara Prefecture, females were recorded ovipositing high up in tree crowns (Higashiura 1984), while under other conditions in Gumma Prefecture nearly all egg masses were deposited lower than 60 cm up on bases of trees (Mishiro et al. 1967). Sato and Takamura (1975) reported females frequently lay eggs on telephone poles and on buildings (generally near the ground). In a Japanese larch plantation in Tamayama, Iwate Prefecture, females tended to prefer to oviposit on larch boles below 1 m and on the trunk of the tree in positions of low illumination and lower temperatures (Takizawa and Yanbe 1986). This illustrates the variability in preferred oviposition sites in different populations and very likely demonstrates the effect of local environmental factors, e.g. temperature and amount of sunshine, on the overall selection of an oviposition site by individual females. Yano (1946) postulated that the underlying reasons why females are not particularly selective of their oviposition sites were the high dispersal ability of neonate larvae (well adapted to ballooning using silk threads) and a general lack of any tendency to aggregate.

BIOLOGY AND BEHAVIOR

Populations are univoltine throughout its range, as in *L. d. dispar*, and all overwinter as eggs deposited in a variety of locations. Populations everywhere may reach destructive outbreak levels. In Japan, Gifu Prefecture, *L. d. japonica* was responsible for repeated severe defoliation and loss of persimmon crops (*Diospyros kaki* Thunberg, Ebenaceae) (Anonymous 1910, 1911, 1933; Nawa 1944). In Fukui Prefecture, this moth damaged 5-year-old Japanese cedar (*Cryptomeria japonica* (L.f.) D. Don) (Inoue and Arisawa 1984) and on Honshu many outbreaks have been recorded over many decades. In contrast, Zwolfer's (1972) summary report noted populations persisted at low densities on Kyushu, but there were no outbreaks. On Shikoku, duration of larval development and number of larval molts was shown to vary with the types of food plants. *Liquidambar formosana* Hance (Hamamelidaceae) and *Corylopsis spicata* Siebold & Zucc. (Hamamelidaceae) were optimal hosts, whereas *Alnus hirsuta* (Spach.) Rupr. (Betulaceae) was regarded as an unsuitable host (Igarashi 1982). Male mating frequency was 4.0 to 5.2 in Iwate Prefecture populations and effective mating required more than 10 minutes duration *in copulo* (Iwata 1976). In the same region, adults are attracted to lights at night (Sato and Takamura 1975). In Hiroshima Prefecture, females flew to light traps in the Early evening (Fig. 1), whereas males tended to fly somewhat later, and all activity terminated before midnight (Kenda 1959). On Kyushu, 54% of moths were male. The mean number of eggs laid was 641 among the females (range 126 to 1102) (Kojima and Mori 1911).

FOOD PLANTS

Polyphagous. Found on many of the same food plants used by both *L. d. dispar* and *L. umbrosa*, as tabulated in Schaefer et al. (1988). Several commonly used preferred food plants tend to characterize *L. d. japonica* in Japan, including *Diospyros kaki* Thunberg (Ebenaceae), *Rhododendron* sp. (Ornamental Azalea) (Ericaceae), *Wisteria floribunda* (Wild.) De Candolle (Leguminosae) and *Zelkova serrata* (Thunb.) Makino (Ulmaceae). Frequently, larvae can be found on these species when they cannot be found on preferred larger trees. In all areas within the range of *L. dispar sensu lato*, including Japan, various species of *Quercus* (Fagaceae) are preferred. Otherwise, the following families and genera serve as major food sources: Aceraceae (*Acer*); Anacardiaceae (*Rhus*); Betulaceae (*Alnus*, *Betula*, *Carpinus*, *Corylus*); Ebenaceae

(*Diospyros*); Ericaceae (*Rhododendron*); Fagaceae (*Castanea*, *Castanopsis*, *Fagus*, *Quercus*); Hamamelidaceae (*Hamamelis*); Leguminosae (*Robina*, *Wisteria*); Moraceae (*Morus*); Oleaceae (*Fraxinus*); Pinaceae (*Larix*, *Pinus*, *Picea*); Rosaceae (*Cydonia*, *Cerasis Eriobotrya*, *Malus*, *Prunus*, *Pyrus*, *Rosa*, *Rubus*); Salicaceae (*Populus*, *Salix*); Taxodiaceae (*Cryptomeria*); Tiliaceae (*Tilia*); and Ulmaceae (*Celtis*, *Ulmus*, *Zelkova*) (Kozhansikov 1950, Kim et al. 1982, Schaefer et al. 1988).

PHEROMONAL COMMUNICATIONS

As in *L. dispar sensu lato*, (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] has been confirmed as the major pheromone in *L. d. japonica*. However, some subtle differences between the species have been recognized. In Tohoku, *L. d. japonica* (Morioka area of Honshu) has shown a clear recognition of sex pheromone components of other sympatric congeners. Gries and Schaefer have shown the major sex pheromone component of *L. ban-taizana* depresses trap catch of *L. d. japonica* males; thus, this compound serves as a repellent to male *L. d. japonica* and clearly contributes to species specificity in a habitat where at least five *Lymantria* species exist.

We have also confirmed that females produce the novel trace component, (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadec-17-ene. However, even though our major field trapping in Morioka, Japan, occurred on *L. d. japonica*, we cannot ascribe a specific function to this secondary (trace) component. By itself, this component is about 1/10 as active as (+)-disparlure (Gries et al. 2005b).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Males are almost exclusively diurnal and gravid females are fully capable of normal sustained level or ascending flight. Females readily respond to outdoor lighting, such as street lights, parking lot flood lights, or outdoor stadium lights, within 1–3 hours after sunset. After that, female flight activity subsides. Males respond to lights less frequently, but most flight activity is diurnal. Males fly in the morning and evening, therefore avoiding the heat of mid-day, and during periods of sunshine on otherwise rainy days (Sato and Takamura 1975). Sato and Takamura [1975] relate that both males and females will fly when disturbed, as when one walks through the vegetation.) An experiment conducted in the town of Iwate, Iwate Prefecture, Japan, demonstrated that males respond to synthetic sex pheromone (+)-disparlure from morning to late afternoon. The experiment first placed traps at 6 AM and recorded the trap catch at hourly intervals, and added more traps to the array four times at hourly intervals, thereafter. Hourly mean trap captures range from 0 at 7 AM to 0.4 at 4 PM, with a peak of 9 at noon (Table 3). Seasonally, adults are already flying in Nagoya, Japan, by 4 July (Schaefer unpubl. coll. data). Farther north, in Iwate Prefecture, adults appear in late July and early August (Sato and Takamura 1975). In Hokkaido, flight occurs in August and as late as mid-September at higher elevations.

DISCUSSION

Lymantria dispar japonica was originally described as a variation of *L. dispar* by Motschulsky (1860). It was then treated as a full species by Kirby (1892) and Swinhoe (1903). Strand (1911, 1923) again treated *L. d. japonica* as a subspecies of *L. dispar*, and this is how subsequent authors have placed it (Inoue 1957, Schintlmeister 2004). These authors are also recognizing the form from Japan as *L. d. japonica*.

Table 3. Mean male response of *L. d. japonica* to synthetic (+)-disparlure. Iwate, Iwate prefecture, Japan, (Schaefer unpubl. data).

Time of day	Number of males in trap
AM	
7	0
8	0.1
9	0.5
10	2.2
11	4.3
PM	
12	9.3 (peak)
1	6.9
2	2.6
3	1.3
4	0.4

A biometrics study that included the Honshu form concluded that *L. d. japonica* should be considered a distinct species from *L. dispar* (Pin-tureau 1980a, b). Keena and Moore (1998) demonstrated a partial incompatibility between crosses of *L. d. dispar* and *L. d. japonica*. The biometric study demonstrates the overall larger size of the specimens from Japan, but size is not necessarily evidence of a separate species. The same is true of the partial incompatibility, which may demonstrate only the differences between subspecies. More work with larger sample sizes from broader geographical ranges is certainly needed to resolve these issues.

Larvae show considerable variation in color and patterning. One percent of *L. d. japonica* larvae displayed the black form in Sekigahara, Aichi Prefecture, Honshu, Japan, June 1977 (Schaefer and Furuta 1979[81]) (Fig. 9). In normal specimens, the ground color is black with paired spots along dorsal line (Pl. 29, Figs. 2, 4). In others, the

ground color can be gray (Pl. 29, Fig. 3) and lack paired spots along dorsal line.

As with *L. d. dispar*, *L. d. japonica* is highly polyphagous. However, whereas *L. d. dispar* females are flightless, *L. d. japonica* females are fully capable of level or ascending flight. Furthermore, the female's ability to fly to lights at night increases the potential for female movement to dock areas, shipping containers, or vessels, where they may readily lay their complement of eggs. Hence, the potential for invasion to other countries or continents is very real. This moth is highly polyphagous and if introduced into North America will likely find adequate alternative food sources, such as ornamentals. Maritime commerce with Japan is significant and could result in *L. d. japonica* invading North America. Persistent surveying will help to prevent such an invasion.

LYMANTRIA (PORTHETRIA) UMBROSA (BUTLER), REVISED STATUS

(Figs. 13–15; Pl. 1, Figs. 3, 9; Pl. 9, Figs. 1–6; Pl. 32, Fig. 3; Pl. 44, Figs. 5–6; Pls. 45–46; Pl. 47, Figs. 1–4)

Porthetria umbrosa Butler, 1881:10. LT male: JAPAN: Hakodate (BMNH, examined); Kirby, 1892:475; Schintlmeister, 2004:22. Note: Lectotype is **here designated** to apply the name to the northern populations on Hokkaido. The other female syntype from Yokohama is identified as *L. d. japonica*.

Lymantria dispar praeterea von Kardakoff, 1928:416. ST: RUSSIA: Ussuri-Gebiet (unknown type depository, not examined); Gaede, 1932:100; Schintlmeister, 2004:22.

Lymantria dispar umbrosa; Matsumura, 1933:135.

Lymantria dispar hokkaidoensis Goldschmidt, 1940:59. ST: JAPAN: Island of Hokkaido (unknown type depository, not examined); Schintlmeister, 2004:22.

Lymantria dispar nesiobia Bryk, 1942:25. ST: RUSSIA: Yeterefu, Kuril Islands (NMS, Stockholm, not examined); Schintlmeister, 2004:22.

COMMON NAMES

Hokkaido Gypsy Moth (HGM), Dosanko Gypsy Moth; Ezo-maimai (in Japanese).

DIAGNOSIS

The forewing ground color is cream to light brown in *L. umbrosa*, as compared to brown in *L. d. dispar* and *L. d. japonica*. The markings of the forewing are similar to those of *L. d. japonica* and are less distinct than in *L. d. dispar*. The hindwing has more white on it than either *L. d. dispar* or *L. d. japonica*, and the dark margin contrasts with the lighter ground color and shares this distinct band with *L. d. dispar*. The female has a more rufous cast to the longer scales of the wings and body and has fewer forewing markings than either *L. d. dispar* or *L. d. japonica*. The male genitalia of each species are essentially indistinguishable, as are female genitalia of each species. Even after many years of working on HGM in Hokkaido, neither Yasutomo Higashiura (Tokyo University Department of Pharmacy and Biological Sciences) nor PWS has encountered the black larval form in *L. umbrosa*.

REDESCRIPTION

MALE

- *Head* Front and vertex tan; scape and antenna tan, bipectinate; labial palpus tan, apical segment gray.
- *Thorax* Tegula, mesothorax and metathorax tan; legs white, tarsi gray dorsally.
- *Forewing* (Pl. 1, Fig. 3) Length 18–25 mm (n=6); ground color cream; all wing markings black; antemedial line a short dash at costa; orbicular spot minute; reniform spot angulate, following veins at end of discal cell; postmedial line a small dash at costa and a faint zigzag line to posterior margin; outer margin dark brown; fringe cream-colored with large dark brown spots between veins.

- *Hindwing* Ground color cream, heavily suffused with dark brown; veins highlighted dark brown; wide, dark brown marginal band; fringe white, with brown highlighting of veins extending onto fringe.
- *Abdomen* Dark brown; tymbals absent on third sternite.
- *Genitalia* (Pl. 9, Figs. 1–6) Essentially the same as *L. d. dispar*; aedeagus 0.75–0.78x height of genital capsule.

FEMALE

- *Head* Front and vertex white; scape white, antenna with short pectinations, shaft and pectinations fuscous, apex white; labial palp black.
- *Thorax* Grayish white; proleg fuscous, tarsi fuscous; middle and hind femur fuscous, tibia white with proximal apex fuscous, tarsi fuscous; underside white.
- *Forewing* (Pl. 1; Fig. 9) Length: 20–30mm; ground color white, but with a distinct light brownish cast; basal area with a black spot on costa and on junction of R and M veins; antemedial line a black bar at costa, a faint sinuate line to posterior margin; orbicular spot a small, black dot in middle of discal cell; reniform spot crescent-shaped, at end of discal cell; postmedial line with a spot at costa, faintly crenulate, to posterior margin; subterminal line crenulate, faint and only distinct in apical half of wing; fringe concolorous with ground color.
- *Abdomen* Tergites white becoming progressively browner to brown apex; sternites white in basal quarter, remainder light brown.

LARVA

PRESERVED SPECIMENS (Pl. 32, FIG. 3; Pl. 44, FIGS. 5–6; Pls. 45–46; . 1Pl. 47, FIGS. 1–4)

- *Length* 18–20 mm
- *Head* Cream-colored speckled with light brown, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 3); primary setae twisted and with microbarbules (Pl. 44, Fig. 6); secondary setae shorter than on *L. d. dispar*, twisted and with microbarbules (Pl. 45, Fig. 1); labrum lobes not as elongate as in *L. d. dispar* (Pl. 44, Figs. 5–6); spinneret narrow (Pl. 44, Fig. 5); stemmata 1, 2, 5, and 6 tripartite; Pl. 45, Fig. 5 shows the tonofibillary platelet with shorter spiculi contrasted with the longer hair-like spiculi on the rest of the head.
- *Thorax* D2 verrucae brown; T1 with XD2, XD1, and D2 verrucae with broad cylindrical setae (Pl. 46, Figs. 3–4) having microbarbules in a slightly spiral pattern (Pl. 46, Fig. 3) and with minute pores at apex (Pl. 46, Fig. 4), several large flattened and twisted setae on L verruca with microbarbules (Pl. 46, Fig. 1), plumose SD1 seta and SD2 verruca on same pinnaculum and separate from the prothoracic shield (Pl. 46, Fig. 5), D1 setae much shorter than in *L. d. dispar*, SD2 verruca with fewer spine-like setae than in *L. d. dispar*, prothoracic shield and pinnaculum bearing SD1 seta and SD2 verruca covered with spiculi (Pl. 46, Fig. 5); legs yellowish-brown with broad flattened setae (Pl. 46, Fig. 6).
- *Abdomen* Ground color black irrorated with an irregular pattern of white laterally; dorsal stripe consisting of broad irregularly shaped white patches; lateral stripe distinct, white; D2 verruca on A1–2 brown, on A3–8 light brown, primary setae on D2 brown and white, secondary setae white, primary setae on D2 shorter than those on L; D1 verruca small with a large white seta and several white secondary setae; SD and

L verrucae contiguous, SD slightly darker than L, both verrucae with a brown lateral bar; SV verrucae white; L verruca with long dark brown and white setae; setae, both dark brown and white on SD and L with minute barbs on shafts; eversible glands light brown on abdominal segments 6–7; ventral broad black stripe between prolegs absent, remainder of underside speckled black and white; prolegs pale with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal meseries.

DISTRIBUTION

From Hokkaido, Japan, northeast into the Kuril Islands, Russia, and might be on the Siberian mainland.

SPECIMENS EXAMINED

JAPAN: HOKKAIDO: No specific locality (3m), male genitalia slides USNM 59151, 59152; Bibai, 10 Aug. 1994 (4m), 8 Aug. 1994 (2m), Y. Higashiura (PWS); Sapporo, Mt. Teine, r. BIRL #10-2003 on *Larix* sp., ova on *Betula ermanii*, Paul W. Schaefer (2m, 7f) (PWS).

OVIPOSITION

Oviposition behavior similar to *L. d. dispar*. However, egg mass color is perhaps more variable. Very occasionally, the egg mass can be bicolored due to differential scale coloration on the female abdomen (Fig. 13). Gravid females usually fly during afternoons. They select white-barked birches (*Betula platyphylla* Sukatshev, Betulaceae) near food trees (*Larix leptolepis* (Sieb. and Zucc.) Gord., Pinaceae) (Kosugi 1954, Higashiura and Kamijo 1977, Schaefer 1978),



Figure 13. Egg mass of *L. umbrosa* showing two color tones in the same egg mass indicating that the female abdomen was bicolored. Photo taken from reared material collected in Hokkaido, Japan in 1979 (photo by Paul W. Schaefer).

on which to oviposit their eggs, often in massive numbers on individual trees (Fig. 14). Most egg masses are deposited at a height of less than 2 m on boles of various trees. The closer to the ground the better, especially in heavy snow areas, as snow cover provides both insulation from cold wind and protection from predatory birds (Higashiura 1980, 1984, 1989). Individual eggs masses are covered with a thick mat of abdominal hairs, which, when viewed under high magnification, are straight and gradually tapered at both ends.

BIOLOGY AND BEHAVIOR

Because of the behavior of both adults and larvae, there is a cycle of tree utilization by *L. umbrosa*. In Hokkaido, females oviposit heavily on *B. platyphylla*. In spring, larvae balloon to

L. leptolepis for food. Female adults develop in association with the *L. leptolepis*, and when they emerge, fly back to the *B. platyphylla* to oviposit, thus completing the cycle. Observations made during high population levels have shown *Betula* often is spared defoliation in favor of the more preferred *Larix* food trees (Fig. 15). Male mating frequency was 3.0, with effective mating lasting more than 10 minutes *in copulo* (Iwata 1976). Adults normally are diurnal but both sexes respond to light traps at night. However, only 27% of trapped moths were females (Kosugi 1954).

FOOD PLANTS

Polyphagous. On Hokkaido, this species generally prefers, and may cause damage to larch (*Larix leptolepis*) in nearby monoculture plantations. Food plants (and other forms) in Japan are tabulated in Schaefer et al. (1988). Principal food plants include: Aceraceae (*Acer*); Betulaceae (*Alnus*, *Betula*, *Carpinus*); Fagaceae (*Quercus*); Moraceae (*Morus*); Pinaceae (*Abies*, *Larix*); Rosaceae (*Prunus*, *Rosa*, *Rubus*); Salicaceae (*Populus*, *Salix*); and Ulmaceae (*Celtis*, *Ulmus*). Populations will move on to many other food plants if and when they defoliate the preferred food trees. Schaefer et al. (1988) tabulated less-favored food trees.



Figure 14. White birch tree in close proximity to many Japanese larch trees showing evidence that the *L. umbrosa* females selectively chose the white birch for oviposition. Photo taken at Mt. Teine, Sapporo, Hokkaido, Japan, in August 1976 (photo by Paul W. Schaefer).

PHEROMONAL COMMUNICATIONS

As with *L. d. dispar*, (7*R*, 8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] is the major sex pheromone component. We have confirmed that pheromone gland extracts of females also contain the trace component, (7*R*, 8*S*)-*cis*-7,8-epoxy-2-methyloctadec-17-ene, but its role during sexual communication is not clear. As with all other forms in the *L. dispar* complex, this moth is diurnal and all calling and male response takes place during daytime, making field research considerably more convenient than if they were nocturnal.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Males fly from mid- to late morning and through the heat of the day until late afternoon. Adults also respond to light traps at night (Kosugi 1954).

DISCUSSION

The larvae in *L. umbrosa*, with their wide dorsal stripes, differ from those of both *L. d. dispar* and *L. d. japonica*. In *L. umbrosa*, the primary setae on the D2 verruca are dark brown and white, but are black in *L. d. dispar* and *L. d. japonica*. The underside is speckled black and



Figure 15. Defoliation of Japanese larch by *L. umbrosa* at Mt. Teine, Sapporo, Hokkaido, Japan, in August 1976. Note nearly complete defoliation of the larch, but relative green of the white birch, yet many egg masses are deposited on the birch (photo by Paul W. Schaefer).

white in *L. umbrosa* and *L. d. dispar* and is a solid color with little or no pattern in *L. d. japonica*. Because of these and other differences (see above), we are treating *L. umbrosa* as a distinct species.

The subspecific synonyms *L. d. praeterca* and *L. d. hokkaidoensis* were listed under *L. d. dispar*, and *L. d. nesiobia* was listed under *L. d. japonica* in Schintlmeister (2004). These subspecific names are considered synonyms of *L. umbrosa*.

Studies begun at Bibai on Hokkaido by Yasutomo Higashiura (Tokyo University of Pharmacy and Biological Sciences, Hachioji, Tokyo), his students, particularly Hirofumi Yamaguchi, and collaborators have shown the presence of male-killing genetic factors, which result in 9% of females producing only female progeny (Higashiura et al. 1999). Since then, it has been determined that this phenomenon results only from the crossing of two haplotypes, one consistent with the moths from other islands of Japan and Asia and the other consistent with Hokkaido Gypsy Moths (HGM). The geological history of Hokkaido appears to have a bearing on these two haplotypes. At one time the island was divided into a western part (which may have been continuous with Honshu at that geological time) and an eastern part. Presumably this completely isolated the two moth haplotypes. Over time, the intervening land rose to connect the two halves and creating Hokkaido as it is today. With these former parts now connected by land, the two moth haplotypes are permitted to intermix. Apparently these populations are stable and produce natural intermatings, which result in all female progeny (Higashiura et al. 1999). The significance of this work (Higashiura et al. and Yamaguchi et al. each with work in progress, pers. comm.), coupled with our present understanding of the taxonomy of these moths, will have a profound impact on our understanding of the origin, biology, behavior, genetics and evolution of these moth populations in Hokkaido.

Based on the ability of females to fly to lights at night, it appears these species have an intermediate invasive potential in North America. *Lymantria umbrosa* would be limited in its chances of finding its preferred food host, Japanese larch, in North America. However, its polyphagous nature would allow it to feed on a number of alternate hosts including a variety of oaks. Severe winter weather causes high mortality in egg masses deposited above winter snow level.

LYMANTRIA (PORTHETRIA) OBFUSCATA WALKER

(Pl. 1, Fig. 7; Pl. 2, Fig. 1; Pl. 10, Figs. 1–3; Pl. 26, Fig. 1; Pl. 29, Fig. 6; Pl. 32, Fig. 4; Pl. 38, Figs. 4–6)

Lymantria obfuscata Walker, 1865:367. HT male: INDIA: North Hindostan (BMNH, examined); Strand, 1910:130; Strand, 1923:321; Schintlmeister, 2004:23.

Liparis obfuscata; Swinhoe, 1923:425.

COMMON NAMES

Indian gypsy moth (IGM); Apple hairy caterpillar and Kashmir willow defoliator (in India); Apple gypsy moth, Ping-wu-do-er (in Chinese).

DIAGNOSIS

This species looks like a small *L. d. dispar*. In *L. obfuscata*, the color of the forewing border is not very distinct from that of the wing, whereas in *L. d. dispar* the border is distinctly dark brown. The hindwing border is more sharply defined in *L. obfuscata* than in *L. d. dispar*. The saccus in the male genitalia is broader, V-shaped, with a more pointed apex in *L. obfuscata*; in *L. d. dispar* the saccus is narrower and the apex tends to be broader. The sacculus tends to have a produced apex in *L. d. dispar* (Pl. 7, Figs. 1, 5; Pl. 8, Fig. 1), but in *L. obfuscata* the apex is straight and not produced (Pl. 10, Fig. 1). In *L. obfuscata* the females have highly reduced wings and are incapable of flight, in *L. d. dispar* the wings are fully formed, but they are still unable to fly.

REDESCRIPTION

MALE

- *Head* Front and vertex light brown; scape light brown, antenna light brown, bipectinate; labial palpus brown, cream-colored ventrally
- *Thorax* Tegula, mesothorax, and metathorax concolorous with head; foretibia brown, long hair-like fringe white, tarsi with basitarsus, second, and third segments brown, remainder cream-colored; middle and hind tibiae cream-colored, long fringe white, tarsi cream-colored with second and third segments brown; underside white.
- *Forewing* (Pl. 1, Fig. 7) Length 15–16 mm (n=2); ground color grayish brown; basal band a short black dash from costa to M vein; antemedial line dark brown, a squiggly line from costa to posterior margin; orbicular spot minute, in middle of discal cell; reniform spot black, crescent-shaped, at end of discal cell; postmedial line a wide indistinct brown band from costa to posterior margin; subterminal line brown, zigzag, from costa to posterior margin; fringe light reddish-brown with brown spots between veins.
- *Hindwing* Ground color reddish brown with dark brown marginal band; discal spot brown, crescent-shaped; fringe light reddish-brown.
- *Abdomen* Dorsally reddish-brown, concolorous with hindwing, indistinct dark brown spots, cream-colored ventrally; tymbals absent on third sternite.

- *Genitalia* (Pl. 10, Figs. 1–3) Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a square plate with dorsal margin slightly concave, ventral margin with broad excavation; sacculus apex broadly rounded; saccus variable, from V-shaped to narrow U-shaped; aedoeagus 0.79–0.86x height of genital capsule, straight, slightly curved distal to opening for ductus ejaculatorius; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape white, antenna black with short pectinations; labial palpus short, dark gray.
- *Thorax* White; forelegs and tarsi gray; middle tibia white with gray apices, tarsi gray; hind leg and tarsi gray; underside white.
- *Forewing* (Pl. 2, Fig. 1): Length: 15–16 mm (n=2); ground color white; basal area a black spot extending to M vein; antemedial line absent; orbicular a minute black spot in middle of discal cell; reniform a crescent-shaped black spot along veins at end of discal cell; terminal band indistinct, black; fringe white with black spots.
- *Hindwing* Ground color white; marginal border a thin black band; fringe white.
- *Abdomen* Light reddish-brown becoming darker reddish-brown distally and ventrally.
- *Genitalia* (Pl. 26; Fig. 1): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae broad, U-shaped, with vertical indentations or medial pockets, apices of these pockets merge medially; ductus bursae shorter than corpus bursae; corpus bursae oblong.

LARVA

PRESERVED SPECIMENS (Pl. 29, Fig. 6; Pl. 32, Fig. 4; Pl. 38, Figs. 4–6)

- *Length* 23–30 mm.
- *Head* Yellowish-brown speckled with black, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 4); variably sized black patches surrounding stemmata extending dorsad, large black patches at vertex.
- *Thorax* D2 verruca black; legs yellowish-brown.
- *Abdomen* Ground color dark brown to black; dorsal stripe indistinct, short white dashes cephalad to small D1 verruca, not contiguous; lateral stripe indistinct, short white dashes below D2 verruca; D2 verruca on A1–2 black, on A3–8 yellowish-brown; D1 verruca small with a large white primary seta and several white secondary setae; SD verruca light brown and L verruca cream-colored, contiguous; SV verrucae cream-colored; primary setae on D2 verruca black and white, secondary setae white; primary setae on D2 verruca shorter than those on L verruca; L verruca with long black and pale-yellow setae; long setae, both black and white on SD and L1 with microbarbules on shafts; eversible glands on A6–7 concolorous with D2 verruca; underside yellowish-brown with obscure brown areas between prolegs; prolegs concolorous with thoracic legs with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries. Gardner (1938) provides a description of full-grown larvae, and Gupta and Agrawal (1985) provide a detailed morphological description of late stage larvae.

DISTRIBUTION

Northern India (including Kashmir, Ladakh, Himachal Pradesh, and Punjab to elevation of 9,000 ft.), Pakistan, and Afghanistan (Schintlmeister 2004).

SPECIMENS EXAMINED

INDIA: Himachal Pradesh, nr. Solan, Kandaghat Forest, N 30 deg. 57.27' E 77deg. 6.80', 22 June 2005, @ phero. Trap., 10:00 A.M. Paul W. Schaefer (5m); Origin Kulu Val., ova ex G. Ramasechiah, r. BIRL #1-2003 on GM diet, Paul W. Schaefer (32m, 29f); Himachal Pradesh, Solan, N 30 deg., 54.5' E 77 deg. 5.7', 23 June 2005, @ phero. @ our hotel window (similar data between 22 to 24 June, with time of day included: 6:45, 8:00, 10:00 A.M., 2:00, 6:00 & 8:00 P.M). Paul W. Schaefer (18m) (PWS); Punjab, Kulu, 1963, V. P. Rou (1m) (USNM). Two males and three females from a lab strain at USDA APHIS SCI & TECH, Otis Methods Dev. Center, Otis ANGB, Massachusetts, 1990, male genitalia slide USNM 58868 (USNM).

OVIPOSITION

Eggs usually laid in a single mass, covered by yellow hairs from female's abdomen, as in the *L. dispar sensu lato* group. Egg color fades with exposure to weather. Egg masses are placed rather indiscriminately on a variety of objects, including tree trunks, branches, stones, walls, or buildings (Chacko and Singh 1990). Maximum fecundity was 614 eggs per egg mass during a 4-year study in Kashmir (Mills 1989).

BIOLOGY AND BEHAVIOR

At times, *L. obfuscata* populations may erupt and become destructive (Beeson 1941, Roonwal 1977). Even then, there is but one generation per year and overwintering occurs in the egg stage (Masoodi 1991). In the Kulu Valley and Simla Hills of northern India, *L. obfuscata* eggs hatched in late March and early April. Dispersal occurs through ballooning by newly hatched larvae. Later larvae feed only at night (Rahman and Kalra 1944). Larval feeding peaks in late May and early June. Late-stage larvae reportedly descend trees after feeding and travel over the ground considerable distances before reaching resting spots, often under loose stones (or "in the loose soil" (Rahman and Kalra 1944)), where they cluster together during the day (Chacko and Singh 1990, Mills 1989). Pupations peak in early July. Adult males fly late June to early August (Chacko and Singh 1990) and as late as early September in Pakistan (Chaudhry 1966). Females have highly reduced wings (Pl. 2, Fig. 1) and consequently only crawl short distances from the pupation site.

FOOD PLANTS

Polyphagous, with larvae reportedly feeding on *Alnus* (Betulaceae); *Quercus* (Fagaceae); *Juglans* (Juglandaceae); *Robinia* (Leguminosae); *Morus* (Moraceae); *Cydonia*, *Malus*, *Prunus*, *Pyrus*, *Rosa* (Rosaceae); and *Populus* (Salicaceae). This species is cited as a major pest of apricot in Kashmir and apple in Himachal Pradesh and Punjab (Butani 1979). Masoodi (1991, citing others) reports this moth as a pest on willows and poplars, apricot, apple, and other fruit trees.

PHEROMONE COMMUNICATION

Based on field trapping experiments, males are attracted to *cis*-7,8-epoxy-2-methyloctadecane [racemic disparlure] (Beroza et al. 1973a, Punjabi et al. 1974, Mayer and McLaughlin 1991). Recent analysis of pheromone gland extract and field testing of candidate pheromone components at Solon, Himachal Pradesh, India indicate that *L. obfuscata* uses a two-component pheromone blend of (7R,8S)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] and (7Z)-2-methyloctadecene [2me-7Z-18Hy] (Gries, K. et al., in press). (Gries and Schaefer, in press). Attempts under laboratory conditions at reciprocal cross mating suggested that *L. obfuscata* males readily responded to calling *L. d. dispar* females, but *L. d. dispar* males generally failed to respond to calling *L. obfuscata* females. This suggests a level of behavioral inter-specific incompatibility (Schaefer unpubl. data), further supporting the validity of *L. obfuscata* as a discrete species.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

As with *L. dispar sensu lato*, male *L. obfuscata* are diurnally active, and females, because of their brachypterous condition, are largely sedentary. Circumstantial evidence gathered from field trappings conducted at Solon, Himachal Pradesh, India (Gries and Schaefer, unpubl. data), males fly in mid- to late morning hours and again near sunset, but tend to avoid flight during the heat of the day. Seasonally, the moth flight occurs from late June through the first week in August, with peak activity in mid-July (Chacko et al. 1988).

DISCUSSION

General coloration and pattern is characteristic of *L. d. dispar*, but forewing length is shorter in *L. obfuscata* than in *L. d. dispar*. This is the northern Indian component of *Lymantria (Porthetria)*.

In the female abdominal hairs that cover the normal egg masses, there is a preponderance of elbowed individual hairs (i.e., they exhibit a rather abrupt bend) usually near the proximal end of the seta (Roonwal 1954). This appears to be unique among all *L. dispar sensu lato*.

All evidence indicates that *L. d. dispar* does not occur in India, despite records to the contrary (Hacker 1992), which must have resulted from *L. obfuscata* being misidentified as *L. dispar*. Roonwal's (1954) conclusion, that *L. obfuscata* is discrete from *L. dispar*, remains valid and is supported by recent mtDNA analysis, which clearly separates *L. obfuscata* from all the *L. dispar* lineages (Ball and Armstrong, 2006).

We recognize that the literature contains reports of *L. obfuscata* from southern India (Misra and BasuChoudhuri 1974, Kumar 1974). However, this information is based on a misidentification of *L. ampla* (Walker) (Chacko and Singh 1990). Furthermore, some propose that *L. obfuscata* is but a small subspecies of *L. dispar* or *L. d. asiatica* (Schintlmeister 2004). But recent molecular evidence, based on mtDNA (Ball and Armstrong, 2006) and pheromonal communication evidence (Gries, Schaefer et al. unpubl. data) support the contention that *L. obfuscata* and *L. d. dispar* or *L. d. asiatica* are not conspecific. Our pheromone data clearly indicate that if these two species were sympatric, they would maintain pheromonal isolation based on chemical specificity.

Potential for invasion is minimal because of the inability of females to fly, leaving the only possibility of invasion being through commerce, whereby egg masses are transported on crates or in packing material or shipping containers.

LYMANTRIA (PORHETRIA) ALBESCENS HORI AND UMENO, REVISED STATUS

(Pl. 1, Fig. 8; Pl. 2, Fig. 2; Pl. 10, Figs. 4, 6–7; Pl. 30, Fig. 1; Pl. 32, Fig. 5; Pl. 47, Figs. 5–6; Pl. 48, Figs. 1–3)

Lymantria dispar ab. *albescens* Matsumura, 1927:25. ST: JAPAN: Okinawa (HUS, Sapporo, examined). Note: This is an infrasubspecific name and is therefore invalid by Article 45.6.2 of the Code of Zoological Nomenclature.

Lymantria dispar albescens Hori and Umeno, 1930:18 LT male: JAPAN: Yakushijima Island, Ishigakijima (HUS, Sapporo, examined); Gaede, 1932:100; Matsumura, 1933:135; Bryk, 1934:150; Inoue, 1956a:398; Ferguson, 1978:90; Kishida and Furukawa, 2000:214. Note: Lectotype was designated by Kishida and Furukawa (2000).

Lymantria albescens albescens; Schintlmeister, 2004:24.

COMMON NAMES

Okinawa Gypsy Moth (OGM), Albescens Gypsy Moth; Shiroshita-maimai (in Japanese).

DIAGNOSIS

Forewing outer margin color is dark gray as compared to brown in *L. apicebrunnea* Gaede. They share the broad costal margin of the hindwing, but it is dark gray in *L. albescens* and brown in *L. apicebrunnea*. The indistinct marginal band in the hindwing is more evident in *L. albescens* than in *L. apicebrunnea*. The distal process in the male genitalia is straight in *L. albescens* (Pl. 10, Fig. 6) and curved dorsally in *L. apicebrunnea* (Pl. 11, Fig. 2). Egg masses are indistinguishable from those of *L. xylina* Swinhoe except for a slight color tone difference (Fig. 16).

REDESCRIPTION

MALE

- *Head* Front and vertex pale gray; scape pale gray, antenna pale gray becoming darker toward apex, bipectinate; labial palpus gray to pale gray dorsally and toward apex, white ventrally.
- *Thorax* Tegula, mesothorax and metathorax concolorous with head; foretibia pale gray with proximal spot and spot at 2/3 length gray, basitarsus and segments 2–3 gray, rest white; underside white.



Figure 16. Egg masses of *L. xylina* appear somewhat like a moth cocoon on a twig. These egg masses are identical to those of *L. albescens* in Okinawa, Japan. Photo taken of material collected at Kume Island, Okinawa, Japan, in March 1977 by K. Katagiri (photo by Paul W. Schaefer).

- *Forewing* (Pl. 1, Fig. 8): Length 22.0–30.0 mm (n=10); ground color white suffused with gray, especially along costa and near base; small black dash at costa proximal to antemedial line; antemedial line a black dash at costa with a narrower dark gray, sinuate line to posterior margin (only on well-marked specimens); orbicular spot small, black, in middle of discal cell; reniform spot V-shaped, black, along veins at end of discal cell; postmedial line a dark brown, zigzag band from reniform spot to posterior margin (only on well-marked specimens); subterminal line narrower than postmedial line, dark brown, zigzag from costa to posterior margin (only on well-marked specimens); outer fourth of wing solid dark gray becoming narrower toward posterior margin; fringe dark gray.
- *Hindwing* Ground color white; costa with an elongate band of dark gray from base to apex; discal spot dark gray, crescent-shaped, at end of discal cell; marginal band not solid, more defined below costal band, becoming less distinct with an obscure spot near anal veins, dark gray; fringe white.
- *Abdomen* White with black bands at proximal margins of tergites, white ventrally; tymbals absent on third sternite.
- *Genitalia* (Pl. 10, Figs. 4, 6–7): Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a broad ovate plate with convex dorsal margin; sacculus apex sharply rounded forming an acute angle; saccus narrow, U-shaped; aedoeagus slightly bent medially; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape white, antenna gray, apex white, bipectinate; labial palpus white, some gray scales laterally, apical segment gray.
- *Thorax* White.
- *Forewing* (Pl. 2, Fig. 2): Length 40–41 mm (n=2); ground color white lightly suffused with reddish-brown; antemedial line absent; orbicular spot black, minute, at middle of discal cell; reniform spot black, crescent-shaped along veins at end of discal cell; postmedial line absent; subterminal band faint, reddish-brown, zigzag, from costa to CuA1; fringe white with black spots between veins.
- *Hindwing* Ground color white; fringe white.
- *Abdomen* White reddish-brown.
- *Genitalia* (Pl. 26, Fig. 2) As illustrated for *L. postalba* Inoue.

LARVA

PRESERVED SPECIMENS (PL. 30, FIG. 1; PL. 32, FIG. 5; PL. 48, FIGS. 1–3)

- *Length* penultimate instar 35–40 mm (n=2), ultimate instar 53 mm (n=1); head width penultimate instar 4.66–5.08 mm (n=2), ultimate instar 6.36 mm (n=1).
- *Head* Tan speckled with brown laterally, coronal stripes present (Pl. 32, Fig. 5); setae twisted; stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a wrinkled surface and a raised rim margin; covered with spiculi, black stripe area with spiculi less dense and slightly shorter (Pl. 48, Fig. 1) than rest of head (Pl. 48, Fig. 2); Pl. 48, Figs. 2–3 show the round tonofibullary platelets having a different pattern of spiculi than the surrounding area.

- *Thorax* L verruca on T1 produced cephalad, larger than other L verrucae; verrucae yellowish-brown, darker on T2–T3 than on T1; legs concolorous with ground color.
- *Abdomen* Ground color tan with irregularly shaped gray spots giving a mottled appearance, most prominent dorsal to the spiracles, and tending to fade ventral to the spiracles; dorsal stripe distinct, becomes less obvious toward last segment; subdorsal stripe (just ventral to D2 verruca) most obvious on A1–10; lateral stripe absent; verrucae yellowish-brown, darker on A1 than on rest of abdomen; D1 verruca small with large brown median seta and several white secondary setae; SD and L verrucae contiguous; primary setae on D2 verruca brown, secondary setae mostly brown with a few white; primary setae on D2 verruca shorter than those on L verruca; L verruca with long white setae; setae on SD and L lacking microbarbules on shaft; SV verrucae concolorous with ground color; eversible glands on A6–7 concolorous with ground color; underside with broad dark stripe between prolegs that extends to A10, remainder of underside concolorous with ground color; prolegs concolorous with ground color with well-developed lateral sclerotized plates slightly darker; crochets in a homioideous uniordinal mesoseries.

DISTRIBUTION

Ryukyu Islands of Japan, including Ishigaki and Okinawa.

SPECIMENS EXAMINED

JAPAN: OKINAWA: Ishikawa, 2 June 1998 (1m), P. W. Schaefer (USNM); ca 15 Km S. Nago, Pheromone trap 2 (1m), Hand collected, 29 June 1994 (1m), P. W. Schaefer (USNM); 15 Km N. Nago, pheromone trap 4, 29 June 1994 (1m), (USNM), (1m) (CMP), P. W. Schaefer; road to Yaka, 2 Km. E. Rt. 58, 28 June 1994 (1m), P. W. Schaefer (CMP); 28 Km N. Nago, pheromone trap 5, 29 June 1994 (1m), P. W. Schaefer (CMP); 35 Km N. Nago, pheromone trap 6, 29 June 1994 (1m), P. W. Schaefer (CMP); cross rd. to Yaka, ca 20 Km S Nago, pheromone trap 2, 26 June 1994 (1m), P. W. Schaefer (CMP); Yakushima Island, Ishigakijima, 25 May 1956 (1m, 1f) (BMNH); Ryukyu Isl., Ishigaki, Yayeyama (1m), genitalia BMNH 2062, 31 May 1952 (1m), K. Sato (BMNH); Ishigaki, 6 June 1962 (1m), 7 June 1962 (2m), R. Kano (BMNH).

OVIPOSITION

Egg masses are generally attached to small twigs in such a way as to suggest mimicry of certain moth cocoons. This ovipositional behavior is very similar to that of sympatric *L. xylina*, but the surface color of the covering hairs is slightly darker than in egg masses of *L. xylina* (Fig. 17).

BIOLOGY AND BEHAVIOR

On Okinawa, males are diurnal and most fly during morning hours before the heat of the day. They are easily mistaken for butterflies because of their light color and active, erratic flight behavior.



Figure 17. Female of *L. xyliina* ovipositing on a twig. Photo taken near Kuanyin, Taiwan, May 21, 1998 (photo by Paul W. Schaefer).

lure, unlike other populations of the *L. dispar sensu lato*, in which this same enantiomer acts in a repellent role. Males are inhibited by admixtures of either 2-methyl-(*Z*)-7-octadecene [2-me-7*Z*-18Hy] or (7*R*,8*S*)-*cis*-7,8-epoxy-octadecane [(+)-monachalure] (Gries and Schaefer, unpubl. trapping data).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

In Okinawa, males respond to pheromone lures in mid-morning and again in late afternoon, appearing to be less likely to fly during the heat of the day. Of 73 males captured in traps at Onna Village, Okinawa, 52% responded between 10:30 AM and noon (Photophase), 46% between noon and 8:00 PM, 1% (one individual) responded between 8:00 PM and 9:00 PM, and none appeared during any nocturnal hours (Schaefer, unpubl. trap data) (Fig. 2). Flying males were observed on May 18, 2003, in Naha, Okinawa, signaling the start of the seasonal

FOOD PLANTS

In Okinawa, feeds on *Castanopsis sieboldii* Hatusima (Fagaceae) (Seizi Azuma, pers. comm.). Larvae were found feeding on an *Elaeocarpus sylvestris* (Lour.) Poir (Elaeocarpaceae) tree near Ishikawa in both 1999 and 2003 (Schaefer unpubl. data), and on a planted roadside shrub or hedge (remains unidentified) in Fentona (Schaefer unpubl. data). Nasu et al. (2004) report successful laboratory rearing on cultivated *Eucalyptus* spp. (Myrtaceae).

PHEROMONAL COMMUNICATIONS

As is the case with both *L. japonica* and *L. d. dispar*, in the field males of this species respond to (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure]. Subsequently, extraction of virgin female sex pheromone glands confirmed (+)-disparlure as the only major sex pheromone. Field trapping experiments have indicated that *L. albescens* males are indifferent to presence of (7*S*,8*R*)-*cis*-7,8-epoxy-2-methyloctadecane (-)-dispar-

flight period. Prior to this, no males had been seen during several days of travel around northern Okinawa (Schaefer, unpubl. data). These males, being the whitest of all members of the *L. dispar* species group, fly during mid-day and clearly resemble butterflies.

DISCUSSION

Male forewing ground color is variably suffused with brownish gray, resulting in specimens that range from white to mostly light brown. The lines of the forewing vary with intensity from quite distinct to almost absent. The marginal band in the hindwing is also variable; in darker individuals it is distinct and well-developed, but in lighter specimens it is only a diffuse spot near the outer apex .

Matusumura (1927) described *L. albescens* as an aberration of *L. dispar*. However, because the International Code of Zoological Nomenclature considers aberrations to be invalid, the authorship of *L. albescens* goes to Hori and Umeno (1930), who were the first to use the trinomen (Kishida and Furukawa 2000).

This species has been treated as a subspecies of *L. dispar*. However, differences between the male genitalia of *L. dispar* and *L. albescens* are sufficient to establish *L. albescens* as a distinct species. The distal process is longer in *L. albescens* than in *L. dispar*, and the apex is slightly broader (expanded) in *L. albescens*, than in *L. dispar*.

Invasion potential into most of North America is minimal, because *L. albescens* inhabits limited areas of semitropical islands. However, as with *L. xyliana*, *L. albescens* could invade Florida, southern California, or Hawaii.

LYMANTRIA (PORHETRIA) POSTALBA INOUE, REVISED STATUS

(Pl. 2, Figs. 3–4, 6; Pl. 10, Fig. 5; Pl. 26, Fig. 2)

Lymantria dispar postalba Inoue, 1956b:141. HT male: JAPAN: Yakushima (BMNH, examined); Inoue, 1956a:398; Ferguson, 1978:92.*Lymantria dispar tsushimensis* Inoue, 1956b:141. HT male: JAPAN: Tshushima (type depository unknown, not examined); Inoue, 1956a:398; Ferguson, 1978:92. **Revised synonymy.***Lymantria albescens postalba*; Schintlmeister, 2004:24.*Lymantria albescens tsushimensis*; Schintlmeister, 2004:24.

COMMON NAMES

Ryukyu Gypsy Moth (RGM), White-winged gypsy moth; Ko-shiroshita-maimai (in Japanese).

DIAGNOSIS

Lymantria postalba can be distinguished from *L. albescens* by its forewing length. It is 21–27 mm in *L. postalba*, versus greater than 30 mm in *L. albescens*. Forewing ground color in males is brown in *L. postalba* and white or white suffused with gray in *L. albescens*.

REDESCRIPTION

MALE

- *Head* Front and vertex light brown; scape white, antenna white, bipectinate; labial palpus light brown dorsally, apex slightly darker, white ventrally.
- *Thorax* Light brown, slightly darker than vertex; foretibia light brown with darker spot at 2/3 length, basitarsus light brown, segments 2–3 brown, rest white; underside white.
- *Forewing* (Pl. 2, Figs. 3–4): Length 21–27 mm (n=10); ground color light brown, area distal to postmedial line brown; indistinct black spots along costa proximal to orbicular spot; orbicular spot a small dot in middle of discal cell; reniform spot V-shaped at end of discal cell; subterminal line brown, faint, scalloped; fringe brown.
- *Hindwing* Ground color white; costal margin brown; discal spot brown; marginal band not solid, more heavily marked along veins, with a slightly larger spot near anal veins.
- *Abdomen* White with brown dorsal bands progressing to black on distal segments; white ventrally; tymbals absent on third sternite.
- *Genitalia* (Pl. 10, Fig. 5): Essentially the same as in *L. albescens*, but valve has a shorter dorsal process and apex of sacculus is less produced.

FEMALE

- *Forewing* (Pl. 2, Fig. 6): Length 34–36 mm (n=4); ground color white with pale rufous tint; a minute orbicular spot in middle of discal cell; reniform spot a faint an-

gulate line at end of discal cell; a faint curved line from costa to M_1 near apex; fringe white with black spots between veins.

- *Hindwing* White.
- *Abdomen* Cream-colored, darker than hindwing.
- *Genitalia* (Pl. 26, Fig. 2): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae broad, U-shaped, with vertical indentations or medial pockets, apices of these pockets merge medially; ductus bursae longer than in *L. obfuscata* or *L. dispar*; corpus bursae ovate.

LARVA

Unknown.

DISTRIBUTION

Japan, from southern Kyushu and Aoshima (Miyazaki Prefecture, Kyushu) south, including the islands of Ishigaki, Tsushima and Yakushima, and in the Ryukyu Islands.

SPECIMENS EXAMINED

JAPAN: No specific locality, 28 June 1960 (1f) (BMNH); HONSHU: Mie Pref., Owase City, Mataguchi, 14 Aug. 1980 (5m), M. Sakabe (BMNH); Owase City, 1 Aug. 1980 (1m, 1f) M. Sakabe (BMNH); KYUSHU: Kagoshima-shi, 5 July 1959 (1m), genitalia slide BMNH 2060, Y. Takemura (BMNH); Meshima, Danjyo-gunto, 4–8 Aug. 1972 (3m) 5–6 Aug. 1972 (1f), A. Miyata (BMNH); Tanegashima, Nishino-omote, 4 July 1952 (1m), 25 July 1950 (1m, 1f), T. Shirozu (BMNH); Yakushima, 20 July 1952 (3m), Y. Kurosawa, 25 July 1951 (1m), Y. Ishiguto, 6 July 1952 (2m), 13 July 1952 (1m), Y. Kurosawa (BMNH); Yakushima, Kosugidani-Amboo, 24 July 1950 (1m), T. Shirozu (BMNH); Yakushima, Shirataki, 25 July 1974 (1m), H. Inoue (BMNH); SHIKOKU: Kochi Pref., Is. Oki no Shima, 24 July–8 Aug. 1960 (1m) (BMNH); Kochi Pref., Okinoshima, Aug. 1951 (1m), T. Ishihara, 1 Aug. 1952 (1m), H. Inoue (BMNH); OKINAWA: Shuri, 15 June 1968 (1f), genitalia slide BMNH 2061, M. Kinju (BMNH); Tokasiki Island., 6 June 1976 (2m), genitalia slide BMNH 2059, H. Sunakawa (BMNH).

OVIPOSITION

Appears to be similar to both *L. d. dispar* and *L. d. japonica*. Recorded laying eggs on the undersurface of *Livistonia* (Palmae) palm leaves (Nakazima and Furukawa 1933). This appears very much in contrast to *L. albescens*, but more field work is needed.

BIOLOGY AND BEHAVIOR

Eggs hatch in early April, whereas adults appear in mid-June and are reportedly attracted to lights, which suggests a means of control (Nakazima and Furukawa 1933).

FOOD PLANTS

Rather exceptional, a palm, *Livistonia subglobosa* Martius (Palmae), is recorded as a food plant for "*L. dispar*" but the adults illustrated clearly represent this *L. postalba* (Nakazima and Furukawa 1933, Inoue 1957, Schaefer 1988).

PHEROMONAL COMMUNICATIONS

In the field, males respond to (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] (M. Kimura unpubl. 2005 data).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Females are reportedly rather sluggish and while it is unclear if they would normally fly (Nakazima and Furukawa 1933), they have been collected at moth collecting lights (Seiji Azuma, pers. comm. 28 June 1994).

DISCUSSION

Lymantria postalba has a more northerly distribution on the Ryuku Islands than does *L. albescens*.

Invasion potential appears very minimal, because of its limited native range, the remote island habitats, and low levels of international commerce conducted from those islands. On the other hand, while the behavior of females is not well known, they have been found at light traps, suggesting they are capable of flight.

LYMANTRIA (PORTHETRIA) APICEBRUNNEA GAEDE

(Pl. 2, Figs. 5, 7–8; Pl. 11, Figs. 1–3; Pl. 26, Fig. 3)

Lymantria apicebrunnea Gaede, 1932:102. HT male: CHINA: Sichuan (BMNH, examined); Collenette, 1933:26; Bryk, 1934:157; Schintlmeister, 2004:25.

COMMON NAMES

Apicebrunnea tussock moth; He-ding-do-er (in Chinese) and a Chinese-English translation refers to it as the Dark-brown tapered tussock moth.

DIAGNOSIS

Lymantria apicebrunnea resembles *L. xylina*. The outer margin of the forewing is brown in *L. apicebrunnea* but not in *L. xylina*. *Lymantria xylina* has a pink neck and underside and pink on the legs, which *L. apicebrunnea* lacks. The labial palpus is white in *L. apicebrunnea* and black in *L. xylina* and smaller in *L. apicebrunnea* than in *L. xylina*. The saccus in the male genitalia is wider and stouter in *L. xylina* than in *L. apicebrunnea*.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape white with a few pink scales medially, antenna white at base becoming dark brown, bipectinate; labial palpus white.
- *Thorax* A narrow line of pink scales between head and thorax; remainder of thorax white; forefemur white long pink and white fringe, foretibia white, lateral border with white fringe, tarsi white, segments 3–4 dark gray; middle and hind femora white with pink scales apically, tibiae white with white fringe, tarsi white, segments 3–4 gray; underside pink medially, white laterally.
- *Forewing* (Pl. 2, Figs. 5, 8): Length 25–28 mm (n=3); ground color white; basal area with two black dots, one at costa and one at M vein; antemedial line a black dash from costa to R vein; orbicular spot absent; reniform spot not evident, incorporated into postmedial line; postmedial line brown, crenulate, from costa to posterior margin; submarginal line brown, crenulate, from costa to posterior margin; outer margin a wide brown band; fringe white with dark brown spots between veins.
- *Hindwing* Ground color white; costal margin a wide brown band solid to Rs cell; fringe white with faint brown spots between veins, usually not extending to inner margin of wing.
- *Abdomen* Entirely white both dorsally and ventrally; tymbals absent on third sternite.
- *Genitalia* (Pl. 11, Figs. 1–3) Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, curved dorsally, apex narrowly rounded; juxta a broad ovate plate with convex dorsal margin; sacculus apex sharply rounded; saccus elongate, V-shaped; aedoeagus slightly bent medially; vesica a triangulate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* White with rufous highlights; antennae black.
- *Thorax* Concolorous with head.
- *Forewing* (Pl. 2, Fig. 7): Length 39–41 mm (n=2); ground color white, suffused with some rufous scales near base; antemedial line rufous, a short dash at costa; orbicular spot absent; reniform spot absent; postmedial line wide, rufous, crenulate, angulate from costa to posterior margin; subterminal band absent; fringe white with rufous spots between veins.
- *Hindwing* Ground color white, suffused with rufous scales; discal spot absent; fringe white.
- *Abdomen* Rufous.
- *Genitalia* (Plate 26, Fig. 3): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae round with an opening to ductus bursae dorsal; ductus bursae very short, shorter than ventral plate of ostium bursae; corpus bursae oblong, constricted medially.

LARVA

Unknown.

DISTRIBUTION

China (Guangdong, Sichuan, Guangxi and Yunnan Provinces) (Chao and Quan 1987, Zhao 2002).

SPECIMENS EXAMINED

CHINA: Yunnan (4m), B.P. Clark donor (USNM).

OVIPOSITION

Unknown, but the female genitalia suggest oviposition follows the *L. dispar sensu lato* pattern and likely deviates little from that of *L. xylina*, to which the overall appearance is very similar. Therefore, we would expect egg masses to be laid on a firm substrate and covered with abdominal hairs.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

Chao and Quan (1987) cite one food plant but its identity is unknown to us.

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Collection records indicate adults fly in June (Zhao 2002), suggesting it is univoltine.

DISCUSSION

The female of *L. apicebrunnea* was described by Collenette (1933). In males, there is some variation in the extent of the costal margin extending down the outer margin of the forewing. Specimens can possess faint brown spots along the veins near the outer margin.

Little is known of the biology and behavior of this species, but from what is known any potential for invasion is minimal .

LYMANTRIA (PORTHETRIA) BRUNNEOLOMA POGUE AND SCHAEFER,
NEW SPECIES

(Pl. 2, Fig. 9; Pl. 11, Figs. 4–6)

TYPE MATERIAL

Holotype male: CHINA, Yunnan, B.P. Clark donor, USNMENT 00217058, genitalia slide USNM 59201, (USNM). *Paratypes*: Same data as holotype, (2m), USNMENT 00217057, genitalia slide USNM 59141; USNMENT 00217059 (USNM).

COMMON NAMES

Brown-bordered Gypsy Moth (BBGM).

DIAGNOSIS

The males of *L. brunneoloma* are very similar to *L. apicebrunnea*, but the forewing length is shorter in *L. brunneoloma* and the outer margin has a much wider brown border than in *L. apicebrunnea*. The subterminal line is not as deeply scalloped in *L. brunneoloma* as in *L. apicebrunnea*. The postmedial line is discernable only as a faint spot along the posterior margin of the forewing in *L. brunneoloma*, but it is a well-defined crenulate line in *L. apicebrunnea*. The male genitalia has a straight dorsal process in the valve of *L. brunneoloma* and in *L. apicebrunnea* it is curved toward the apex. The saccus is short with a truncated apex in *L. brunneoloma*, and elongate and narrow with a rounded apex in *L. apicebrunnea*.

ETYMOLOGY

The species epithet is derived from the Medieval Latin, *brunneus*, meaning “brown,” and the Greek *loma*, meaning “border,” and refers to the prominent brown band bordering the outer margin of the forewing in males.

DESCRIPTION

MALE

- *Head* Front and vertex light brown; scape light brown, antenna brown, bipectinate; labial palpus cream-colored, apex light brown.
- *Thorax* Pronotum and tegula light brown, remainder of thorax white; foretibia light brown dorsally with a brown subapical spot, white ventrally, basitarsus light brown, remainder of tarsi white; middle and hind legs white, tarsi white; underside white.
- *Forewing* (Pl. 2, Fig. 9): Length 23–24 mm (n=3); ground color white; basal area with brown dots above and below M vein; antemedial line faint and curved to posterior margin; orbicular spot absent; reniform spot a brown angulate bar at end of discal cell; postmedial line, a broad brown band at costa to just below R vein, remainder an obscure crenulate line to posterior margin; subterminal line brown and crenulate, darkest at costa, and extending to posterior margin; outer margin a wide brown band; fringe brown.

- *Hindwing* Ground color white; Rs vein brown; discal spot faint at base of Rs and M1 veins; apical portion of veins brown; fringe white with faint brown spots between veins along outer margin.
- *Abdomen* White, brown dorsal bands at distal margin of tergites; tymbals absent on third sternite.
- *Genitalia* (Pl. 11, Figs. 4–6): Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta rectangular with rounded dorsal margin, ventral margin with broad excavation; sacculus apex acute; saccus short with a truncate apex; aedoeagus 0.71–0.72x height of genital capsule, straight, slightly curved at opening of ductus ejaculatorius; vesica an ovate, dorsally produced lobe; cornuti absent.

FEMALE

No known specimens.

LARVA

Unknown.

DISTRIBUTION

Known only from unspecified locality within Yunnan, China.

DISCUSSION

Maculation in *L. brunneoloma* is most similar to that in *L. apicebrunnea*, but lacks the small tuft of pink scales on the pronotum just behind the head.

LYMANTRIA (PORHETRIA) XYLINA SWINHOE

(Figs. 16–17; Pl. 2, Fig. 10; Pl. 3, Fig. 6; Pl. 12, Figs. 1–2; Pl. 26, Fig. 4; Pl. 30, Figs. 2–4; Pl. 32, Fig. 6; Pl. 48, Figs. 4–6; Pl. 49, Fig. 1)

Lymantria xyлина Swinhoe, 1903:490. HT male: TAIWAN: (BMNH, examined); Swinhoe, 1923:430; Strand, 1923:324; Matsumura, 1933:140; Bryk, 1934:166.

Lymantria xyлина xyлина; Inoue, 1956a:400. Schintlmeister, 2004:26.

Lymantria nobunaga Nagano, 1912:264. ST: JAPAN: Gifu (type depository unknown, not examined); Bryk, 1934:165. Inoue, 1982b:333 [synonym].

Lymantria xyлина nobunaga; Inoue, 1956a:400; Schintlmeister, 2004:26.

Lymantria nigricosta Matsumura, 1921:891. HT male: TAIWAN: Horisha (HUS, examined); Bryk, 1934:165.

Lymantria horishanella Matsumura, 1927:25. HT male: TAIWAN: Horisha (HUS, examined); Bryk, 1934:167.

Lymantria sakaguchii Matsumura, 1927:26. HT male: JAPAN: Okinawa Island (HUS, examined); Bryk, 1934:157; Kishida, 1995:115; Schintlmeister, 2004:26.

COMMON NAMES

Casuarina tussock moth, Xylina tussock moth; Mae-guro-maimai or Nobunaga-maimai (in Japanese); Mu-do-er (in Chinese) and other local names in Chinese translate as Dark-margined tussock moth, Wood tussock moth, or Acacia tussock moth.

DIAGNOSIS

Lymantria xyлина resembles *L. apicebrunnea*, but *L. xyлина* lacks the brown forewing outer margin that is present in *L. apicebrunnea*. Also, and unlike *L. apicebrunnea*, *L. xyлина* is pink on the legs and has a pink neck and underside. The labial palpus is larger and black in *L. xyлина* and smaller and white in *L. apicebrunnea*. In *L. xyлина* the saccus in the male genitalia is wider and stouter than that in *L. apicebrunnea*.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape white with a few pink scales medially, antenna white at base becoming dark brown apically, bipectinate; labial palpus black with some white basally and apically.
- *Thorax* A narrow line of pink scales between head and thorax; remainder of thorax white; forefemur black medially, white laterally, long pink fringe laterally, pink at apex, foretibia black with black fringe medially, lateral border white with white fringe, tarsi black, basitarsus with white apical ring; middle and hind femora black with pink fringe, tibiae white with white fringe and black subapical spot, tarsi black, basitarsus black with white apical ring; underside pink medially, white laterally.
- *Forewing* (Pl. 2, Fig. 10): Length 25–28 mm (n=3); ground color white; basal area with two black dots, one at costa and one at M vein; antemedial line a black dash from

costa to R vein; orbicular spot absent; reniform spot not evident, incorporated into postmedial line; postmedial line brown, crenulate, from costa to posterior margin; submarginal line brown, crenulate, from costa to posterior margin, less distinct than postmedial band; fringe white with black spots between veins.

- *Hindwing* Ground color white; costal margin a wide black band; fringe white with black spots between veins to M3 vein.
- *Abdomen* White, with black spiracular band separating tergum from sternum, a few scattered pink scales ventrally at base; tymbals absent on third sternite.
- *Genitalia* (Pl. 12, Figs. 1–2): Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process contiguous with costal margin of valve, straight, apex narrowly rounded; juxta a square plate with dorsal margin heavily sclerotized and straight to slightly convex, ventral margin with broad excavation; sacculus apex broadly rounded; saccus U-shaped; aedoeagus 0.70–0.71x height of genital capsule, slightly bent at middle; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* White.
- *Thorax* White; legs black, femora with lateral pink fringe, tarsi black.
- *Forewing* (Pl. 3, Fig. 4): Length 35 mm (n=1); ground color white; antemedial line light brown, a short dash at costa; orbicular spot absent; reniform spot absent; postmedial line wide, light brown, angulate from costa to posterior margin; subterminal band absent; fringe white with light brown spots between veins.
- *Hindwing* Ground color white; discal spot absent; fringe white.
- *Abdomen* White, highlighted pink basally, remainder cream-colored.
- *Genitalia* (Pl. 26, Fig. 4): Ovipositor not telescopic; papillae anales quadrate, dorsal margin truncate; anterior and posterior apophyses short; ventral plate of ostium bursae round with apices merging creating a dorsal groove; ductus bursae very short, shorter than ventral plate of ostium bursae; corpus bursae oblong.

LARVA

PRESERVED SPECIMENS) (PL. 30, FIGS. 2–4; PL. 32, FIG. 6; PL. 48, FIGS. 4–6; PL. 49, FIG. 1)

- *Length* 45–47 mm.
- *Head* Cream speckled with brown laterally, coronal stripes present (Pl. 32, Fig. 6); setae twisted; stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin (Pl. 48, Fig. 5); irregularly shaped tonofibullary platelets with a different pattern of spiculi than the surrounding area (Pl. 48, Fig. 6 and Pl. 49, Fig. 1).
- *Thorax* L verruca on T1 produced cephalad, larger than all other L verrucae; legs concolorous with ground color.
- *Abdomen* Ground color cream with no markings, or entire abdomen covered with irregularly shaped brown spots giving a mottled appearance; dorsal stripe indistinct forward of A5, a thin stripe from A5–10; subdorsal stripe (just ventral to D2 verruca) a thin line from thorax to A10; lateral stripe absent; all verrucae concolorous with ground color; D1 verruca small with large black primary median seta and several white

secondary setae; SD and L verrucae contiguous; primary setae on D2 verrucae brown to black, secondary setae white; primary setae on D2 verruca shorter than those on L verruca; L verruca with long white setae; setae on SD and L lacking microbarbules on shaft; eversible glands on A6–7 concolorous with ground color; underside with broad dark stripe between prolegs that extends to A10, remainder of underside concolorous with ground color; prolegs concolorous with ground color with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseris.

DISTRIBUTION

Japan, Taiwan, and China (Fujian, Guangdong).

SPECIMENS EXAMINED

JAPAN: OKINAWA: Arakawa 28 May 1994, Seizi Azuma et al., at lights, (2m,3f) (PWS); Ishikawa Mt., elev. 160 m, 31 May 1998, Paul W. Schaefer, in phero trap xylinalure, (15m) (PWS). TAIWAN: FuShan, 18 May 1994 (1f), 11 May 1994 (1m), 17–19 May 1994 (1m,1f), Paul W. Schaefer (PWS); Rt 9 @ 56 Km marker, 2 June 1994, Jane & Paul W. Schaefer (1m,1f); Taoyuen, 9 May 1994 (2m,1f), 14 May 1994 (1m), Paul W. Schaefer (PWS); Taoyuen Co., Kuanyin, 23 May 1994, at lights/sheet, Paul W. Schaefer (2m) (PWS); Tapyuen (sic) Co., Paleng, 1250 m, 4 June 1996, P. Schaefer & M. Montgomery (2m,3f) (PWS). Nan Tow Co., Lienhuachi Exp. For. Sta., 15 km SW Puli, 750 m, 22–26 May 1980 (2m), D.R. Davis (USNM); Sun Moon Lake, 760 m, 20–25 June, 1980 (1m), D.R. Davis (USNM).

FOOD PLANTS

Polyphagous. Commonly found as a pest of *Casuarina equisetifolia* L. or *C. cunninghamiana* Miq. (Casuarinaceae) in windbreak plantations in Taiwan and China (Li et al. 1981, Zhao 1982, Chang and Weng 1985, Chao et al. 1996). In Taiwan, *L. xylina* is recorded as feeding on 63 tree species belonging to 29 families (nearly 1/4 of these belong to the Euphorbiaceae and the Fagaceae), and the host plant list includes important fruit trees such as longan (*Diospyros (=Euphorbia) longan* Lour.) and litchi (*Litchi chinensis* Sonn.) (both Sapindaceae) and mango (*Mangifera indica* L.) (Anacardiaceae) (Chao et al. 1996). Other important hosts include Ebenaceae, Ericaceae, Lauraceae, Leguminosae, Moraceae, Myrtaceae, Rosaceae, Sapindaceae, Theaceae and Ulmaceae, and 15 other plant families each containing but a single host tree. Several tree species have been reported severely defoliated (*Mallotus japonicus* L.f. Müll. Arg. and *Ricinus communis* L. (both Euphorbiaceae), *Persea thunbergii* (Sieb. & Zucc.) Kostermans (Lauraceae) and *Syzygium samarangense* (Blume) Merr. (Myrtaceae) (Chao et al. 1996). Severe damage has been reported in Fujian Province, China, (Sun 1989). A previously unrecorded host is *Distylium racemosum* Siebold & Zucc. (Hamamelidaceae) in Okinawa, according to Seiji Azuma (pers. comm.).

OVIPOSITION

Similar to *L. dispar sensu lato* with eggs in a mass and covered with female abdominal hairs. However, egg masses are positioned most often on small twigs or branches (and not tree trunks), giving them the overall appearance of a moth cocoon (Figs. 16, 17). The masses closely resemble Lasiocampidae cocoons found sympatrically. It is not known if there is any adaptive advantage to either moth resulting from this apparent mimicry.

BIOLOGY AND BEHAVIOR

Despite the climatic conditions in Okinawa and Taiwan, which would be conducive to multiple generations, *L. xyliana* is univoltine. (All other known *Lymantria* species in Taiwan are multivoltine). Eggs deposited in June and July go into diapause and will hatch in March of the following year. In Taiwan, in mid-June, 1994, female fecundity was measured as 658.3 eggs per mass (SD = 200.1, n=7) at Taichung Harbor and 323.0 (SD=117.3, n=5) at Tayuen. This clearly reflects a population density effect, because measurements at Taoyuen were made during an outbreak (Schaefer, unpubl. data). Another estimate of females collected 30 May 1996 at Taichung harbor gave a mean of 476.0 eggs per mass (n=10) (Schaefer, unpubl. data). Chao et al. (2001) further studied this phenomena in Taiwan and calculated an overall average of 592.5 eggs per mass (SD=213.8, n=360) with a range from 180 to 1,544 eggs per egg mass. Neonate larvae disperse by ballooning on the wind (Sun 1989). Under the name *L. sakaguchi*, we are aware of unpublished reports of past severe outbreaks in Japan on Kume Island (1975–76) and Okino Erabu Island (1989) (Masakazu Gushiken, pers. comm.).

PHEROMONAL COMMUNICATIONS

Based on our collaborative work in Taiwan (Gries et al. 1999a), this moth uses *cis*-7,8-epoxy-2-methyleicosane [xylinalure (named for the moth)]. This moth population is exceptional, in that it is not enantiomer specific. It uses racemic xylinalure; males are equally attracted to (+)-xylinalure and (-)-xylinalure. This phenomenon is unique among *Lymantria* species, because many other species use specific enantiomers. For example, *L. dispar* uses (+)-disparlure, and *L. monacha* uses a blend containing both (+)-monachalure and (+)-disparlure (Gries et al. 1999). Our trapping on Okinawa gave results more consistent with the norm. The Okinawan form of *L. xyliana* responded only to (+)-xylinalure and not to (-)-xylinalure, reflecting a contrast between the two insular (Taiwan/Okinawa) populations of *L. xyliana* (Gries and Schaefer, unpubl. trapping data).

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Female Flight: Gravid females readily fly in early evening (sunset to about 9 PM) with full egg complements. In late May and early June 1996, a sample of these females (n=110) was collected and isolated either in paper or plastic bags with paper towels added and held for egg deposition. After the eggs were embryonated, it was determined that 91.2% of the females were unmated (i.e. not viable) when collected in the early evening. Therefore, calling and mating occurs sometime after 9 PM. On 13 June 1996, 15 females were tethered (thread around base of one wing) in place on the external surface of a screen flower house at the Shindian Forestry Substation, near Wulai, Taiwan. At nearly hourly intervals, the tethered females were examined. Three females were found *in copulo* at 3:20 AM, and five were found *in copulo* at 4:15 AM. **Male Response:** In Taiwan, males respond to synthetic pheromone lures between 10 PM and 4 AM, no males appeared at 10 PM but 30 males had been captured by 4 AM (Schaefer, unpubl. data). Capture data from two nights later (11 PM, 6; 12PM, 5; 1 AM, 1; 2 AM, 7; 3 AM, 5) indicate *L. xyliana* represents a Near-Midnight to Early-Morning active species (G. Gries and Schaefer unpubl. data). On Okinawa, in the presence of a cohabitant *L. albescens* (a diurnal species), *L. xyliana* displayed a somewhat different pattern of activity with the greatest capture (n=14 of 27 total) occurring between 9 PM and 10 PM, suggesting an Early-Late Evening activity. **Male/Female Coordination:** These data are unique among all the studied species of *Lymantria*, because they begin to pinpoint the time of female flight, apparent calling, mating, and male responses to both virgin females and the synthetic sex

pheromone. It does not appear to coincide precisely for the two sexes but does provide a basis on which further detailed studies into the phenology of these normally nocturnal events might be based.

DISCUSSION

The females of *L. xyлина* and *L. apicebrunnea* are more similar to one another than the males. The angulate postmedial line in *L. xyлина* is straighter than the somewhat crenulate line in *L. apicebrunnea*. Kishida (1995) synonymized *L. sakaguchii* with *L. xyлина* based on the variable forewing pattern, intermediate-sized specimens, and the absence of structural differences in the male and female genitalia of each species (male-to-male and female-to-female comparisons). Nevertheless, in the opinion of Prof. Seiji Azuma (pers. comm.) on Okinawa, the moth formerly called *L. sakaguchii* was restricted to feeding on *Casuarina* spp. (Casuarinaceae), while a second form that he called *L. xyлина* was a pest of various Okinawan fruits (mentioned were mango, loquat and litchi). This should be resolved through careful field study because if Professor Azuma is correct, it appears inappropriate to synonymize the two names.

Lymantria xyлина, native to south China and Taiwan, has great potential to become a serious invasive species for semitropical locations in the United States, such as Hawaii, southern California, or Florida, as well as other countries of the Pacific Rim. As do all the “Asian Gypsy Moths” (i.e. *L. d. japonica*, *L. umbrosa* and others), females fly to lights at night and, in areas around ports, might lay eggs on shipping containers or transoceanic vessels. If these shipping containers or vessels then move to other similar habitats, *L. xyлина* would readily establish if egg hatch occurred following normal, albeit somewhat more lengthy, diapause.

Our collaborative work on *L. xyлина* (Gries et al. 1999a) has identified xylinalure as the single major sex pheromone of this species. Should an invasion occur anywhere, use of xylinalure-baited traps will be indispensable for any efforts to eradicate an incipient population.

LYMANTRIA (PORTHETRIA) DETERSA WALKER

(Pl. 3, Figs. 1, 5; Pl. 12, Figs. 3–4)

Lymantria detersa Walker, 1865:365. ST: MAURITIUS: (BNMH, examined); Schintlmeister, 2004:26.

Enome detersa; Swinhoe, 1885:300; Swinhoe, 1886:438; Cotes and Swinhoe, 1887:156.

Pachenome detersa; Butler, 1883:156.

COMMON NAMES

Detersa tussock moth.

DIAGNOSIS

Lymantria detersa is similar to *L. obfuscata*. In *L. detersa* the hindwing ground color is dirty white and in *L. obfuscata* the hindwing ground color is dark reddish brown. The female is brachypterous in *L. detersa*, whereas the wings are present, but highly reduced, in *L. obfuscata*. The male genitalia are similar to those of *L. obfuscata*. However, in comparison the distal process of the valve is shorter and more robust in *L. detersa* and more elongate and slender in *L. obfuscata*.

REDESCRIPTION

MALE

- *Head* Front and vertex brown; scape and antenna brown, bipectinate; labial palpus brown, short, barely extending beyond front.
- *Thorax* Tegula brown; mesothorax and metathorax brown; legs cream-colored.
- *Forewing* (Pl. 3, Fig. 1): Length: 17 mm (n=1); ground color brown; basal area black with spot on anal vein; antemedial line black, wider at costa, curved to anal vein, then abruptly angulate to posterior margin; orbicular spot black; reniform spot brown, angulate bar following veins at end of discal cell, a black spot on costa just touches reniform apically; postmedial line black, crenulate from costa to posterior margin, bordered distally by light brown; subterminal band brown consisting of wide crescent-shaped spots between veins from costa to posterior margin; fringe light brown with black spots between veins.
- *Hindwing* Ground color white suffused with brown; indistinct brown marginal band; thin brown lines between veins along outer margin; fringe light brown with brown spots between veins.
- *Abdomen* Dorsum light brown with brown distal margins.
- *Genitalia* (Pl. 12, Figs. 3–4): Lateral processes absent from tegumen; uncus elongate, narrow, apex round; valve undivided, not fused ventrally; dorsal process originating medially on valve, straight, short, apex narrowly rounded; juxta a rectangulate, dorsal margin excavated to a broad U-shape, ventral margin straight; sacculus gently curved to dorsal process, not produced, apex broadly rounded; saccus elongate, V-shaped; aedoeagus straight; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* White.
- *Thorax* White.
- *Wings* (Pl. 3, Fig. 5): Brachypterous.
- *Abdomen* Brown.

LARVA

Recorded as “caterpillars are yellowish brown ...clothed with circles of bristle like (sic) hairs borne on circular depressions present on the body segments” and illustrated by Pillai et al. (1999).

DISTRIBUTION

Southern India (Ahmednagar, Bombay, Belgaum, Nagrishpur, Poona, S. Coorg) (Gupta 1992).

SPECIMENS EXAMINED

INDIA: Calcutta (1m) (USNM).

FOOD PLANTS

Gum arabic tree, *Acacia nilotica* (L.) Willd. ex Delile, (Fabaceae) was reported as a host by Strand (1923). Pullai et al. (1999) recently recorded *Casuarina equisetifolia* L. (Casuarinaceae) as a larval host planted in hedges around homes in Coimbatore City.

OVIPOSITION

An egg mass appearing to be on a leaf of a broad-leaved twig is illustrated by Pillai et al. (1999), but no further clarification is presented to suggest either a normal site of oviposition or how many eggs might be included.

BIOLOGY AND BEHAVIOR

Larvae have been recorded feeding on tender needles of *C. equisetifolia* in Coimbatore, India (Pillai et al. 1999). The same authors reported that larvae feed at night and hide during the day in loosely spun silken mats to which cut tree needles are appressed to provide further protection.

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Unknown.

DISCUSSION

Lymantria detersa is a tropical species that was included in this study because of its similarity to species related to *L. d. dispar*. The brown forewing ground color and dark brown zigzag postmedial line are characteristics shared with some species related to *L. dispar*. Unlike *L. d. dispar*, females of *L. detersa* have highly atrophied wings. We speculate that, as with other flightless females (e.g. North American Gypsy Moth and species in the related genus *Orgyia*), fecundity is largely influenced by flightlessness.

LYMANTRIA (PORHETRIA) LUNATA (STOLL)

(Pl. 3, Figs. 2, 4; Pl. 13, Figs. 1–3)

Bombyx lunata Stoll, 1782:pl. 369, fig. c. HT lost: INDONESIA: Amboina (unknown type depository, not examined).*Porthetria lunata*; Hübner, [1819]:160.*Lymantria lunata*; Walker, 1855b:879; Snellen, 1879:111; Cotes and Swinhoe, 1887:153; Swinhoe, 1892:220; Semper, 1898:461; Strand 1923:326; Edwards 1996:276.*Pegella curvifera* Walker, 1866:1922. HT female: PHILIPPINES (BNMH, examined). **New synonymy.***Pegella ichorina* Butler, 1884:201.*Lymantria diversa* Turner, 1936:46. HT male: AUSTRALIA: North Queensland, Ingham (ANIC, Canberra, not examined); Edwards 1996:276 [synonym].*Lymantria lunata ingrami* Schintlmeister, 2004:29. HT male: INDONESIA: Irian Jaya, Insel Biak, Menoerwar (ASD, Dresden, examined figure). **New synonymy.***Lymantria lunata carteri* Schintlmeister, 2004:31. HT male: INDONESIA: N. Moluccas, Bacan, Mt. Sibeta, 14 km SE Labahua (ASD, Dresden, examined figure). **New synonymy.***Lymantria lunata curvifera*; Schintlmeister, 2004:31.

COMMON NAMES

Lunata tussock moth.

DIAGNOSIS

Lymantria lunata is a distinct species. The male has a well-marked, light-brown forewing and a cream-colored hindwing, which sometimes has a light-brown margin. The abdomen is pink with brown quadrate spots, dorsally. The female has white forewings with a broad brown postmedial line and a thin subterminal line.

REDESCRIPTION

MALE

- *Head* Front and vertex light brown; scape light brown, antenna light brown with wide fuscous patch at 2/3 length, bipectinate; labial palpus of moderate length, extending beyond front, light brown.
- *Thorax* Tegula concolorous with head, prothoracic collar with lateral fuscous spots behind eye, pink flush between head and thorax; forefemur pink with cream-colored fringe, tibia light brown with very broad long lateral scales, basitarsus brown, then tarsi alternate light brown and brown with apical segment lightest and with a hint of pink; mid femur cream-colored, flushed with pink, dorsally, tibia light brown with long fringe and darker dorsally, basitarsus light brown, tarsi 2–4 brown, and apical

segment cream-colored with pink apically; hind leg like mid leg except tarsi are lighter in color; underside light brown to cream-colored.

- *Forewing* (Pl. 3, Fig. 2): Length: 23–26 mm (n=4); ground color light brown; basal area spotted black with a white spot medially; antemedial line represented by a faint, fuzzy, fuscous spot on costa, then a faint light brown line to posterior margin; orbicular spot a small black dot in middle of discal cell; reniform spot black, chevron-shaped at end of discal cell; postmedial line faint fuscous, curved around reniform spot then slightly angulate to posterior margin; subterminal line faint, crenulate; light terminal area with a series triangular black spots of various sizes between wing veins; fringe checkered cream-colored and black.
- *Hindwing* Ground color cream-colored with veins highlighted in some specimens; pink flush on longer scales of posterior margin; outer margin light brown, not solid, but with slightly lighter areas between veins; fringe cream-colored with minute brown spots between veins.
- *Abdomen* Dorsum pink with fuscous quadrate spots on proximal margin of tergites; venter light brown; tymbals absent on third sternite.
- *Genitalia* (Pl. 13, Figs. 1–3): Tegumen with lateral processes present; uncus elongate, narrow, apex round; valve undivided, costal margin greatly convex, not fused ventrally; dorsal process originating medially on valve, straight, short, apex narrowly rounded; juxta triangulate, dorsal margin slightly convex; sacculus forming an obtuse angle to dorsal process, not produced, apex sharply angulate; saccus U-shaped; aedoeagus length 0.84x height of genital capsule, straight; vesica an ovate, ventrally produced lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape white; antenna pectinations short, fuscous bipectinate; labial palpus short, barely extending beyond front, pale fuscous.
- *Thorax* Tegula white; mesonotum white; foretibia brown; tarsi brown, apical tarsus cream-colored; midtibia white; tarsi brown, apical tarsus cream-colored; hind tibia brown, tarsi brown, apical tarsus cream-colored.
- *Forewing* (Pl. 3, Fig. 4): Length 35–37 mm (n=2); ground color white; antemedial line brown, wider at costa, angulate to M vein, slightly curved from M vein to anal vein; orbicular spot brown, minute, located beyond middle of discal cell; reniform spot brown, chevron-shaped at end of discal cell; postmedial line brown, a broad band that widens from costa to posterior margin; subterminal line brown, narrow, from costa to posterior margin where it joins postmedial band; fringe white with minute brown spots between veins.
- *Hindwing* Ground color white; fringe white with minute brown spots between veins
- *Abdomen* Pale gray becoming dirty white toward apex.
- *Genitalia* Ovipositor not telescopic; papillae anales quadrate; ventral plate of ostium bursae an elongate ribbon that narrows apically on each side; ductus bursae shorter than corpus bursae and gradually widens toward corpus bursae; corpus bursae ovate.

LARVAE

Corbet (1963) illustrated both young and mature larvae and mentioned that there is color variation among individuals (light and dark), suggesting larval color polymorphism.

DISTRIBUTION

From India throughout Southeast Asia, Indonesia, New Guinea, the Philippines, and the northeast coast of Australia.

SPECIMENS EXAMINED

PHILIPPINES: Los Banos, Baker (1m); Surigao, Mindanao, Aug. (2m), genitalia slide USNM 47057, B. P. Clark, Nov. (1m); Leyte, Santa Cruz, Oct. 7, 1915 (1f), genitalia slide USNM 47058, B. P. Clark; Luzon, Bangui, Jan. 1918 (1f) (USNM).

LARVAL HOSTS

Rather polyphagous, feeding on Mango (*Mangifera indica* L., Anacardiaceae), lightwood (*Semecarpus australiensis* Engl., Anacardiaceae), weeping fig (*Ficus benjamina* L. Moraceae) (Herbison-Evans and Crossley 2002), *Diospyros* sp. (Ebenaceae), *Eugenia* sp. (Myrtaceae), *Sesbania* sp. (Fabaceae), *Ricinus* sp. (Euphorbiaceae), and *Terminalia* sp. (Combretaceae) (Strand 1923).

In Queensland, Australia, larvae preferentially fed on mango flower inflorescences and newly formed fruits and did not feed on the leaves. On *Buchanania muelleri* Engl. (Anacardiaceae) they fed on the leaves; on “Tar trees” (*Semecarpus australiensis* Engl., Anacardiaceae) they ate flowers, on weeping fig they consumed leaves. By implication, they also fed on mangrove, probably *Avicennia marina* (Forsk.) Vierh. (Verbenaceae) (Corbet 1963).

OVIPOSITION

In the Philippines, eggs are laid in irregular masses on leaves; females deposit their complement in two to three installments (Baltazar and Salazar 1979), and egg masses range up to 874 eggs. In northern Australia, females flew to street lamps and laid their egg complement on the lamp posts (Corbet 1963).

BIOLOGY AND BEHAVIOR

Populations in Cairns, Queensland, Australia, have reached plague proportions (Corbet 1963). According to Corbet (1963), larvae feed at night and rest on tree trunks during the day on conspicuous mats of silk. Also adult females, after laying their complement of eggs, are frequently “cemented” to the egg mass by a “glutinous (sic) substance combined with the fine hairs surrounding the abdomen” (Corbet 1963). About 2 weeks after the eggs are laid, larvae hatch and begin to feed on the remaining egg mass and the mother’s remains. In the Philippines, eggs hatch in 8 days on average. Complete development averages 51 days for males and 56 days for females under ambient conditions (Baltazar and Salazar 1979).

PHEROMONAL COMMUNICATIONS

In Queensland, Australia, males responded to traps baited with *cis*-7,8-epoxy-2-methyleicosane [(+)-xylinalure] (PWS, D. Britton and G. Gries, unpubl. data) and thus, appear to be enantiomer specific, unlike the similar appearing *L. xylina* in Taiwan.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

In northern Australia, adults appeared in large numbers (suggesting mass migration) in Cairns in early August (Corbet 1963). Such an event has been reported in other congeners (i.e. *L. d. dispar*, *L. d. asiatica*) but no speculation as to an origin is presented.

DISCUSSION

There is some slight variation in the intensity of the marginal band in the hindwing of the male. It varies from distinct to almost absent. The intensity of the light brown highlighting of the hindwing veins varies from distinct to absent. This variation is not enough to accord subspecific status to the various populations of *L. lunata*.

Lymantria lunata can erupt into massive outbreak populations as recorded by Corbet (1963). Because of this, it represents both a public health problem, due to the urticating properties of larval hairs, and a potentially invasive species to many other tropical areas of the world.

LYMANTRIA (PORTHETRIA) BROTEA (STOLL)

(Pl. 3, Fig. 3; Pl. 13, Figs. 4–6)

Phalaena Bombyx brotea Stoll in Cramer, 1780:68, plate 322, Fig. E. HT Lost.*Porthetria lepcha* Moore, 1879b:54. LT male: INDIA, Darjeeling (BMNH, London, examined); Cotes and Swinhoe, 1887:155. Note: Lectotype was designated by Gupta, et al., 1984:26.*Barbona carneola* Moore, 1879b:55. HT female: INDIA, Darjeeling (BMNH, London, examined)*Lymantria lepcha*; Kirby, 1892:478; Hampson, 1892:465; Semper, 1898:463; Swinhoe, 1892:223; Swinhoe, 1903:490; Strand, 1923:322; de Joannis, 1929:420; Holloway, 1999:13.*Lymantria galinara* Swinhoe, 1903:490.*Liparis lepcha*; Swinhoe, 1923:431.*Lyparis* [sic] *brotea*; Swinhoe, 1923:434.*Lymantria lepcha galinara*; Collenette, 1932:98.*Lymantria brotea*; NT male: CHINA: Singapore (BMNH, London, examined); Cotes and Swinhoe, 1887:155; Kirby, 1892:478; Strand, 1923:327. Note: Neotype was designated by Schintlmeister, 2004:36. Specimen was the holotype of *Lymantria galinara* Swinhoe.*Lymantria (Porthetria) brotea brotea*; Schintlmeister, 2004:35.*Lymantria (Porthetria) brotea lepcha*; Schintlmeister, 2004:36. **New synonymy.***Lymantria (Porthetria) brotea rudloffii* Schintlmeister, 2004:36. **New synonymy.**

COMMON NAMES

Brotea tussock moth.

DIAGNOSIS

Lymantria brotea is most similar to *L. apicebrunnea*, but can be distinguished by the lack of a wide brown margin on the forewing that is present in *L. apicebrunnea*. There also can be a pale pink flush in the posterior area of the hindwing in *L. brotea* that is absent in *L. apicebrunnea*. The male genitalia differ from those of other *Lymantria (Porthetria)* species in that the costal margin of the valve is relatively short and slightly curved.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape white, antenna white, bipectinate; labial palpus black, well-developed, apex white.
- *Thorax* White, tegula with black spot near wing base, mesothorax with black anterior median spot and pair of black median posterior spots; foreleg with white femur and pink knee, tibia pale gray with long white fringe, tibia white with elongate, inner black

spots on basitarsus and segments 3–4, apex pink; middle and hind legs white with black spot on tarsal segments 3–4; underside white to a mixture of white and pink.

- *Forewing* (Pl. 3, Fig. 3): Length: 24–28 mm (n=3); ground color white; all wing markings black; basal line is a series of small dots from costa to posterior margin; antemedial line a small spot at costa, chevron-shaped spot in middle of discal cell, faint to posterior margin; orbicular spot a minute dot; reniform spot chevron-shaped at end of discal cell; postmedial and subterminal lines deeply crenulate from costa to posterior margin; terminal line crenulate from costa to tornus; outer margin with black spots between veins; fringe white.
- *Hindwing* White with a flush of pale pink on the longer scales covering the anal veins and the fringe along inner margin; discal spot faint; marginal gray and can be complete or partial; a series of small black dots between veins from costa to middle of outer margin; fringe white.
- *Abdomen* White with median row of black spots; tymbals absent on third sternite.
- *Genitalia* (Pl. 13, Figs. 4–6): Tegumen with lateral process absent; uncus very narrow, apex pointed; valve undivided, basal lobe fused with base of valve and is not as conspicuous as in other species, minute process at distal apex of lobe, valves not fused ventrally; dorsal process contiguous with costal margin of valve, slightly curved, shorter than valve; juxta a thin band; saccus U-shaped; aedoeagus approximately 0.75x height of genital capsule, slightly bent and narrowed at middle.

FEMALE

No material was available for study. The description below was derived from the illustrations in Schintlmeister (2004).

- *Forewing* Ground color white; markings are only represented by a diagonal line on costal near base and a V-shaped reniform spot at end of discal cell; outer margin greatly angulate from apex to posterior margin.
- *Hindwing* Ground color white with a pink flush in posterior area; no other markings present.
- *Abdomen* White with black dorsal spots and a pink flush laterally.

LARVA

No specimens were available for study.

DISTRIBUTION

In India (Assam and Andaman Island) and Nepal east to Thailand, Malaysia, Vietnam, and the Philippines; south throughout Indonesia including Sumatra and Borneo (Holloway 1999, Schintlmeister 2004).

SPECIMENS EXAMINED

INDIA: Assam, Margherita, 1888 (3m), genitalia slide USNM 49837, Holland Coll. (CMP). INDONESIA: Sumatra, Darat Langkat, E. Coast, 1909 (1m), genitalia slide USNM 59125, L. P. De Bussy Coll., (USNM). PHILIPPINES: Mindanao, Surigao, July (1m),), genitalia slide USNM 59131, B.P. Clark (USNM).

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

In Borneo larvae feed on Sal (*Shorea* spp., Dipterocarpaceae) and mangroves (*Sonneratia* spp., Sonneratiaceae) (Holloway 1999).

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Collection records indicate that *L. brotea* is present during February, March, August, and November in the Andaman Islands (Schintlmeister 2004); June and October in Nepal (Kishida 1995); September in the Philippines (Semper 1898); and December through April in Bogor, Java, Indonesia (Chikaya Sakai, pers. comm. 2001).

DISCUSSION

Lymantria brotea is distinct among other species in the subgenus *Porthetria*, but most resembles *L. apicebrunnea*. Within the subgenus *Lymantria*, *L. brotea* resembles a faded *L. concolor* Walker. The forewing markings of *L. brotea* are paler and less bold than the black, bold markings in *L. concolor*. The hindwing has a pale pink flush in the posterior area in *L. brotea* and the pink flush is absent in *L. concolor*. The abdomen in *L. brotea* is white with black dorsal spots and a pink flush laterally and in *L. concolor* it is rosy pink with larger black dorsal and lateral spots. Upon dissection the tymbals on the third sternite are absent in *L. brotea* and present in *L. concolor*.

Little is known of this species and no information on pheromone bait is available.

Its potential for invasion appears quite minimal.

SUBGENUS *LYMANTRIA* HÜBNER

Lymantria Hübner, [1819]:160. Type species: *Phalaena monacha* Linnaeus, 1758:501; designated by Moore, [1883]:99.

Hyppgymna Billberg, 1820:84. Type species: *Phalaena monacha* Linnaeus, 1758:501; designated by Curtis, 1839:767.

Psilura Stephens, 1829:57. Type species: *Phalaena monacha* Linnaeus, 1758:501; by monotypy.

Nagunda Moore, 1879b:53. Type species: *Alope semicincta* Walker, 1855a:620; by original designation.

Most species in this subgenus have a white forewing with distinct black lines and a distinct V-shaped reniform spot at the distal end of the discal cell. Some species have a gray or grayish-brown forewing ground color with less distinct lines. The hindwing fringe has a checked pattern. The valve in the male genitalia has a produced costal process similar to that of the subgenus *Porthetria*, but it is usually shorter than the valve. A basal process is present at the base of the valve and is variously shaped and appressed to the inner surface of the valve.

LYMANTRIA (LYMANTRIA) MONACHA (LINNAEUS)

(Pl. 3, Figs. 9–10; Pl. 14, Figs. 1–3; Pl. 27, Fig. 1; Pl. 30, Fig. 5; Pl. 32, Fig. 7; Pl. 38, Fig. 3; Pl. 49, Fig. 2)

Phalaena (Bombyx) monacha Linnaeus, 1758:501 ST: TL: EUROPE: (unknown type depository, not examined).

Noctua heteroclita Müller, 1764:47. ST: GERMANY: (unknown type depository, not examined).

Bombyx eremita Hübner, [1808]:pl. 57, fig. 246. ST: LAPPLAND: (unknown type depository, not examined).

Bombyx nigra Freyer, 1833:5. ST: GERMANY: Augsburg: (unknown type depository, not examined).

Liparis monacha var. *oethiops* de Selys-Longchamps, 1857:52. ST: BELGIUM: (unknown type depository, not examined).

Psilura transiens Thierry-Mieg, 1886:236. ST: EUROPE: (unknown type depository, not examined).

Lymantria monacha nigra; Krulikovsky, 1907:103; Krulikovsky, 1908:218; Spuler, 1908:131; Auel, 1909:159; Rebel, 1910:118; Vorbrod, 1911:233; Eckstein, 1915:52; Marschner, 1932:247.

Lymantria monacha; Krulikovsky, 1908:218; Spuler, 1908:131; Auel, 1909:159; Rebel, 1910:118; Strand, 1911:128; Vorbrod, 1911:233; Eckstein, 1915:52; Gaede, 32:100; Marschner, 1932:246; Bryk, 1934:151; Inoue, 1956a:399; Inoue, 1957:192; Inoue et al., 1982:635; Schintlmeister, 2004:82.

Lymantria monacha eremita; Krulikovsky, 1908:218; Spuler, 1908:131; Auel, 1909:159; Rebel, 1910:118; Vorbrod, 1911:233; Eckstein, 1915:52; Gaede, 1932:100; Marschner, 1932:247.

- Lymantria monacha* forma *transiens* Lambillion, 1909:10. ST: EUROPE: (unknown type depository, not examined).
- Lymantria monacha* forma *flaviventer* Krulikovsky, 1909:303. ST: RUSSIA: (unknown type depository, not examined).
- Lymantria monacha* forma *gracilis* Krulikovsky, 1911:445. ST: RUSSIA: (unknown type depository, not examined).
- Lymantria monacha* forma *brunnea* Stipan, 1923:40. HT male: EUROPE: (unknown type depository, not examined).
- Lymantria monacha* forma *kuznezovi* Kolossov, 1928:481. ST: RUSSIA: (unknown type depository, not examined).
- Lymantria monacha* *chosenibia* Bryk, 1948 [1949]:16. ST: KOREA: (unknown type depository, not examined); Witt, 1985:188.
- Lymantria monacha* *matuta* Bryk, 1948 [1949]:16. HT male: KOREA: Chidisan (NRS, Stockholm, not examined); Witt, 1985:188.
- Lymantria monacha* *lateralis* Bryk, 1948 [1949]:17. HT male: KOREA: Motojondo (NRS, Stockholm, not examined); Witt, 1985:188.
- Lymantria monacha* *idae* Bryk, 1948 [1949]:17. HT male: KOREA: Kariuzawa (NRS, Stockholm, not examined); Witt, 1985:188.
- Lymantria monacha* *neirai* Agenjo, 1959:109. ST: SPAIN: (unknown type depository, not examined).
- Lymantria monacha* *ceballosi* Agenjo, 1959:110. [ST: SPAIN: (unknown type depository, not examined).

COMMON NAMES

Nun moth (in North America); Black Arches, Black arched or Black arches tussock moth (in England or Europe); Nonne-maimai (in Japanese); Eolrukmaemi-Nabang (in Korean); Mo-do-er (in Chinese) and translations of local names refer to it as Pine-needle tussock moth or Fir tussock moth; Mariposa monacha, Mariposa monja, Lagarta monacha, or monja (in Spanish); nonne, Bombix or Bombyx moine, or moine (in French); Monashenka (in Russian); Fichten spinner or Nonne (in German); Monaca (in Italian); Nonnetje or Nonvlinder (in Dutch); Bekyne mniska (in Czech or Slovakian); Nonnen (in Danish); Barrskogsnunna (in Swedish); shovkopryad-monashka (in Ukrainian), and Brudnica mniszka (in Polish). There are very likely many other colloquial names among the many Asian countries which are covered within the distribution of this widespread Eurasian species.

DIAGNOSIS

Within the subgenus *Lymantria*, the male of *L. monacha* shares the overall forewing pattern of *L. pulverea* Pogue and Schaefer, *L. minomonis* Matsumura, and *L. concolor*. *Lymantria monacha* is most similar to *L. pulverea* in size and forewing pattern. The forewing is irrorated with some gray scales in *L. monacha* giving it an overall lighter appearance than the more heavily irrorated forewing of *L. pulverea*. The melanic form of *L. monacha* is common in Europe, but absent in eastern Asia. Melanic individuals have dark gray instead of white on the forewings, and lack the white marginal borders and black spots that are present in the non-melanic form.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape white, antenna light brown medially, apex white, bipectinate; labial palp well developed, brown with white apex.
- *Thorax* White, a median black bar anterior to tegulae; tegula white with black posterior margin; black spot between tegulae; black spot at distal apex of metathorax; tibia white with proximal apex black, a black spot at 2/3 length of tibia, tarsi white with black spot at distal apex of basitarsus, ultimate segment black; underside brown anterior to head, remainder white.
- *Forewing* (Pl. 3, Fig. 9): Length 18–20 mm (n=6); ground color white; all markings black; basal area with a narrow horizontal bar from costa to Sc vein, a narrow vertical bar from R to A vein; antemedial line a quadrate spot at costa, then sinuate to posterior margin; reniform spot chevron-shaped at end of discal cell; postmedial line a quadrate spot at costa, crenulate to posterior margin; subterminal line contiguous and similar to postmedial line; terminal line crenulate; fringe white with black spots between wing veins.
- *Hindwing* Ground color pale gray; discal spot absent; marginal band indistinct, slightly darker than ground color; fringe white with gray spots between wing veins.
- *Abdomen* Dorsum white; lateral line a series of black spots divided by tufts of pale pink; underside white; tymbals present on third sternite.
- *Genitalia* (Pl. 14, Figs. 1–3): Tegumen with lateral process present; uncus narrow, apex pointed; valve undivided, basal projection thumb-like, valves not fused ventrally; dorsal process contiguous with costal margin of valve, slightly curved, slightly shorter than valve; juxta a rectangular plate, wider than high, dorsal margin concave; saccus V-shaped, apex truncate; aedoeagus approximately 0.65x height of genital capsule, slightly bent and narrowed just before middle; vesica a small triangle-shaped lobe; cornuti absent.

FEMALE

- *Head* Front and vertex white; scape white, antenna black; labial palpus dark brown.
- *Forewing* (Pl. 3, Fig. 10): Length 27–29 mm (n=2); color and pattern similar to male.
- *Abdomen* Dorsum white at anterior becoming pale pink at posterior, anterior margin of segments 6 and 7 brown, segment 8 brown; venter brown with white margins along posterior margins.
- *Hindwing* color and pattern similar to male.
- *Genitalia* (Pl. 27, Fig. 1): Ovipositor slightly telescopic; papillae anales rectangulate, apex round and slightly angulate; anterior and posterior apophysis elongate, anterior apophysis longer than posterior apophysis; ostium bursae with a pair of small sclerotized lobes; ductus bursae sclerotized; corpus bursae ovate; signa absent.

LARVA

FIRST INSTAR (Pl. 38, Fig. 3)

Differences from *L. d. dispar*:

- *Head* Width at widest point 0.57–0.60 mm (n=6).

- *Thorax* T1 with elongate barbs on SD1 seta, SD2 with short barbs throughout length (Pl. 38, Fig. 3).

PRESERVED SPECIMENS (PL. 30, FIG. 5; PL. 32, FIG. 7; PL. 49, FIG. 2)

- *Length* 23–30 mm.
- *Head* Cream-colored, speckled with brown, coronal stripes absent; labrum with deep medial cleft (Pl. 49, Fig. 2).
- *Thorax* Brown patch on T2 cephalad to D2 verruca; D2 verruca concolorous with ground color; legs yellowish-brown.
- *Abdomen* Ground color cream; dorsal stripe absent; lateral stripe indistinct, consisting of irregular shaped lines caudad to SD and L verrucae; D2 verruca concolorous with ground color, primary setae black, secondary setae white; D1 verruca small with large black primary setae and several white secondary setae; primary setae on D2 verruca shorter than those on L verruca; SD and L verrucae concolorous with ground color, contiguous, brown primary setae and long white setae, both colors of setae with microbarbules on shaft; SV verrucae concolorous with ground color; eversible glands on A6–7 concolorous with ground color; underside with slightly darker area between prolegs and extending to A10, remainder of underside concolorous with ground color; prolegs pale with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries.

DISTRIBUTION

Eurasia, with a nearly continuous distribution across Asia. At the end of its range in Europe there is a high percentage of melanic or dark adult forms whereas in the Japanese archipelago and Korea only the white or non-melanic form is found. One record in North America is documented for Long Island, New York, about 1900 (Holland 1903), but fortunately the population has not persisted (Ferguson 1978).

SPECIMENS EXAMINED

CHINA: Tse Kou, 1903 (4m, 2f), P. Dubernard (BMNH). Frontiere orientale du Thibet, 1905 (1m), P. Dejean (BMNH). West-Tien-Mu-Shan, Pz. Chekiang, 1600 m, 6 Sep. 1932 (1m), H. Höne (BMNH). Yesso, 1882 (1f), H. Pryor Coll. (BMNH). CZECH REPUBLIC: Bohemia, Brdy Mts., 650 m. a.s.l., 25–30 July 1963, Jan Liska leg. (2m, 6f) (PWS). JAPAN: HOKKAIDO: Bibai, HFRI, 3 August 1997, Paul W. Schaefer (4f) (PWS); Bibai, Hok. For. Res. Inst., r. BIRL as #8-2003, on *Larix* foliage, Paul W. Schaefer (16m, 3f) (PWS); Bibai, 10–14 August 2002 (18m, 5f), 10 August 2002, at garage light (9m, 1f), 16 August 2002, at light on garage (2m, 1f), Paul W. Schaefer (PWS); Chitose, 14 VIII (19)76, Paul W. Schaefer (1m) (PWS); Futatsuyama, Kushiro, 24 Aug. 1952 (2m), K. Ijima (BMNH); Hidakaiwania, 10 IX (19)76, Paul W. Schaefer (1m, 18f); Okushibetsu, 7 Aug. 1947 (1f), 13 Sep. 1947 (1m), T. Masegawa (BMNH); Sapporo, Mt. Teine, 29 VI (19)76 (5m, 2f), 8 August (19)76, (1m, 3f), 16 VIII (19)76 (3m), Paul W. Schaefer (PWS); HONSHU: Fuji-yoshida, 4–14 Aug. 1954 (1m), A. Haga (BMNH); Hoppo-ousen, 1600 m, 23–4 July 1952 (1m), H. Inoue (BMNH); Kiyosato, 1300 m, 23 Aug. 1975 (1m), H. Inoue (BMNH); Morioka, 7 July 1994, ex phero. trap. Paul W. Schaefer (10m) (PWS); Morioka, GFRI, 7 July 1994 (1m), 9 July 1994 (1m), Paul W. Schaefer (PWS); nr. Morioka, Mt. Hemikami, 5 August 2001, removed ex phero trap, Paul W. Schaefer (21m) (PWS); 20 Km W. of Morioka, Nanatumori Bird

Sanct. 20 July 1998, ex periodicity test, Paul W. Schaefer (22m) (PWS); Morioka, Takizawa Village, 29 July 1996, at lights (3m), FFPRI, 29 July 1996, in phero. trap (2m), GFRI, 8 July 1994 (1m), Paul W. Schaefer (PWS); Nagano Pref., Tobira Pass, 1400 m, 28 July 1978 (1f), H. Inoue (BMNH); Saitama Pref., Mitsuminesan, 900 m, 26 Aug. 1984 (1m, 1f), H. Inoue (BMNH); Saitama, Mitsumine, 25 Aug. 1957 (4m), K. Ishizuka (BMNH); 25 km S. Sakata, 5 July 1994, Paul W. Schaefer (1m) (PWS); Shinano Prov., Karuizawa, 14 Aug. 1894 (1f), A.E. Wileman (BMNH); Yamanash-ken, Kiyosato, 1300 m, 29–31 Aug. 1971 (2f), H. Inoue (BMNH); Yamanashi, Yashajin Pass, 1400 m, 26 July 1955 (1m, 1f), H. Inoue (BMNH); YAKUSHIMA: Kurio, 1 Aug. 1974 (1f), T. Watanabe (BMNH); Shiratani, 25 July 1974 (2f), H. Inoue (BMNH); Anbo-rindo, 5 Aug. 1974 (2m), T. Watanabe (BMNH). RUSSIA: Far East, Tigrovoi Settlement, 11 Aug. 1975 (1m), Y.U. Chistjakov (BMNH); Siberia, Tyumen, rec. coll. ex Y. Baranchikov, r. BIRL on *Larix*, May 2000, Paul W. Schaefer (1m, 2f). SWEDEN: Byerum Sandvik, 1.3 km N pensionatet Tallhed Örter, 29 July 1975, O. Pellmyr (2m), (USNM); Na, Öbro, Myrö, 13 Aug. 1976, O. Pellmyr (2m), (USNM). SWITZERLAND: Zermatt (2m), genitalia slide USNM 52609, 4 Aug. 1887 (2f) (USNM).

OVIPOSITION

Females possess a long flexible ovipositor (Grijpma 1989) and use it to oviposit eggs well under bark scales and into cracks on the bole of the host tree. Eggs are naked within the mass and are not usually visible without completely removing the bark scale.

BIOLOGY AND BEHAVIOR

Grijpma (1989) has previously summarized the biology of *L. monacha* in Europe.

Wallner et al. (1995) showed in the Russian Far East that, as with both *L. mathura* and *L. d. japonica*, the pattern of nocturnal attractancy of adult *L. monacha* to ultraviolet lamps peaked from 2 AM to 5 AM, with a male-to-female sex ratio of 20:1. Wallner et al. (1995) showed in Mineralni, in the Russian Far East, that, although its activity patterns were distinctly different from both *L. mathura* and *L. d. japonica*, nocturnal attractancy of adult *L. monacha* to ultraviolet lamps peaked from 2 AM to 5 AM, with a male-to-female sex ratio of 20:1. Nocturnal activity of this sort is further evidenced in Morioka, Honshu, Japan (Schaefer et al. 1999), where males responded to pheromone traps at the same time during the night as they responded to the lights in Russia.

FOOD PLANT

Both conifers and hardwoods are utilized. In Europe, periodic destructive outbreaks are recorded on *Pinus sylvestris* L. (Pinaceae) (Bejer 1988, Grijpma 1989). Among the coniferous hosts are *Abies alba* P. Mill., *A. fabri* (Mast.) Craib; *Larix decidua* P. Mill., *L. koreana* Nakai, *L. leptolepis* Siebold & Zucc., *L. gmelinii* (Rupr.) Rupr.; *Picea abies* (L.) Karst., *P. asperata* Mast., *P. excelsa* Lam., *P. pungens* Engelm., *P. sitchensis* (Bong.) Carr., *Pinus armandii* Franch, *P. banksiana* Lamb., *P. cembra* L., *P. concerta* Douglas ex Loudon, *P. densiflora* Siebold & Zucc., *P. sylvestris*, *P. strobus* L., *P. yunnanensis* Franch., *Pseudotsuga menziesii* (Mirb.) Franko., *P. sinensis* Dode, *Juniperus chinensis* L. and *Tsuga chinensis* (Franch.) Pritzel. (all Pinaceae). The deciduous hardwood hosts include many genera among seven plant families, including *Acer* (Aceraceae); *Betula*, *Carpinus cordata* Blume and *Corylus heterophylla* Fisch. ex Trautv. (all Betulaceae); *Crataegus monogyna* Jacq., *C. oxyacantha* L., *Cydonia vulgaris* Pers., *Malus domestica* Borkh., *M. pumila* P. Mill., *M. sylvestris* P. Mill., *Prunus padus*

L., *P. serotina* Ehrh., *P. spinosa* L., *P. armeniaca* L., *Rosa cania* L., and *Sorbus aucuparis* L., *S. alnifolia* Siebold & Zucc., *S. torminalis* (L.) Crantz. (all Rosaceae); *Quercus aliena* Blume, *Q. robur* L., *Q. serrata* Murray, *Q. sessiliflora* Salisb. (Fagaceae); *Fraxinus* (Oleaceae); *Populus davidiana* Dode; *Salix alba* L., *S. babylonica* L., *S. viminalis* L. (both Salicaceae); and *Vaccinium myrtillus* L., *V. uliginosum* L. (Ericaceae).

PHEROMONAL COMMUNICATIONS

Analysis of both female gland extract and effluvium suggest that *L. monacha* communicates using a three-component blend (monachalure blend), which consists of (*7R,8S*)-*cis*-7,8-epoxy-octadecane [(+) monachalure], (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure], and 2-methyl-(*Z*)-7-octadecene [2-Me-7Z-18Hy], with an optimal ratio of 10:10:1, respectively (Gries et al. 2001). Earlier trapping in Japan had revealed the same attractiveness to this blend (Gries et al. 1997) as had been observed in Europe (Gries et al. 1996).

FLIGHT AND PHEROMONE PERIODICITY

Another important distinction between the Asian and European forms of *L. monacha* involves the time of night when they respond to synthetic sex pheromones. In the Czech Republic, males responded to traps baited with synthetic lures during Late PM, with a peak at 10 PM. In contrast, in Japan the response was during the hours after Early AM (1 AM) with the peak at 2 AM (Gries et al. 2001, Fig. 5).

DISCUSSION

Lymantria monacha exhibits melanism with these specimens having a dark gray forewing ground color with indistinct lines that are visible only as faint spots. The degree of melanism varies from very dark to somewhat lighter. The frequency of melanic individuals is very high in Europe, whereas in Korea and Japan it is not expressed.

Based on recent investigations involving sex pheromone communication and their periodicity of response, we find evidence to support the designation of an “Asian form” (Early-Late morning active; many melanics) and a “European form” (Early-Late evening active; no melanics) of *L. monacha*. It remains unclear if these two forms occupy the two discrete areas making up the apparent disjunct pattern of distribution across Eurasia. This moth is a more serious pest in Europe than is *L. d. dispar*.

LYMANTRIA (LYMANTRIA) PULVEREA POGUE AND SCHAEFER, NEW SPECIES

(Pl. 3, Fig. 7; Pl. 14, Figs. 4–6)

TYPE MATERIAL

Holotype male: TAIWAN, Tayuljing, 22 June 1994, P.W. Schaefer, in pheromone trap, USNM ENT 00217142, genitalia slide DCF 1647 (USNM). *Paratypes*: Same data as holotype, (1m), USNM ENT 00217141 (PWS); FuShan, 18 May 1994 (1m), P.W. Schaefer, at lights (PWS).

ETYMOLOGY

The species epithet is derived from the Latin, *pulvis*, meaning “dust,” and refers to the black irrorated scales in the forewing.

COMMON NAMES

Pulverea tussock moth.

DIAGNOSIS

This species is most similar to *L. monacha*, and is difficult to distinguish without dissection. The reniform spot is a short angular bar at the end of the discal cell that is more prominent in *L. pulverea* than in *L. monacha*. The basal projection in the male genitalia is fused with the base of the valve in *L. pulverea* and is not as conspicuous as the rectangular basal projection in *L. monacha*.

DESCRIPTION

MALE

- *Head* Front and vertex white; scape white, antenna shaft white, bipectinate; labial palp porrect, black with white on interior surface.
- *Thorax* Prothoracic collar white with a very narrow anterior band of pink; mesothorax and metathorax white; tegula white; foretibia gray with white fringe, tarsi with basal segment gray with white apical ring, rest white; middle and hind tibia gray and some white; tarsi with basal segment white, gray in distal half, rest white; underside dirty white, darker anteriorly.
- *Forewing* (Pl. 3, Fig. 7): Length 17–18 mm (n=3); ground color white; all markings black: basal area consists of a few small spots; antemedial line with a dark costal spot then a faint sinuate line; reniform spot a dark bar at end of discal cell with a very short arm angled toward costa; postmedial line sharply and deeply crenulate from a prominent costal spot to posterior margin; subterminal line sharply and deeply crenulate from a prominent costal spot to posterior margin; fringe white with black spots between wing veins.
- *Hindwing* Ground color grayish-white; faint discal spot present; a series of marginal spots extending onto fringe; fringe appears checkered black and white.

- *Abdomen* White; lateral tufts alternating black and pink; apical tuft black and white; tymbals present on third sternite.
- *Genitalia* (Pl. 14, Figs. 4–6): Tegumen with lateral process absent; uncus wide, apex pointed; valve undivided, basal lobe fused with base of valve and is not as conspicuous as in other species, minute process at distal apex of lobe, valves not fused ventrally; dorsal process contiguous with costal margin of valve, straight, shorter than valve; juxta rectangular, lateral margins round, dorsal and ventral margins excavated; saccus broad, V-shaped; aedoeagus approximately 0.70x height of genital capsule, slightly bent and narrowed at middle; vesica a small triangle-shaped lobe; cornuti absent.

FEMALE

No known specimens.

LARVA

Unknown.

DISTRIBUTION

Known only from Taiwan.

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

Unknown.

PHEROMONAL COMMUNICATIONS

At the type locality in 1994, males were captured in pheromone traps baited with (+)-disparlure or (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Adults fly at least during May and June.

DISCUSSION

The male genitalia differ in the length of the dorsal process of the valve, which is half as long in *L. pulverea* as it is in *L. monacha*; the basal process of the valve is more or less fused with the valve and is only represented by a small spine-like process in *L. pulverea*, whereas it is well-developed and thumb-like in *L. monacha*; saccus is broad and V-shaped in *L. pulverea*, and narrower and constricted in *L. monacha*. Collecting and sampling *L. pulverea* is possible using traps baited with (+)-disparlure.

LYMANTRIA (LYMANTRIA) MINOMONIS MATSUMURA

(Pl. 3, Figs. 8, 11; Pl. 15, Figs. 1–3; Pl. 30, Fig. 6; Pl. 32, Fig. 8)

Lymantria minomonis Matsumura, 1933:137. ST: JAPAN: Honshu, Minomo (HUS, Sapporo, examined); Gaede, 1934:283; Bryk, 1934:165; Inoue, 1956a:399; Inoue, 1957:192; Inoue et al., 1982a:635.

Lymantria minomonis okinawaensis Kishida, 1987:292. HT male: JAPAN: Okinawa I., Yona (Kishida coll., not examined); Kishida, 2002:354; Schintlmeister, 2004:83. **Revised synonymy.**

COMMON NAMES

Minomonis tussock moth; Minoh-maimai (in Japanese); San-wen-do-er (in Chinese) and a translation in China refers to this moth as the Fan-like tussock moth.

DIAGNOSIS

Lymantria minomonis is most similar to *L. concolor* in overall wing pattern and coloration. The forewing pattern is bold and more heavily patterned in *L. concolor* than it is in *L. minomonis*. The hindwing is a solid gray in *L. minomonis*. In *L. concolor* the hindwing has a prominent series of white marginal spots along outer margin with the ground color being white to light gray. The white marginal spots in the hindwing are less distinct when the ground color is white, but there are usually some contrasting gray areas adjacent to the marginal spots. The dorsal process of the valve in the male genitalia is shorter and thicker in *L. minomonis* than in *L. concolor*, and the basal projection is rectangular in *L. minomonis* and triangular in *L. concolor*.

REDESCRIPTION

MALE

- *Head* Front and vertex white with a median black spot between antennal bases; scape white, with white extending to base of antenna remainder gray, bipectinate; labial palp short, barely extending beyond front, black, apex white.
- *Thorax* White, a median black bar anterior to tegulae; tegula with an anteromedian black spot; black spot between tegulae; black spot at distal apex of metathorax; tibia white with proximal apex black, a black spot at 2/3 length of tibia, tarsi white with black spot at distal apex of basitarsus, ultimate segment black; underside brown cephalad becoming dirty white caudad.
- *Forewing* (Pl. 3, Fig. 8): Length 17–23 mm (n=10); ground color white; all markings black; basal area with a narrow horizontal bar from costa Sc vein, a narrow vertical bar from R to A vein; antemedial line with a bold spot at costa, sinuate to posterior margin; postmedial line a bold spot at costa, crenulate to posterior margin; reniform spot chevron-shaped at end of discal cell; subterminal line a bold spot at costa, a faint crenulate line to tornus; a few chevron-shaped spots between subterminal line and outer margin; fringe white with black spots between wing veins.

- *Hindwing* Ground color gray; discal spot faint; broad dark gray marginal band; fringe white with indistinct gray spots between wing veins.
- *Abdomen* Dorsum pink, caudal margin of segments black; lateral line a series of black spots divided by tufts of pink; underside pink, caudal margin of segments black, much wider than in dorsum; tymbals present on third sternite.
- *Genitalia* (Pl. 15, Figs. 1–3): Tegumen with lateral process absent; uncus narrow, apex pointed; valve undivided, basal lobe rectangular with a thumb-shaped process at ventrodistal corner, dorsal process contiguous with costal margin of valve, curved ventrad at middle, wide, shorter than valve; juxta a narrow band, widest in middle narrowing toward attachment with valve, dorsal margin concave; saccus narrow, U-shaped; aedoeagus approximately 0.74–0.80x height of genital capsule, slightly bent and narrowed at middle; vesica a small ovate lobe; cornuti absent.

FEMALE

- *Head* As in male except antenna black.
- *Thorax* Forelegs and tarsi black; middle and hind tibiae black with median and apical white patches, tarsi black.
- *Forewing* (Pl. 3, Fig. 11): Length 29–36 mm (n=5); lines proximal to discal cell bolder than in male.
- *Hindwing* Ground color pale gray, submarginal band dark gray; fringe white with large black quadrate spots between veins.
- *Abdomen* Dorsum pink with broad black borders on caudal margins of segments; underside black with narrow pink borders on caudal margins of segments.

LARVA (PL. 30, FIG. 6; PL. 32, FIG. 8)

- *Head* Cream-colored, covered with a pattern of small black spots (Pl. 32, Fig. 8).
- *Thorax* A large black patch between T1 and T2; T2 with D2 verruca larger than D1 and both blue; T3 with D2 verruca cream-colored; SD and L verrucae cream-colored and adjacent, SD with black spine-like setae and white hair-like barbed setae, L with very long spine-like black setae and white hair-like barbed setae.
- *Abdomen* Overall ground color brown; dorsal stripe a thin double black line narrowly bordered by cream-colored line; a large cream-colored area from the posterior half of A4 extending to the anterior half of A6 (this area is much lighter than the rest of the abdomen); eversible glands reddish-brown on A6–7; A10 generally lighter in overall color than A9.

DISTRIBUTION

Northern India, China, Taiwan, Japan (Honshu, Shikoku, Ryukyu Islands including Okinawa).

SPECIMENS EXAMINED

JAPAN: Akiya/Miura, Sep. 1967, K.H. Nikodemus (1f), (MAKB); HONSHU: Hikawa, 1 Aug. 1935 (1m) (BMNH); Kurama, Kyoto, 21 Aug. 1925 (1m), 22 Aug. 1931 (1m), genitalia slide BMNH 2067, I. Sugitani (BMNH); Kyota, Tamba, Mt. Chorogadake, 17 Aug. 1957

(1m), Y. Yamamoto (BMNH); Nashimoto, South Izu, 25 May 1960 (1m), 5 July 1959 (1m), 13 July 1959 (1m), 25 July 1960 (1m), 29–31 July 1957 (1m) 10–12 Aug. 1959 (1m), H. Inoue (BMNH); Rokkosan bei, Kobe, 1000 m, Aug. 1934 (1m, 1f), H. Höne (BMNH); Shizuoka Pref., Misakubo, 22 Aug. 1950 (1f), K. Kojima (BMNH); Shizuoka Pref., Misakuni, Yamazumi, 22 Aug. 1950 (1m), K. Kojima (BMNH); Yunotani, Mt. Kirishima, 20 July 1963 (2m), 4 Aug. 1962 (1m), Y. Takemura (BMNH); KYUSHU: Yakushima, Nagata, 6 Aug. 1972 (1f), T. Watanabe (BMNH); Yakushima, Kosugidani, 29 July 1963 (1m), T. Okada, 8 Aug. 1967 (1m), H. Futada & H. Tanaka (BMNH); Yakushima I., Okawa-rindo, 12 Sep. 1972 (2f), T. Watanabe (BMNH); OKINAWA: Yona, 22 May 1976 (1m), genitalia slide BMNH 2068, S. Azuma (BMNH); Yesso, (1f), (CMP); SHIKOKU: Kochi Pref., Mt. Yokokura, 1 Aug. 1959 (1m), Y. Kawakami (BMNH); Nishi-iyayama-v, 20 Aug. 1954 (1m), K. Ochi (BMNH). TAIWAN: Han Co., Fushan, 17 Aug. 1994 (1m), Y. Chen (PWS); Nan Tow Co., Lien-Hua-Chih For. Sta, 12 km S Puli, 700 m, 7–12 Sep. 1983, J.B. Heppner (1m), (FSCA). INDIA: Arunacha Pradesh, Namorah, 450 ft., 6 Feb. 1978, M.L. Ripley (1m), (USNM).

OVIPOSITION

Apparently of the insertion type based on a single live specimen captured in Okinawa, June 9, 1999, but identity of host(s) is unknown (Schaefer unpubl. data).

BIOLOGY AND BEHAVIOR

Adults attracted to lights in Okinawa and Taiwan as females flew to lights in Late Evening (9:10 PM) in the parking lot at Fungawa Dam, Okinawa, on 9 June 1999 (Schaefer and Gries, unpubl. data).

FOOD PLANTS

Recorded to feed on pines, *Pinus* spp. (Pinaceae) and cypress, likely *Cupressus sempervirens* L. (Cupressaceae) (Zhao 2002). However, it is reported to feed on *Distylium racemosum* Siebold & Zucc. (Hamamelidaceae) in Okinawa according to Seiji Azuma (pers. comm.). Under quarantine laboratory conditions at Newark, DE, neonate larvae were offered and accepted lichen (Lichenes) whereas intermediate larvae accepted deciduous hardwoods in the Fagaceae (*Quercus* spp.), Aceraceae (*Acer* spp.) and Betulaceae (*Ostrya* sp.) (Schaefer, unpubl. data). Other tree species in these same orders were offered but were rejected.

PHEROMONAL COMMUNICATIONS

In Okinawa, males responded to traps baited with (*7R,8S*)-*cis*-7,8-epoxy-octadecane [(+)-monachalure], (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] and 2-methyl-(*Z*)-7-Octadecene [2-Me-7Z-18Hy] in May 1999 (Schaefer and Gries, unpubl. data). In another experiment conducted over ten different sites on Okinawa, two *L. minomonis* males responded to (+)-monachalure alone among traps designed to clarify the sex pheromone communication in *L. xylina* (Gries and Schaefer, unpubl. data). Subsequent analysis of a single pair of *L. minomonis* collected in Okinawa and transported live to Simon Fraser University confirmed the similarity of *L. minomonis* pheromone components to that of *L. monacha* (R. and G. Gries, unpubl. 1999 data). We now believe that (+)-monachalure is the major pheromone component, but this has yet to be properly field tested.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

In Okinawa, adults fly in early June, based on our finding of females flying to parking lot lights (Schaefer and G. Gries, unpubl. data). Labels on preserved specimens indicated that adults occurred on 9 June in northern Okinawa, May through August at various locations in China (Zhao 2002), and fly in August in southern Japan (Honshu and Shikoku) (Inoue 1957).

DISCUSSION

Lymantria minomonis is more southerly distributed, seemingly replacing *L. monacha*, with which it has been confused in the past. The similarity of the two species is also evidenced by the response on Okinawa of *L. minomonis* males to the pheromone blend of *L. monacha*, suggesting that sampling appears possible using the monachalure blend.

LYMANTRIA (LYMANTRIA) CONCOLOR WALKER

(Pl. 3, Fig. 12; Pl. 4, Fig. 4; Pl. 15, Figs. 4–5)

Lymantria concolor Walker, 1855b:876. HT female: INDIA: Sikkim (BMNH, London, examined); Butler, 1881:55; Hampson, 1892:462; Kirby, 1892:478; Swinhoe, 1903:486; Strand, 1910:130; Gaede, 1932:101; Matsumura, 1933:135; Bryk, 1934:159; Kishida, 1993:83; Kishida, 1994:73; Kishida, 1998:36.

Lymantria superans Walker, 1855b:876. ST: INDIA: Sikkim, Himalaya, North (BMNH, London, examined); Butler, 1881:55; Kirby, 1892:478.

Lymantria micans Felder and Rogenhofer, 1874:pl. 99, fig. 2. HT female: BANGLADESH: Silhet (BMNH, London, examined); Strand, 1910:131; Strand, 1923:322; Bryk, 1934:160 (synonymized).

Lymantria carnecolor Moore, 1888:399. ST: INDIA: Dharmasala (BMNH, London, examined); Kirby, 1892:478; Strand, 1910:131; Strand, 1923:321; Bryk, 1934:160 (synonymized).

Imaus micans; Kirby, 1892:481.

Lymantria concolor superans; Strand, 1910:131; Strand, 1923:321; Gaede, 1932:102; Bryk, 1934:160 (synonymized).

Liparis concolor; Swinhoe, 1923:428.

Lymantria concolor horishana Matsumura, 1927:25. [TL: TAIWAN]; Matsumura, 1931:713; Bryk, 1934:159 (synonymized); Inoue, 1965:144.

Lymantria concolor lacteipennis Collenette, 1933:24. HT female: CHINA: Sichuan, Tatsien-lou (BMNH, London, examined).

Lymantria (Lymantria) concolor septentrionalis Schintlmeister, 2004:86. HT male: CHINA: Shaanxi, Taibaishan Nat. Park (ASD, Dresden, examined figure). **New synonymy.**

COMMON NAMES

Concolorous tussock moth; Luo-do-er, which translates to net-like tussock moth while another translation in China refers to this as the Yellow-colored tussock moth (in Chinese).

DIAGNOSIS

The forewing markings are fainter in *L. concolor* and heavier and bolder in *L. monacha*. The postmedial and subterminal lines are thin and separated in *L. concolor*, whereas in *L. monacha* these lines are thicker (especially the postmedial line) and closer together. The male genitalia are similar, but the dorsal process is shorter in *L. concolor* than in *L. monacha*, and the saccus is wider in *L. concolor* than in *L. monacha*.

REDESCRIPTION

MALE

- *Head* Front white with black margin above eye, vertex white with a black spot between antennae; scape white; antenna black, apex white, bipectinate; labial palp black with white apex.

- *Thorax* Prothorax white with an oblong medial black spot; tegula white with black spot at wing base and thin black caudal margin; mesothorax white; metathorax white with black spot; foretibia black with long white fringe, a medial white patch invading tibia from fringe, apex white, basitarsus white with broad black apex, segments 2–4 white, apical segment black or brown; middle and hind tibia banded, black basally, white band, smaller black band, white apex, tarsi as in fore leg; underside black.
- *Forewing* (Pl. 3, Fig. 12): Length 22–24 mm (n=2); ground color white; all markings black; basal area with a series of spots angulate from costa to posterior margin; antemedial line originates from a rectangular spot on costa, remainder a sinuate line to posterior margin; orbicular spot small, in middle of discal cell; costal spot just proximal to reniform spot; reniform spot along veins at end of discal cell; postmedial line from costal spot, crenulate to posterior margin; subterminal line originates from same rectangular costal spot as antemedial line, crenulate to posterior margin; terminal area with various sized crescent-shaped spots, some of these extend to outer margin; fringe white with black spots between veins.
- *Hindwing* Ground color white; heavily irrorated with pale gray scales; submarginal band incomplete with some gray scales extending down wing veins to margin giving the appearance of large white spots along outer margin; a thin gray line along outer margin; fringe white.
- *Abdomen* Dorsum pink in anterior half, black median band; lateral line a series of black and white spots; underside white with black basal bands; genital tuft white; tymbals present on third sternite.
- *Genitalia* (Pl. 15, Figs. 4–5): Tegumen with lateral process absent; uncus narrow apex pointed; valve undivided, basal lobe rectangular with ventrally curved apex, valves not fused ventrally; dorsal process contiguous with costal margin of valve, slightly curved, shorter than valve; juxta rectangular with round lateral margins, dorsal margin excavated with a slight medial projection; saccus wide U-shaped; aedoeagus 0.75–0.80x height of genital capsule, slightly bent and narrowed at middle; vesica a small ovate lobe; cornuti absent.

FEMALE

- *Head* As in male.
- *Thorax* As in male except tarsi black.
- *Forewing* (Pl. 4, Fig. 4): Length 33.0 mm (n=1).
- *Hindwing* Ground color white with an incomplete submarginal band.
- *Abdomen* Dorsum pink in anterior half, lateral line black, underside white.

LARVA

Gardner (1938) provided a detailed description of the full grown larva.

DISTRIBUTION

Widely distributed from Pakistan east in northern India (to 7,000 feet elevation, Sikkim), Bhutan, Tibet, Nepal, Myanmar, Thailand, south China and Taiwan.

SPECIMENS EXAMINED

CHINA: Ta-tsien-lou, 1910 (3m) (BMNH); Tsekou, 1898 (1m), P. Dubernard (BMNH); Siao-Lou, 1903 (2m, 1f) (BMNH); Tien-Tsuen, Yuin-Kin (1m), 1899 (1m) (BMNH); Tien-Tsuen, 1897 (1m), R.P. Dejean (BMNH); Frontiere orientale du Thibet, 1906 (1f) (BMNH); Shaanxi, Taibaishan Nat. Park, 33° 35' N, 107° 43' E, 1300–1500 m, 20 Aug.–4 Sep. 1998 (1m), V. Murzin & V. Sinlaev (BMNH); Shaanxi, South Taibaishan, Tsinling Mts., Houzhenzi, 33° 51' N, 107° 49' E, 1400 m, Sep. 1999 (1f), local collector (BMNH); Tapaishan im Tsinling, Sued-Shengi, ca. 1700 m, 13 Aug. 1936 (1m), H. Höne (BMNH); Yunnan, Pe Yen Tsin (1f) (BMNH); Jujimichi, 5000 ft., 26 Aug. 1908, A.E. Wileman (BMNH). INDIA: Assam, (1f), Coll. Wm. Schaus (USNM); Dharmsala (1m, 1f) (BMNH); Kangra (1m, 1f) (BMNH); Naga Hills, 5500–7000 ft., Sep.–Oct. 1889 (1m) (BMNH); Naini Tal, 6600 ft., 10 Sep. 1934 (1m), J.A. Graham (BMNH); Assam, Shillong, 5000 ft., 26 July 1928 (1m), T.B. Fletcher, (1f) H. M. Parish (BMNH); Assam, Khasia Hills (1f), Nissary (2m) (BMNH); Iawai Hills (1m), N.E. Bengal (BMNH); Darjeeling (1m, 1f) (BMNH); Calcutta (1m) (BMNH); Punjab, Khyra Gully, road to Rawalpindi, 19 Oct. 1880 (1m, 1f) (BMNH); Kulu Dist. (1m) (BMNH); Kulu, Sultanpore, 1889 (1m), G. Young (BMNH); Subathu, May 1883 (1m) (BMNH); Kujiar, 6000 ft., Apr. 1889 (1m), McArthur Coll. (BMNH); Sikkim, Gangtok, 6000 ft., 24 Apr. 1928 (1m) (BMNH); Sikkim, Kurseong, 1894 (1f), R.P. Bretaudeau (BMNH); Assam, Jaintia Hills (1m), ex. Coll. Swinhoe (BMNH); Kangra (1m) (BMNH); Simla, 7000 ft. (1m), A.E. Jones (BMNH); Madras, Tamil Nadu, 12–17 Nov. 1971 (1f), C.J.H. Pruettt (BMNH); Himachel Pradesh, Kulu Valley, Nagger, 6500 ft., 17–22 July 1971 (2f), C.J.H. Pruettt (BMNH); Bernardmyo, 5500–7000 ft., May 1890 (1m), W. Doherty (BMNH); Kambaiti, 7000 ft., 10 May 1934 (1m), R. Malaise (BMNH); Rantaizan, 10 May 1909 (1m), 14 May 1909 (1m), A.E. Wileman, May 1909 (2m) (BMNH); Kandaghat Forest, Solan, 27 June 2005 (PWS). TAIWAN: Fushan, 27 May 1994, 16 June 1994 (PWS). Nan Tow Co., Mei-feng, 30 km S Tayuling, 2200 m, 1–8 June 1990, D.R. Davis (2m), (USNM).

OVIPOSITION

Unknown, but based on female morphology it would appear to be of the insertion type.

BIOLOGY AND BEHAVIOR

Little is recorded on this species, but apparently bivoltine (see below). Around midnight on 21 June 1994, males responded to trap lights in Tayuling, Taiwan (Yi-Bin Fan and Schaefer, unpubl. data).

FOOD PLANTS

In India, reported to feed on *Quercus serrata* Thunb. and *Q. incana* Roxb. (Fagaceae) (Gardner 1938) as well as fruit trees (Chander and Dogra 1983). It is listed as a pest on apple, *Pyrus malus* L. (Rosaceae) (Mathur and Singh 1960) and reported to feed on benguet pine or *Pinus kesiya* Royle ex Gard. (= *P. insularis* Endl.) (Pinaceae) (Anonymous 1966, Mabberley 1987).

PHEROMONAL COMMUNICATIONS

Males are attracted to *cis*-7,8-epoxy-2-methyloctadecane [racemic disparlure] (Bhardwaj 1987). We confirmed attraction of males (n=4) to (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadec-

ane [(+)-disparlure] at Solan, Himachal Pradesh, India, in late June 2005. Three of those individuals were captured in traps baited with an admixture of (+)-disparlure and 2-methyl-(Z)-7-Octadecene [2-Me-7Z-18Hy] (Schaefer and Gries, unpubl. data), which suggests that, unlike males of some other species, males of *L. concolor* are not inhibited by the presence of the 2-Me-7Z-18Hy. No analysis of female gland extract has been made.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Based on the response to pheromone-baited traps, Bhardwaj (1987) showed a seasonal peak of activity in September–October in the Indian state of Himachal Pradesh. In Solan, Himachal Pradesh, we captured *L. concolor* males (n=4) in the Kandaghat National Forest, 25–27 June 2005 (Schaefer, unpubl. data). No periodicity of nocturnal flight is recorded but our preliminary observations showed male flight activity is near midnight or after in Taiwan. Two males appeared at an outdoor light sometime between ca. 10:30 PM and dawn (Schaefer, unpubl. data). At Anmashan, Taiwan, *L. concolor* specimens were collected in July, August, January, and February (Fu and Tzuoo 2004) and specimens at the Taiwan Forestry Research Institute in Taipei, were collected during the months of June–July (n=10) and September–January (n=9), suggesting bivoltinism (Schaefer, unpubl. data).

DISCUSSION

In Taiwan, *L. concolor* has been collected at an elevation of 2200 meters, where it flies with *L. grisea* Moore. Inoue (1965) stated that *L. concolor horishana* is synonymized for the first time, but Bryk (1934) was the first to treat it as a synonym. Schintlmeister (2004) also incorrectly synonymized *L. concolor horishana*. There is virtually no significant difference between *L. concolor septentrionalis* Schintlmeister and other specimens of *L. concolor*. The forewing markings appear intermediate in density from other specimens examined, but this is not sufficient to warrant designating it as a new subspecies. Females of *L. concolor* were described by Walker (1855b) as *Lymantria superans*.

Lymantria concolor may be collected with nominal success with traps baited with (7R,8S)-*cis*-7,8-epoxy-2-methyloctadecane,(+)-disparlure.

Invasion potential appears quite minimal.

LYMANTRIA (LYMANTRIA) UMBRIFERA WILEMAN

(Pl. 3, Fig. 13; Pl. 4, Fig. 5; Pl. 16, Figs. 1–2; Pl. 27, Fig. 2)

Lymantria umbrifera Wileman, 1910:309. HT male: TAIWAN: Rantaizan (BMNH, London, examined); Matsumura, 1921:898; Strand, 1923:3 24; Matsumura, 1931:716; Matsumura, 1933:139; Bryk, 1934:166.

Lymantria dissoluta f. *takasagonis* Matsumura, 1933:136. ST: TAIWAN: Horisha (HUS, Sapporo, examined); Bryk, 1934:166; Schintlmeister, 2004:96.

COMMON NAMES

Umbrifera tussock moth; L-hui-wen-du-er, or L-lined grey tussock moth (in Chinese).

DIAGNOSIS

Lymantria umbrifera has a gray forewing ground color compared to the white ground color of most other species in the subgenus *Lymantria*. *Lymantria umbrifera* is close in size to *L. monacha*, but is easily distinguished by its gray forewing color, diffuse dark marginal border in the hindwing, and pink abdomen. In *L. monacha*, the forewing ground color is white and the hindwing is gray, with the border being barely visible and narrower, and the abdomen is gray, with a hint of pink on some specimens. The male genitalia are similar, with the costal process of the valve shorter in *L. umbrifera* (Pl. 16, Fig. 1) than in *L. monacha* (Pl. 13, Fig. 5) and the saccus is V-shaped in *L. umbrifera* (Pl. 16, Fig. 1) and U-shaped in *L. monacha* (Pl. 13, Fig. 4).

REDESCRIPTION

MALE

- *Head* Front and vertex brownish-gray; scape and antenna concolorous with head, bipectinate; labial palp slender, appressed to front, brown.
- *Thorax* Pale grayish-brown; legs pale grayish-brown, tarsi pale grayish-brown flushed with light pink toward apical segment; underside dirty white.
- *Forewing* (Pl. 3, Fig. 13): Length 18–21 mm (n=5); ground color pale gray; lines incomplete; broad brownish-black band between antemedial line and reniform spot from below M vein to posterior margin; reniform spot well developed, black, V-shaped at end of discal cell; terminal line irregularly shaped, black (in some specimens this can become a wider brownish-black, irregularly shaped band); fringe dirty white with dark gray spots between wing veins.
- *Hindwing* Ground color pale gray; discal spot faint; diffuse gray marginal band; fringe white with indistinct gray spots between wing veins.
- *Abdomen* Dorsum gray; lateral line a series of black spots divided by tufts of pale pink; underside light brownish-gray; genital tuft white to light brownish-gray with a darker mediodorsal spot; tymbals present on third sternite.
- *Genitalia* (Pl. 16, Figs. 1–2): Tegumen with lateral process absent; uncus wide, apex pointed; valve undivided, basal lobe ovate with small, ventrally curved apex, valves not fused ventrally; dorsal process contiguous with costal margin of valve, slightly curved,

shorter than valve; juxta rectangulate, lateral margins straight to round ventral corner, dorsal margin greatly excavated, ventral margin slightly excavated; saccus broad, V-shaped; aedoeagus approximately 0.65x height of genital capsule, slightly bent and narrowed at middle; vesica a small ovate lobe; cornuti absent.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 4, Fig. 5): Length 21–26mm (n=3); lines faint, reniform spot a V-shaped mark at end of discal cell; terminal margin with spots between wing veins; fringe appearing checkered with faint pinkish cast.
- *Hindwing* Pale gray with a slight pinkish cast; fringe checkered with pinkish cast.
- *Abdomen*: Pink with alternating black spot and pink tuft laterally.
- *Genitalia* (Pl. 27, Fig. 2): Ovipositor slightly telescopic; papillae anales rectangulate, apex round; anterior and posterior apophyses elongate, anterior apophysis longer than posterior apophysis; ostium bursae with a pair of large kidney-shaped lobes; ductus bursae sclerotized; corpus bursae ovate; signa absent.

LARVA

Zhao (1982) described the egg, larva, and pupa.

DISTRIBUTION

Taiwan, southeastern China (Jiangsu, Zhejiang, Hebei, Hunan and Jiangxi Provinces), and southwestern China (northern Yunnan Province).

SPECIMENS EXAMINED

CHINA: Nord Yunnan Province, Li-Kiang, 22 June 1935 (1m), 1 July 1934 (1f), 15 July 1935 (1m) H. Höne (BMNH). TAIWAN: Nan Tow Co., Tayuling, 2500 m, 9–18 June 1980, D.R. Davis (3m), (USNM); Pilushi, 1900 m, 11–12 May 2002, P.W. Schaefer (2m), (USNM); Rantaizan, Feb. 1909 (1m), 7500 ft., 17 Feb. 1909 (1m), 20 Feb. 1909 (1m), 10 May 1909 (3m), genitalia slide BMNH 2074, 11 May 1909 (1m), A.E. Wileman (BMNH).

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Apparently bivoltine, based on collection records of Kishida (1984).

FOOD PLANTS

Reported to feed on maples, *Acer* spp. (Aceraceae) (Zhao 1982).

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Adults fly April–May and again August–September, in China (Kishida 1984). The seasonality of adult flight seems appreciably later in Taiwan with collections made in August and again from November–January (Fu and Tzuoo 2004).

DISCUSSION

The forewing lines are incomplete and irrorated with dark gray scales, giving them an overall “fuzzy” or out-of-focus appearance. Schintlmeister (2004) illustrated a female form with distinct forewing lines and bold checkered hindwing fringe.

LYMANTRIA (LYMANTRIA) DISSOLUTA SWINHOE

(Pl. 3, Fig. 14; Pl. 4, Fig. 6; Pl. 16, Figs. 3–5; Pl. 27, Fig. 3)

Lymantria dissoluta Swinhoe, 1903:484. ST: CHINA: Hong Kong (BMNH, London, examined); Strand, 1923:323; de Joannis, 1929:418; Matsumura, 1933:136; Bryk, 1934:165.*Liparis dissoluta*; Swinhoe, 1923:427.

COMMON NAMES

Dissolute tussock moth; Tiao-do-er (in Chinese) and a local Chinese-English translation refers to this moth as the Striped tussock moth, possibly referring to some larval feature.

DIAGNOSIS

Lymantria dissoluta is a small grayish-brown species with faint forewing markings, except for a distinct dark bar along the distal margin of the discal cell. A very slight hint of a marginal band is on the hindwing. *Lymantria umbrifera* and *L. sinica* Moore have much more distinct forewing patterns.

REDESCRIPTION

MALE

- *Head* Front and vertex brown mixed with light brown scales; scape concolorous with vertex; antenna light brown, bipectinate; labial palp well developed, dark brown.
- *Thorax* Brown mixed with some light brown scales; foretibia light brown with brown inner margin, basitarsus and segment 5 brown, rest light brown; middle tibia light brown, basitarsus light brown with brown apical band, rest of tarsi light brown; hind tibia light brown, basitarsus brown, rest of tarsi light brown; underside light brown.
- *Forewing* (Pl. 3, Fig. 14): Length 14–19 mm (n=8) (Note: this is the shortest forewing length of all species covered in this publication); ground color light brown heavily irrorated with brown; antemedial line black, indistinct, curved to A vein, then angulate posteriorly to posterior margin; orbicular spot a small black dot in middle of discal cell; reniform spot V-shaped, at end of discal cell; postmedial line faint, a series of linked crescents from costa to posterior margin; subterminal line a series of linked crescents between veins that are heavier than in postmedial line; black spots along outer margin between veins that extend onto a white fringe.
- *Hindwing* Ground color dirty white; marginal band dark brown; some minute dark spots along margin; fringe white.
- *Abdomen* Dirty white, lateral brown line; tymbals present on third sternite.
- *Genitalia* (Pl. 16, Figs. 3–5): Tegumen with lateral process absent; uncus wide, apex pointed; valve undivided, basal lobe triangulate with small curved apex, valves not fused ventrally; dorsal process contiguous with costal margin of valve, straight, shorter than valve; juxta quadrate, lateral margins round, dorsal margin convex with slight medial excavation; saccus broad, U-shaped; aedoeagus approximately 0.65x height

of genital capsule, bent and narrowed at middle; vesica a small ovate lobe; cornuti spiculate.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 4, Fig. 6): Length 25–28 mm (n=3); most lines absent; orbicular spot a fine short dash in middle of discal cell; reniform V-shaped at end of discal cell; post-medial line very faint, a series of linked crescents from costa to posterior margin; sub-terminal line faint, a series of linked crescents from costa to posterior margin; black spots along outer margin between veins that extend onto a light pink fringe.
- *Hindwing* As in male except ground color flushed with pink; marginal band faint; minute dark spots along margin that extend onto a light pink fringe.
- *Abdomen* Brownish pink.
- *Genitalia* (Pl. 27, Fig. 3): Ovipositor telescopic; papillae anales rectangulate, apex round; anterior and posterior apophyses elongate, anterior apophysis longer than posterior apophysis; ostium bursae with a pair of large kidney-shaped lobes; ductus bursae sclerotized and enlarged at base of corpus bursae; corpus bursae ovate; signa absent.

LARVA

Unknown.

DISTRIBUTION

China (Anhui, Jiangsu, Jiangxi, Hubei, Hunan, Nanking, Guangdong, and Sichuan Provinces, including Hong Kong), Taiwan and Vietnam (Collenette 1934, Zhao 1982, Schintlmeister, 1987).

SPECIMENS EXAMINED

CHINA: Foochow, (1f), H.R. Caldwell (USNM); Sichuan, Siufu, (1f), D.C. Graham (USNM). West-Tien-Mu-Shan, Pz. Chekiang, 1600 m, 2 Nov. 1932 (1m), H. Höne (BMNH). Hunan Province, Hoeng-Shan, 900 m, 27 May 1933 (1m), 28 May 1933 (1m), 30 May 1933 (1m), 21 Aug. 1933 (1f) H. Höne (BMNH). Canton (1m) (BMNH). Ya-chiao-ling, Sep. 1922 (1m), C.T. Bowering (BMNH). Nanking Province, Lungtan bei, Kiangsu, 11 June 1933 (1m), H. Höne (BMNH). Kowloon, Nov. 1911 (1m) Dec. 1911 (1m), E. Wahr (BMNH). Kwangtung Province, Lafaoshan (1m) (BMNH). HONG KONG: Hong Kong, (1m, 1f) (BMNH). Shatin, Lion Rk. Pk., 130 m elev., 6/28-7/6/1997, in phero trap (+)-disparlure, USDA 1997 batch, Paul W. Schaefer (2m) (PWS); Shatin, World Wide Garden, 28 June 1996, on window, Paul W. Schaefer (1m) (PWS); N.T. (New Territory), Tai Lung Farm, 31 Oct. 1994, in phero trap, C.S.K. Lau (2m) (PWS). TAIWAN: Horisha, 1917 (1f), (HUS).

OVIPOSITION

Females lay 180 to 250 eggs in the early evening in bark crevices on the lower 2 meters of pine trunks (Sun 1989).

BIOLOGY AND BEHAVIOR

Recorded as a serious pest of *Pinus massioniana* Lamb. (Pinaceae) in Anhui Province, China, in 1981 (Sun 1989). It has three generations per year with flights occurring late June, early August, and in late September (Sun 1989). Adults are attracted to lights. Larvae feed gregariously on pine needles (Sun 1989).

FOOD PLANTS

Recorded as feeding on conifers and deciduous hardwoods, specifically pines (*Pinus elliotti* Engelm., *P. massoniana* Lamb., *P. nigra* Arnold, *P. sylvestris* L., *P. tabulaeformis* Carr., *P. taeda* L., *P. taiwanensis* Hayata, *P. thunbergii* Parl. (all Pinaceae)); oaks (*Quercus acutissima* Carr., *Q. chenii* Nakai and *Q. variabilis* Blume (all Fagaceae)), and cypress (*Taxodium* sp. (Taxodiaceae)) (Zhou 1982, C. Lau 1998 unpubl. database, Sun 1989).

PHEROMONAL COMMUNICATIONS

Males are attracted to traps baited with (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] in Shatin, Hong Kong (Schaefer unpubl. data).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Based on adult collections, Collenette (1934) records adults from April–May, July, and October. This suggests possibly three generations per year, somewhat similar to that reported by Sun (1989).

DISCUSSION

With nominal success males can be lured to traps baited with (+)-disparlure.

Because it may cause serious damage to pine species, *L. dissoluta* represents a potentially dangerous invasive to semitropical areas where pines are common.

LYMANTRIA (LYMANTRIA) SINICA MOORE

(Pl. 4, Figs. 1, 7; Pl. 17, Figs. 1–3; Pl. 27, Fig. 4)

Lymantria sinica Moore, 1879a:403. ST males: CHINA, TAIWAN: (BMNH, London, examined); Leech, 1899:131; Strand, 1911:127; Strand, 1923:321; Matsumura, 1933:139; Bryk, 1934:158.

Porthetria sinica; Kirby, 1892:476.

Lymantria nebulosa Wileman, 1910:309. HT male: TAIWAN: Kanshirei (BMNH, London, examined); Strand, 1923:324; Bang-Haas, 1926:132; Bryk, 1934:166; Schintlmeister, 2004:112.

Lymantria formosana Matsumura, 1911:97. HT male: TAIWAN: (HUS, Sapporo, examined); Bang-Haas, 1926:132; Bryk, 1934:167; Schintlmeister, 2004:112.

Lymantria melanopogon Strand, 1914:331. ST: TAIWAN: Kosempo (DEI, Eberswalde, not examined); Strand, 1923:324; Bang-Haas, 1926:132; Bryk, 1934:166; Schintlmeister, 2004:112.

Liparis sinica; Swinhoe, 1923:424.

Lymantria nebulosa forma *aprilis*; Strand, 1923:324. HT male: TAIWAN: (ZMHB, Berlin, not examined); Strand, 1923:324; Bang-Haas, 1926:132; Bryk, 1934:166;

Lymantria baibarana; Matsumura, 1931:713. ST: TAIWAN: (HUS, Sapporo, not examined); Bryk, 1934:166; Schintlmeister, 2004:112.

Lymantria sinica sinica; Schintlmeister, 2004:112.

Lymantria (Lymantria) sinica albido Schintlmeister, 2004:112. HT male: N. VIETNAM: Mt. Fan-si-pan, Cha-pa (ASD, Dresden, examined figure). **New synonymy.**

COMMON NAMES

Sinica tussock moth; Zhong-guo-do-er (Chinese tussock moth) or Fong-do-er (Maple tussock moth) (in Chinese).

DIAGNOSIS

Lymantria sinica resembles a pale gray *L. monacha*. The spot at the end of the discal cell is pronounced in *L. sinica* but not in *L. monacha*, and resembles the other forewing markings. The male genitalia in *L. sinica* are distinct and unique. *Lymantria sinica* is the only species of *Lymantria* with a bifurcate ventral process of the valve (Pl. 17, Figs. 1–2).

REDESCRIPTION

MALE

- *Head* Front and vertex white to light brown; scape white, antenna white, bipectinate; labial palpus well-developed, dark brown.
- *Thorax* Brown anteriorly, becoming white toward posterior; legs light brown with long dark brown fringe on tibiae, tarsi light brown.

- *Forewing* (Pl. 4, Fig. 1): Length: 19–20 mm (n=3); ground color white irrorated with brown scales; all wing markings brown, faint; antemedial line a series of short scallops and not well-developed; reniform spot a well-developed angulate line at end of discal cell, from base to middle of cell; postmedial and subterminal lines deeply crenulate; small dots between wing veins that extend onto fringe along outer margin.
- *Hindwing* White with faint, slightly darker, marginal band; discal spot faint; fringe white.
- *Abdomen* White; tymbals present on third sternite.
- *Genitalia* (Pl. 17, Figs. 1–3): Tegumen with lateral process absent; uncus narrow, apex pointed; valve undivided, basal lobe absent, a dorsomedial sclerotized shelf present, ampulla arises from middle of outer margin of valve, elongate with small, sharp dorsal projection, valves not fused ventrally; dorsal process contiguous with costal margin of valve, very short, round apex; juxta large ovate, wide central projection with truncate apex; saccus broad, U-shaped; aedoeagus large, 1.04x height of genital capsule, sinuate; vesica a small ovate lobe; a few minute cornuti at base of vesica.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 4, Fig. 7): Length 25–29 mm (n=3); ground color irrorated with fewer brown scales; lines less distinct.
- *Hindwing* Gray with dark gray submarginal band.
- *Abdomen* Grayish white.
- *Genitalia* (Pl. 27, Fig. 4): Ovipositor telescopic; papillae anales rectangulate, apex round; anterior and posterior apophyses elongate, anterior apophysis longer than posterior apophysis; ostium bursae a large, sclerotized, ovate structure with ventral margin straight and a medial, triangulate dorsal projection that extends above ventral margin with a truncate apex; ductus bursae sclerotized; corpus bursae ovate; signa present.

LARVA

Unknown.

DISTRIBUTION

China, from Shanghai south to Kwangtung, Vietnam and Taiwan.

SPECIMENS EXAMINED

CHINA: Kwangtung, Lafaoshan, 13 Apr. (1f), (BMNH). TAIWAN: 30 June 1975 (3m); Kosempo, Oct. 1911 (1f), H. Sauter (BMNH); Nantou Hsien, Lushan spa, 1200 m, 20–23 Aug. 1984 (1f), Y. Kishida; Taoyuan, Paleng, 1250 m, 4 July 1996 (2f), M. Montgomery.

OVIPOSITION

Based on the female ovipositor being telescopic, we conclude that oviposition is of the insertion type and that bark cracks are likely used for oviposition.

BIOLOGY AND BEHAVIOR

Bivoltine, perhaps trivoltine, based on various collection records. Little is known about its behavior.

FOOD PLANTS

Reported under "*L. nebulosa*" as feeding on *Liquidambar formosana* Hance (Hamamelidaceae) and *Keteleeria fortunei* (A. Murray) Carrière (Pinaceae) (Lau 1998). Possibly feeds on maples, *Acer* spp. (Aceraceae), as implied from the common names in China (Zhao 2002).

PHEROMONAL COMMUNICATIONS

In Hong Kong, specimens identified as *L. nebulosa* were collected in pheromone traps baited with disparlure by R. Winney in 1976–77 (Thai Lung Farm Collection, Hong Kong) and again at the same location in the early 1980s (Schaefer et al. 1984b).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

In Taiwan, adults appear in July–August (Kishida 1984); in China, records show adults appear in May and July–October (Zhao 2002). Specimens deposited in the collection at the Taiwan Forestry Research Institute, Taipei, under both "*L. baibarana*," (= *L. sinica*) and "*L. roseola*," (= *L. grisea*) indicate adults fly June–July and October–November (Schaefer unpubl. data), suggesting bivoltinism.

DISCUSSION

The specimens from Vietnam and southwestern China (*L. sinica albido*, Schintlmeister 2004) have a white ground color, instead of pale gray, in both the fore- and hindwings. The male genitalia are identical. Differences in forewing ground color, being the only distinguishing character, are not enough to warrant the naming of a subspecies, because no biological information is known about *L. sinica*.

In earlier literature, this species has been recorded under many names, including among others: *L. nebulosa*, *L. melanopogon*, *L. aprilis*, and *L. formosana*. It was misidentified as *L. umbrifera* by Matsumura (1933), but should now be referred to as *L. sinica*.

Preliminary evidence suggested that under the name *L. nebulosa*, now *L. sinica*, males responded to traps baited with (+)-disparlure, but confirmation is necessary.

Invasion potential seems minimal and with all the name changes and synonymies, re-analysis of existing data, together with further field and laboratory study, is necessary to fully understand the current distribution and behavior of *L. sinica*.

LYMANTRIA (LYMANTRIA) LUCESCENS (BUTLER)

(Figs. 18–19; Pl. 4, Figs. 2, 8; Pl. 17, 4–5; Pl. 32, Fig. 9; Pl. 49, Figs. 3–6; Pl. 50, Fig. 1)

Porthetria lucescens Butler, 1881:11. HT male: JAPAN: Tokyo (BMNH, London, examined).

Lymantria takamukui Nagano, 1918:411. ST: TAIWAN: (unknown type depository).

Lymantria aomoriensis Matsumura, 1921:876. HT male: JAPAN: northern Honshu (HUS, Sapporo, examined).

COMMON NAMES

Lucescens tussock moth; Ohyama-maimai, Ohyama-dokuga, Takamuku-maimai, and Aomori-maimai (in Japanese); Mulgyeolmaemi-Nabang (in Korean).

DIAGNOSIS

In Japan *L. lucescens* is most similar to *L. umbrifera* in overall forewing coloration and maculation. Differences included the forewing length which is longer in *L. lucescens* than in *L. umbrifera*; the abdomen in *L. lucescens* is various shades of fuscous with only a hint of light pink scales laterally, whereas in *L. umbrifera* the abdomen is pink; the discal spot in the hindwing is more distinct in *L. lucescens* than in *L. umbrifera*. The male genitalia in these two species are distinct from one another, placing the moths in different species groups. The most obvious difference is evident in the saccus, which is extremely elongate and narrow in *L. lucescens*, but broad and triangular in *L. umbrifera*.

REDESCRIPTION

MALE

- *Head* Front and vertex black mixed with white scales; scape white, antenna white speckled with black, bipectinate; labial palpus of moderate length, extending beyond front, basal segment white with a few black scales basally, middle segment black with white basally, apical segment black with white apex.
- *Thorax* Black mixed with white scales; fore and middle tibia black mixed with white, tarsi black with white apical bands; hind tibia mostly white with a few black scales and a larger black patch near distal apex, tarsi black with white apical bands; underside cream-colored with slight pink cast.
- *Forewing* (Pl. 4, Fig. 2): Length 19–24 mm (n=3); ground color white, irrorated with fuscous scales; basal area with several black dots; antemedial line sinuate from costa to posterior margin; orbicular spot a small dot in middle of discal cell; reniform spot V-shaped along vein at end of discal cell; postmedial line faint, crenulate from below reniform spot to posterior margin, becoming thicker and contiguous with subterminal line at posterior margin; subterminal line crenulate from costa to posterior margin; terminal line consists of a few spots near ends of R cells; fringe white with black spots between wing veins.
- *Hindwing* Ground grayish brown; discal spot V-shaped, gray, faint; an obscure dark marginal band present; fringe white with black spots between wing veins.

- *Abdomen* Fuscous with cream-colored distal borders, largest basally, becoming smaller distally; tymbals present on third sternite.
- *Genitalia* (Pl. 17, Figs. 4–5): Tegumen with lateral process absent; uncus wide, apex rounded; valve undivided, basal lobe ovate, apex a small curved, finger-like projection, valves not fused ventrally; dorsal process contiguous with costal margin of valve, angulate medially, shorter than valve; juxta a narrow band, dorsal margin excavated; saccus elongate, narrow, V-shaped; aedoeagus approximately 0.75x height of genital capsule, slightly bent and narrowed at 1/3 length; vesica a small elongate lobe; cornuti absent.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 4, Fig. 8): Length 30–33 mm (n=2); more irrorated with brown scales.
- *Hindwing* Gray with slightly darker marginal band; fringe rufous with black spots between veins.
- *Abdomen* Pink, especially on caudal border of segments.

LARVA

PRESERVED SPECIMENS (PL. 32, FIG. 9; PL. 49, FIGS. 3–6; PL. 50, FIG. 1)

- *Length* 35–40 mm.
- *Head* Yellowish-brown, speckled with light brown, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 9); 3 pairs of dark brown spots, smallest an elongate spot dorsal to stemmata, a round spot between small spot and coronal stripe, and a larger elongate spot near vertex; labrum deeply cleft (Pl. 49, Fig. 4); F1 seta single (Pl. 49, Fig. 3); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin (Pl. 49, Fig. 5); black stripe area with spiculi less dense, wide bases, and curved apices (Pl. 49, Fig. 6); rest of head with spiculi more dense than black stripe, narrow bases, and straight apices (Pl. 50, Fig. 1).
- *Thorax* D2 verruca pale yellowish-brown; legs yellowish-brown.
- *Abdomen* Ground color black irrorated with an irregular pattern of white dorsally and laterally; dorsal stripe absent; lateral stripe white, distinct; D2 verruca on abdominal segments, pale yellowish-brown, primary setae black, secondary setae white, primary setae shorter than those on L verruca; D1 verruca small with large black primary setae and several white secondary setae; SD verruca pale yellowish-brown with brown anterior patch and L verruca pale yellowish-brown, contiguous; L verruca with long black and white setae, no barbs on shafts of black primary setae, microbarbules on shafts of white secondary setae; SV verrucae mostly brown; eversible glands on A6–7 yellowish-brown; ventral area between prolegs brown, remainder of underside patterned with black and white; prolegs pale with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoserries. Immature stages are also illustrated in Sugi (1987).

DISTRIBUTION

Japan (Islands of Honshu, Kyushu and Hokkaido (Inoue 1957; Sugi 1987) and Korea (Nam and Kim, 1981).

SPECIMENS EXAMINED

JAPAN: HONSHU: Nagano, Toyoshima, Tazawa, 600 m, 20 Aug. 1989 (1m), Y. Kishida (PWS); Toyoshima, 36 deg 18.23' N, 137 deg. 56.72' E, 31 Aug. 2000, at lights (10 m), 6 Sept. 2000, at lights app. 8:30 P.M. (1m), Paul W. Schaefer (PWS); Nagano Prefecture, Toyoshima, 27 Aug. 1997 (1m) (PWS); Aichi Prefecture, Toyota City, 17 July 2000 (3m, 2f), P. W. Schaefer (PWS); Toyota, Mifune, 10 July 2000, at street lamp (19 m), 18 June 2000, at lights convenience store (22 m), Paul W. Schaefer (PWS); Toyota City, 17 July 2000, at store front lights, Paul W. Schaefer (30m, 15f); Toyota, 28 May 2000 (1f), 13 July 2000, at lights (7m, 12f), 11 July 2000, at convenience store lights (28m, 2f), Paul W. Schaefer (PWS). KOREA: Soraksan Nat. Park, Okinotang Rest Area, 29 Aug. 2000 (1m), 24 Aug. 2000 (3m), 18 Aug. 2000 (1f), Paul W. Schaefer (PWS); nr. Soraksan Nat. Park, 23 Aug. 2000, at lights of gas station, (1m), 29 Aug. 2000, at lights (1f), Paul W. Schaefer (PWS).

OVIPOSITION

Oviposition is of the insertion type with egg masses laid under bark scales or cracks, and presumably on boles of trees (Fig. 18). Noritaka (2000) reported an egg mass inserted into a hole apparently made by borers in a *Quercus acutissima* Carruthers (Fagaceae) branch.



Figure 18. Female of *L. lucescens* ovipositing within a mesh bag showing the long extension of the ovipositor that is used to insert eggs deep within a bark crack. Photo taken at Toyota City, Aichi Prefecture, Honshu, Japan, July 12, 2000 (photo by Paul W. Schaefer).

BIOLOGY AND BEHAVIOR

May develop outbreak populations in localized areas, as exemplified by an abundance of adult moths of both sexes flying to lights within the city of Toyota, Aichi Prefecture, Honshu, Japan, in 2000 (Fig. 19).

FOOD PLANTS

We observed feeding on Fagaceae, specifically *Quercus acutissima* Carr., *Quercus variabilis* Blume, *Q. serrata* Thunb. ex. Murray, and *Q. glauca* Thunb. in Toyota, Aichi Prefecture, Japan, and often competing for the same food trees with both *L. d. japonica* and *L. mathura*. Noritaka (2000) reported late stage larvae feeding on *Ulmus davidiana* Planchon, *U. parvifolia* Jacq., *Zelkova serrata* (Thunb.) Makino (Ulmaceae), *Morus bombycis* Koidz. (Moraceae), and *Q. acutissima*.

PHEROMONAL COMMUNICATIONS

Communicates using 2-methyl-(Z)-7-octadecene [2-Me-7Z-18Hy] as a single pheromone component (Gries et al. 2002). Earlier, Schaefer and Kishida (1999) reported *L. lucescens* males being

captured in traps intended for *L. monacha*, and baited with a three-component blend of 2-Me-7Z-18Hy and both (+)-disparlure and (+)-monachalure. This suggests *L. lucescens* males

are not totally inhibited by the presence of either (+)-disparlure or (+)-monachalure.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Males responding to traps baited with synthetic 2-Me-7Z-18Hy showed a pronounced peak of activity at 8–9 PM with some activity lasting until just after midnight (Schaefer unpubl. data).



Figure 19. Moths attracted to an exterior wall by the lights from an all-night convenience store. Responding during the night were mostly males of *L. lucescens*, a lesser number of females, and one pair of *L. dispar japonica* showing, Toyota City, Aichi Prefecture, Honshu, Japan, July 13, 2000 (photo by Paul W. Schaefer).

DISCUSSION

Inoue (1957) synonymized *L. takamukui* and *L. aomoriensis* with *L. lucescens*. The holotype of *L. aomoriensis* was examined; it is slightly smaller than the other specimens, but fits the description of *L. lucescens*. Locally, *L. lucescens* may be quite abundant, and as witnessed in Toyota City, Aichi Prefecture, Honshu, in mid-July 2000 (Schaefer, unpubl. data), both sexes are readily attracted to outdoor lighting, including store fronts of all-night convenience stores.

Populations can readily be detected or monitored with baited traps. Males respond to traps baited only with 2-Me-7Z-18Hy, making it easy to detect or monitor populations of this species.

Invasion potential is moderate because females can fly considerable distances and tend to respond to outdoor lighting. This behavior could occur in close proximity to seaports, which could accidentally result in the transoceanic transportation of well hidden egg masses.

SUBGENUS *BEATRIA* SCHINTLMEISTER

Beatria Schintlmeister, 2004:8. Type species: *Phalaena Bombyx beatrix* Stoll, 1790:173; original designation.

The shape of the male forewing—triangulate, with straight margins and a sharp obtuse angle where the outer and posterior margins meet—is characteristic for this subgenus. Tymbals are absent on the male abdomen. The hindwing in the female is white with a wide, black, solid or white-spotted, marginal band. The male genitalia have a triangular valve with a curved elongate dorsal projection.

LYMANTRIA (BEATRIA) MARGINATA WALKER

(Pl. 4, Figs. 3, 9; Pl. 18, Figs. 1–3)

Lymantria marginata Walker, 1855b:877. HT male: BANGLADESH: Silhet (BMNH, London, examined); Kirby, 1892:478; Swinhoe, 1892:222; Swinhoe, 1903:487; Schintlmeister, 2004:118.

Lymantria pusilla Felder and Rogenhofer, 1874:6 HT male: INDIA: Bengalia (BMNH, London, examined); Cotes and Swinhoe, 1887:154; Kirby, 1892:478; Schintlmeister, 2004:118.

Lymantria nigra Moore, 1888:399 LT male: INDIA: Kangra (BMNH, London, examined); Butler, 1889:37; Kirby, 1892:479; Schintlmeister, 2004:118.

Liparis marginata; Swinhoe, 1923:428.

COMMON NAMES

Dark mango tussock moth, Marginata tussock moth; Mong-gao-do-er (in Chinese) or Mango tussock moth, and a Chinese translation refers to it as the Black-edged tussock moth.

DIAGNOSIS

There is considerable sexual dimorphism in *L. marginata* with the small dark male and the large white female. The female forewing ground color can be white with black markings or light brown with dark brown markings. The male of *L. atemeles* has two forms, one with a white forewing ground color and the other with a brownish-gray forewing. The hindwing in *L. marginata* is brown with small white patches along the margin. In *L. atemeles* the hindwing is yellow with a broad black marginal band. The male genitalia in *L. marginata* have an elongate, curved dorsal process on the valve, and the valve lacks a subapical process. In *L. atemeles*, the dorsal process on the valve has a small subapical process.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape white, antenna white, bipectinate; labial palpus well developed, outside brown, inside white with a few white scales at apex.

- *Thorax* White, tegula white with brown distal margin, caudal apex of mesothorax brown, metathorax white; fore and middle tibiae brown with white spot at 2/3 length, basitarsi brown with white proximal apex, tarsal segments 2–4 white, segment 5 brown; hind legs were missing from specimen; underside dirty white.
- *Forewing* (Pl. 4, Fig. 3): Length: 17.0 mm (n=1); ground color brown; all wing markings dark brown; basal area, from base of forewing to antemedial line, with a series of oblong spots distributed between the veins; antemedial line a rectangular spot on costa, remainder crenulate to posterior margin; round orbicular spot in middle of discal cell; reniform spot curved at end of discal cell; postmedial line a quadrate spot at costa above reniform, crenulate below reniform to posterior margin; submedial line a rectangular spot at costa, crenulate to posterior margin, line bolder at apex and tornus broader; fringe white with broad ovate spots between veins that extend onto fringe.
- *Hindwing* Brown, some small white patches with small brown spots at margin; fringe white.
- *Abdomen* Yellow with large brown dorsomedial patches; lateral line brown; tymbals absent on third sternite.
- *Genitalia* (Pl. 18, Figs. 1–3): Tegumen has no lateral process; uncus short, narrow, apex pointed; valve triangulate, apex slightly produced and narrowly rounded, not fused medially, a small pointed process medially at base of valve; dorsal process elongate, slightly longer than valve, sinuate; juxta a large rectangular plate, curved ventrally, dorsal margin concave; saccus broad, V-shaped; vesica with two distinct lobes, one large the other small and finger-like, cornuti spiculate and concentrated near apex of aedeagus.

FEMALE

- *Head* Front and vertex white; scape white, antenna black, short bipectinations; labial palpus black.
- *Thorax* White with area between head and tegulae black.
- *Forewing* (Pl. 4, Fig. 9): Length 27–33 (n=5); ground color white; all wing markings black; basal markings two rectangular spots, one at base along costa, second distal to first from M vein to A vein; antemedial line a rectangular spot at costa, a series of contiguous crescent-shaped spots with curve toward base to posterior margin; reniform spot indistinct at end of discal cell; postmedial line a quadrate spot above reniform on costa, a series of contiguous crescent-shaped spots that curve toward apex to posterior margin; antemedial and postmedial lines contiguous at posterior margin; subterminal line a rectangular spot on costa, a series of contiguous crescent-shaped spots to posterior margin; terminal line a series of crescent-shaped spots that vary in thickness and are contiguous to spots along wing margin; fringe white with black spots between wing veins extending onto fringe.
- *Hindwing* White with broad black distal margin; fringe white with black spots between veins extending onto fringe.
- *Abdomen* Yellow with broad black dorsal oblong spots; yellow ventrally with broad black lateral oblong spots that wrap around abdomen toward midline.

LARVA

Illustrated in Beeson (1941) and described in detail and illustrated by Gardner (1938).

DISTRIBUTION

Indonesia, India, and Myanmar north into southern Tibet and China.

SPECIMENS EXAMINED

INDIA: Northern [no specific locality] (2f), (CMP); INDONESIA: Java, Depok, March 10 (1f), Bryant and Palmer Coll., (USNM); Java, 1891 (1f), (USNM); Java, Tjibodas, Mt. Gede, Aug. 25 (1m), Bryant and Palmer Coll., (USNM).

OVIPOSITION

Naked grayish eggs, are laid on bark or in crevices or hollows of trees (Singh and Goel 1986). Eggs turn black a few days after they are laid.

BIOLOGY AND BEHAVIOR

Thought to have continuous overlapping generations in the tropics, but pheromone trapping showed the majority of males (total n=13) were captured in December–January, suggesting seasonality (Kamata et al. 2000).

FOOD PLANTS

L. marginata is known to be a potential pest of various tropical fruits. In India, *L. marginata* feeds on mango, *Mangifera indica* L. (Anacardaceae) (Chao 1978; Singh and Goel 1986; Goel et al. 1986; Zhao 1982, 2002) and on *Eucalyptus torreliana* F. Muell. (Myrtaceae) (Barlow 1982), and *L. nigra* feeds on *Ficus religiosa* L. (Moraceae) and litchi, *Litchi chinensis* Sonn. (Sapindaceae) (Beeson 1941, Mathur and Singh 1960). On mango, larvae feed selectively on flowers and fruits as well as the leaves (Mathur et al. 1958). Holloway (1999, citing others or unpubl. records), recorded this species on durian, *Durio zibethinus* Murray (Bombacaceae), and pomegranate, *Punica granatum* L. (Punicaceae). Singh and Goel (1991) recorded serious damage to mango by *L. marginata* in western Uttar Pradesh in 1983.

PHEROMONAL COMMUNICATIONS

Near Pedang, western Sumatra, Kamata et al. (2000) have successfully trapped this species (reported as “*L. beatrix*”) in milk carton traps baited with (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure]. A single male responded to a (+)-disparlure bait placed on a hotel window screen in Bali, Indonesia, 16 April 2000 (Schaefer unpubl. data). Males (n= 4) were trapped in sticky traps baited with racemic disparlure at Bangalore, India, 25–27 January 1978 (T. Kumata and Schaefer, unpubl. data). Because of the similarities of *L. marginata* and *L. beatrix*, and recognizing Holloway’s (1999) opinion that both mentioned species are valid species, we are not fully confident in the “*L. beatrix*” collections reported in Kamata et al. (1999). Clearly, more careful comparative study of these similar tropical species is needed.

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Unknown.

DISCUSSION

Forewing ground color in the females can vary from white to light brown. The color of the forewing lines of light brown specimens is dark brown instead of black.

Earlier references in the literature include "*L. beatrix*" (e.g. Beeson (1941)), "*L. ganaha*," and "*L. pusilla*" form "*nigra*," or simply "*L. nigra*" in India. Holloway (1999) considers both *L. beatrix* and *L. marginata* as similar but distinct species with the same food habits.

LYMANTRIA (BEATRIA) ATEMELES COLLENETTE

(Pl. 4, Fig. 10; Pl. 5, Fig. 1; Pl. 18, Figs. 4–6; Pl. 31, Fig. 1; Pl. 32, Fig. 10; Pl. 50, Figs. 2–6)

Lymantria atemeles Collenette, 1932:93. HT male: MALAYSIA: Penang Is. (BMNH, London, examined).

COMMON NAMES

Orange-winged tussock moth or Mango-leaf-eating caterpillar; Nong kin bai mamoung (in Thai).

DIAGNOSIS

The hindwing in *L. atemeles* is yellow with a broad black marginal band, in *L. marginata* the hindwing is brown. The female *L. atemeles* is more heavily marked and somewhat smaller than the female *L. marginata*.

REDESCRIPTION

MALE

- *Head* Front and vertex white; scape black, antenna black at base and at middle, bipectinate; labial palpus black, short, barely extending beyond eye, apex white.
- *Thorax* Prothoracic collar yellow, prothorax black, tegulae black, mesothorax with a black central spot adjacent to prothorax flanked by a pair of yellow spots, caudad to yellow spots a pair of black spots on a white field, metathorax black; foreleg and hind leg black, basitarsus white at basal third, rest black, tarsi black; middle leg black with subapical white patch on tibia, tarsi as in other legs; underside golden yellow.
- *Forewing* (Pl. 4, Fig. 10): Length: 16–19 mm (n = 2); ground color pale gray to brown; all wing markings black; basal spot present; antemedial line an ill-defined band; orbicular spot round in middle of discal cell; reniform spot round at end of discal cell and partially contiguous with crenulate, postmedial line; subterminal line broad crenulate band from costa to tornus; terminal line a series of large, oblong spots between wing veins; fringe short and concolorous with terminal line.
- *Hindwing* Yellow, wide, black marginal band containing some small white patches at margin with small black spots; fringe concolorous with terminal margin.
- *Abdomen* Golden yellow with dorsal black stripe, lateral black spots, venter golden yellow; tymbals absent on third sternite.
- *Genitalia* (Pl. 18; Figs. 4–6): Lateral process absent from tegumen; uncus elongate, wide, with pointed apex; valve triangulate with narrowly round apex, not fused medially, an elongate, pointed process medially at base of right valve; dorsal process elongate, curved, a small ventral projection about 3/4 length of process; juxta a large broad plate curved ventrally, apex rounded with multiple toothy projections; saccus broad, V-shaped, with a short medial projection; vesica with a single lobe; cornuti spiculate and concentrated near apex of aedoeagus.

FEMALE

- *Head* Front and vertex white; scape black, antenna black except for white patch beginning just above base and extending 1/3 length of antenna; labial palpus black.
- *Thorax* Prothoracic collar yellow; prothorax black with a pair of lateral white stripes, tegula white, thorax white with same layout of yellow and black spots as in male.
- *Forewing* (Pl. 5, Fig. 1): Length 25 (n=1); ground color white; all wing markings black; basal spot present; antemedial line a wide band that becomes contiguous with a wide postmedial line below discal cell; orbicular spot round in middle of discal cell; reniform spot completely absorbed by wide postmedial line; subterminal line a series of irregular, crescent-shaped spots that are contiguous with spots of the terminal line subapically and medially; terminal line a series of unequal-sized spots that are either between veins or encompassing them; fringe short and concolorous with terminal line.
- *Hindwing* White with broad black marginal band; fringe black with some white patches distally on outer margin.
- *Abdomen* Golden yellow with median line of small black spots; venter golden yellow with black bands that wrap around abdomen.

LARVA

PRESERVED SPECIMENS. (Pl. 31, FIG. 1; Pl. 32, FIG. 10; Pl. 50, FIGS. 2–6)

- *Length* Ultimate instar 29–34 mm (n=3); head width ultimate instar 3.60–4.45 mm (n=3).
- *Head* Tan, dark brown irregularly shaped spots arranged mosaic-like to form an indistinct lateral stripe, coronal stripe present and solid (Pl. 32, Fig. 10); labrum deeply cleft (Pl. 50, Fig. 3); F1 seta associated with three secondary setae in a tight cluster (Pl. 50, Fig. 3); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin; black stripe area with spiculi less dense, wide bases, and curved apices rest of head with spiculi more dense than black stripe, narrow bases, and straight apices; (Pl. 50, Fig. 2 shows the tonofibullary platelet with elongate hair-like spiculi contrasted with the spiculi on the rest of the head.)
- *Thorax* T1 with L verruca dark and larger than other L verrucae, two types of setae present, shorter spine-like and longer, barbed, hair-like setae; D1 verruca on T2–3 with spine-like setae and short bulbous setae; dark horizontal band across T2–3; T2–3 with short red bushy setae intermixed with spine-like setae (Pl. 50, Fig. 6); L verrucae on T2–3 concolorous with ground color; setae on L verruca with microbarbules (Pl. 50, Fig. 6).
- *Abdomen* Ground color light brown; a pair of small eversible glands posterior to D1 verrucae and between the D2 verrucae on segments A1–4, eversible glands absent on A5, and a large single eversible gland between D2 verrucae on A6–7; D1 verruca on abdominal segments small and lighter in color than D2 verruca; D2 verruca on abdominal segments dark; D verrucae on abdominal segments with spine-like setae; A1–8 with thin black angular lines, ventral to D2 verruca, extending from near anterior margin approximately to middle of D2 verruca; a dorsal, somewhat diamond shaped white spot with a central dark stripe on the posterior half of A4 and most of A5; L verruca with dark spines and lighter-to-white elongate, barbed, hair-like setae; SV verrucae with only elongate, barbed, hair-like setae; underside a single solid color;

abdominal prolegs concolorous with underside of abdomen; crochets in a homoid-eous uniordinal mesoserics.

- *Color* (from Pl. 31, Fig. 1) Head dirty white with black coronal and lateral stripes; prothorax dirty white with light blue verrucae, setae mostly black with some white peripherally; T2–3 with black horizontal band, verrucae light blue, central setae black encircled by more numerous white setae, short, bulbous setae red; ground color of abdomen gray, thin, black diagonal lines on anterior half of abdominal segments; a dorsal, white, diamond-shaped spot on anterior half of A4 and A5; D and L verrucae light blue; verrucae on A10 concolorous with abdomen.

DISTRIBUTION

Malaysia, Thailand, Cambodia, and Vietnam.

SPECIMENS EXAMINED

THAILAND: Kampaeng Saen (2m, 1f) (PWS); Bangkok (1m) (PWS).

OVIPOSITION

Morphological evidence suggests that females are of the insertion type and likely to deposit eggs in cracks in bark of their host mango trees.

BIOLOGY AND BEHAVIOR

Little is known about this species. On occasion, *L. atemeles*, like *L. marginata*, may cause damage to mango plantations (W. Suasa-ard and O. Kernasa, pers. comm. 2003). It was significant that for an extended period of time, we could capture males in pheromone baited traps but could not find females. It remains unclear how readily females respond to mercury-vapor lights.

FOOD PLANTS

Only known to feed on mango, *Mangifera indica* L. (Anacardiaceae), which it may defoliate, as observed by Wiwat Suasa-ard and Oraphan Kernasa (Central Regional Center, Nat. Biol. Control Res. Center, Kampaeng Saen, Nakhon Pathom, Thailand) during a field trip to Surat Thani Province, southern Thailand, January 2003.

PHEROMONAL COMMUNICATIONS

Methods not used previously were implemented to study the pheromone communication system of *L. atemeles* in Thailand (Schaefer, G. and R. Gries, W. Suasa-ard, and O. Kernasa). First simply placing several traps, each baited with a single identified *Lymantria* species sex pheromone, we confirmed male attraction to (*7R,8S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure]. Months later, a female was discovered by O. Kernasa from which an egg mass was obtained. That egg mass was shipped to quarantine facilities, USDA, Newark, Delaware, under USDA permit and was successfully reared by providing larvae with mango leaves shipped in from Florida. Virgin females were obtained, sex pheromone glands extracted and analyzed by Regine Gries, and found to produce only the (+)-disparlure (Schaefer et al. in

prep.). Further field trapping has confirmed that male *L. atemeles* are attracted by (+)-disparlure, but are neither attracted to, nor repelled by, an admixture of (+)-disparlure and (7*S*,8*R*)-*cis*-7,8-epoxy-2-methyloctadecane [(-)-disparlure] (Schaefer et al. in prep.).

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

In tropical Thailand, long-term trapping with impregnated lures (rubber septa) by O. Kernasa confirmed male *L. atemeles* activity in every month of the year. During the study, the lures remained active for at least 10 months, an exceptionally long period of time. During visits to Thong Pha Phum (Green World Resort) in western Thailand, hourly trap surveillance by PWS in 2002 revealed five males, all of which responded between 10 PM and 11 PM (3 on 26 April, 2 on 7 May). This suggests that *L. atemeles* is a Late Evening (Fig. 1) flyer even though the data are sparse.

DISCUSSION

The forewing markings in males can become browner in older specimens, whereas the yellow hindwings are unique.

This tropical species can be trapped with synthetic (+)-disparlure. It has potential to invade tropical regions, providing its primary food source, mango, is available.

SUBGENUS *NYCTRIA* SCHINTLMEISTER

Nyctria Schintlmeister, 2004: 9. Type species: *Lymantria mathura* Moore, 1865:501; original designation.

The forewing ground color in the male varies; it can be white, yellow, greenish-gray, or brown, with a dark brownish-gray pattern. The female forewing has a white ground color with a dark brown to brownish-gray pattern. The hindwing in the female is flushed with pink and is yellow in the male. The submarginal band is broken in both sexes and can vary from bold to faint. The male genitalia have a lateral digitate process arising from the ventral margin of the tegumen and the valves are deeply divided.

LYMANTRIA (NYCTRIA) MATHURA MOORE

(Pl. 4, Fig. 11; Pl. 5, Fig. 2; Pl. 19; Pl. 28, Fig. 1; Pl. 31, Figs. 2–3; Pl. 32, Fig. 11; Pl. 38, Fig. 2; Pl. 51, Figs. 1–5)

Lymantria mathura Moore, 1865:805. HT male: INDIA: N. E. Bengal (BMNH, London, examined); Hampson, 1892:464; Kirby, 1892:479; Kirby, 1892:223; Swinhoe, 1903:489; Matsumura, 1933:137; Bryk, 1934:151; Collenette, 1936:344; Inoue, 1956a:399; Inoue et al., 1982a:634; Park, 2000:116; Schintlmeister, 2004:127.

Lymantria aurora Butler, 1877:403. ST: JAPAN: Yokohama (BMNH, London, examined); Kirby, 1892:478; Swinhoe, 1903:488; Bryk, 1934:151. **Revised synonymy.**

Porthetria mathura; Cotes and Swinhoe, 1887:155.

Lymantria aurora var. *fusca* Leech, 1888:629. HT male: JAPAN: Nagahama (BMNH, London, examined); Bryk, 1934:151.

Liparis aurora; Swinhoe, 1923:429.

Liparis mathura; Swinhoe, 1923:429.

Lymantria mathura subpallida Okano, 1960:36 HT male: TAIWAN: Puli-Wushe (unknown type depository); Schintlmeister, 2004:127.

Lymantria mathura aurora; Schintlmeister, 2004:127.

COMMON NAMES

Pink gypsy moth, Mathura tussock moth, Rosy Russian Moth; Sal Defoliator (in India); Bulkeunmaemi-Nabang (in Korean); Kashiwa-maimai (in Japanese); Shelkopryad rozovyy neparnyy (in Russian); Le-do-er (in Chinese), and local translations in China refer to it as Oak tussock moth, Oak gypsy moth, and Scalloped-edge tussock moth.

DIAGNOSIS

Lymantria mathura and *L. flavida* Pogue and Schaefer are very similar, but have subtle differences. The male forewing shape is more pointed in *L. mathura* (Pl. 4, Fig. 11) and more rounded in *L. flavida* (Pl. 4, Fig. 12); veins are white in *L. mathura* and yellow in *L. flavida*; and the hindwing fringe is white in *L. mathura* and yellow in *L. flavida*. The female has a narrow V-shaped reniform spot at the end of the discal cell in the forewing in *L. mathura*;

this spot is much wider in *L. flavida*. The pink on the dorsal surface in *L. mathura* extends approximately 2/3 the length of the abdomen, whereas in *L. flavida* it extends to about half the abdominal length.

REDESCRIPTION

MALE

- *Head* Front and vertex pale gray to gray with yellow stripe above eye; scape yellow, antenna pale gray, bipectinate; labial palpus well developed, yellow with gray lateral patch on middle segment.
- *Thorax* White with narrow yellow collar bordered by gray; prothorax with pair of median distal gray spots; tegula white with gray spot at wing base; mesothorax with a pair of median caudal yellow spots followed by smaller gray spots and another pair of gray spots near apex of tegula; metathorax white. Femur yellow; foretibia gray with white median and yellow apical spots, basitarsus gray with white at proximal apex and yellow at distal apex, segments 2–3 white, 4–5 yellow; middle and hind tibia white with pale gray patch below proximal apex and above distal apex, long fringe white, distal apex yellow, basitarsus white with apical gray patch, rest white becoming more yellow toward apical segment; underside with yellow prosternum becoming pale yellow to white toward metasternum.
- *Forewing* (Pl. 4, Fig. 11): Length: 21–24 mm (n=3); ground color white; veins white; all markings gray; basal area with a yellow spot and small spots between veins; antemedial line wide, separated into patches between veins; orbicular spot round and adjacent to slightly darker reniform spot; reniform spot obscure, V-shaped, at end of discal cell; postmedial line curves under reniform and becomes widest toward posterior margin; subterminal line variable, elongate patches apically, lighter colored chevrons medially, two or three quadrate patches at posterior margin; terminal area with rectangulate and crescent-shaped patches between veins from costa to CuA2 vein; small rectangular patches between veins along outer margin that extend on to white fringe.
- *Hindwing* Ground color yellow; all markings gray; discal spot present; submarginal band consists of patches of various sizes, those in anal area larger and further from margin; small dots along margin between veins with first dot largest and extending on to fringe; fringe white.
- *Abdomen* Yellow with a median row of black dorsal spots, ventrally with a pair of black lateral spots on each segment, apical tuft white; tymbals present on third sternite.
- *Genitalia* (Pl. 19): Tegumen with lateral process present; uncus of moderate length with rounded apex; valve bifurcate with prominent dorsal and ventral processes, valves fused ventrad; dorsal process bifurcate with dorsal-most process shorter than ventral process; juxta reduced to a faint V-shaped sclerotization in membrane just dorsal to fused valves; sacculus undifferentiated from valve; saccus broad, U-shaped; vesica ovate; cornuti small to minute spiculi.

FEMALE

- *Head* Front white with central area pale gray, lateral margins along eye pink; vertex white; scape pink, antenna black; labial palp well-developed, pink, black laterally.

- *Thorax* White; tegula with black spot at wing base; median black spot on mesothorax; femur pink, tibia black with white or pink median spot and pink apex, fringe white; basitarsus black with proximal apex pink, tarsi 2–4 pink, long fringe white; underside white with some light pink ventrally and laterally.
- *Forewing* (Pl. 5, Fig. 2): Length 38 mm (n=1); ground color white; base of wing with a pair of distinct black spots, remainder of markings gray; thin basal line from costa to posterior margin; antemedial line with wide patch at costa, chevron-shaped spot the width of discal cell that extends slightly past M vein, disjunct to a short vertical line above 1A+2A vein, a slightly wider angulate bar to posterior margin; orbicular spot ovate; postmedial line a series of contiguous scallops below discal cell to a horizontal V-shaped spot at posterior margin; reniform follows vein at end of discal cell and slightly darker than surrounding markings; subterminal line a distinct patch at costa, adjacent to reniform spot, a series of contiguous scallops curving below reniform to a horizontal V-shaped spot at posterior margin; terminal line with elongate chevron-shaped patches apically, becoming triangulate on either side of veins in medial area, rectangulate patches at posterior apex; small black spots between veins along outer margin that extend onto a pink fringe.
- *Hindwing* White irrorated with pink; submarginal band pale gray, a series of contiguous patches between wing veins; small pale gray spots along wing margin between veins; fringe pink.
- *Abdomen* Pink in 2/3 of basal, white to apex; black lateral spots from base decreasing in size toward, and absent from, last segments.
- *Genitalia* (Pl. 28, Fig. 1): Ovipositor moderately telescopic; papillae anales kidney-shaped, dorsal margin with a slight dip before apex; anterior apophysis longer than posterior apophysis, apex of posterior apophysis wider than anterior apophysis; ostium bursae membranous with a small, slightly sclerotized dorsal lobe; ductus bursae sclerotized and shorter than corpus bursae; corpus bursae oblong; signa absent.

LARVA

FIRST INSTAR (PL. 38, FIG. 2)

Differences from *L. d. dispar*: T1: SD2 half length of SD1 and spine-like, SD1 with elongate barbs (Pl. 38, Fig. 2).

PRESERVED SPECIMENS (PL. 31, FIGS. 2–3; PL. 32, FIG. 11; PL. 51, FIGS. 1–5)

- *Length* 42–45 mm
- *Head* Yellowish-brown speckled with brown, coronal stripes indistinct (Pl. 32, Fig. 11); F1 seta single (Pl. 51, Fig. 1); clypeus as in *L. d. dispar*, but with narrow, distinctly raised ventral margin (Pl. 51, Fig. 1); labrum deeply cleft (Pl. 51, Fig. 1); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin (Pl. 51, Fig. 2); spiculi in patches, very fine and hair-like with matted appearance (Pl. 51, Fig. 3); shows the tonofibullary platelet with shorter spiculi contrasted with the longer hair-like spiculi on the rest of the head (Pl. 51, Fig. 4); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin (Pl. 51, Fig. 2).
- *Thorax* Ground color black with minute yellowish-brown dots; dorsal stripe thin, yellowish-brown; XD1, XD2, and D verrucae on pronotal shield; XD1 verruca large, yellowish-brown, setae black; XD2 verruca small between XD1 and L verrucae; D verru-

ca small bearing one seta; SD verruca black dorsal to spiracle; L verruca with elongate, black plumose hair pencils, consisting of setae with elongate microbarbules; SV verruca yellowish-brown with long plumose setae; large ovate spiracle caudad to L verruca. Segments T2 and T3 with D and SD verrucae yellowish-brown with spine-like setae; L and SV verrucae yellowish-brown with spine-like setae and longer plumose setae.

- *Abdomen* Ground color dark brown with minute yellowish-brown dots; a faint double dorsal stripe darker brown than ground color; a yellowish-brown irregular stripe from D verruca on A4 angled to L verruca on A5; A9 with white irregular shaped spots larger than the minute dots; A1–A4 with pairs of glands; large median glands on segments A6–7. Segments A1–8 with conical D verrucae, largest on A1 and A8; SD and L verrucae partially fused, SD with spine-like setae, L with spine-like setae and long plumose hair-like setae; SV verruca with spine-like setae; V verruca small with spine-like setae on A1–2, V seta present on A7–9; A9 with D, SD, and L verrucae with spine-like setae and long plumose hair pencils, oriented caudad, not dorsal; prolegs present on A3–6 and A10; yellowish-brown with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries.

DISTRIBUTION

Widespread in eastern Asia, from Japan (all major islands), eastern Russian Siberia (Ussuri and Amur), south to Taiwan and Vietnam, and westward across China, Thailand, and Nepal to India and Sri Lanka.

SPECIMENS EXAMINED

CHINA: Shin Kai Si, Mt. Omei, 4400 ft., July (1m), genitalia slide USNM 58863, Yunnan, (1f) (USNM). JAPAN: HOKKAIDO: Hidakaiwanai, 15 IX 76 (21m, 18f), 10 IX 76 (1m, 12f), P. Schaefer (PWS); Hobetsu, 7 Aug. 1978, Paul W. Schaefer (3m, 4f); Bibai, 10-14 Aug. 2002 (2m), 2 Aug. 1997, at blacklight (1m), Paul W. Schaefer (PWS); Hidakaiwanai, 7 Aug. 1978 (3m), 31 July 1978 (1m), 2 Sept. 1976 (3m, 5f), Paul W. Schaefer (PWS); HONSHU: Morioka, FFPRI For., dead on 8/6/97, laid eggs on *Carya* (source of colony for phero study) Paul W. Schaefer (1f) (PWS); nr. Morioka, Koma, 9 August 2001, removed ex phero. Trap., Paul W. Schaefer (6m) (PWS); Aichi Pref., Toyota, 28 May 2000, coll. as larva, Paul W. Schaefer (1m); Toyota, Mifune Bot. Gdn., 13 July 2000, dead post oviposition, Paul W. Schaefer (3f); Toyota, Mifune, 15 June 2000, at lights (1m), 17 July 2000 (1m), 17 July 2000, in phero trap mathuralure (8m), Paul W. Schaefer (PWS); Nagano P., Toyoshina, 27 Aug. 1998, at lights 21:30 in light rain (1m), 24 August 1998, at lights (1m), Paul W. Schaefer (PWS); KOREA: Soraksan Nat. Park, 21 Aug. 1999, at lights (5m), 20 Aug. 1999 (1m), 19 Aug. 1999, at lights (5m), Paul W. Schaefer (PWS); Yongsu-ri, Lee's Farm, 27 Aug. 1999, Paul W. Schaefer (PWS); Yongsu-ri, Kyoinggi-do, VIII 12, 1992, J.H. Lee & K.S. Lee (3m) (PWS); Soraksan Nat. Pk., Okinotang Rest Area, 21 Aug. 2000, at lights (3m), 23 Aug. 2000 (1m), 28 Aug. 2000 (1m); Yongsu-ri, Lee Farm, 37 deg. 33.96' N, 127 deg. 17.10 E, 26 Aug. 2000, Paul W. Schaefer (2m) (PWS). TAIWAN: FuShan, 10 May 2002, at MV light (1m), 17-19 May 1994, coll. as larva, emg. 1 June 94 (1m, 1f), Paul W. Schaefer (PWS); FuShan, Mr. Ho, emg. 18 June 1994, Paul W. Schaefer (1f) (PWS); Nan Tow Co., Lu Shan, ca. 30 km e Wu She, 1000 m, 27–31 May 1980 (1m), D.R. Davis; Nan Tow Co., Sun Moon Lake, 760 m, 20–25 June 1980 (1m), D.R. Davis (USNM); Kenting Nat. Park, 30 May 1994, at lights, Paul W. Schaefer (1m) (PWS); Paleng, 7 June 1996, at lights, Mike Montgomery (1m, 2f) (PWS).

OVIPOSITION

Insertion type with eggs normally tucked under a bark scale and edge of exposed egg mass covered with whitish hairs from female abdomen. (Same behavior as exhibited by *L. flavida* (Fig. 20)). Under severe outbreak conditions, egg masses are deposited less discriminately on an exhaustive listing of tree species (Roonwal 1979, appendix). In northern Japan, larvae defoliated apple orchards, and females flew into forests of pine (*Pinus* sp. (Pinaceae)) and Japanese cedar (*Cryptomeria japonica* (L.f.) D. Don.) (Taxodiaceae) to lay their eggs (Nishitani 1918). In the Botanical Garden near Toyota City, Aichi Prefecture, Japan, egg masses were found in late summer deposited on *Pinus* spp. (Pinaceae) and *Choerospondias axillaris*

(Roxb.) Burtt & A.W. Hill (Anacardiaceae). Both tree species have rough bark, which provides cracks for oviposition, but neither serves as a host species because they do not provide suitable food for larval feeding (Schaefer, unpubl. data). This behavior—different trees and locations for oviposition and larval feeding—is similar to that exhibited by *L. d. asiatica* and *L. umbrosa*.



Figure 20. Insertion type of egg mass of *L. flavida* where the female lays eggs under a bark scale and covers them with whitish abdominal hairs, Camp Fasto, Okinawa, Japan (photo by Paul W. Schaefer).

BIOLOGY AND BEHAVIOR

Larvae frequently rest in the peculiar shape of a tight inverted “J”, with both anterior and posterior ends pointed downward, on the bole of a tree. This behavior is the same in *L. flavida* (Fig. 21). Occasionally, *L. mathura* erupt into outbreak populations, as in India in 1953–54, during which larvae showed clear diel behavior feeding in tree crowns at night and resting on the boles during daylight (Roonwal 1979). Similar mass outbreaks on apple in northern Honshu, Japan, have been documented (Nishitani 1918).

FOOD PLANTS

In Japan, polyphagous on a variety of deciduous hardwoods, including: Anacardiaceae (*Mangifera*, *Rhus*); Betulaceae (*Betula*); Combretaceae (*Terminalia*), Dipterocarpaceae (*Shorea robusta* Gaertner f.); Fagaceae (*Castanea*, *Quercus*); Myrtaceae (*Eugenia*, *Syzygium*); Rosaceae (*Malus*, *Prunus*, *Pyrus*); Sapindaceae (*Litchi*) Theaceae (*Cleyera*); and Ulmaceae (*Abelicea*, *Zelkova*) (Inoue 1957, Inoue et al. 1982a, b). In India, similarly confined to a variety of deciduous hardwoods, including: Anacardiaceae (*Mangifera*); Apocynaceae (*Alstonia*); Celastraceae

(*Eleodendron*) Combretaceae (*Anogeissus*, *Terminalia*); Fagaceae (*Castanea*, *Quercus*); Dipterocarpaceae (*Shorea*); Euphorbiaceae (*Mellotus*); Caesalpinaceae (*Acrocarpus*); Papilionaceae (*Butea*, *Pongamia*); Lythraceae (*Duabanga*); Meliaceae (*Ammora*, *Cedrela*, *Melia*); Myrtaceae (*Syzygium* (= *Eugenia*)) and Rosaceae (*Prunus*) (Roonwal 1979). The most heavily defoliated trees in India were *Acrocarpus fraxinifolius* Arn. (Leguminosae), *Mangifera indica* L. (Anacardiaceae), *Quercus incana* Bartr. (Fagaceae), *Shorea robusta* (Dipterocarpaceae), *Syzygium cimini* (L.) Skeels (Myrtaceae) and *Terminalia myriocarpa* van Heurck & Muell.-Arg. (Combretaceae) (Roonwal 1979).



Figure 21. Larva of *L. flavida* showing the inverted "J" position, Ishikawa, Okinawa, Japan (photo by Paul W. Schaefer).

PHEROMONAL COMMUNICATIONS

Research done in Morioka, Iwate Prefecture, Honshu, Japan (Gries et al. 1999b), shows that *L. mathura* communicates using (9R,10S,3Z,6Z)-*cis*-9,10-epoxynonadecadiene [(+)-mathuralure] and (9S,10R,3Z,6Z) *cis*-9,10-epoxynonadecadiene [(-)-mathuralure] in a 1:4 ratio. (Mathuralure is named for this moth species.) Previously, O'Dell et al. (1992) reported successful capture in northeastern China of 23 *L. mathura* males in traps baited with (+)-disparlure or the admixture of (+)-disparlure and olefin. We now speculate that, because mathuralure is quite distinct from disparlure, perhaps the attraction to traps in China might have been due to contaminants that might have been present in the disparlure- or 2-Me-Z7-Hy-based lures. Otherwise, we cannot explain any attraction to disparlure.

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

In the Russian Far East, Wallner et al. (1995) showed the pattern of nocturnal attractancy of adult *L. mathura* to ultraviolet lights, with a peak of activity from 1 to 3 AM, with a male/female sex ratio of 2:1. (It would be interesting to know if that ratio was constant throughout the active period. We have no comparative temporal data on the response of males to sex pheromone lures but it would be helpful to see if there is concordance.) Trapping took place from 23 July to 8 August and *L. monacha*, *L. d. japonica* and *L. mathura* were sympatric and co-active (Wallner et al. 1995).

DISCUSSION

Males of *L. mathura* often have melanic forms. The white of the forewing is pale gray and the wing markings are black. The hindwing is dark brown with black markings.

Our current understanding from studied populations is that the sex pheromone is mathuralure at a specific and unusual ratio of one part (+)-mathuralure to four parts (-)-mathuralure. Synthetic lures at this ratio have been used successfully in Bibai, Hokkaido, and Morioka, Honshu, Japan. These same lures were also ineffective in Hentona, Okinawa, Japan, but that population is now considered to be *L. flavida*. When the very same lures were transported to Korea, they failed to attract *L. mathura* males effectively. We had thought this was due to problems in the pheromone chemistry but we now consider the two moth populations to be separate species (see *Lymantria (Nyctria) flavida*, below). Clearly the *L. mathura* and *L. flavida* situation warrants further careful study into the evolutionary mechanisms, which have led to speciation. We suspect Okinawa's isolation is a factor.

LYMANTRIA (NYCTRIA) FLAVIDA POGUE AND SCHAEFER, NEW SPECIES

(Figs. 20–21; Pl. 4, Fig. 12; Pl. 5, Fig. 3; Pl. 20, Figs. 1–3; Pl. 28, Fig. 2)

TYPE MATERIAL

Holotype male: Japan, Okinawa, Hentona, ova coll. by Norio Arakaki, [reared] BIRL as #5-2000 on *Quercus* ex GH, Paul W. Schaefer (USNM); Paratypes seven males, same data as holotype; two females, same data as holotype, one female, nr. Hiji Falls, 16 May 2003, Coll. late larva, [reared] BIRL on *Quercus*, Paul W. Schaefer.

COMMON NAMES

Flavid tussock moth; Okinawa-maimai (in Japanese).

DIAGNOSIS

There are very subtle differences between the male genitalia of *L. flavida* and *L. mathura*, but they are similar to those among other *Lymantria* (*Porthetria*) species. The lateral process of the tegumen is shorter in *L. flavida* than in *L. mathura*, and the apex is round in *L. flavida* and slightly narrowed in *L. mathura*. The ventral process of the valve has parallel sides in *L. flavida*, but in *L. mathura* the sides converge slightly toward the apex, resulting in the process being wider at the base than at the apex. The female ovipositor is shorter in *L. flavida* than in *L. mathura*. The ostium bursae in the female genitalia is a large ovate shape in *L. flavida* and is a smaller ventrally produced flap in *L. mathura*.

ETYMOLOGY

The species epithet is derived from the Latin, *flavus*, meaning “yellow,” and refers to the ground color of the hindwing in males

DESCRIPTION

MALE

- *Head* Front and vertex pale gray with yellow stripe above eye; scape yellow, antenna pale gray, bipectinate; labial palpus well developed, gray laterally, yellow medially and at apex.
- *Thorax* Prothorax pale gray, with narrow yellow collar posterior to head; tegula pale gray with obscure median white stripe; mesothorax white with a pair of pale gray spots at posterior edge of prothorax and another pair of gray spots near apex of tegula; metathorax white. Legs with yellow femur; foretibia gray with white median and pale yellow apical spots, basitarsus gray with white at proximal apex and faint pale yellow at distal apex, segments 2–3 white, 4–5 yellow; middle tibia white with a few pale gray scales at apex, tarsi white, apical segment pale yellow; hind tibia white with distal apex yellow, tarsi white, apical segment pale yellow; underside yellow.
- *Forewing* (Pl. 4, Fig. 12): Length: 18–21 mm; ground color white; veins yellow; all markings dark gray; basal area with a yellow spot and small spots between veins; antemedial line wide separated into patches between veins; orbicular spot round and

adjacent to slightly darker reniform spot; reniform spot black, obscure patch at end of discal cell; postmedial line curves under reniform and becomes widest toward posterior margin; subterminal line with elongate patches apically, irregularly shaped chevrons medially, three quadrate patches at posterior margin; terminal area with rectangulate and crescent-shaped patches between veins from costa to CuA2 vein; small rectangular patches between veins along outer margin that extend on to white fringe.

- *Hindwing* Ground color yellow; all markings gray; discal spot present; submarginal line consists of patches of various sizes, with those in anal area largest and further from margin; small dots along margin between veins; fringe yellow.
- *Abdomen* Yellow with a median row of black dorsal spots, ventrally with a pair of black lateral spots on each segment, apical tuft white; tymbals present on third sternite.
- *Genitalia* (Pl. 20, Figs. 1–3): Tegumen with lateral process present; uncus of moderate length with rounded apex; valve bifurcate with prominent dorsal and ventral processes, valves fused ventrad; dorsal process bifurcate with dorsal-most process shorter than ventral process; ventral process at ventral margin of valve shorter than dorsal process; juxta reduced to a faint V-shaped sclerotization in membrane just dorsal to fused valves; sacculus undifferentiated from valve; saccus broad, U-shaped; vesica ovate; cornuti small to minute spiculi.

FEMALE

- *Head* Front white with central area pale gray, lateral margins along eye pink; vertex white; scape pink, antenna black; labial palp well developed, pink, black laterally.
- *Thorax* White; tegula with black spot at wing base; mesothorax with median black spot bordered on either side with small pink spots; legs with femur pink, tibia black with white or pink median spot and pink apex, fringe white; basitarsus black with proximal apex pink, tarsi 2–4 pink, long fringe white; underside white with some light pink ventrally and laterally.
- *Forewing* (Pl. 5, Fig. 3): Length 36–38 mm; ground color white; base of wing with a pair of distinct black spots, remainder of markings black; thin basal line from costa to posterior margin; antemedial line with wide patch at costa, chevron-shaped spot the width of discal cell that extends slightly past M vein, disjunct to a short vertical line above 1A+2A vein, a slightly wider angulate bar to posterior margin; orbicular spot ovate; postmedial line a series of contiguous scallops below discal cell to a horizontal V-shaped spot at posterior margin; reniform wide and follows vein at end of discal cell, slightly darker than surrounding lines; subterminal line, a distinct patch at costa, adjacent to reniform spot, crenulate below reniform to a horizontal V-shaped spot at posterior margin; terminal line with elongate chevron-shaped patches apically, becoming triangulate on either side of veins in medial area, rectangulate patches at posterior apex; small black spots between veins along outer margin that extends onto a pink fringe.
- *Hindwing* White irrorated with pink; submarginal band gray, a series of contiguous patches between wing veins that become larger and darker at distal margin; fringe pink.
- *Abdomen* Pink in basal half, white to apex; black lateral spots from base decreasing in size toward, and absent from, last segments.
- *Genitalia* (Pl. 28, Fig. 2): Ovipositor moderately telescopic; papillae anales slightly curved dorsally to round apex; anterior apophysis longer than posterior apophysis, apex of posterior apophysis wider than anterior apophysis; at entrance to ostium bur-

sae a slightly sclerotized ovate lobe; ductus bursae sclerotized and shorter than corpus bursae; corpus bursae oblong; signa absent.

LARVA

PRESERVED SPECIMENS

- *Length* 25–27 mm.
- *Head* Dark brown speckled with black, coronal stripes absent.
- *Thorax* Ground color dark brown with minute yellowish-brown dots; dorsal stripe thin, yellowish-brown; XD1, XD2, and D verrucae on pronotal shield; XD1 verruca large, black, setae white; XD2 verruca small between XD1 and L verruca; D verruca small bearing one seta; SD verruca black dorsal to spiracle; L verruca with elongate, black plumose hair pencils; SV verruca yellowish-brown with long plumose setae; large ovate spiracle caudad to L verruca. Segments T2 and T3 with D and SD verrucae yellowish-brown with spine-like setae; L and SV verrucae yellowish-brown with spine-like setae and longer plumose setae.
- *Abdomen* Ground color dark brown with minute yellowish-brown dots; a faint double dorsal stripe darker brown than ground color; A5 with a pair of yellowish-brown curved bars adjacent to dorsal stripe; A9 with white irregular shaped spots larger than the minute dots; A1–A4 with pairs of glands; large median glands on segments A6–A7. Segments A1–A8 with conical D verrucae, largest on A1 and A8; SD and L verruca partially fused, SD with spine-like setae, L with spine-like setae and long plumose hair-like setae; SV verruca with spine-like setae; V verruca small with spine-like setae on A1–2, V seta present on A7–9; A9 with D, SD, and L verrucae with spine-like setae and long plumose hair pencils, oriented caudad, not dorsal. Prolegs present on A3–6 and A10; yellowish-brown with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries.

DISTRIBUTION

Known from limited localities (e.g., Hentona, Camp Foster, Ishikawa and Hiji) on Okinawa, Japan, but presumed to be island-wide.

OVIPOSITION

On Okinawa, oviposition is of the insertion type; photographs of eggs on boles of *Casuarina* spp. (PWS 1998 and 1999). (*Casuarinaceae*) show the exposed edges of the egg mass covered with white abdominal hairs (Fig. 20).

BIOLOGY AND BEHAVIOR

Like *L. mathura*, larvae of *L. flavida* also sometimes rest in an inverted “J” position.

FOOD PLANTS

On Okinawa, collected larvae apparently feed on *Terminalia catappa* L. (*Combretaceae*) (N. Arakaki, pers. comm). A pupa was found on an isolated *Elaeocarpus sylvestris* (Lour.) Poir.

(Elaeocarpaceae) tree near Ishikawa on 31 May 1998. It is presumed that the larvae had fed on and developed successfully on this species (Schaefer, unpubl. data).

PHEROMONAL COMMUNICATIONS

G. Gries and Schaefer tentatively assumed the pheromone for *L. flavida* would be similar to *L. mathura* in Honshu, Japan, and therefore conducted the same field trapping at Hentona, Okinawa, in June 1999. We used trap lures consistent with those used for of *L. mathura* and in the 1:4 blend ratio. We captured no males in an area where we saw females of *L. flavida* ovipositing on nearby trees. (Note: This was all done before we knew there were two distinct species involved.) We now assume the pheromone systems in *L. flavida* in Okinawa and *L. mathura* in Japan and Korea are different (See discussion under *L. mathura* (Gries and Schaefer, unpubl. data).

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Adults appear on the wing in May and June, and many females were seen ovipositing in early June 1999 (Schaefer and Gries, unpubl. data).

DISCUSSION

The type series was laboratory reared on *Quercus* sp. (Fagaceae) from eggs field collected by Norio Arakaki. No melanic forms were reared.

The setae on the XD1 verruca are white on the larvae of *L. flavida* whereas they are black on *L. mathura*. On A5 there is a pair of curved bars on *L. flavida* and in *L. mathura* there is a yellowish-brown stripe angled from the D verruca on A4 to the L verruca on A5.

The separation of the Okinawan *L. flavida* from the more widespread *L. mathura* based on mtDNA analysis by Ball and Armstrong (2006) raises questions as to the subtle differences that might exist between pheromone chemistries of these moths. Previously we had mixed results studying the pheromone communication in several populations of these moths. Initially, we thought the problems had been with the chemistry. We now have reason to suspect variation among the moths. Clearly, intensive study is needed on *L. flavida* and logically one would start with the unusual 1:4 ratio of mathuralure enantiomers, so important to the similar species, *L. mathura*.

Considering the females' flight ability and attractiveness to outdoor lighting, the potential for invasion to other semi-tropical areas appears moderate.

SUBGENUS *COLLENTRIA* SCHINTLMEISTER

Collettoria Schintlmeister, 2004:11. Type species: *Lymantria grisea* Moore, 1879b:55; original designation.

Schintlmeister (2004) defined the subgenus *Collettoria* as having a violet-brown forewing ground color, a brown pattern, and a rounded forewing apex. There is a prominent discal spot and a series of three dashes in the tornal area of the forewing that are part of the sub-terminal line. These markings are also present on the female. The male genitalia are quite variable and those of *L. grisea* Moore and *L. fumida* are easy to distinguish.

LYMANTRIA (COLLENTRIA) GRISEA MOORE

(Pl. 4, Fig. 13; Pl. 5, Fig. 4; Pl. 20, Figs. 4–5)

Lymantria grisea Moore, 1879b:55. LT male: INDIA: Darjeeling (BMNH, London, examined); Cotes and Swinhoe, 1887:153; Hampson, 1892:464; Kirby, 1892:478; Swinhoe, 1903:492; Bryk, 1934:164

Lymantria kosemponis Strand, 1914:330. HT male: TAIWAN: Kosempo (DEI, Eberwalde, not examined); Strand, 1923:324; Bang-Haas, 1926:132; Bryk, 1934:166.

Lymantria roseola Matsumura, 1931:715. HT male: TAIWAN: Karenko (HUS, Sapporo, examined); Matsumura, 1933:138; Schintlmeister, 2004:143.

Lymantria servula; Collenette, 1936:344. HT male: CHINA: Nord Yunnan, Li-kiang (MAKB, Bonn, examined). **New synonymy.**

Lymantria grisea servula; Schintlmeister, 2004:143.

Lymantria grisea kosemponis; Schintlmeister, 2004:143.

Liparis grisea; Swinhoe, 1923:432.

COMMON NAMES

Grisea's tussock moth; Gui-du-er, translating to Rare tussock moth, or L-hui-he-du-er or L-lined brown tussock moth (in Chinese).

DIAGNOSIS

Lymantria grisea is much paler overall than *L. fumida*. The male forewing ground color is white in *L. grisea* and brown in *L. fumida* and the pattern is virtually identical. The male hindwing in *L. grisea* is white with barely a hint of a marginal band and brown with a marginal band in *L. fumida*.

REDESCRIPTION

MALE

- *Head* Front and vertex dirty white; scape white; antenna white, bipectinate; labial palp well developed, brown, dirty white internally.

- *Thorax* Light brown; legs dirty white mixed with light brown, tarsi light brown; underside dirty white.
- *Forewing* (Pl. 4, Fig. 13): Length 17–19 mm (n = 3); ground color white, suffused with brown scales; all markings brown; a series of indistinct spots along costa; reniform spot consists of two spots linked by a narrow line at end of discal cell; postmedial line not well-defined, consists of a few crescent-shaped spots between wing veins; scattered brown scales in terminal area; fringe white.
- *Hindwing* Ground color dirty white; faint marginal band; fringe white.
- *Abdomen* Pale gray; tymbals present on third sternite.
- *Genitalia* (Pl. 20, Figs. 4–5): Tegumen with lateral process present; uncus short, wide, with pointed apex; valve undivided, dorsal and ventral projections absent, fused along ventral margin, apex truncate, rounded, with small spine-like projection on ventral margin; juxta narrow, elongate; saccus wide, V-shaped; vesica curved, elongate, narrowing apically; cornuti absent.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 5, Fig. 4): Length 21–25 mm (n=5).
- *Hindwing* Dirty white; submarginal band pale gray; minute spots between veins at wing margin; fringe white.
- *Abdomen* Cream-colored with slight flush of pink dorsobasally.

LARVA

Unknown.

DISTRIBUTION

Nepal, Northeast India, and Myanmar east to northern Thailand, southwestern (Yunnan) and eastern China, and Taiwan.

SPECIMENS EXAMINED

INDIA: Gopaldhara, Darjeeling, 4720 ft., Aug. 1918 (1f), H. Stevens (BMNH); Sikkim, Interior (1f), Möller (BMNH); N.E. India (1m), Moore Coll. (BMNH). TAIWAN: Kaohsiung, Shanping, 640 m, 23–31 Mar. 1988 (2m), J. Rawlins, C. Young, 1–10 May 1988 (1m, 1f), R. Davidson, C. Young, J. Rawlins, 11–20 May 1988 (1f), J. Rawlins, C. Young, R. Davidson (CMNH).

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

Unknown.

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Adults reported taken in mid-June in Godok, Nepal (Kishida 1994) and 12 October on Mt. Anma in Taiwan (Fu and Tzuoo 2004).

DISCUSSION

The male genitalia of *L. grisea* are unique in *Lymantria* with the shape of the valve and the elongate pointed projections on the dorsomedial margin of the tegument (Pl. 20, Fig. 4). Schintlmeister (2004) synonymized *L. roseola* on Taiwan with *L. grisea kosmeponis* Strand, and lowered the rank of *L. servula* Collenette from China and *L. kosemponis* Strand to subspecies. We take a conservative approach and treat all of these entities as *L. grisea*. There is variation in the male genitalia, but because the quality of the images in Schintlmeister (2004) is too poor to make reasonable comparisons, we recognize a single species.

LYMANTRIA (COLLENTRIA) FUMIDA BUTLER

(Pl. 4, Fig. 14; Pl. 5, Fig. 5; Pl. 21, Figs. 1–4; Pl. 28, Fig. 3; Pl. 31, Fig. 4; Pl. 32, Fig. [12; Pl. 51, Fig. 6; Pl. 52])

Lymantria fumida Butler, 1877:402. HT female: JAPAN: Yokohama (BMNH, London, examined); Butler, 1878:10; Leech, 1888:630; Swinhoe, 1903:483; Gaede, 1934:283; Matusumura, 1933:136; Bryk, 1934:150; Inoue, 1956a:398; Inoue, 1982a:634.

Porthetria fumida; Kirby, 1892:475.

Liparis fumida; Swinhoe, 1923:426.

Lymantria dispar fumida; Strand, 1911:127.

Lymantria (Collettaria) fumida; Schintlmeister, 2004:145.

COMMON NAMES

Red-bellied tussock moth; Yellow-striped caterpillar; Fumida tussock moth; Haraaka-mai-mai (in Japanese); Yen-do-er (Smokey tussock moth) or Hung-fu-do-er (Red-bellied tussock moth) (in Chinese).

DIAGNOSIS

Lymantria fumida is darker than *L. grisea*. The male genitalia are quite different between *L. fumida* and *L. grisea*. The valve has multiple projections in *L. fumida* and only two very small projections in *L. grisea*. The saccus is very narrow in *L. fumida* and very wide in *L. grisea*. The vesica in *L. fumida* is covered with minute cornuti, but not in *L. grisea*.

REDESCRIPTION

MALE

- *Head* Front and vertex brown; scape brown, antenna brown, bipectinate; labial palpus well developed, brown with cream-colored apex.
- *Thorax* A mixture of white and brown scales, a few pink scales directly behind head, prothoracic collar brown; legs brown mixed with light brown scales, tarsi light brown mixed with some brown scales; underside dirty white to light brown with pink flush under head.
- *Forewing* (Pl. 4, Fig. 14): Length: 19–22 mm (n =5); ground color brown; basal area irrorated with white scales; antemedial line black, indistinct, curved, slightly jagged; reniform spot black, shallow, V-shaped at end of discal cell; subterminal line white, a series of contiguous horizontal U-shaped spots between veins; three elongate black spots between veins at tornus; black spots between veins at margin extending onto light brown fringe.
- *Hindwing* Brown, discal spot faint, broad dark brown marginal band; dark brown spots between veins at margin extending onto light brown fringe.
- *Abdomen* Brown, lateral line a series of dark brown and amber tufts; tymbals present on third sternite.

- *Genitalia* (Pl. 21, Figs. 1–4): Tegumen with lateral process absent; uncus elongate, parallel-sided, with a produced pointed apex; valve bulbous, not fused, with two distinct dorsal processes, apex truncate with short ventral process; two dorsal processes present, inner most dorsal process attached to dorsobasal edge of valve, process wide, flat, with an apical spine-like process, a small spine-like process present on ventral surface; second dorsal process fused with apicobasal area of valve, longer than first dorsal process, narrow, curved ventrally near pointed apex; juxta a rectangular plate, higher than wide; saccus broad and V-shaped; vesica ovate with a ventral thumb-like lobe; cornuti spiculate.

FEMALE

- *Head* Front and vertex brown; scape brown with a few pink scales, antenna brown; labial palpus brown.
- *Thorax* White mixed with a few brown scales.
- *Forewing* (Pl. 5, Fig. 5): Length 27.0–33.0 mm (n=4); ground color white irrorated with dark brown scales.
- *Hindwing* Tan, discal spot present; wide brown marginal band; fringe white with occasional brown spot.
- *Abdomen* White with thin pink margins on terminal segments, lateral line with brown and pink tufts.
- *Genitalia* (Pl. 28, Fig. 3): Ovipositor telescopic; papillae anales rectangulate, apex angulate; anterior and posterior apophyses elongate, anterior apophysis longer than posterior apophysis; ostium bursae less sclerotized than ductus bursae, quadrate; ductus bursae sclerotized with a proximal quadrate band, with rest divided and slightly produced at juncture with corpus bursae; corpus bursae ovate; signa absent.

LARVA

PRESERVED SPECIMENS (PL. 31, FIG. 4; PL. 32, FIG. 12; PL. 51, FIG. 6; PL. 52)

- *Length* 28–40 mm.
- *Head* Yellowish-brown, a pair of broad black coronal stripes from above frons paralleling ecdysial line (Pl. 32, Fig. 12); few secondary setae on adfrontal sclerites (Pl. 51, Fig. 6); F1 seta with few associated secondary setae; labrum broadly notched (Pl. 52, Fig. 1); clypeus as in *L. d. dispar*, but with narrow, distinctly raised ventral margin (Pl. 52, Fig. 1); stemmata 1, 2, 5, and 6 tripartite; stemmata 3 and 4 with a smooth surface and a raised rim margin (Pl. 52, Fig. 2); Pl. 52, Fig. 3 shows the difference in spicule structure on the black stripe (right) and on the rest of the head (left); spiculi on the rest of the head are less dense, longer, and curved (Pl. 52, Fig. 4); spiculi on the black stripe are densely packed together, short, and straight (Pl. 52, Fig. 5).
- *Thorax* D2 verruca yellowish-brown; legs brown; microbarbules on seta of L verruca with raised shaft parallel to shaft of seta, apex pointed (Pl. 52, Fig. 6).
- *Abdomen* Ground color cream; dorsal pattern with a narrow white middorsal stripe bordered by thin brown stripes, which in turn are bordered by wider white stripes, next set of wide brown stripes, most of which have small white dots at cephalic margin, interrupted by D2 verruca; lateral stripe a distinct wide white stripe above SV verruca; D2 verruca yellowish-brown; primary setae black, secondary setae white, pri-

mary setae on D2 verrucae shorter than those on L; D1 verruca small with a large brown seta and several white secondary setae; SD and L verrucae yellowish-brown, contiguous; SV verrucae yellowish-brown; L verruca with long black setae, short secondary setae white; no barbs on shafts of black primary setae, microbarbules on shafts of white secondary setae; eversible glands on abdominal segments 6–7 white; underside pale yellowish-brown with obscure brown areas between prolegs; area between SV verrucae and prolegs brown, speckled with pale yellowish-brown; prolegs pale yellowish-brown with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal meso-series. Larvae illustrated in Sugi (1987).

DISTRIBUTION

Japan (Honshu, Shikoku and Kyushu) (Inoue 1957), Korea and Yunnan Province, China (Chao and Quan 1987, Zhao 2002).

SPECIMENS EXAMINED

CHINA: [No specific locality], (1m), genitalia on USNM slide 58864, E. T. Owen collection. JAPAN: Hoshu, Ueda, reared May 1979 (1m), P. W. Schaefer (PWS); Honshu, Iwate Pref., 10 km W Morioka, 22 July 1996 (1m), 28 July 1997 (1f), 29 July 1997 (1f), P. W. Schaefer (PWS); Honshu, Iwate Pref., 10 km W Morioka, em. 28 Apr. 1997 (1m, 1f), lab reared, P. W. Schaefer (PWS).

OVIPOSITION

Females oviposit by inserting egg masses hidden tightly under bark scales on the bole of their host trees and they tend to select those parts of the tree bole with ample bark scales, rejecting younger (higher) parts of the trunks with smooth bark. Sato (1976) recorded the height distribution of *L. fumida* egg masses on larch, *Larix leptolepis*, in northern Honshu, Japan, and in a 21-year-old larch plantation; the majority of *L. fumida* egg masses were positioned on the boles between 2 and 5 meters above ground level. Eggs are deposited into a bubbly froth, which is produced with accessory gland fluids. The froth hardens relatively quickly into a rather tough Styrofoam-like mass, which normally obscures all individual eggs. Typically, the entire egg mass is inserted into a narrow crack only about one egg-layer thick (up to ca. 2 sq. cm. in size). The egg mass is visible only when the bark scale is removed.

BIOLOGY AND BEHAVIOR

Experience has shown that larvae tend to feed in the crowns of their food trees, and during strong winds the larvae might fall to the ground. On 11 July 1996, larvae were detected in this way in mature larch trees in Morioka, Honshu, Japan (Schaefer unpubl. data). It appears that, unlike several of its congeners *L. d. japonica* or *L. d. dispar*, larvae of *L. fumida* do not regularly descend the tree boles to seek daytime retreats, but remain on the branches in the upper crowns to rest. On occasion, populations build up to outbreak proportions, as they did in the Tohoku area of Honshu from 1963 through 1965. During this outbreak, noticeable feeding damage first appeared in the tops of larch trees (Kamiyama 1966). Recurring outbreaks of *L. fumida* occurred in Hachioji, just west of Tokyo, at intervals of about 6 or 7 years. During outbreak conditions, massive flights of moths of both sexes were collected in light traps (Katagiri 1977). Katagiri (1977) also recorded that, in populations causing little

defoliation, ova production averaged 134.1 ova per female (n= 68), whereas in a defoliating population this number dropped to less than half. At Shizukuishi, Iwate Prefecture, Honshu, larvae tended to pupate between 2 and 7 meters high on larches; females accounted for only 27.3% of pupae; and most egg masses were distributed between 2 meters and 5 to 6 meters above ground (Sato 1976).

FOOD PLANTS

Long considered a serious pest feeding only on fir, *Abies firma* Sieb. & Zucc. (Pinaceae) (Inoue 1957), in recent decades *L. fumida* has been recorded to cause defoliation and damage to Japanese larch, *Larix leptolepis* Gordon (= *kaempferi* Sargent) (Pinaceae) in the Tohoku district of Honshu, Japan (Sato, 1976, 1979; Sato and Sotodate 1977; Kobayashi 1980). (Perhaps this is indicative of a recent host shift.) In China, *L. fumida* reportedly feeds on *Keteleeria fortunei* (A. Murray) Carrière, *Abies* spp. (Pinaceae) and Chinese juniper, *Juniperus chinensis* L. (Cupressaceae) (Zhao 2002).

PHEROMONAL COMMUNICATIONS

Lymantria fumida utilizes a two-component pheromone composed of (7*R*,8*S*)-*cis*-7,8-epoxy-2-methyloctadecane [(+)-disparlure] and 2-methyl-(*Z*)-7-octadecene [2-Me-7*Z*-18Hy] (Schaefer et al. 1999). Even though these compounds are two of the three components for *L. monacha*, there was complete isolation of the two species in interspersed traps baited for one or the other species (traps as little as 15 m apart) in field experiments in Morioka, Iwate Prefecture, Honshu on 19 July 1998 (Schaefer et al. 1999). Our experiments also showed *L. fumida* males to be completely indifferent to (neither attracted to nor repelled by) the enantiomer (-)-disparlure. Beroza et al. (1973b) reported capture of seven males at baits of *cis*-7,8-epoxy-2-methyloctadecane [racemic disparlure] (and 16 other males responded to three different disparlure analogues), but we now know that these males were responding to only one component in the optimal two-component blend.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

We have shown (Schaefer et al. 1999) that male *L. fumida* are active in Late Evening while *L. monacha* are active Late Morning. Although *L. fumida* and *L. monacha* co-habit the same larch plantations and produce and respond to the same two-chemical compounds (with *L. monacha* also adding (+)-monachalure), they remain behaviorally isolated through both temporal stratification and chemical specificity. In one experiment, in which interspersed traps were baited for either *L. monacha* or *L. fumida*, we illustrated the significance of temporal stratification even at inter-trap distances of 15 or fewer meters (Schaefer et al. 1999).

DISCUSSION

There is some variation in the forewing ground color in both sexes. The males are generally darker than the females, but light colored males are similar to dark females. In males the forewing ground color can be a rich, deep brown to brown; the females can have a similar brown ground color or it can be white, irrorated with brown scales.

Schintlmeister (2004) treated *Lymantria fumida caliginosa* Collenette as *L. caliginosa*. It is difficult to compare the images of male genitalia of *L. fumida* and *L. caliginosa*, because

they are not presented as comparable views. Also, the male genitalia of *L. fumida* are distorted due to flattening of the preparation in Schintlmeister (2004, Fig. 652).

Lymantria fumida is stenophagous on Pinaceae and Cupressaceae. In forests with suitable host trees, *L. fumida* may be abundant and cause complete defoliation in plantations of *Larix leptolepis* (Sieb. & Zucc.) Gord. (Pinaceae). In such habitats, *L. fumida* is in direct competition with both *L. d. japonica* and *L. monacha* for food, but they maintain a clear pheromone channel by using both (+)-disparlure and 2-Me-7Z-18Hy. (It is important to note that *L. d. japonica* is inhibited by the 2-Me-7Z-18Hy whereas *L. monacha* is attracted predominately to the (+)-monachalure component in the monachalure blend). Thus, pheromone trapping using synthetic (+)-disparlure and 2-Me-7Z-18Hy can result in a nearly perfect separation of the three closely associated species.

SUBGENUS *SPINOTRIA* SCHINTLMEISTER

Spinotria Schintlmeister, 2004:12. Type species: *Bombyx serva* Fabricius, 1793:474; original designation.

This subgenus forms a compact group characterized by a ventromedially fused valve that is divided into dorsal and ventral arms. The ventral arms are longer than the dorsal arms. The saccus is evenly curved ventrally.

LYMANTRIA (SPINOTRIA) SERVA (FABRICIUS)

(Pl. 4, Fig. 15; Pl. 5, Fig. 6; Pl. 21, Figs. 5–6; Pl. 31, Fig. 5; Pl. 32, Fig. 13)

Bombyx serva Fabricius, 1793:474. ST male: INDIA: Orientali (ZMUC, Copenhagen, not examined).

Liparis serva; Swinhoe, 1923:427.

Lymantria serva; Collenette, 1933:31; Gupta, 1992:107; Schintlmeister 2004:151.

COMMON NAMES

Serva tussock moth; Ficus tussock moth; Xian-yue-du-er (Crescent-moon tussock moth), or Hung-do-er (Rainbow tussock moth) (in Chinese).

DIAGNOSIS

Lymantria serva is similar to *L. hreblayi* Schintlmeister in overall forewing color and pattern. The reniform spot is more distinct in *L. serva* than in *L. hreblayi*. The fine brown line that separates the margin of the hindwing from the fringe in *L. serva* is absent in *L. hreblayi* and the spots on the fringe in *L. hreblayi* are more distinct and darker than on *L. serva*.

REDESCRIPTION

MALE

- *Head* Front and vertex a mixture of white and light brown scales; scape white, antenna brown mixed with a few white scales at base, becoming whiter toward apex, bipectinate; labial palpus well developed, outside fuscous to black with base and apex cream-colored, inside cream-colored.
- *Thorax* Mixture of white and tan to white and fuscous; foretibia white mixed with some fuscous scales, basitarsus with apical half fuscous, segments 3–4 fuscous, remainder white; middle tibia white with fuscous scales, basitarsus with apical half fuscous, segments 3–4 fuscous, remainder white; hind tibia white with a subapical fuscous band, basitarsus with apical half fuscous, segments 3–4 fuscous, remainder white; underside with dirty white laterally, ventrally light pink mixed with dirty-white hair-like scales.
- *Forewing* (Pl. 4; Fig. 15): Length: 17–19 mm (n=2); ground color white suffused with black scales; all markings black; basal half of wing with no distinct lines, suffused with black scales; orbicular spot minute; reniform spot not well-defined at end of discal

cell; postmedial line indistinct at costa, but becomes distinct and crenulate toward posterior margin; subterminal band crenulate; small dashes between wing veins along outer margin that extend onto fringe; fringe white.

- *Hindwing* Ground color white; veins highlighted with light brown; indistinct brown marginal band; thin brown line along outer margin; fringe white with indistinct light brown dashes between veins.
- *Abdomen* Cream-colored dorsally, indistinct pale pink lateral line, cream-colored ventrally with pale pink along distal margins of sternites; tymbals present on third sternite.
- *Genitalia* (Pl. 21, Figs. 5–6): Tegumen with lateral process absent; uncus triangulate with pointed apex; valve bifurcate with prominent dorsal and ventral processes, ventral processes fused; dorsal process slightly more than half as wide and half as long as ventral process, apex with spine-like projection; ventral process similar in shape to dorsal process, but larger; sacculus undifferentiated from valve; saccus broad, U-shaped, no ventral projection; vesica ovate; cornuti small to minute spiculi.

FEMALE

- *Head* Front and vertex brown with a few cream-colored scales; scape brown and cream-colored ventrally, antenna black with white apex; labial palp well developed, black with a few ventral cream-colored scales.
- *Thorax* Thin band of pink scales separating head from thorax; thorax brown mixed with dirty white scales; fore and middle tibia mixed with fuscous and dirty white scales, tarsi fuscous; hind tibia fuscous, ventral fringe dirty white, tarsi fuscous; underside light brown with pale pink ventrally.
- *Forewing* (Pl. 5, Fig. 6): Length 26–36 mm (n=2); ground color brown; [specimens are worn]; no distinct lines but a few darker spots at base, along costa, and subapically; fringe brown.
- *Hindwing* Tan; veins and wing margin highlighted brown; fringe white.
- *Abdomen* Cream dorsally with a few pale pink tufts toward apex, pink laterally, fuscous ventrally with lighter scales along apical margin of sternites.

LARVA

PRESERVED SPECIMENS (PL. 31, FIG. 5; PL. 32, FIG. 13): LARVAE 23–30 MM.

- *Head* Brown, coronal stripes absent (Pl. 32, Fig. 13); ecdysial line white.
- *Thorax* D2 verruca brown; legs yellowish-brown.
- *Abdomen* Ground color brown; dorsal stripe absent; lateral stripe absent; D2 verrucae brown, primary setae dark brown, secondary setae dark brown with barbed shaft; D1 verruca dark brown, half the size of D2; primary setae on D2 verruca shorter than those on L; SD and L verrucae brown, contiguous; SV verruca brown; L verruca with brown primary setae, long brown secondary setae with barbed shaft; eversible glands on abdominal segments 6–7 concolorous with ground color; underside yellowish-brown, no stripe or pattern; prolegs pale with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoseries.

DISTRIBUTION

Northern India (Assam), Nepal, and South China (Yunnan Province). Previously recorded in Hong Kong (in Moths of Hong Kong (<http://www.hkls.org/mot-list.html>) and Taiwan (Gries et al. 2002), but some of these records are now thought to be *L. iris* Strand (Schintlmeister 2004).

SPECIMENS EXAMINED

CHINA: (1f) (USNM); Tapaishan im Tainling Sued Shensi, 1700 m, 9 July 1936 (1f), H. Hone (MAKB). INDIA: Assam, Coll. Wm. Schaus, (1m) (USNM).

OVIPOSITION

Laboratory observations of a female confined in a nylon bag suggest oviposition is of the insertion type and that eggs are likely tucked tightly into bark cracks or crevices on trees. The female was observed ovipositing eggs in a crease in the bag, identical in behavior to that shown for *L. lucescens* (Fig. 18).

BIOLOGY AND BEHAVIOR

Development is unusually long in larvae of *L. serva* (or *L. iris*) which can go through up to 10 to 12 instars (Schaefer, unpubl. data).

FOOD PLANTS

Thought to feed primarily on banyan or *Ficus* trees (Moraceae), especially *F. bengalensis* L., *F. religiosa* L., and *F. microcarpa* L. (Anonymous (CAB) 1966, Radha and Rangarajan 1970, C. Lau 1998 unpubl.). Beeson (1941) recorded *L. serva* feeding on *Shorea robusta* Gaertn. F. (Dipterocarpaceae) in Assam, India.

PHEROMONAL COMMUNICATIONS

Apparently, *L. serva* communicates using 2-methyl-(*Z*)-7-octadecene [2-Me-7Z-18Hy], as does *L. iris*, based on incidental trapping of males during trapping studies for *L. obfuscata* in Solan, Himachal Pradesh, India, in June 2005 (Gries and Schaefer, unpubl. data). All males (n= 9) appeared in traps containing 2-Me-7Z-18Hy. Seven of these males responded even if (+)-disparlure was included, but no *L. serva* males appeared in traps baited only with (+)-disparlure. (It should be noted that our report announcing the findings of the sex pheromone for “*L. serva*” (Gries et al. 2002) in Taiwan has been identified by Schintlmeister (2004) as *L. iris*. Nevertheless, all evidence to date suggests that both *L. iris* and *L. serva* use 2-Me-7Z-18Hy as a major pheromone component.)

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Lymantria serva is not well known, in part because of confusion in the nomenclature—it was long confused with *L. iris*—and partly because of its close association with *Ficus*. It is known that adult moths are collected at lights at night but little else is recorded. Our encounter with *L. serva* involved the appearance of a few individuals in our pheromone traps at Solon,

Himachal Pradesh, India, confirming that adults were flying in late June (Schaefer and Gries, unpubl. data).

DISCUSSION

Lymantria serva is nearly stenophagous on *Ficus* spp. (Moraceae). Also, like *L. iris*, males respond to the synthetic lure 2-Me-7Z-18Hy and can be collected by pheromone trapping. We recognize that more needs to be done to fully clarify the sex pheromone communication systems of *L. serva* and *L. iris* that now appear to be allopatric (Schintlmeister 2004) and ecological equivalents closely associated with *Ficus* spp. Although they appear capable of invasive behavior, the possibility appears minimal because of the restricted food source.

LYMANTRIA (SPINOTRIA) LASZLORONKAYI SCHINTLMEISTER

(Pl. 5, Fig. 7; Pl. 22, Fig. 1–2)

Lymantria (Spinotria) laszloronkayi Schintlmeister, 2004:153. HT male: LAOS: Thalat, Viang Khan, 500m (ASD, Dresden, examined figure).

COMMON NAMES

Laszloronkayi's tussock moth.

DIAGNOSIS

Lymantria laszloronkayi has the same general indistinct pattern as *L. serva*, but has a bold black bar subbasally below the M vein, which is absent in *L. serva*. The male genitalia in *L. laszloronkayi* differ from *L. serva* in the shape of both the dorsal and ventral processes. The dorsal process is short and triangular in shape in *L. laszloronkayi* (Pl. 22, Fig. 1) and in *L. serva* it is longer, with a spine-like apical projection (Pl. 21, Fig. 5).

REDESCRIPTION

MALE

- *Head* Front and vertex cream to brown; scape white with some brown scales basally, antenna brown with some white scales basally, bipectinate; labial palpus well developed, dark brown.
- *Thorax* Cream-colored to tannish-white; foretibia dark brown with some white scales medially and distal apex white, basitarsus dark brown with white proximal and distal apices, segment 2 dark brown with white distal apex, segments 3–4 dark brown, 5 white; middle and hind tibia dark brown with white spot at 2/3 length and white apex, tarsi as in foreleg; underside light brown.
- *Forewing* (Pl. 5, Fig. 7): Length: 16–20 mm (n=2); ground color white; black scales along costa forming irregular spots; irregular patches of black scales within discal cell; reniform spot on r-m cross vein at end of discal cell; subbasal black patch below M vein; subterminal line indistinct, a series of black chevrons between wing veins; dark spots along outer margin extending into white fringe.
- *Hindwing* Ground color white infuscated with brown; discal spot absent; marginal band faint; brown spots between veins along outer margin that extend into white fringe.
- *Abdomen* Dorsum white becoming light brown distally; lateral brown spots becoming larger and darker distally; white ventrally; tymbals present on third sternite.
- *Genitalia* (Pl. 22, Figs. 1–2): Tegumen with lateral process absent; uncus triangulate with pointed apex; valve bifurcate with prominent dorsal and ventral processes, ventral processes fused; dorsal process triangulate, slightly less half as long as ventral process, apex rounded; ventral process elongate, widest at base and slightly curved to a narrow distal half, apex slightly curved medially; sacculus undifferentiated from valve; saccus broad, U-shaped, no ventral projection; vesica ovate; cornuti small to minute spiculi.

FEMALE

No known specimens.

LARVA

Unknown.

DISTRIBUTION

Occurs from the northern areas of Vietnam, Laos, Thailand and China (Yunnan and Sichuan Provinces).

SPECIMENS EXAMINED

CHINA: Szechuen [sic], Mt. Omei, 5000 ft., Aug. (1m), D.C. Graham Coll., genitalia slide USNM 59210 (USNM); Prov. Nord Yunnan, Li-kiang, ca. 3000M 23 July 1934 (1m), H. Höne (USNM).

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

Unknown.

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Collection records of the paratype series tend to suggest three flight periods (February–March; June–August, and October–November). Further field research may well show continuous overlapping generations.

DISCUSSION

Specimens of this species were found mixed with a series of *L. albolunulata* Moore. When dissections were made, there were major differences in the male genitalia. The ventral process of the valve in *L. albolunulata* Moore is only slightly wider at base than at apex (Pl. 24, Fig. 1), but in *L. laszloronkayi* this process is bulbous basally and is significantly narrower toward apex (Pl. 22, Fig. 1). We know nothing about *L. laszloronkayi* except that it is similar in appearance to *L. albolunulata*.

LYMANTRIA (SPINOTRIA) HREBLAYI SCHINTLMEISTER

(Pl. 5, Fig. 8; Pl. 22, Figs. 3–4)

Lymantria (Spinotria) hreblayi Schintlmeister, 2004:154. HT male: VIETNAM: Mt. Fan-si-pan, N-Seite, Cha-pa, 1525m (ASD, Dresden, examined figure).

COMMON NAMES

Hreblay's tussock moth; Hreblay's-do-er (in Chinese).

DIAGNOSIS

Lymantria hreblayi has the same general indistinct pattern as *L. serva*, but is larger. The reniform spot, which outlines the veins at the end of the discal cell, is distinct in *L. serva*, but in *L. hreblayi* it is obscured by the suffusion of black scales that make the other elements of the forewing pattern indistinct.

REDESCRIPTION

MALE

- *Head* Front and vertex brown mixed with black; scape white mixed with brown and black, antenna white with indistinct black scales at base of segments, bipectinate; labial palpus well-developed, black on outside with white apex and white inside.
- *Thorax* Mixture of white, brown, and black scales; foretibia a mixture of black and white with a white distal apex, basitarsus black with white apex, segment 2 white with black proximal apex, segments 3–4 black, 5 white; middle and hind tibia black with white band at 2/3 length and white apex, tarsi as in foreleg; underside light brown.
- *Forewing* (Pl. 5, Fig. 7): Length: 19 mm (n=1); ground color white with scattered black scales; antemedial line obscure, small spot on costa, a large ovate, fuzzy spot on M vein, a short angulate dash at posterior margin; reniform spot restricted to ventral half of r-m cross vein at end of discal cell; postmedial line angulate from costa to R₅, then a series of lunules between veins to posterior margin; subterminal line faint, a series of black dashes between veins; dark spots along outer margin extend onto white fringe.
- *Hindwing* Ground color white; discal spot absent; marginal band faint, from Rs to posterior apex; brown spots between veins along outer margin that extend into white fringe.
- *Abdomen* Missing; tymbals present on third sternite.
- *Genitalia* (Pl. 22, Figs. 3–4): Lateral processes absent from tegumen; uncus elongate, narrow, with pointed apex; valve deeply divided into two narrow processes, shorter than dorsal process, basal projection absent, fused with juxta; dorsal process contiguous with costal margin of valve, elongate, more than half length of ventral process, broad basally; ventral process along same plane as valve, straight shaft; juxta narrow, elongate; saccus narrow band, not differentiated from tegumen, not produced; vesica ovate; cornuti spiculate.

FEMALE

No females were available for study. Schintlmeister (2004, Fig. 696) illustrates a female as being larger than the male with a diffuse pattern making the female appear darker than the male, with a short, dark horizontal line at the distal end of the discal cell. The forewing pattern is obscure with an ill-defined subterminal line. Hindwing is suffused with more brown and is darker than in the male.

LARVA

Unknown.

DISTRIBUTION

Known from northern Vietnam and Yunnan and Sichuan Provinces in China.

SPECIMENS EXAMINED

CHINA: Nord. Yunnan, Li-kiang, ca. 2000m, 8 Aug. 1954 (1m), H. Höne, genitalia slide DCF 1644 (MAKB).

IMMATURE STAGES

Unknown.

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Unknown.

FOOD PLANTS

Unknown.

PHEROMONAL COMMUNICATIONS

Unknown.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

The collections making up the type series suggest two rather well-defined flight periods, January–February and July (Schintlmeister 2004).

DISCUSSION

This species resembles *L. serva*, but the male genitalia are quite different. In *L. hreblayi*, the ventral process is roughly the same width from the base to the slightly narrower apex as in *L. serva*, but it is wider and the apex has a spine-like apical process in *L. serva*.

LYMANTRIA (SPINOTRIA) IRIS STRAND

(Pl. 5, Fig. 9, 12; Pl. 23, Fig. 1–2)

Lymantria obsoleta iris Strand, 1911:130. ST: CHINA: Hong Kong (SMF, Frankfurt, not examined).

Lymantria serva iris, Bryk, 1934:159.

Lymantria iris, Schintlmeister, 2004:161.

COMMON NAMES

Iris tussock moth; Iris-rong-wu-do-er translating to Iris fig tussock moth (in Chinese).

DIAGNOSIS

Lymantria iris has a browner forewing ground color and is smaller than *L. bantaizana* Matsumura, which has a grayish ground color. The black spots on the fringe of the wings are more distinct in *L. bantaizana* being much less obvious in *L. iris*.

REDESCRIPTION

MALE

- *Head* Front and vertex gray mixed with dirty white; scape dirty white, antenna fuscous, bipectinate; labial palpus well developed, black on outside and dirty white inside.
- *Thorax* Gray, becoming lighter on mesonotum with scutellum gray; legs with black tibia speckled with white, long fringe dirty white, basitarsus speckled black and white with a wide median black band, segments 2–4 black, apical segment white; underside with long dirty white hair-like scales.
- *Forewing* (Pl. 5, Fig. 9): Length: 20 mm (n=2); ground color brownish-gray; antemedial line obscure, faint lunules between M and 1A+2A veins; orbicular spot absent; median line absent; reniform spot a faint angled dash at end of discal cell; postmedial line absent; subterminal line faint, a series of white lunules obscured by darker shades of ground color; dark spots along outer margin extending into dirty white fringe.
- *Hindwing* Dirty white to infuscated with light brown; discal spot faint; marginal band somewhat darker than ground color; a distinct dark line along outer margin; fringe white with faint light-brown spots between veins.
- *Abdomen* Dirty white with black spots interspersed with hair-like pink scales laterally; tymbals present on third sternite.
- *Genitalia* (Pl. 23, Figs. 1–2): Lateral process absent from tegumen; uncus triangulate with broadly rounded apex; valve bifurcate with prominent dorsal and ventral processes, ventral processes fused; dorsal process thumb-like, slightly more than 1/3 the length of the ventral process, apex rounded; ventral process elongate, angled medially, apical third sharply angled laterally, apex pointed; sacculus undifferentiated from valve; saccus broad, U-shaped, no ventral projection; vesica ovate; cornuti small to minute spiculi in basal half of vesica.

FEMALE

- *Head* As in male.
- *Thorax* As in male.
- *Forewing* (Pl. 5, Fig. 12): Length 32–33 mm (n=2); pattern similar to male.
- *Hindwing* Dirty white; wide brown marginal band; obscure spots between veins at margin; fringe white with brown marginal spots.
- *Abdomen* Pinkish-brown, mid-dorsal black stripe.

LARVA

Color illustrations of larvae, as well as pupae and adults from Taipei (identified as *L. serva iris*) are presented by Sen and Fan (2001).

DISTRIBUTION

China, Taiwan, northeastern India.

SPECIMENS EXAMINED

CHINA: Canton, Pr. Kwangtung, 2 Oct. 1923 (1m), genitalia slide DCF 1645 (MAKB).
 TAIWAN: FuShan, 18 May 1994, at lights, Paul W. Schaefer (1m) (PWS); Kaohsiung, Shanping, 640 m, 11–20 May 1988 (1m), J. Rawlins, C. Young, R. Davidson (CMP); Taipai, coll. (as larva) on *Ficus* in school yard, r. as #31-1999 on *Ficus*, Paul W. Schaefer (1m) (PWS); Tayuling, 21 June 1994, at lights, Paul W. Schaefer (2m) (PWS).

OVIPOSITION

Based on the appearance of the female ovipositor (Schintlmeister 2004), *L. iris* possesses an insertion type ovipositor and we predict that eggs should be found in cracks or under bark flakes on trees.

BIOLOGY AND BEHAVIOR

During daylight hours in Taiwan, intermediate to last instar larvae show a very strong tendency to conceal themselves in the tightest, darkest, crevices on their food trees (Schaefer, unpubl. data). We presume these same larvae emerge at night to feed on available leaves, but this has not been verified. Adults are attracted to outdoor lighting (Y.B. Fan, unpubl. records).

FOOD PLANTS

Several *Ficus* spp. (Moraceae). In 1995, Yi-Bin Fan (Taiwan For. Res. Inst., Taipei) found larvae of *L. iris* on *Ficus lyrata* Hort. in the Taipei Botanical Garden.

PHEROMONAL COMMUNICATIONS

Although first published under the name “*L. serva*” in Taiwan, we determined that the communication system for *L. iris* was simply 2-methyl-(Z)-7-octadecene [2-Me-7Z-18Hy]. Also

L. iris males were completely indifferent to either enantiomer of disparlure (Gries et al. 2002, as *L. serva*. Note that a true *L. serva* is a distinct and valid species in India).

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Trapping conducted in the Taipei Botanical Garden, 9 May 2000, suggests a possible bimodal trapping periodicity as four males were captured prior to 11 PM, one between 11 PM and 4 AM, and 17 between 4 AM to 5 AM (Y.B. Fan and P.W.S. unpubl. data, but not included in Gries et al. 2002). Thus, *L. iris* is at least Late Morning active.

DISCUSSION

Originally described as a subspecies of *L. obsoleta*, both *L. obsoleta* and *L. iris* were then synonymized under *L. serva* (Swinhoe 1923). Schintlmeister (2004) was the first to examine the genitalia of *Lymantria (Spinotria)* and determined that *L. obsoleta*, *L. iris*, and *L. serva* were all valid species. The male genitalia of each of these species are distinct from the others, and the laterally angled ventral process is unique for *L. iris*.

Our study of this moth on Taiwan resulted in the publication of our findings on the sex pheromone (Gries et al. 2002), but we referred to this moth species as "*L. serva*." More recently, Schintlmeister (2004) concluded that the Taiwan population which we had studied should be referred to as "*L. iris*," although he reported it rarely occurs in Taiwan. Following that nomenclature, it appears that *L. iris* is distributed in Taiwan, southern China, Vietnam, and northeastern India (Assam) (Schintlmeister 2004).

LYMANTRIA (SPINOTRIA) BANTAIZANA MATSUMURA, REVISED STATUS

(Pl. 5, Fig. 10; Pl. 6, Fig. 1; Pl. 23, Fig. 3–4; Pl. 28, Fig. 4; Pl. 31, Fig. 6; Pl. 32, Fig. 14)

Lymantria bantaizana Matsumura, 1933:134. ST: JAPAN: Honshu, Fukushima, Mt. Bantaizan, Kibune, and Chichibu (HUS, Sapporo, examined); Bryk, 1934:165; Inoue, 1956a:398; Inoue, 1982a:634; Park, 2000:113.

Lymantria grisescens bantaizana; Schintlmeister, 2004:168; Schaefer et al., 2006:115.

COMMON NAMES

Bantai tussock moth; Baitai-maimai or Bantai-dokuga (in Japanese); Juisaegmaemi-Nabang or Zuisaekmaemi-Nabang (in Korean); Zhao-weng-do-er (Chevroned tussock moth) (in Chinese).

DIAGNOSIS

Lymantria bantaizana is the only representative of this subgenus in Japan. It is gray, whereas the other species in Japan are either white or brown. The male genitalia differ from *L. iris*, in that the ventral process of the valve is straight, with a slight medially curved apex.

REDESCRIPTION

MALE

- *Head* Front and vertex white with a few dark gray scales; scape white, antenna fuscous, bipectinate; labial palpus well-developed, black with a few white scales toward apex on outside and white inside.
- *Thorax* Brown mixed with white.
- *Forewing* (Pl. 5, Fig. 10): Length: 19–21 mm (n=4); ground color gray; all markings black; basal area with spot at costa; antemedial line curved from costa to posterior margin; elongate dash at distal end of M vein; reniform spot an angulate bar at end of discal cell; postmedial line absent; subterminal line a spot on costa, absent below; terminal area with a few triangulate spots between wing veins; small rectangular patches between veins along outer margin that extend on to white fringe.
- *Hindwing* Ground color gray; discal spot present; marginal band wide and darker than ground color; marginal spots extend onto brown fringe.
- *Abdomen* Gray; tymbals present on third sternite.
- *Genitalia* (Pl. 23, Figs. 3–4): Lateral process absent from tegumen; uncus triangulate with broadly rounded apex; valve bifurcate with prominent dorsal and ventral processes, ventral processes fused; dorsal process broad, slightly more than a half as long as ventral process, apex broadly rounds to a slight point; ventral process elongate, widest in basal 2/3, constricted at distal third into an elongate process, apex rounded; sacculus undifferentiated from valve; saccus broad, U-shaped, no ventral projection; vesica ovate; cornuti small, spiculi entirely covering vesica.

FEMALE

- *Head* As in male.

- *Thorax* As in male.
- *Forewing* (Pl. 6, Fig. 1): Length 28 mm (n=1); pattern similar to male.
- *Hindwing* Gray with a broad dark gray marginal band.
- *Abdomen* Gray.
- *Genitalia* (Pl. 28, Figs. 4–5): Ovipositor telescopic; papillae anales rectangulate, apex round; anterior and posterior apophyses elongate, anterior apophysis longer than posterior apophysis; ostium bursae less sclerotized than ductus bursae; ductus bursae with a pair of elongate sclerotized structures that are tapered proximally and are fused distally with a slightly forked apex that extends into corpus bursae; corpus bursae ovate; signa rectangulate with many pointed projections, somewhat stellate (Pl. 28, Fig. 5)..

LARVA

PRESERVED SPECIMENS (PL. 31, FIG. 6; PL. 32, FIG. 14)

- *Length* 12–18 mm.
- *Head* Brown, coronal stripes absent (Pl. 32, Fig. 14); frons slightly paler than head.
- *Thorax* Some specimens with dorsal white patches on T2; D2 verruca black; legs brown.
- *Abdomen* Ground color dark brown to dark gray; dorsal stripe absent; lateral stripe absent; some specimens with white dorsal patches on A3–4; D2 verruca black on abdomen; D1 verruca black, small; SD and L verrucae concolorous with ground color, contiguous; SV verrucae concolorous with ground color; primary setae on D2 verruca dark brown, secondary setae white with hairs on shaft; only a few brown primary setae on SD and L; SD and L verrucae with many long white secondary setae with hairs on shaft; eversible glands on abdominal segments 6–7 white; underside brown, no stripe or pattern; prolegs brown with well-developed lateral sclerotized plates; crochets in a homoideous uniordinal mesoserries. Only recently illustrated by Gotoh et al. (2004), the immature stages are primarily black with dorsal white markings only on mesothorax and metathorax and on abdominal segments 4 and 5.

DISTRIBUTION

Until recently, *L. bantaizana* had been restricted to the island of Honshu, Japan, from Mt. Bantaizan, Kibune, and Chichibu (Matsumura 1933). It was recently confirmed on the island of Hokkaido (Schaefer et al. 2006), but we had accepted the nomenclature of Schintlmeister (2004) and reported this moth as *L. grisescens bantaizana*.

SPECIMENS EXAMINED

JAPAN: HONSHU: Morioka, Iwashimizu, 14 July 2001 (1f), 17 July 2001 (3f), at lights, 19 July 2001 (1m), N. Doi (PWS); nr. Morioka, Rt. 158, *Juglans* forest site, 28 July 2001 (1m), 30 July 2001 (1m), 7–10 Aug. 2001 (1m), P.W. Schaefer (PWS); Nagano Pref., 4 km E. Naganohara, 10 July 1994, at lights/sheet, Paul W. Schaefer (2m) (PWS); Iwate Pref., Morioka, Iwamimizu, coll. 20 July 2000, N. Doi, via T. Gotoh, eggs led to lab. culture (2f) (PWS); KOREA: Soraksan Nat. Park, Okinotang Rest Area, 20 August 2000, at lights, Paul W. Schaefer (1f); nr. Wontong, 24 July 2001, at M.V. light, app. 3:50 A.M., Paul W. Schaefer (1f); Jangsudae Camp area, 16 July 2001, Paul W. Schaefer (1m) (PWS).

IMMATURE STAGES

Only recently illustrated by Gotoh et al. (2004), the immature stages are primarily black with white dorsal markings only on mesothorax and metathorax and on abdominal segments 4 and 5.

OVIPOSITION

Based on caged rearings, apparently deposits naked eggs (without hairs or hardened foam as in some congeners) on bark or leaves of host trees (Gotoh et al. 2004).

BIOLOGY AND BEHAVIOR

Lymantria bantaizana is univoltine. It overwinters as third or fourth instar larvae, unlike all other known *Lymantria* spp. which overwinter in the egg stage. Thus, *L. bantaizana* has feeding periods during late summer and fall and then again the following spring (Gotoh et al. 2004). It is unclear just where larvae prefer to overwinter, as these findings are based on larvae retained in mesh bags (Gotoh et al. 2004).

FOOD PLANTS

Stenophagous only on Juglandaceae, specifically *Juglans mandshurica* Maxim. var. *sachalinensis* Komatso, *J. regia* L. var. *orientalis* (Dode) Kitam., *Pterocarya rhoifolia* Siebold & Zucc. (in rearing in Japan) and *J. nigra* L. (in USA quarantine rearing) (Gotoh et al. 2004).

PHEROMONAL COMMUNICATIONS

Lymantria bantaizana communicates with the sex pheromone, (7Z,9E)-2-methyl-7,9-octadecadiene (Gries et al. 2005a) which is unique among known *Lymantria* spp. This sex pheromone compound is inhibitory to sympatric *L. monacha*, *L. fumida*, and *L. d. japonica* (Gries & Schaefer unpubl. data).

FLIGHT AND PHEROMONE PERIODICITY, SEASONALITY

Females are attracted to lights and apparently fly readily. Males are Early Morning active and respond to synthetic sex pheromone lures between midnight and 2 AM (Gries et al. 2005). Adults fly in mid-July in Iwate Prefecture, Honshu, whereas in Hokkaido they were captured 10–15 August (Gotoh et al. 2004, Schaefer et al. 2006).

DISCUSSION

Schintlmeister (2004) treated *L. bantaizana* as a subspecies of *L. grisescens* Staudinger and described a new subspecies, *L. grisescens goergneri* Schintlmeister. The genitalia of these three are very different, much more so than in other closely related species in *Lymantria*. In *L. bantaizana*, forewing and hindwing patterns are similar in both sexes. The male genitalia of *L. bantaizana* and *L. laszloronkayi* are very similar, but the cornuti are larger and more conspicuous in *L. bantaizana*.

LYMANTRIA (SPINOTRIA) ALBOLUNULATA MOORE

(Pl. 5, Fig. 11; Pl. 6, Fig. 2; Pl. 24)

Lymantria albolunulata Moore, 1879a:403. LT male: INDIA: Dhurmsala (BMNH, London, examined); Kirby, 1892:478; Cotes and Swinhoe, 1887:151; Swinhoe, 1892:222; Schintlmeister, 2004:170.

Lymantria albolunata; Swinhoe, 1903:485. [Incorrect subsequent spelling]

Lymantria serva albolunulata; Bryk, 1934:158.

Lymantria elassa Collenette, 1938:381. HT male: CHINA: Ya-chiao-ling (BMNH, London, examined); Schintlmeister, 2004:170.

COMMON NAMES

Albolunulata tussock moth; Yue-guong-do-er (Moonlight-like tussock moth) (in Chinese).

DIAGNOSIS

Lymantria albolunulata is similar to *L. serva*, but the forewing pattern is darker and of higher contrast in *L. albolunulata* than in *L. serva* which has a more washed appearance. The female abdomen is pink in *L. serva* as compared to brown with some pink in *L. albolunulata*. The male genitalia of *L. albolunulata* and *L. breblayi* are similar. The dorsal process is more bulbous basally and the apex is evenly produced and longer in *L. albolunulata* (Pl. 24, Fig. 1); in *L. breblayi* the dorsal process is shorter and the apex is more abruptly produced (Pl. 22, Fig. 3).

REDESCRIPTION

MALE

- *Head* Front and vertex brown mixed with some white scales; scape white, antenna white, bipectinate; labial palpus well developed, outside black, inside light brown.
- *Thorax* Mixture of dark brown, brown, and white, darker anteriorly, a few pink scales between head and thorax; foretibia mixed with light brown and brown with black scales medially, long fringe on either side light brown, basitarsus concolorous with tibia in proximal half, black distally with white apical ring, segment 2 white, segments 3–4 black, 5 white; middle tibia light brown and black, long fringe white. tarsi as in foreleg; hind tibia dirty white with black subapical spot, tarsi as in fore leg; underside brown anteriorly, remainder pink and light brown.
- *Forewing* (Pl. 5, Fig.11): Length: 16–22mm (n=10); ground color light brown heavily overscaled with black; all markings black; prominent markings include a basal spot; a series of spots along costa; indistinct bands at base and middle of discal cell; an elongate dash with dorsal black scales between vein M and anal vein; reniform spot at end of discal cell; adjacent to reniform distally an indistinct spot; subterminal line a series of elongate crescent-shaped, distal white spots between veins; fringe light brown with black spots between veins extending onto fringe.
- *Hindwing* Ground color dirty white; discal spot faint; marginal band faint; fringe white with a few brown scales between veins.

- *Abdomen* Light brown with black lateral spots, light brown to pink below and toward apex.
- *Genitalia* (Pl. 24): Tegumen with lateral process absent; uncus elongate, narrow, with pointed apex.; valve deeply divided into two narrow processes, dorsal shorter than ventral, basal projection absent, fused with juxta; dorsal process contiguous with costal margin of valve elongate, more than half length of ventral process, broad basally; ventral process along same plane as valve, straight shaft; juxta narrow, elongate; saccus a narrow band, not differentiated from tegumen, not produced; cornuti absent.

FEMALE

- *Head* Front and vertex dark brown; scape dark brown, antenna black with white apex; labial palp well developed, black with a few cream scales toward apex on the inside.
- *Thorax* Dark brown; a few pink scales between head and thorax; foretibia a mixture of light brown and black scales with a light brown apical ring; basitarsus and segment 2 black with a light brown apical ring, 3–4 black, 5 light brown; middle tibia brown and black, tarsi as in foreleg; hind tibia dark brown, tarsi as in other legs; underside brown.
- *Forewing* (Pl. 6, Fig. 2): Length: 16–22 mm (n=10); ground color dark brown; all markings black; a series of black spots along costa; small orbicular spot a short dash in middle of discal cell; reniform spot at end of discal cell; a small round spot contiguous with and below M vein at approximately 2/3 length of discal cell; below this spot is an elongate dash between M and anal veins; postmedial line faint, crenulate; subterminal line a series of crescent-shaped spots filled with white distally; a few other crescent-shaped spots in terminal area, bolder near apex; a series of small spots along outer margin; fringe a mixture of light-brown and black scales.
- *Abdomen* Light brown dorsally, dark brown ventrally; in some specimens dark bands occur in the last few apical segments.

LARVA

Unknown.

DISTRIBUTION

Southwestern China to the Himalayan regions of northern India, as well as Bangladesh, Myanmar, and Thailand.

SPECIMENS EXAMINED

CHINA: Nord Yunnan Province, Li-kiang, 18 June 1934 (1m), 6 July 1935 (1m), 22 July 1935 (1m), 2 Aug. 1935 (1f), H. Höne (BMNH); West Tien-Mu-Shan, Pz. Chekiang, 1600 m, 10 July 1932 (1m), H. Höne (BMNH); Hunan 1(m), Pratt (BMNH); Siao Lu, 1902 (1m), P. Dejean (BMNH); Ta-tsien-lou, 1910 (1f) (BMNH); Ichang (2m), June 1922 (2m), C.T. Bowering (BMNH); Tsekou, 1909 (2m), T. Monbeig (BMNH); Tien-Tsuen, 1901 (2m), P. Dejean (BMNH); Moupin, June 1890 (1m), Kricheldorf Coll. (BMNH). INDIA: Sabathu, 92-98, Harford Coll. (3m) (BMNH); Dalhousie, June 1891 (2m, 3f), 92-98, Harford Coll. (1m) (BMNH); Punjab, Khyra Gully, 11–20 June 1881 (1m), H. Roberts Coll.; Punjab, Murray Hills, Khyra Gully (1f), H. Roberts Coll. (BMNH); United Provinces, Naini Tal.,

6500 ft., 1 May 1934 (1m), 2 May 1934 (1f), 6550 ft., 3 May 1934 (1f), 6600 ft., 1 May 1934 (1m), 11 May 1934 (1f), on *Quercus incana*, em. 31 May 1934, 7100 ft., ex. larva on *Quercus sodilatata*, pupated 28 April 1934, em. 27 May 1934 (1f), J.A. Graham (BMNH); Khasia Hills (1m) (BMNH); Assam, Naga Hills, Kahima, 4600 ft., 1918 (1m), H.C. Tyller (BMNH); Simla Hills, 6500 ft., July 1930 (1f), A.E. Jones (BMNH); Khasis (1m), (BMNH); Mussoorie, 6500 ft., 27 June 1917 (1m), H.D. Peile (BMNH). MAYANMAR: Shan States, Maymyo, June–Aug. 1902 (2f), Hauxwell (BMNH). THAILAND: Bangkok (1m), E.M. Barnes.

OVIPOSITION

Unknown.

BIOLOGY AND BEHAVIOR

Specimens in the BMNH collection were reared from *Quercus incana* Bartr. and *Quercus dilatata* Lindl. (both Fagaceae) from United Provinces, Naini Tal, India.

PHEROMONAL COMMUNICATION

Unknown.

FLIGHT AND PHEROMONE PERIODICITY; SEASONALITY

Museum collection records suggest that *L. albolunulata* is univoltine with a single emergence occurring May–July.

DISCUSSION

The record from Bangkok, Thailand, seems out of place considering most others occurrences have been in the mountainous regions of northern India and southwestern China. Types of *L. elassa* and *L. albolunulata* were examined and we agree with Schintlmeister (2004) that they are synonyms. Schintlmeister (1989) speculated that this species may extend further east into southern China and Vietnam. Based on the larval rearing on *Quercus* spp. (Fagaceae) and museum host records, we expect *L. albolunulata* to inhabit oak or related deciduous forests.

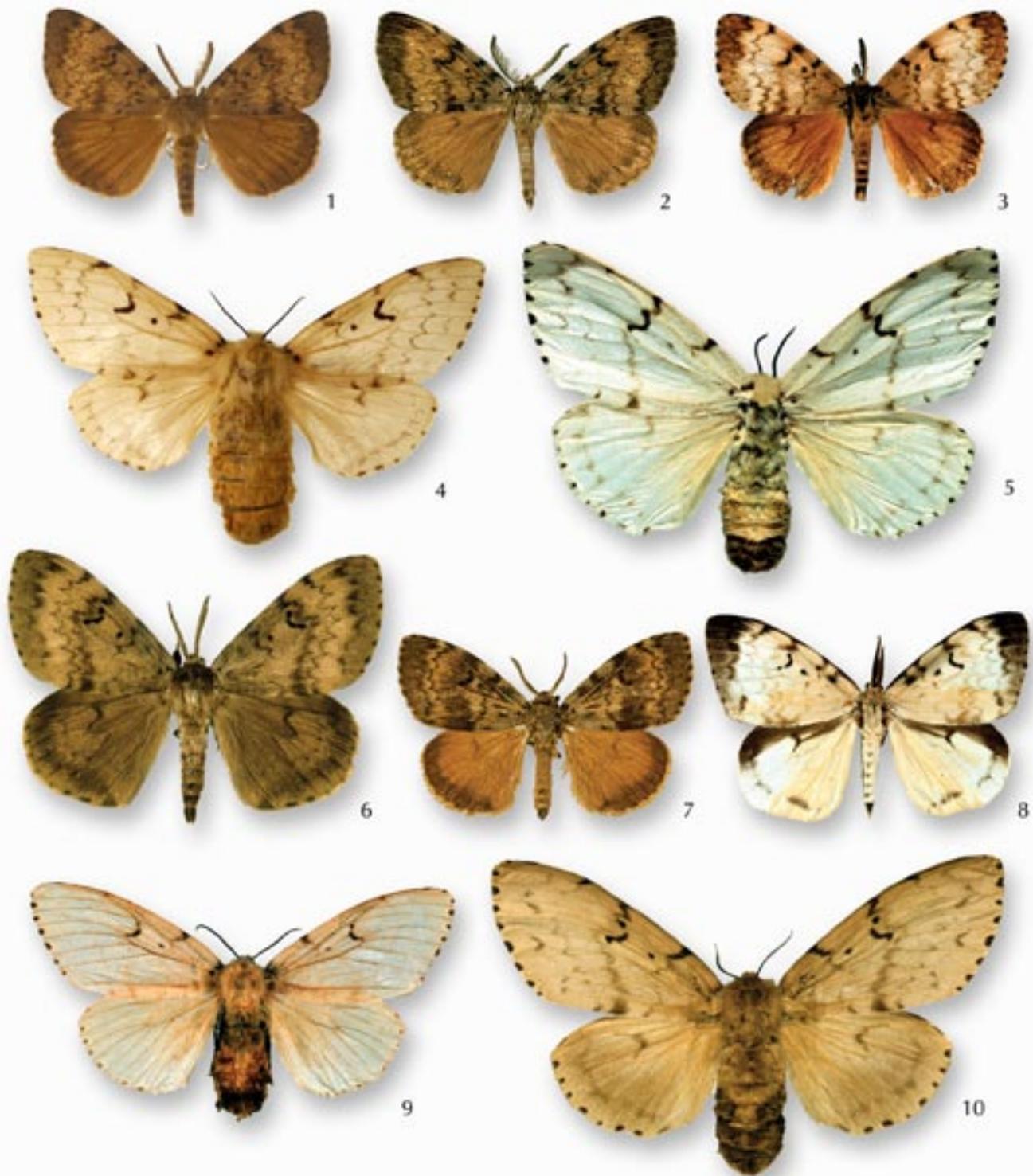


PLATE 1. ADULTS. **Fig. 1.** *Lymantria (Porthetria) dispar dispar*, male, USA, Maryland, Cecil Co., Pleasant Hill, 14-16 July 1989, W.E. Steiner & J.M. Swearingen (USNM). **Fig. 2.** *Lymantria (Porthetria) dispar asiatica*, male, China, Shantung, Tsingtao (BMNH). **Fig. 3.** *Lymantria (Porthetria) umbrosa*, male, Russia, Partisanskiye Region, Primorye Terr., 26.VI.1978, Y.A. Tshistjakov (BMNH). **Fig. 4.** *Lymantria (Porthetria) dispar dispar*, female, USA, New Hampshire, Portsmouth, July, Schaus & Barnes Coll. (USNM). **Fig. 5.** *Lymantria (Porthetria) dispar asiatica*, female, Russia, South Ussuri, Kedrovaja Pad, 16.VIII.1977, Mati Metsaviir (USNM). **Fig. 6.** *Lymantria (Porthetria) dispar japonica*, male, Japan, Bushi, Iruma City, Saitama-ken (BMNH). **Fig. 7.** *Lymantria (Porthetria) obfuscata*, male, India, Simla (BMNH). **Fig. 8.** *Lymantria (Porthetria) albescens*, male, Japan, Ishigaki Island, Ryukyu, 6.VI.1962, R. Kano (BMNH). **Fig. 9.** *Lymantria (Porthetria) umbrosa*, female, Japan, Nukabira, Hokkaido, 31.VII.1962, H. Ono (BMNH). **Fig. 10.** *Lymantria (Porthetria) dispar japonica*, female, Japan, Bushi, Iruma City, Saitama-ken, 11.VII.1977, H. Inoue (BMNH).



PLATE 2. ADULTS. **Fig. 1.** *Lymantria (Porthetria) obfuscata*, female, Lab reared from USDA, Otis Methods Development Center, MA, 1990 (USNM). **Fig. 2.** *Lymantria (Porthetria) albescens*, female, Japan, Ishigaki Island, S. Azuma (BMNH). **Fig. 3.** *Lymantria (Porthetria) postalba*, male, Japan, Meshima, Danjyo-gunto, 4-8.VIII.1972, A. Miyata (BMNH). **Fig. 4.** *Lymantria (Porthetria) postalba* (melanic form), male, Japan, Mataguchi, Owase City, Miye Prefecture, 14.VIII.1980, M. Sakabe (BMNH). **Fig. 5.** *Lymantria (Porthetria) apicebrunnea*, male, China, Yunnan, B.P. Clark donor (USNM). **Fig. 6.** *Lymantria (Porthetria) postalba*, female, Japan, Shuri, Okinawa Island, 15.VI.1968, M. Kinjo (BMNH). **Fig. 7.** *Lymantria (Porthetria) apicebrunnea*, female, China, Yunnan, B.P. Clark donor (USNM). **Fig. 8.** *Lymantria (Porthetria) apicebrunnea*, male, China, Ta-tsein-lou, 1910, Oberthür Coll. (BMNH). **Fig. 9.** *Lymantria (Porthetria) brunneoloma*, male, Holotype, China, Yunnan, B. P. Clark, Donor, USNM genitalia Slide 59201 (USNM). **Fig. 10.** *Lymantria (Porthetria) xylina*, male, Locality unknown.



PLATE 3. ADULTS. **Fig. 1.** *Lymantria (Porthetria) detersa*, male, India, Poona, at light, 8.IX.1942, J.A. Graham (BMNH). **Fig. 2.** *Lymantria (Porthetria) lunata*, male, Philippine Islands, Surigao, Mindanao, Nov., B.P. Clark donor (USNM). **Fig. 3.** *Lymantria (Porthetria) brotea*, male, India, Assam, Margherita, 1888, Holland collection (CMP). **Fig. 4.** *Lymantria (Porthetria) lunata*, female, Philippine Islands, Bangui, Luzon, Jan. 1918, B.P. Clark donor (USNM). **Fig. 5.** *Lymantria (Porthetria) detersa*, female, India, Poona, 11.83, Swinhoe Coll. (BMNH). **Fig. 6.** *Lymantria (Porthetria) xyliina*, female, Locality unknown. **Fig. 7.** *Lymantria (Lymantria) pulverea*, male, Taiwan, R.O.C., FuShan, 18 May 1994, P.W. Schaefer, at lights (USNM) (Paratype). **Fig. 8.** *Lymantria (Lymantria) minomonis*, Holotype, Japan, (Matsumura Collection) (HUS). **Fig. 9.** *Lymantria (Lymantria) monacha*, male, Japan, Mitsuminesan, 900 m, Saitama Prefecture, 26.VIII.1984, H. Inoue (BMNH). **Fig. 10.** *Lymantria (Lymantria) monacha*, female, Japan, Kurio, Yakushima Island, 1.VIII.74, T. Watanabe (BMNH). **Fig. 11.** *Lymantria (Lymantria) minomonis*, female, Japan, Yakushima Island, (Okawa-rindo), 12.IX.72, T. Watanabe (BMNH). **Fig. 12.** *Lymantria (Lymantria) concolor*, male, Taiwan, Luoying Lodge, 2800 m, Hualien Hsien, Mt. Houhuan-shan, 2.III.1990, A. Kawabe (BMNH). **Fig. 13.** *Lymantria (Lymantria) umbriifera*, male, Taiwan, 15 Oct. 1976 (PWS). **Fig. 14.** *Lymantria (Lymantria) dissoluta*, male, China, Lofaoshan Prov., Kwantung, 15.V (BMNH).



PLATE 4. ADULTS. **Fig. 1.** *Lymantria (Lymantria) sinica*, male, Taiwan, Chihpen Spa, 200 m, Taitung Hsien, 28.VI.1984, A. Kawabe (BMNH). **Fig. 2.** *Lymantria (Lymantria) lucescens*, male, Japan, Aokicho, Toyota City, Aichi Prefecture, 16.VIII.1986, B. Tanaka. **Fig. 3.** *Lymantria (Beatia) marginata*, male, Java, Tjibodas, Mt. Gede, Aug. 25, Bryant & Palmer Coll. (BMNH). **Fig. 4.** *Lymantria (Lymantria) concolor*, female, Taiwan, Lushan Spa, 1200 m, Nantou Hsien, 7-9.XI.1983, K. Yazaki (BMNH). **Fig. 5.** *Lymantria (Lymantria) umbrifera*, female, Taiwan, 29 Nov. 1975 (PWS). **Fig. 6.** *Lymantria (Lymantria) dissoluta*, female, China, Kowloon, Nov. 1911, E. Wahr, Rothchild Coll. (BMNH). **Fig. 7.** *Lymantria (Lymantria) sinica*, female, Taiwan, Nantou Hsien, Nanshanchi, 25-26.VII.1983, A. Kawabe (BMNH). **Fig. 8.** *Lymantria (Lymantria) lucescens*, female, Japan, Aokicho, Toyota City, Aichi Prefecture, 21.VII.1985, B. Tanaka (BMNH). **Fig. 9.** *Lymantria (Beatia) marginata*, female, China, Nord Yunnan, Li-kiang, ca 2000 m, 24.IX.1934, H. Hne, (BONN). **Fig. 10.** *Lymantria (Beatia) atemeles*, male, Thailand, CRC, Kampaeng Sean, r BIRL # 2-2003 on mango leaves, Paul W. Schaefer, (PWS). **Fig. 11.** *Lymantria (Nyctria) mathura*, male, Nepal, Katmandu Valley, Godavari, 1500 m, 26.V.1992, H. Schmitzler (MAKB). **Fig. 12.** *Lymantria (Nyctria) flavida*, male, Japan, Okinawa, Hentona, ova coll. By Norio Arakaki, r. BIRL as # 5-2000 on *Quercus*, ex GH, Paul W. Schaefer (PWS) (Paratype). **Fig. 13.** *Lymantria (Collentria) grisea*, male, China, Mong Po, 4,000' (BMNH). **Fig. 14.** *Lymantria (Collentria) fumida*, male, Japan, Takao san, 15.VII.1954, H. Inoue (BMNH). **Fig. 15.** *Lymantria (Spinotria) serva*, male, China, Prov. Yunnan, Li-Kiang, ca 3000 m, 6.VII.1935, H. Hne. (MAKB).



PLATE 5. ADULTS. **Fig. 1.** *Lymantria (Beatritia) atemeles*, female, Thailand, CRC, Kampaeng Saen, r BIRL # 202003 on mango leaves, Paul W. Schaefer (PWS). **Fig. 2.** *Lymantria (Nyctria) mathura*, female, China, Yunnan, B.P. Clark donor (USNM). **Fig. 3.** *Lymantria (Nyctria) flavida*, female, Japan, Okinawa, nr Hiji Falls, 16 May 2003, Coll. Late larva, r BIRL on *Quercus*, Paul W. Schaefer (PWS). **Fig. 4.** *Lymantria (Collentria) grisea*, female, India, Gopaldhara, Darjeeling, 4720', viii.1918, H. Stevens (BMNH). **Fig. 5.** *Lymantria (Collentria) fumida*, female, Japan, Ueda, Honshu, reared May 1979, P. Schaefer (PWS). **Fig. 6.** *Lymantria (Spinotria) serva*, female, Nepal, Katmandu Valley, Godavari Phulchoki, 2600 m, 7-10.VI.1988, Schnitzler (MAKB). **Fig. 7.** *Lymantria (Spinotria) laszloronkayi*, male, China, Prov. Nord-Yuennan, Li-kiang ca. 3000 m, 23.vii.1934, H. Hne. (BMNH). **Fig. 8.** *Lymantria (Spinotria) hreblayi*, male, China, Prov. Nord-Yuennan, Li-kiang, ca 3000 m, 6.vii.1935, H. Hne., MGP genitalia slide 1197 (BMNH). **Fig. 9.** *Lymantria (Spinotria) iris*, male, Taiwan (Formosa), Anping, IV.1912, H. Sauter (BMNH). **Fig. 10.** *Lymantria (Spinotria) bantaizana*, male, Japan, Naka-Karuizawa, Nagano Prefecture, 4-6.VIII.1962, T. Mainami (BMNH). **Fig. 11.** *Lymantria (Spinotria) albolutulata*, male, India, Dalhousie, Harford coll., VII.91 (BMNH). **Fig. 12.** *Lymantria (Spinotria) iris*, female, China, Tuyen Quang, Cochin, V.1936, S. Masseyeff (BMNH).

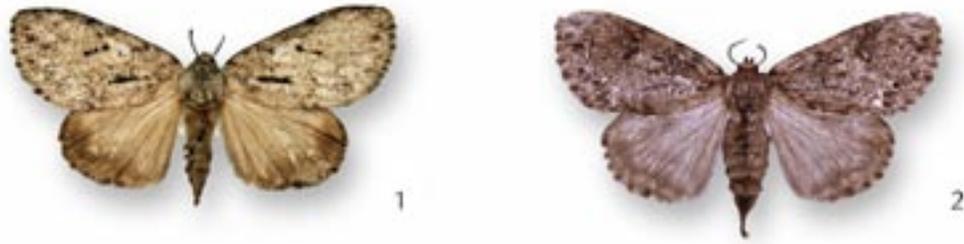


PLATE 6. ADULTS. Fig. 1. *Lymantria (Spinotria) bantaizana*, female, Japan, Takao-san, 7.VIII.1928 (PWS). Fig. 2. *Lymantria (Spinotria) albolunulata*, female, India, Dalhousie, Harford coll. (BMNH).

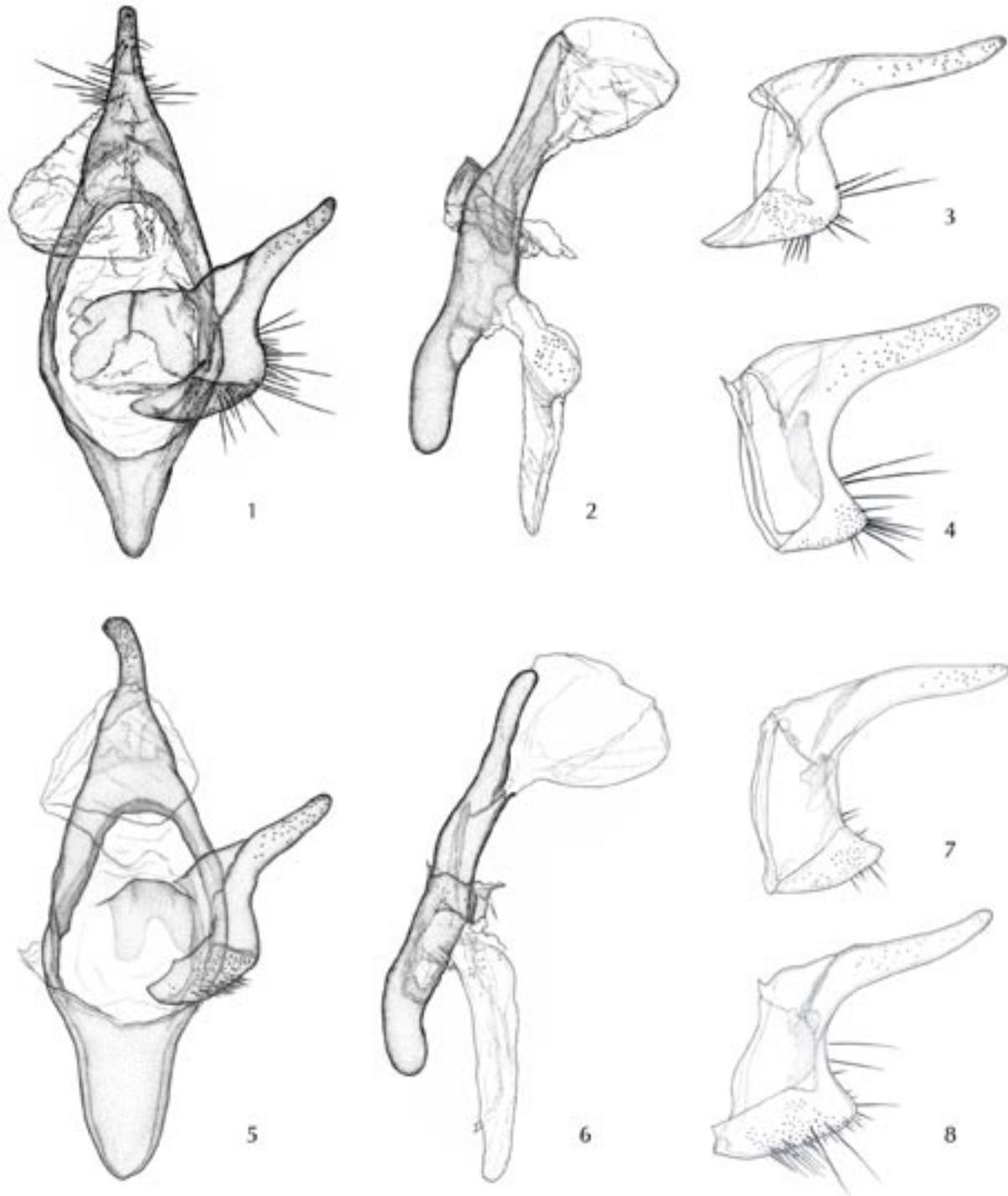


PLATE 7. MALE GENITALIA. *Lymantria (Porthetria) dispar dispar*. **Fig. 1.** Genital capsule, USA, Maryland, Montgomery Co., genitalia slide USNM 59088. **Fig. 2.** Aedeagus genitalia slide USNM 59088. **Fig. 3.** Valve, France, genitalia slide USNM 57648. **Fig. 4.** Valve, Sardinia, genitalia slide USNM 59165. **Fig. 5.** Genital capsule, USA, New Hampshire, Portsmouth, genitalia slide USNM 59097. **Fig. 6.** Aedeagus genitalia slide USNM 59097. **Fig. 7.** Valve, Russia, genitalia slide USNM 59150. **Fig. 8.** Valve, Baskin, Kazakhstan, Altai Territory, genitalia slide USNM 59193.

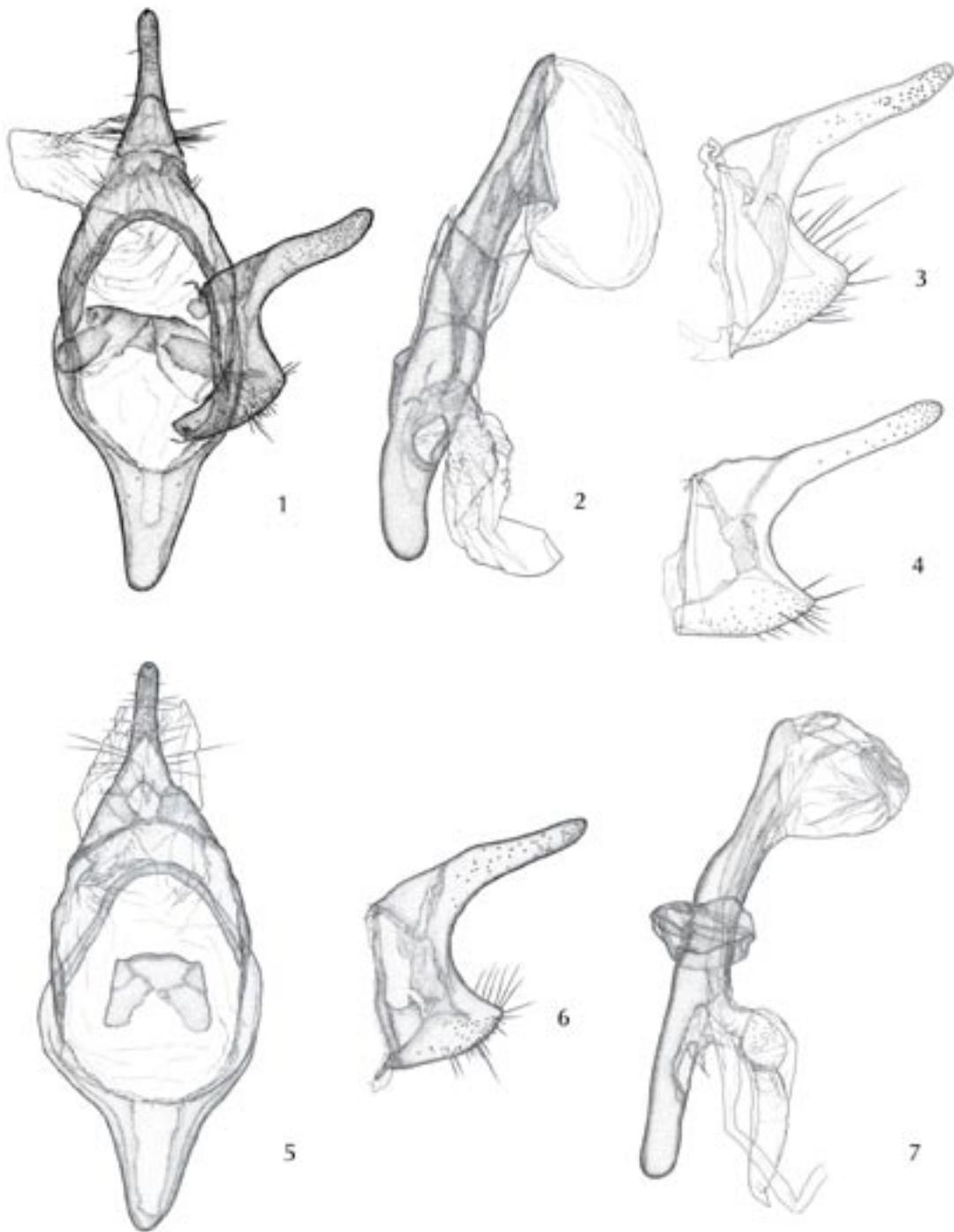


PLATE 8. MALE GENITALIA. *Lymantria (Porthetria) dispar asiatica*. **Fig. 1.** Genital capsule, Eastern Asia, genitalia slide USNM 57645. **Fig. 2.** Aedeagus, genitalia slide USNM 57645. **Fig. 3.** Valve, Korea, genitalia slide USNM 59163. **Fig. 4.** Valve, China, Yachou, genitalia slide USNM 59195. **Fig. 5.** Genital capsule, China, Liaoning Prov., Shenyang, genitalia slide USNM 59160. **Fig. 6.** Valve, genitalia slide USNM 59160. **Fig. 7.** Aedeagus genitalia slide USNM 59160.

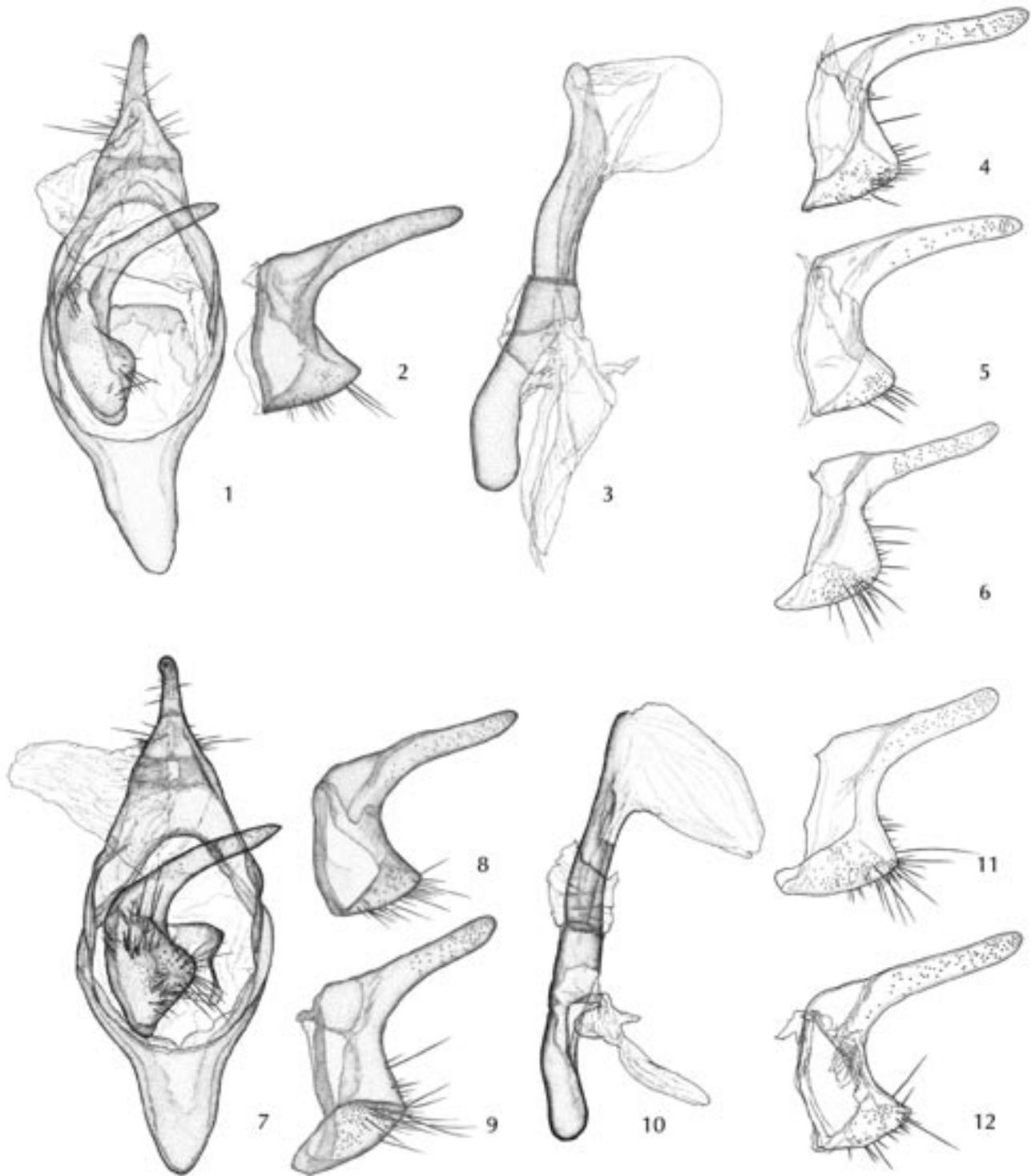


PLATE 9. MALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) umbrosa*, genital capsule, Japan, Hokkaido, genitalia slide USNM 59152. **Fig. 2.** *Lymantria (Porthetria) umbrosa*, valve, genitalia slide USNM 59152. **Fig. 3.** *Lymantria (Porthetria) umbrosa*, aedeagus, genitalia slide USNM 59152. **Fig. 4.** *Lymantria (Porthetria) umbrosa*, valve, Japan, Hokkaido, genitalia slide USNM 59181. **Fig. 5.** *Lymantria (Porthetria) umbrosa*, valve, Japan, Hokkaido, genitalia slide USNM 59151. **Fig. 6.** *Lymantria (Porthetria) umbrosa*, valve, Japan, Hokkaido, genitalia slide USNM 59153. **Fig. 7.** *Lymantria (Porthetria) dispar japonica*, genital capsule, Japan, Kukisaki, Ibaraki, genitalia slide USNM 59155. **Fig. 8.** *Lymantria (Porthetria) dispar japonica*, valve, genitalia slide USNM 59155. **Fig. 9.** *Lymantria (Porthetria) dispar japonica*, valve, Japan, Honshu, genitalia slide USNM 58267. **Fig. 10.** *Lymantria (Porthetria) dispar japonica*, aedeagus, Japan, Honshu, USNM 58867. **Fig. 11.** *Lymantria (Porthetria) dispar japonica*, valve, Japan, Jizu, genitalia slide USNM 59119. **Fig. 12.** *Lymantria (Porthetria) dispar japonica*, valve, Japan, genitalia slide USNM 59118.



PLATE 10. MALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) obfuscata*, genital capsule, India, Solan, genitalia slide USNM 59198. **Fig. 2.** *Lymantria (Porthetria) obfuscata*, valve, genitalia slide USNM 59198. **Fig. 3.** *Lymantria (Porthetria) obfuscata*, aedoeagus, India, Kashmir, genitalia slide USNM 59111. **Fig. 4.** *Lymantria (Porthetria) albescens*, genital capsule, Japan, Ryukyu Is., genitalia slide USNM 59192. **Fig. 5.** *Lymantria (Porthetria) postalba*, valve, Japan, genitalia slide USNM 59191. **Fig. 6.** *Lymantria (Porthetria) albescens*, valve, Japan, genitalia slide USNM 59192. **Fig. 7.** *Lymantria (Porthetria) albescens*, aedoeagus, genitalia slide USNM 59192.

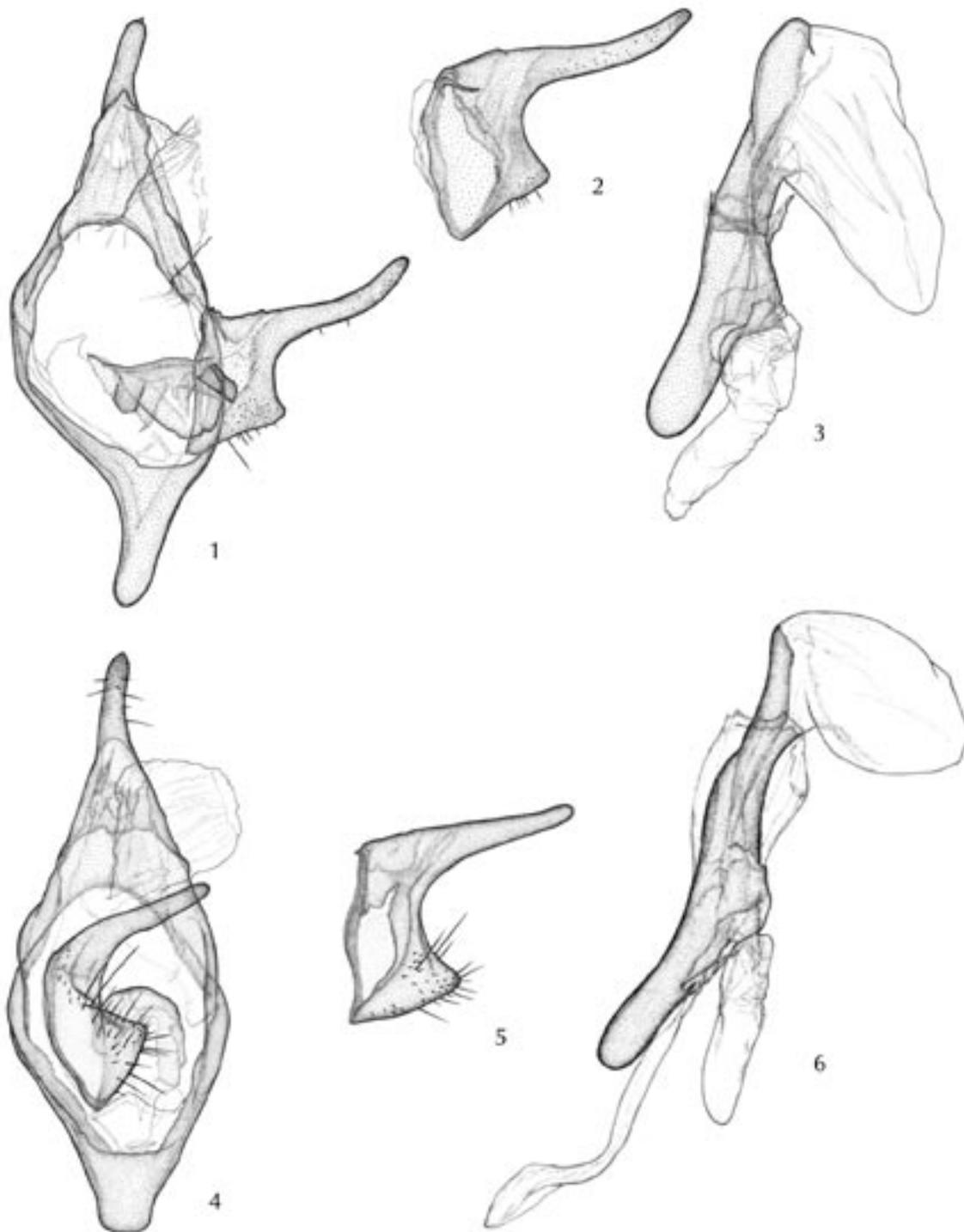


PLATE 11. MALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) apicebrunnea*, genital capsule, China, Yunnan, genitalia slide USNM 59188. **Fig. 2.** *Lymantria (Porthetria) apicebrunnea*, valve genitalia slide USNM 59188. **Fig. 3.** *Lymantria (Porthetria) apicebrunnea*, aedeagus, genitalia slide USNM 59188. **Fig. 4.** *Lymantria (Porthetria) brunneoloma*, genital capsule, China, Yunnan, genitalia slide USNM 59141). **Fig. 5.** *Lymantria (Porthetria) brunneoloma*, valve, China, Yunnan, genitalia slide USNM 59201. **Fig. 6.** *Lymantria (Porthetria) brunneoloma*, aedeagus, China, Yunnan, genitalia slide USNM 59141.

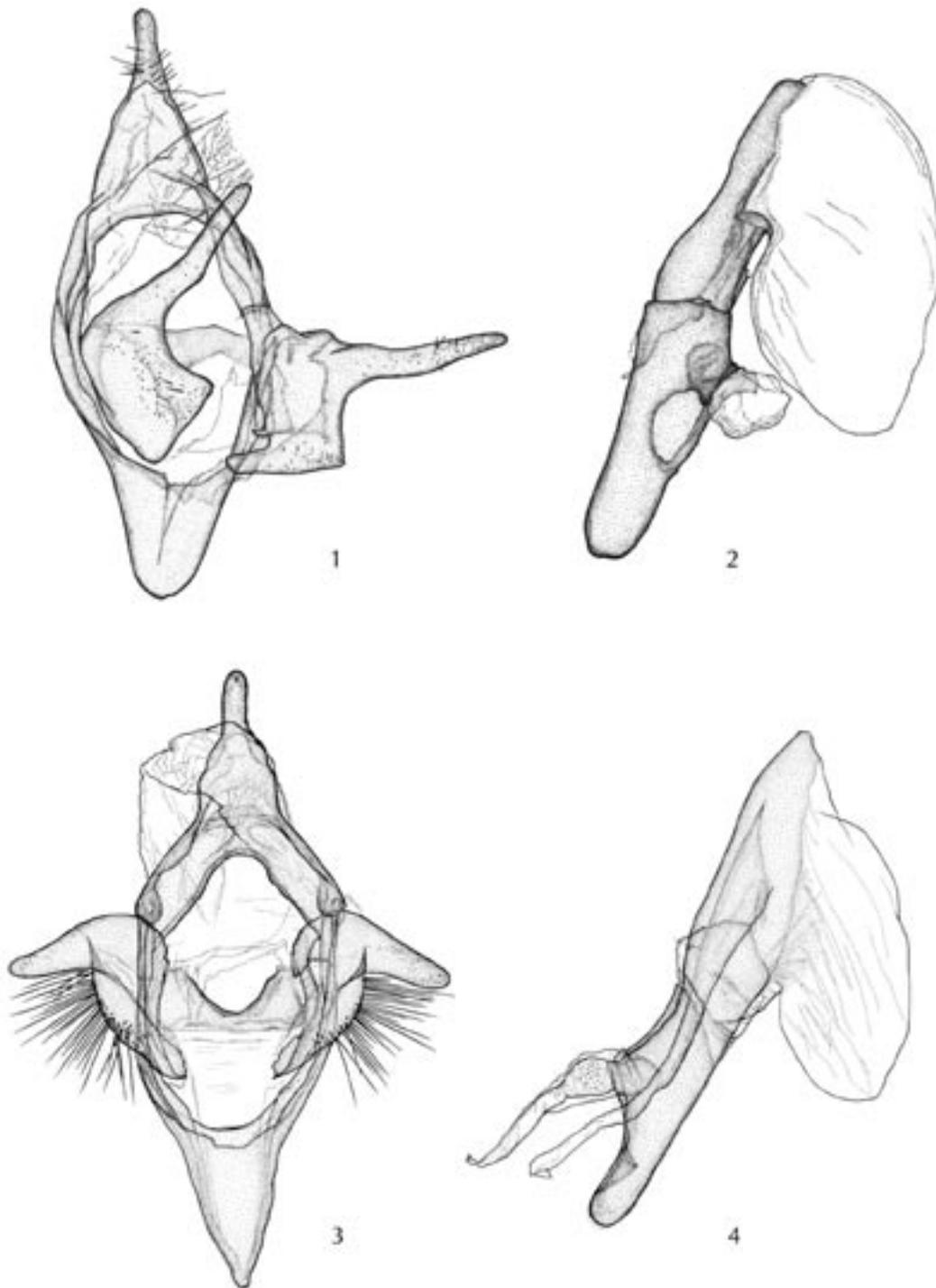


PLATE 12. MALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) xyliana*, genital capsule, Taiwan, genitalia slide USNM 58954. **Fig. 2.** *Lymantria (Porthetria) xyliana*, aedoeagus, genitalia slide USNM 58954. **Fig. 3.** *Lymantria (Porthetria) detersa*, genital capsule, India, genitalia slide USNM 59174 (BMNH). **Fig. 4.** *Lymantria (Porthetria) detersa*, aedoeagus, genitalia slide USNM 59174 (BMNH).

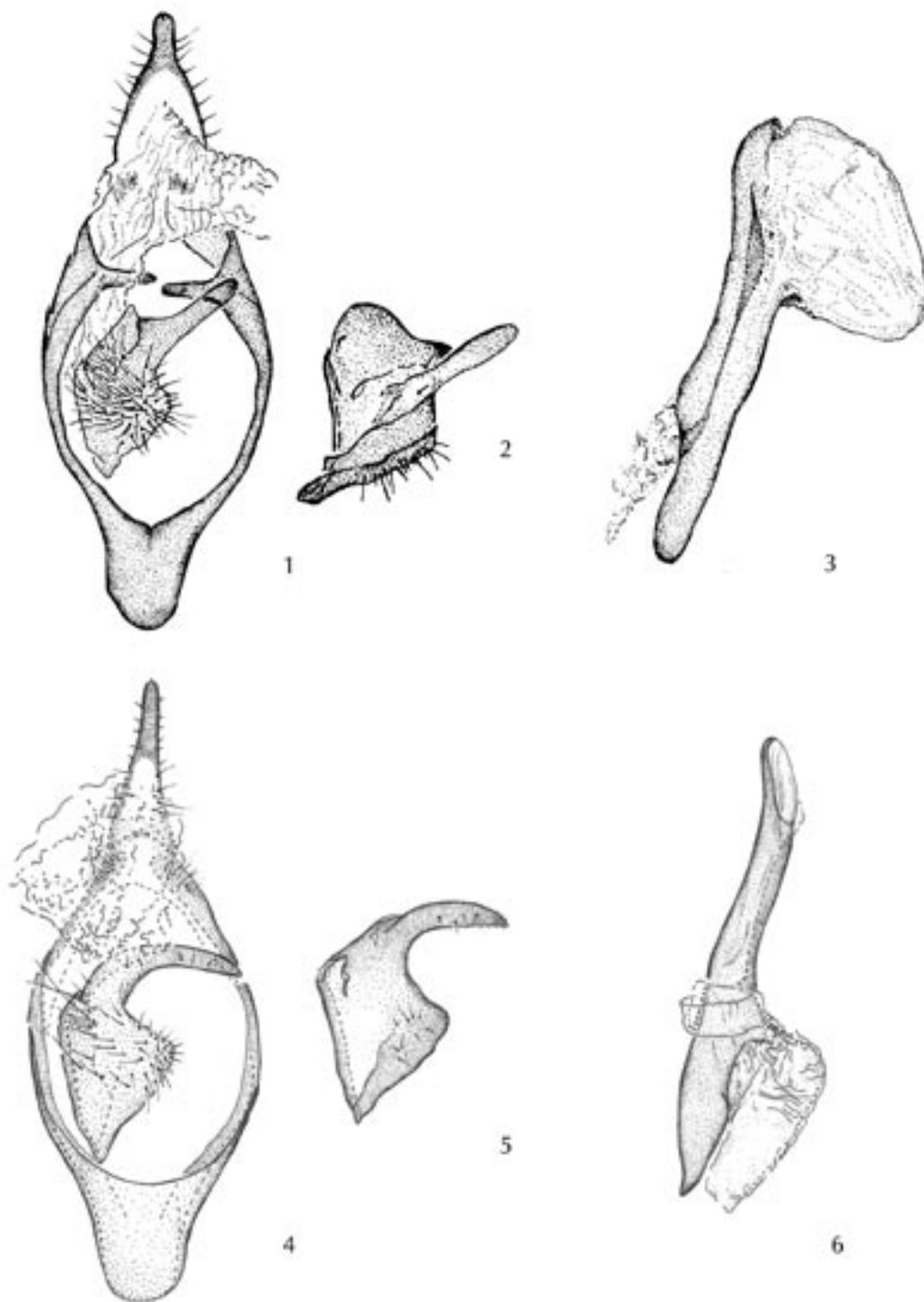


PLATE 13. MALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) lunata*, genital capsule, Philippines, Mindanao, genitalia slide USNM 59132. **Fig. 2.** *Lymantria (Porthetria) lunata*, valve, genitalia slide USNM 59132. **Fig. 3.** *Lymantria (Porthetria) lunata*, aedeagus, genitalia slide USNM 59132. **Fig. 4.** *Lymantria (Porthetria) brotea*, genital capsule, Sumatra, Darat, genitalia slide USNM 59125. **Fig. 5.** *Lymantria (Porthetria) brotea*, valve, genitalia slide USNM 59125. **Fig. 6.** *Lymantria (Porthetria) brotea*, aedeagus, genitalia slide USNM 59125.

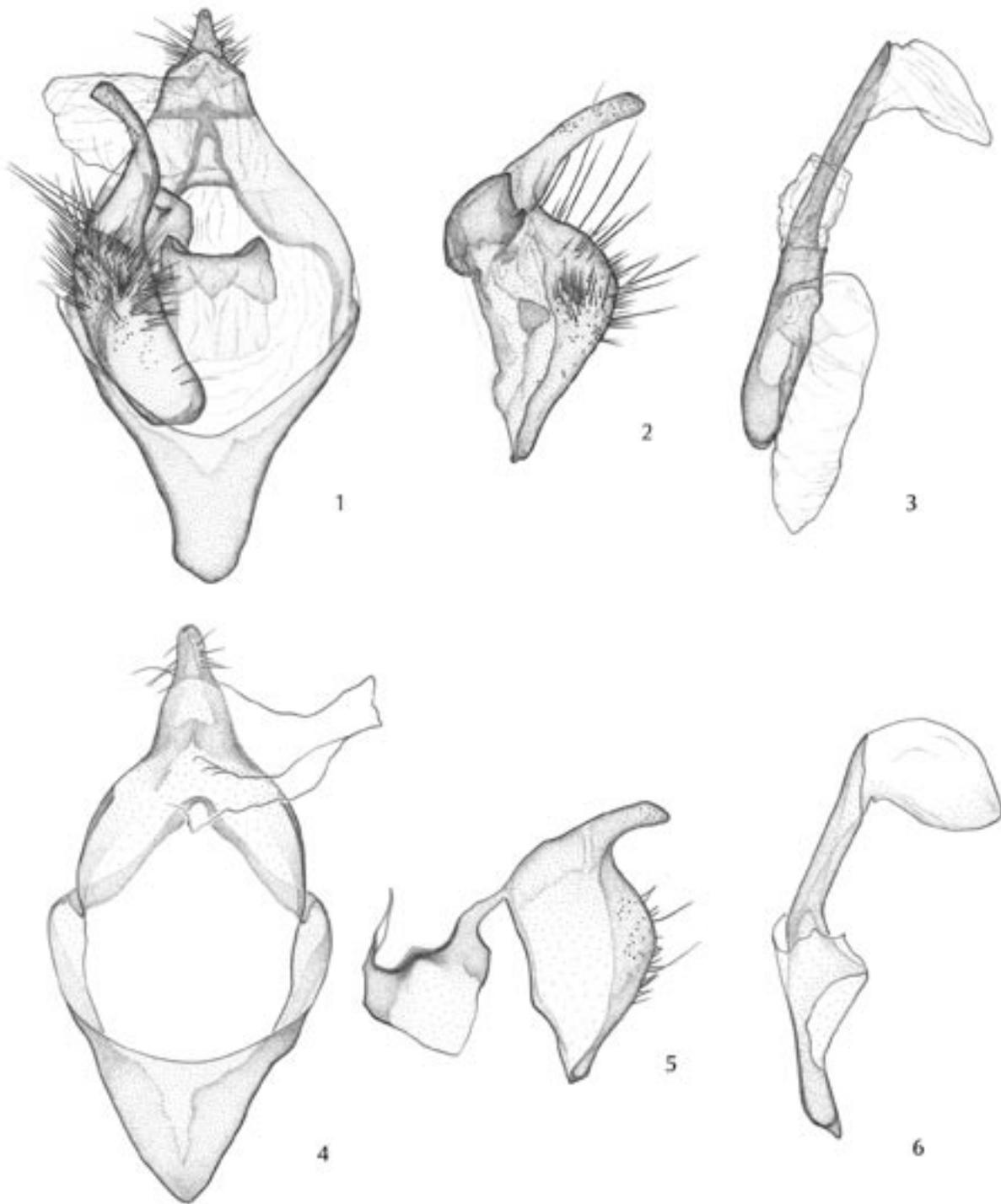


PLATE 14. MALE GENITALIA. **Fig. 1.** *Lymantria (Lymantria) monacha*, genital capsule, No data, genitalia slide USNM 59108. **Fig. 2.** *Lymantria (Lymantria) monacha*, valve, Sweden, genitalia slide USNM 58968. **Fig. 3.** *Lymantria (Lymantria) monacha*, aedeagus, genitalia slide USNM 58968. **Fig. 4.** *Lymantria (Lymantria) pulverea*, genital capsule, Taiwan, Tayuling, genitalia slide DCF 1647 (PWS). **Fig. 5.** *Lymantria (Lymantria) pulverea*, valve, genitalia slide DCF 1647 (PWS). **Fig. 6.** *Lymantria (Lymantria) pulverea*, aedeagus, genitalia slide DCF 1647 (PWS).

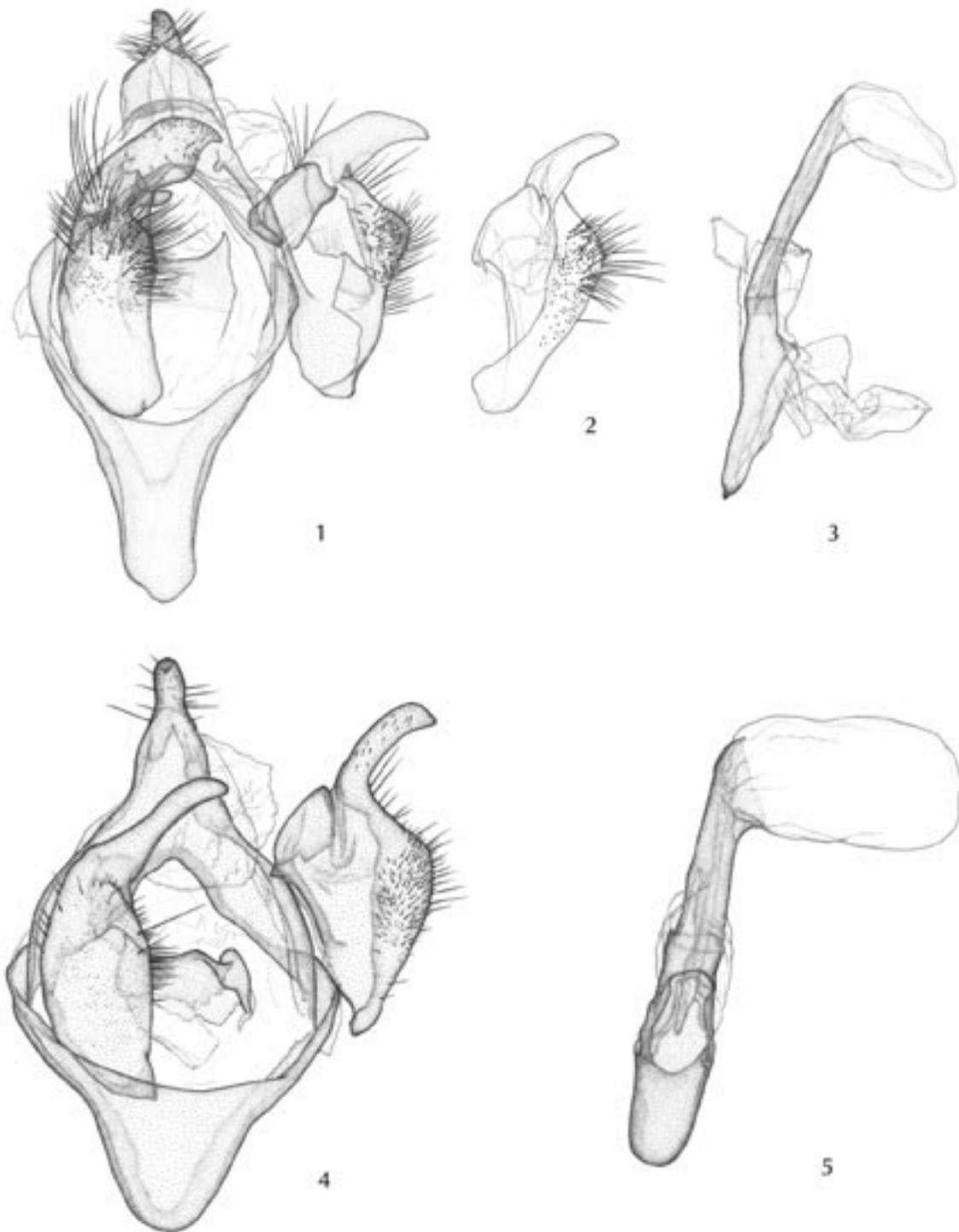


PLATE 15. MALE GENITALIA. **Fig. 1.** *Lymantria (Lymantria) minomonis*, genital capsule, Japan, Okinawa, genitalia slide DCF 1632 (BMNH). **Fig. 2.** *Lymantria (Lymantria) minomonis*, valve, genitalia slide DCF 1632 (BMNH). **Fig. 3.** *Lymantria (Lymantria) minomonis*, aedoeagus, genitalia slide DCF 1632 (BMNH). **Fig. 4.** *Lymantria (Lymantria) concolor*, genital capsule, Taiwan, genitalia slide USNM 58955. **Fig. 5.** *Lymantria (Lymantria) concolor*, aedoeagus, genitalia slide USNM 58955.

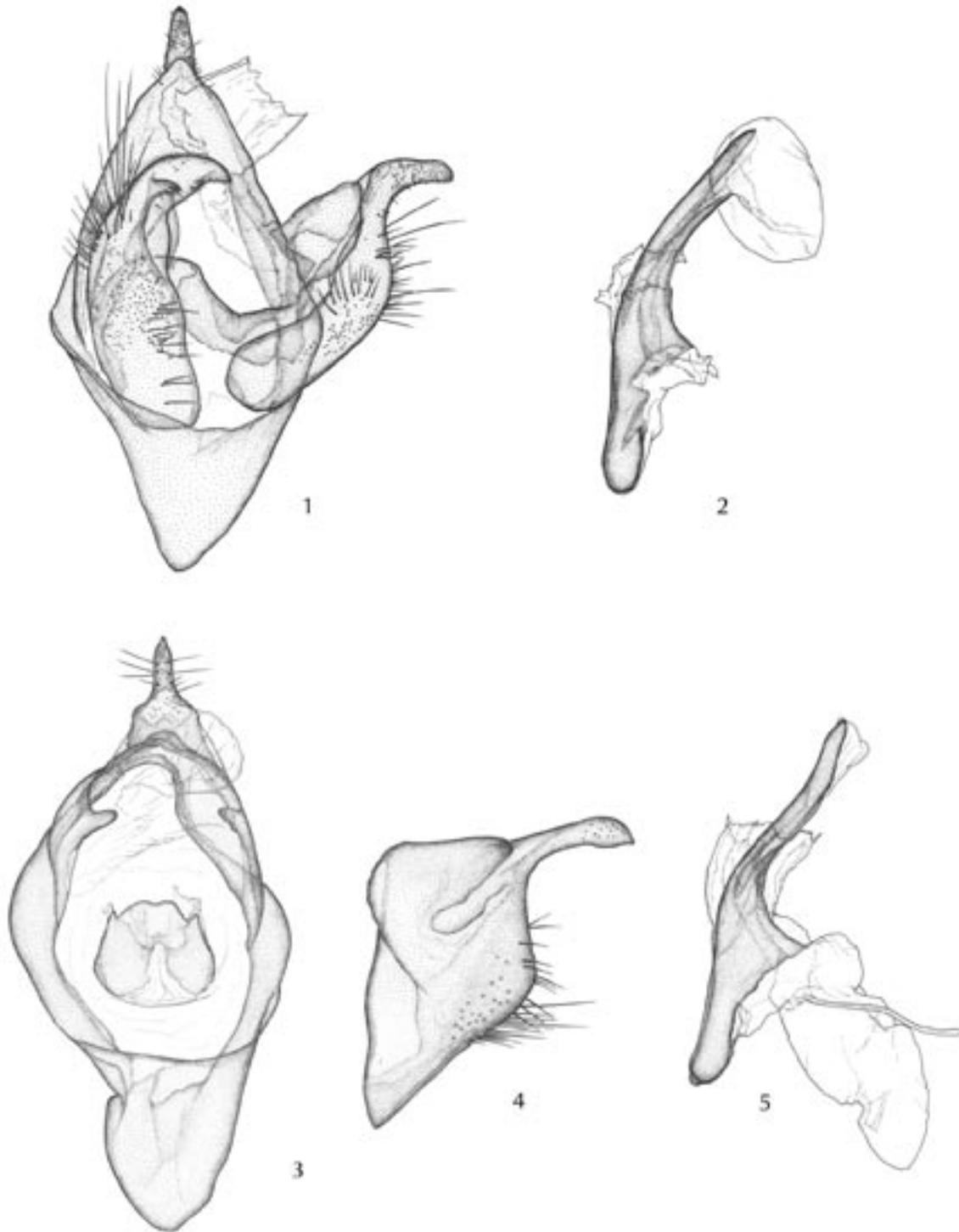


PLATE 16. MALE GENITALIA. Fig. 1. *Lymantria (Lymantria) umbrifera*, genital capsule, Taiwan, Rantaizan, genitalia slide DCF 1625 (BMNH). **Fig. 2.** *Lymantria (Lymantria) umbrifera*, aedoeagus, genitalia slide DCF 1625 (BMNH). **Fig. 3.** *Lymantria (Lymantria) dissoluta*, genital capsule, China, Hunan, genitalia slide USNM 59215. **Fig. 4.** *Lymantria (Lymantria) dissoluta*, valve, genitalia slide USNM 59215. **Fig. 5.** *Lymantria (Lymantria) dissoluta*, aedoeagus, genitalia slide USNM 59215.

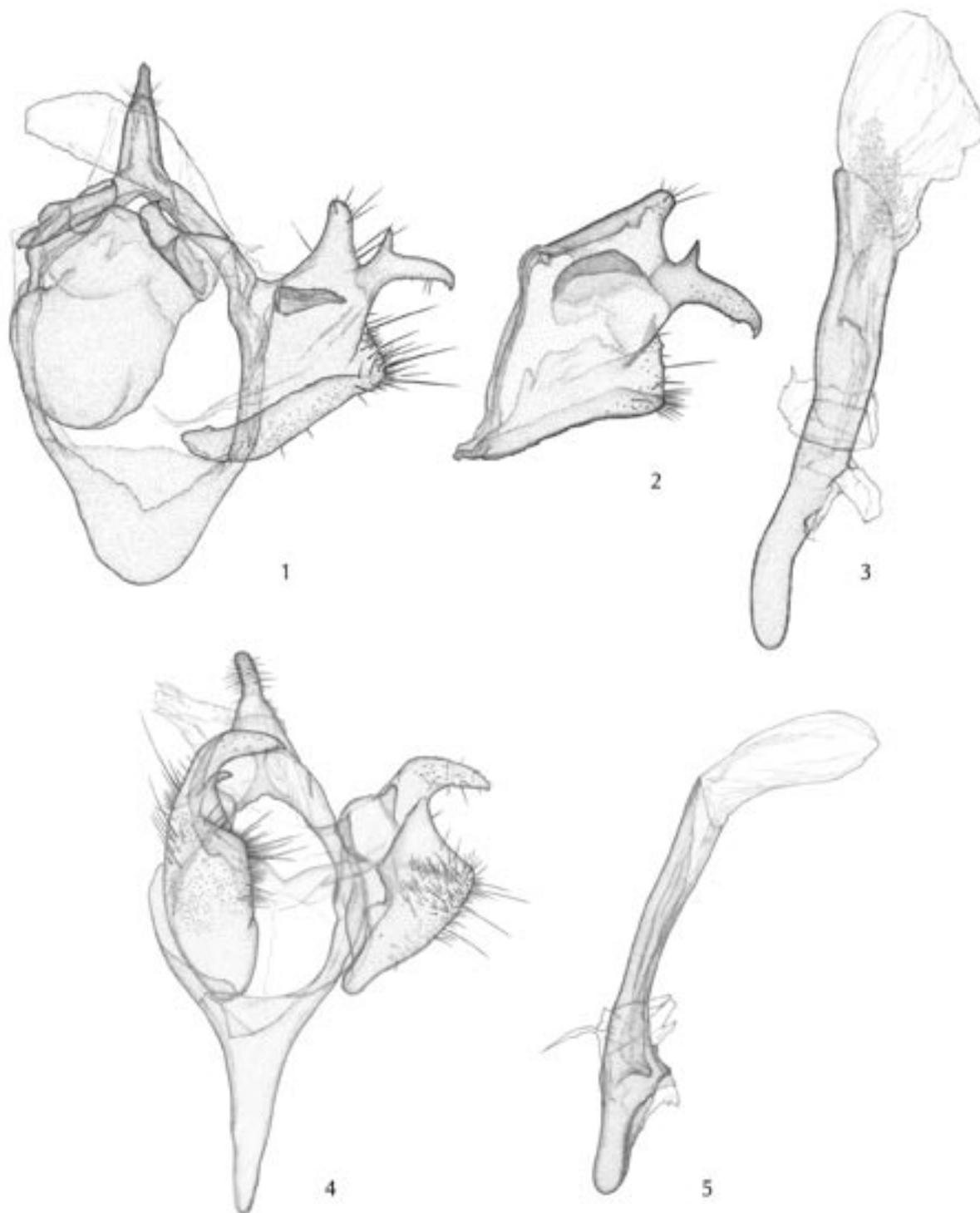


PLATE 17. MALE GENITALIA. **Fig. 1.** *Lymantria (Lymantria) sinica*, genital capsule, China, Nanking, Lungtan, genitalia slide DCF 1626 (BMNH). **Fig. 2.** *Lymantria (Lymantria) sinica*, valve, Holotype, N. China, genitalia slide DCF 1623 (BMNH). **Fig. 3.** *Lymantria (Lymantria) sinica*, aedoeagus, genitalia slide DCF 1626 (BMNH). **Fig. 4.** *Lymantria (Lymantria) lucescens*, genital capsule, Japan, Aichi Prefecture, Toyota City, genitalia slide DCF 1627 (BMNH). **Fig. 5.** *Lymantria (Lymantria) lucescens*, aedoeagus, genitalia slide DCF 1627 (BMNH).

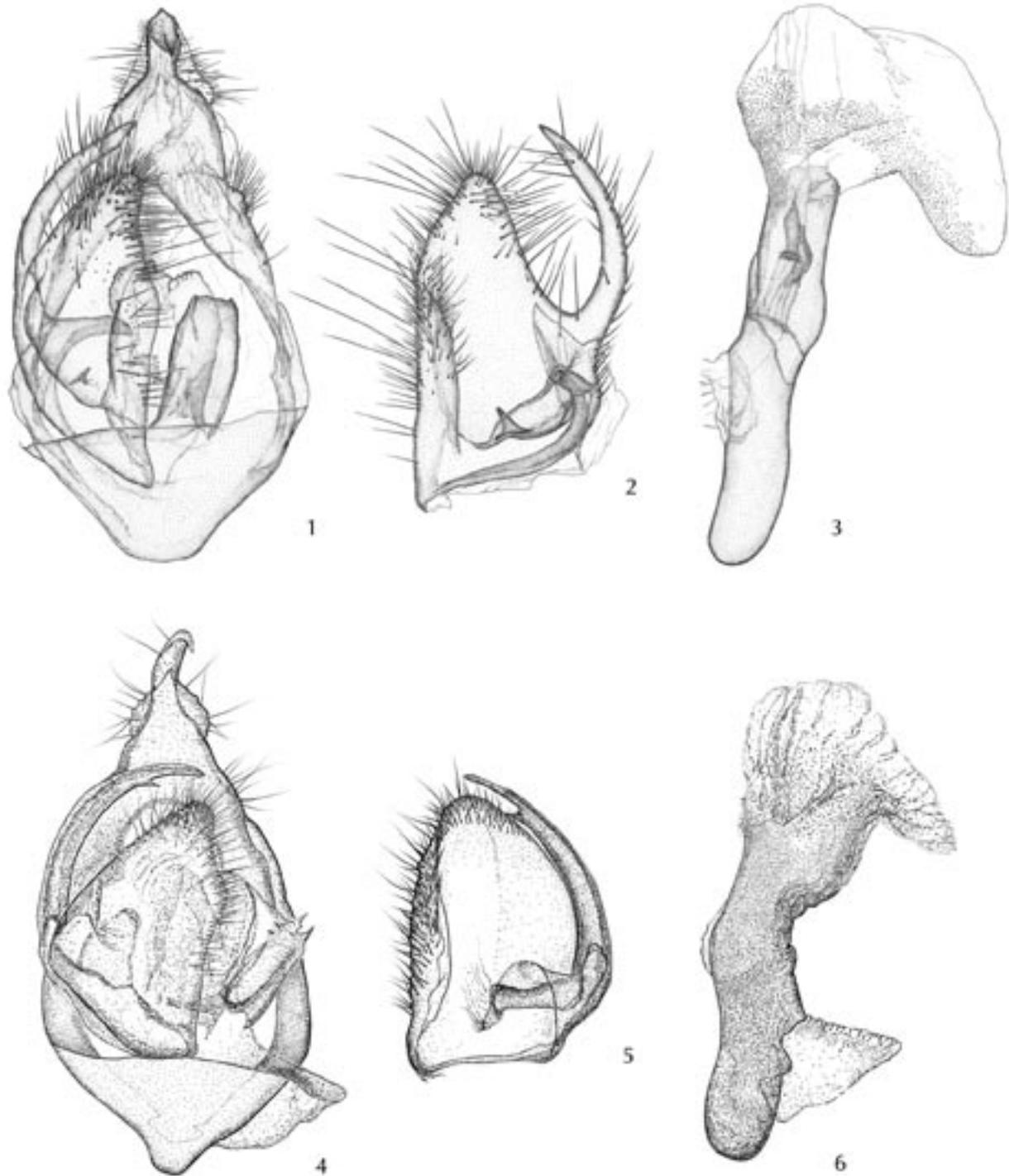


PLATE 18. MALE GENITALIA. **Fig. 1.** *Lymantria (Beatria) marginata*, genital capsule, China, Wangui, genitalia slide USNM 59145. **Fig. 2.** *Lymantria (Beatria) marginata*, valve, genitalia slide USNM 59145. **Fig. 3.** *Lymantria (Beatria) marginata*, aedeagus, genitalia slide USNM 59145. **Fig. 4.** *Lymantria (Beatria) atemeles*, genital capsule, Thailand, Kamphaeng Sean, Kasetsart University Campus, genitalia slide MGP 1178 (PWS). **Fig. 5.** *Lymantria (Beatria) atemeles*, valve, genitalia slide MGP 1178 (PWS). **Fig. 6.** *Lymantria (Beatria) atemeles*, aedeagus, genitalia slide MGP 1178 (PWS).

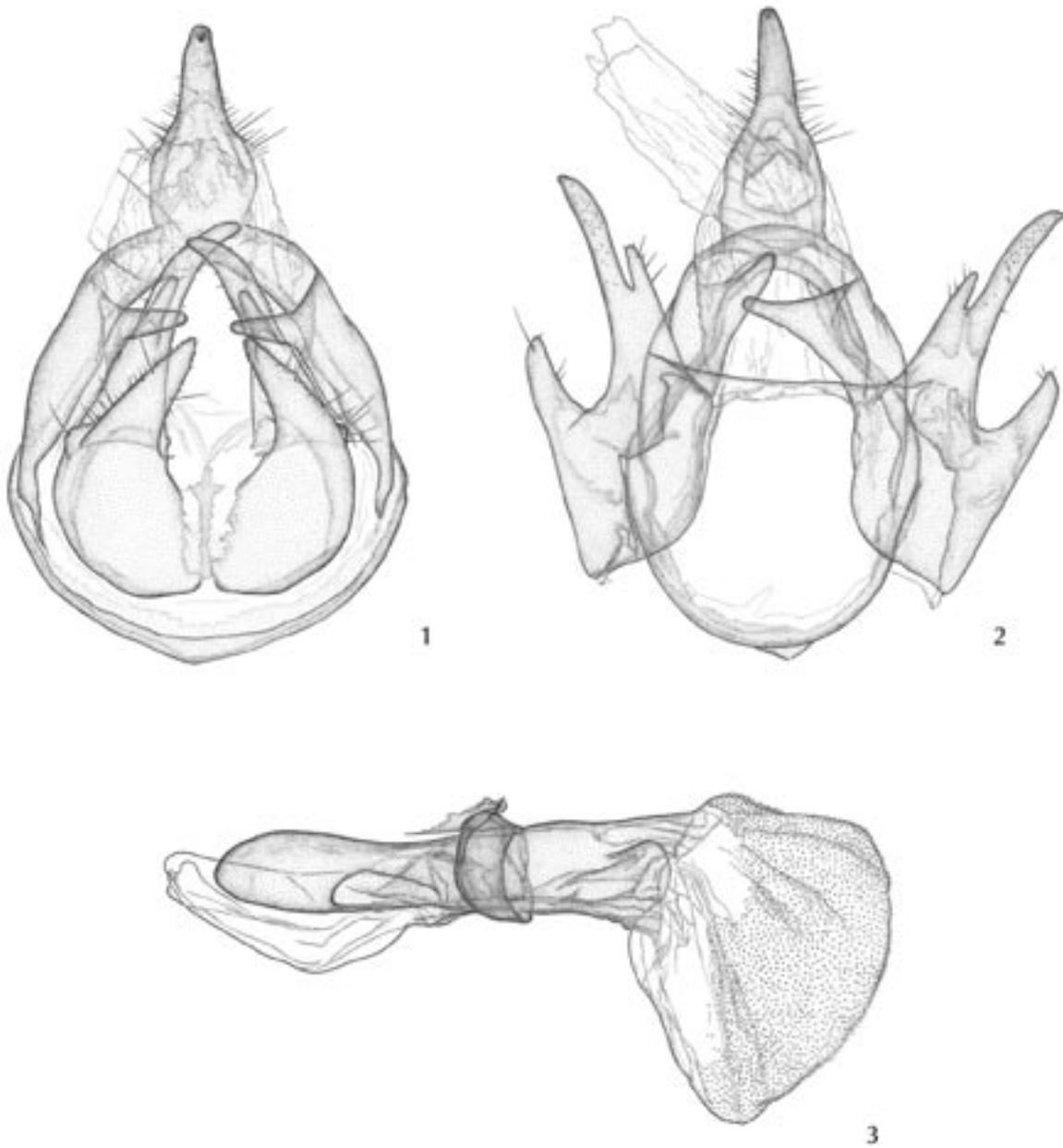


PLATE 19. MALE GENITALIA. *Lymantria (Nyctria) mathura*. **Fig. 1.** Genital capsule, Taiwan, genitalia slide USNM 59200. **Fig. 2.** Genital capsule, Russia, Siberia, Kongaus, genitalia slide USNM 58862. **Fig. 3.** Aedoeagus, genitalia slide USNM 59200.

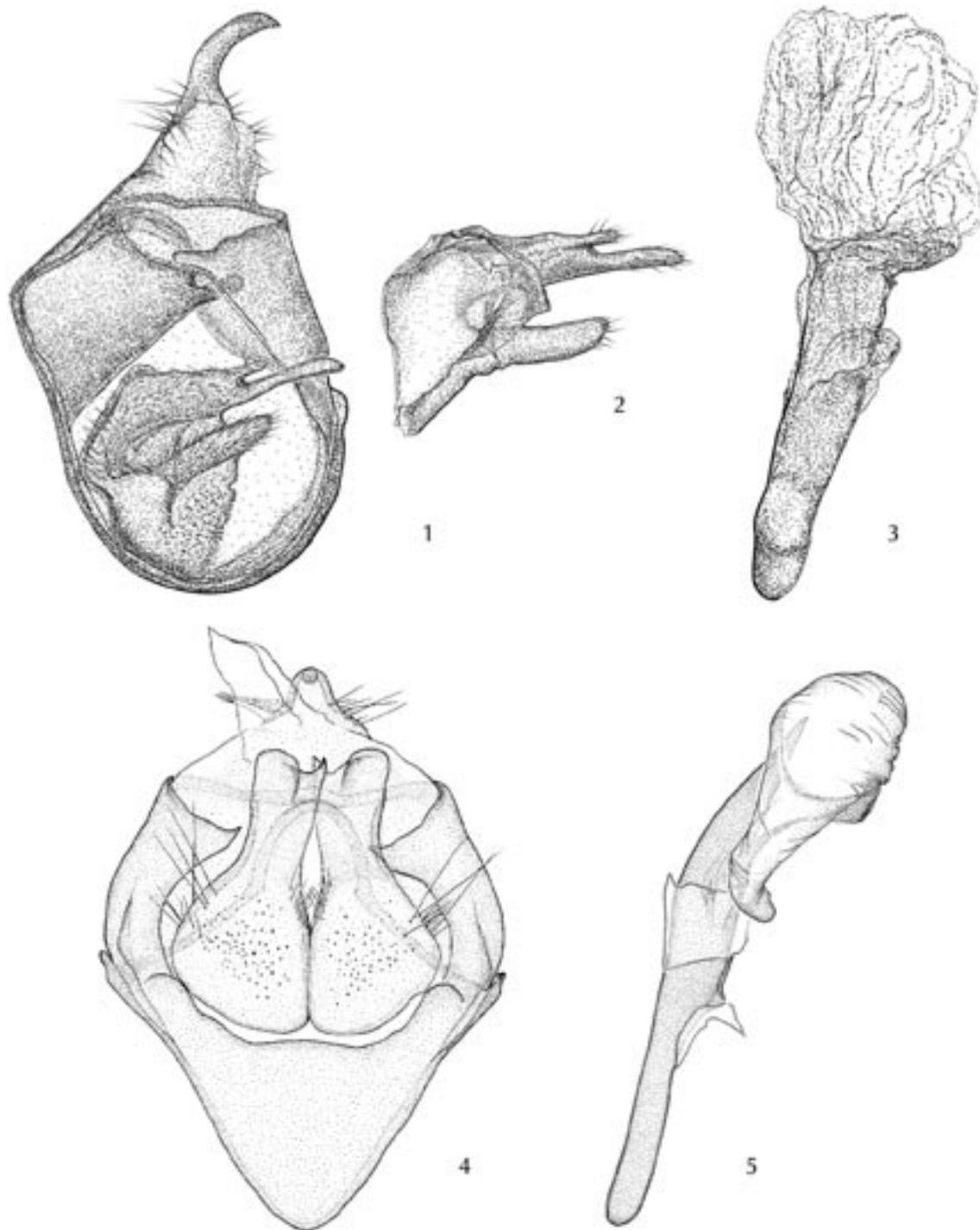


PLATE 20. MALE GENITALIA. **Fig. 1.** *Lymantria (Nyctria) flavida*, genital capsule, Japan, Okinawa, Hentona, genitalia slide MGP 1213 (PWS) (Paratype). **Fig. 2.** *Lymantria (Nyctria) flavida*, valve, genitalia slide MGP 1213 (PWS) (Paratype). **Fig. 3.** *Lymantria (Nyctria) flavida*, aedoeagus, genitalia slide MGP 1213 (PWS) (Paratype). **Fig. 4.** *Lymantria (Collentria) grisea*, genital capsule, China, N. Yunnan, Li-kiang, genitalia slide DCF 1646 (BMNH). **Fig. 5.** *Lymantria (Collentria) grisea*, aedoeagus, genitalia slide DCF 1646 (BMNH).

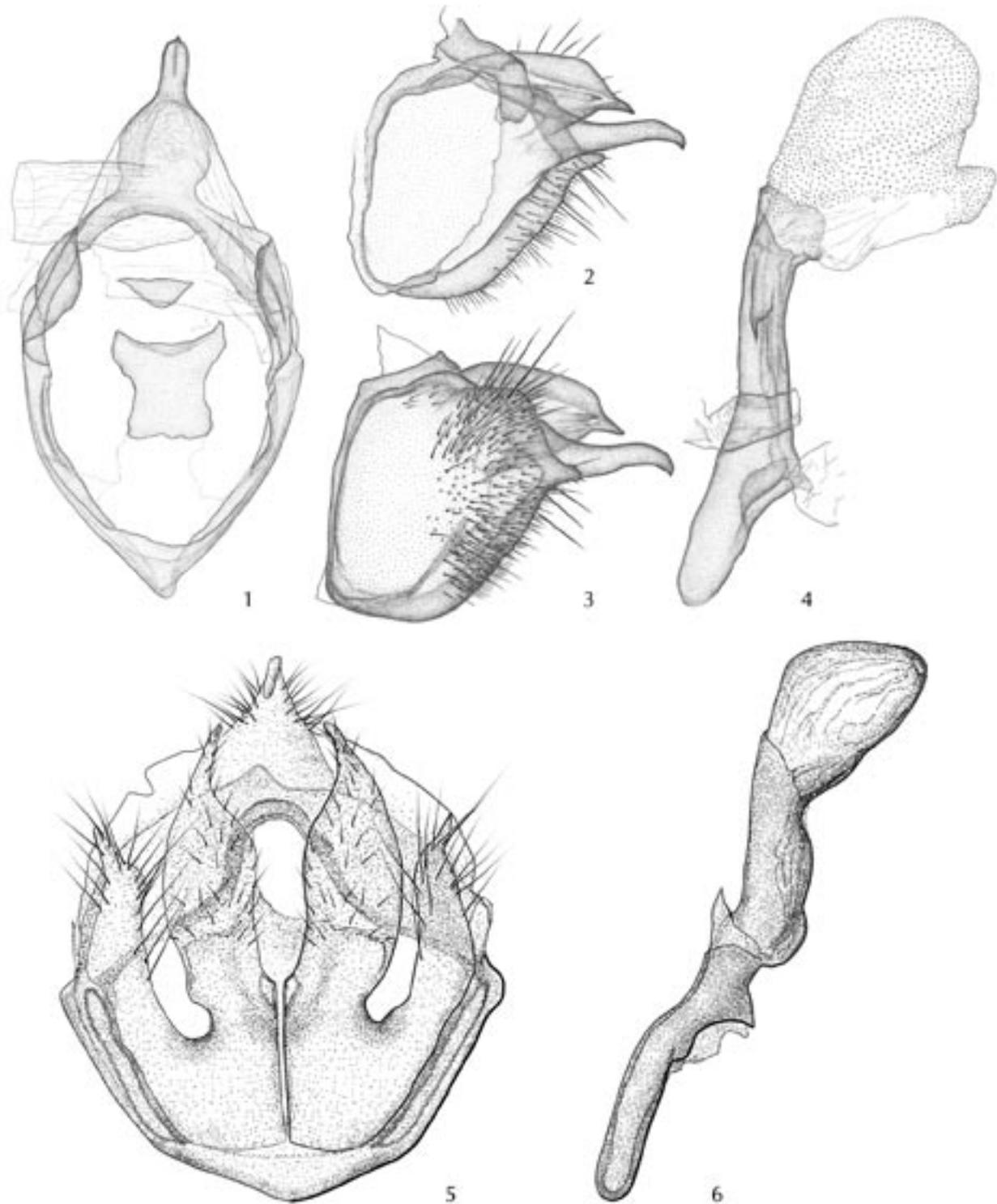


PLATE 21. MALE GENITALIA. **Fig. 1.** *Lymantria (Collentria) fumida*, genital capsule, Japan, genitalia slide USNM 58864. **Fig. 2.** *Lymantria (Collentria) fumida*, valve, genitalia slide USNM 58864. **Fig. 3.** *Lymantria (Collentria) fumida*, valve, genitalia slide USNM 58864. **Fig. 4.** *Lymantria (Collentria) fumida*, aedoeagus, genitalia slide USNM 58864. **Fig. 5.** *Lymantria (Spinotria) serva*, genital capsule, India, Assan, genitalia slide USNM 49731. **Fig. 6.** *Lymantria (Spinotria) serva*, aedoeagus, genitalia slide USNM 49731.

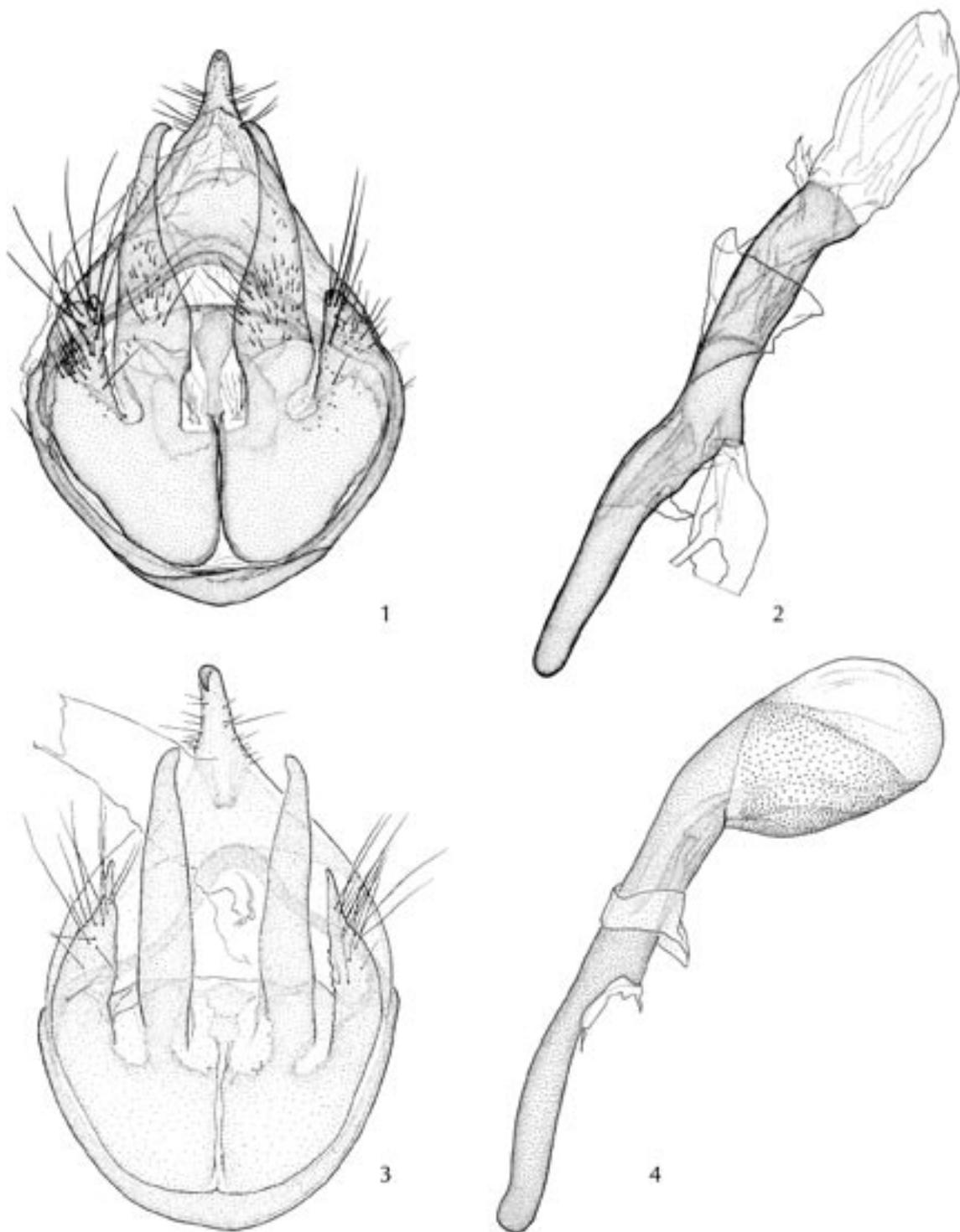


PLATE 22. MALE GENITALIA. **Fig. 1.** *Lymantria (Spinotria) laszloronkayi*, genital capsule, China, Szechuen, Mt. Omei, genitalia slide USNM 59210. **Fig. 2.** *Lymantria (Spinotria) laszloronkayi*, aedeagus, genitalia slide USNM 59210. **Fig. 3.** *Lymantria (Spinotria) hreblayi*, genital capsule, China, N. Yunnan, Li-kiang, genitalia slide DCF 1644 (MAKB). **Fig. 4.** *Lymantria (Spinotria) hreblayi*, aedeagus, genitalia slide DCF 1644 (MAKB).

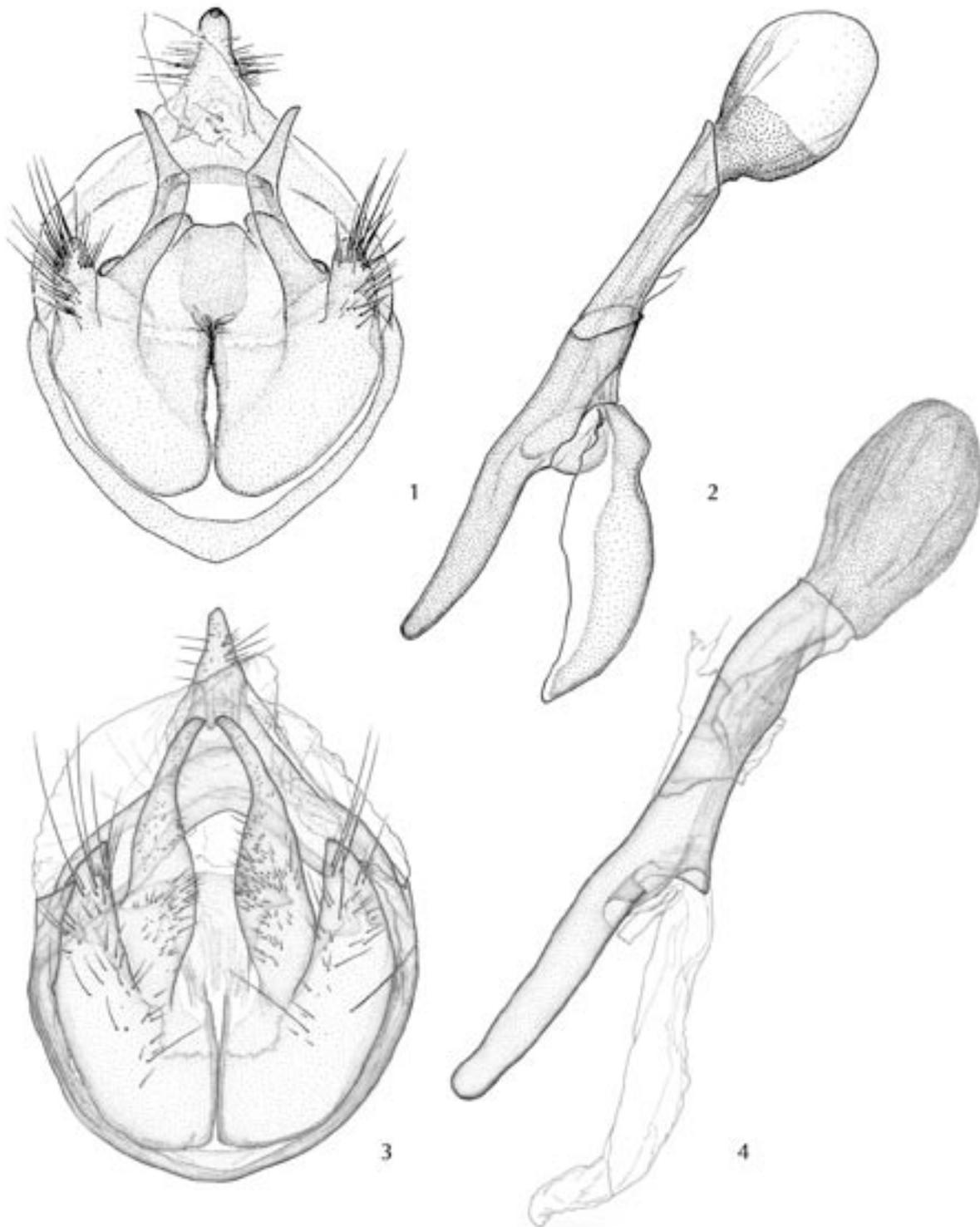


PLATE 23. MALE GENITALIA. Fig. 1. *Lymantria (Spinotria) iris*, genital capsule, China, Canton, Kwantung, genitalia slide DCF 1695 (BMNH). Fig. 2. *Lymantria (Spinotria) iris*, aedeagus, genitalia slide DCF 1695 (BMNH). Fig. 3. *Lymantria (Spinotria) bantaizana*, genital capsule, Japan, genitalia slide USNM 59170. Fig. 4. *Lymantria (Spinotria) bantaizana*, aedeagus, genitalia slide USNM 59170.

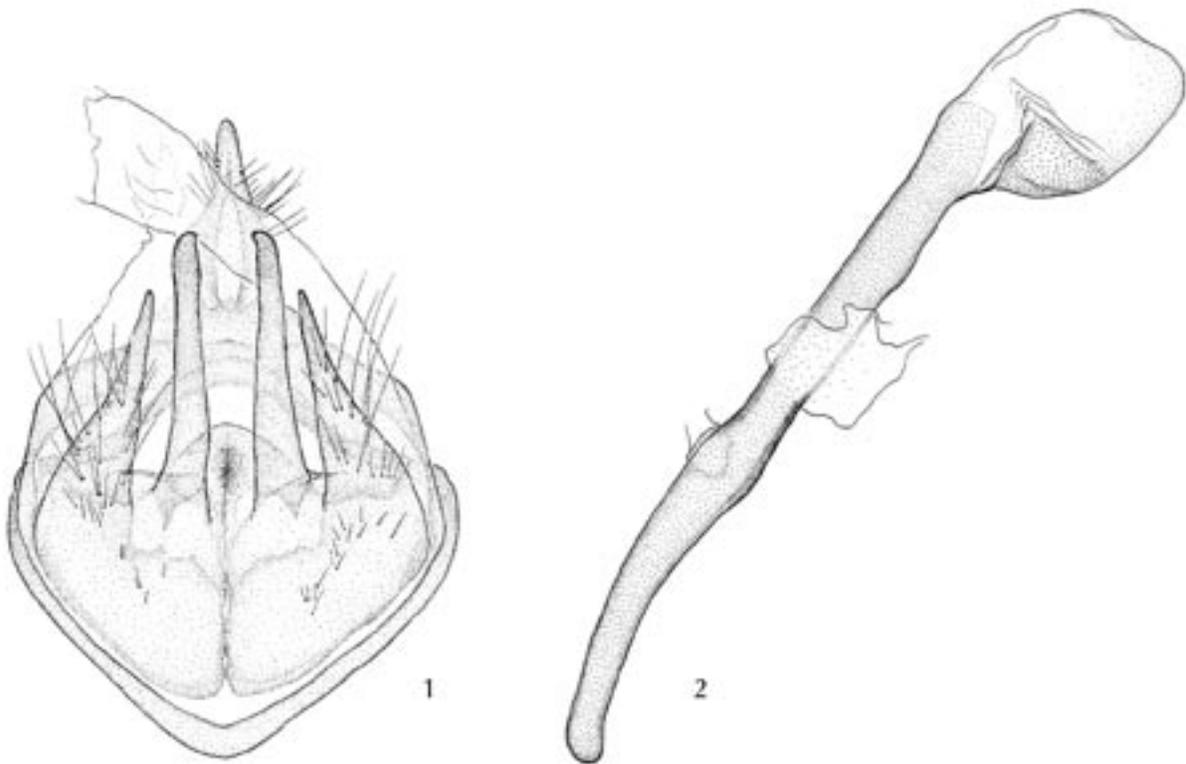


PLATE 24. MALE GENITALIA. . *Lymantria (Spinotria) albolunulata*. **Fig. 1.** Genital capsule, India, Dalhousie, genitalia slide DCF 1692 (BMNH). **Fig. 2.** Aedeagus, genitalia slide DCF 1692 (BMNH).

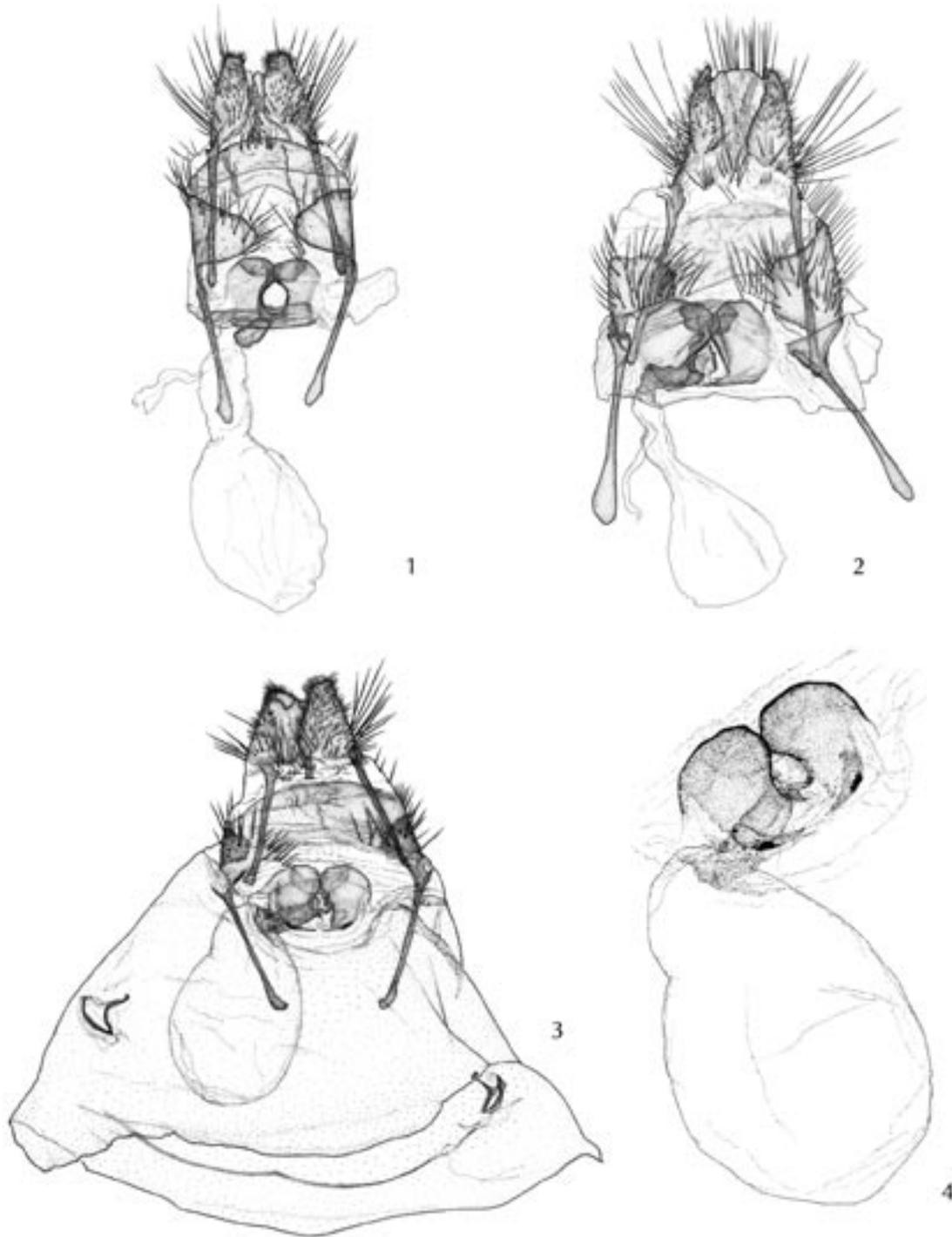


PLATE 25. FEMALE GENITALIA. Fig. 1. *Lymantria (Porthetria) dispar dispar*, USA, Massachusetts, Sturbridge, genitalia slide USNM 59094. **Fig. 2.** *Lymantria (Porthetria) dispar japonica*, Japan, Mitzokura, genitalia slide USNM 59120. **Fig. 3.** *Lymantria (Porthetria) dispar japonica*, Japan, Hokkaido, genitalia slide USNM 59223. **Fig. 4.** *Lymantria (Porthetria) dispar japonica*, genitalia slide USNM 59223.

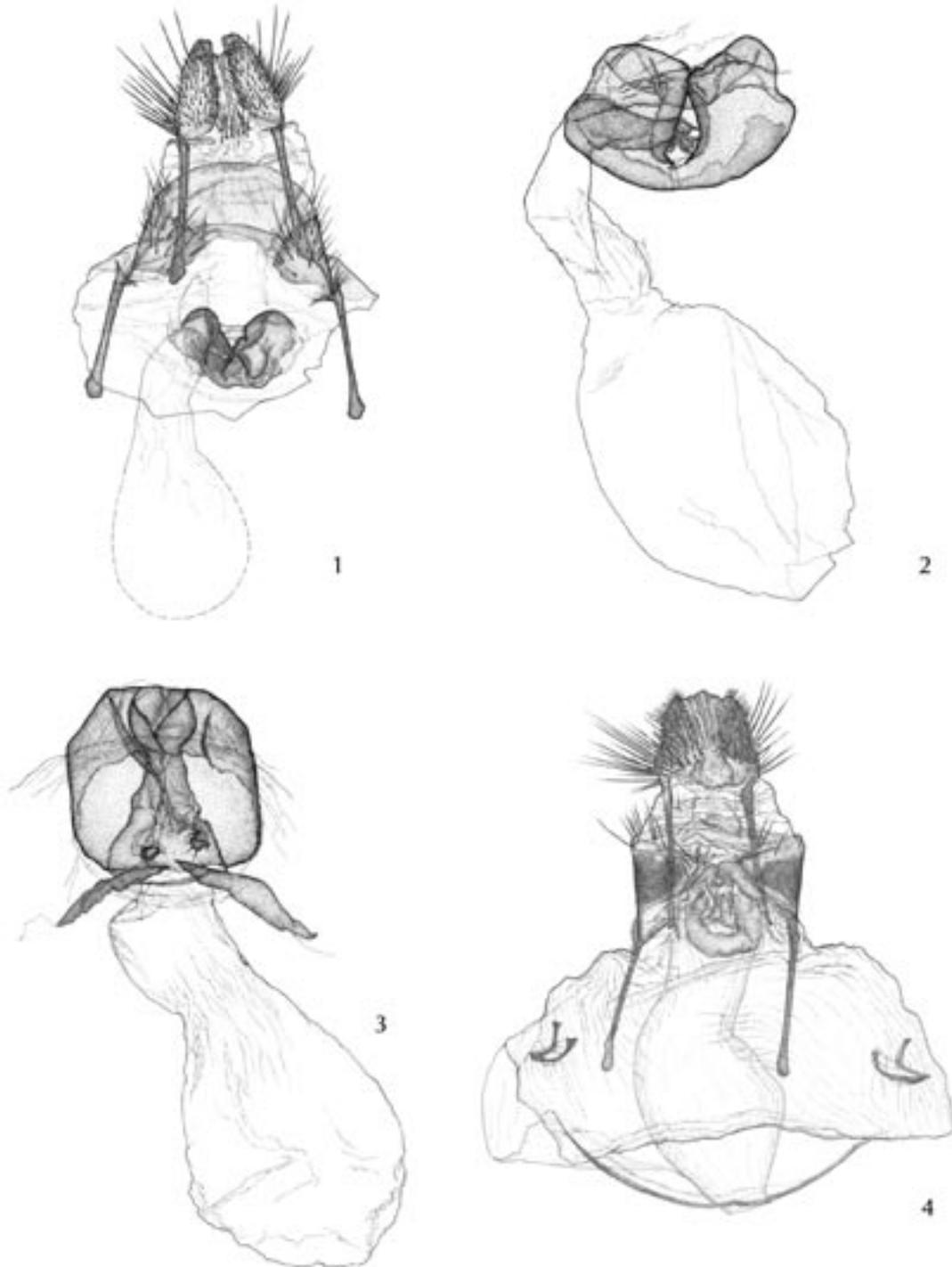


PLATE 26. FEMALE GENITALIA. **Fig. 1.** *Lymantria (Porthetria) obfuscata*, N. India. **Fig. 2.** *Lymantria (Porthetria) postalba*, Japan, Okinawa, genitalia slide USNM 59179. **Fig. 3.** *Lymantria (Porthetria) apicebrunnea*, China, Yunnan, genitalia slide USNM 59189 (BMNH). **Fig. 4.** *Lymantria (Porthetria) xylina*, Taiwan, genitalia slide USNM 58974.

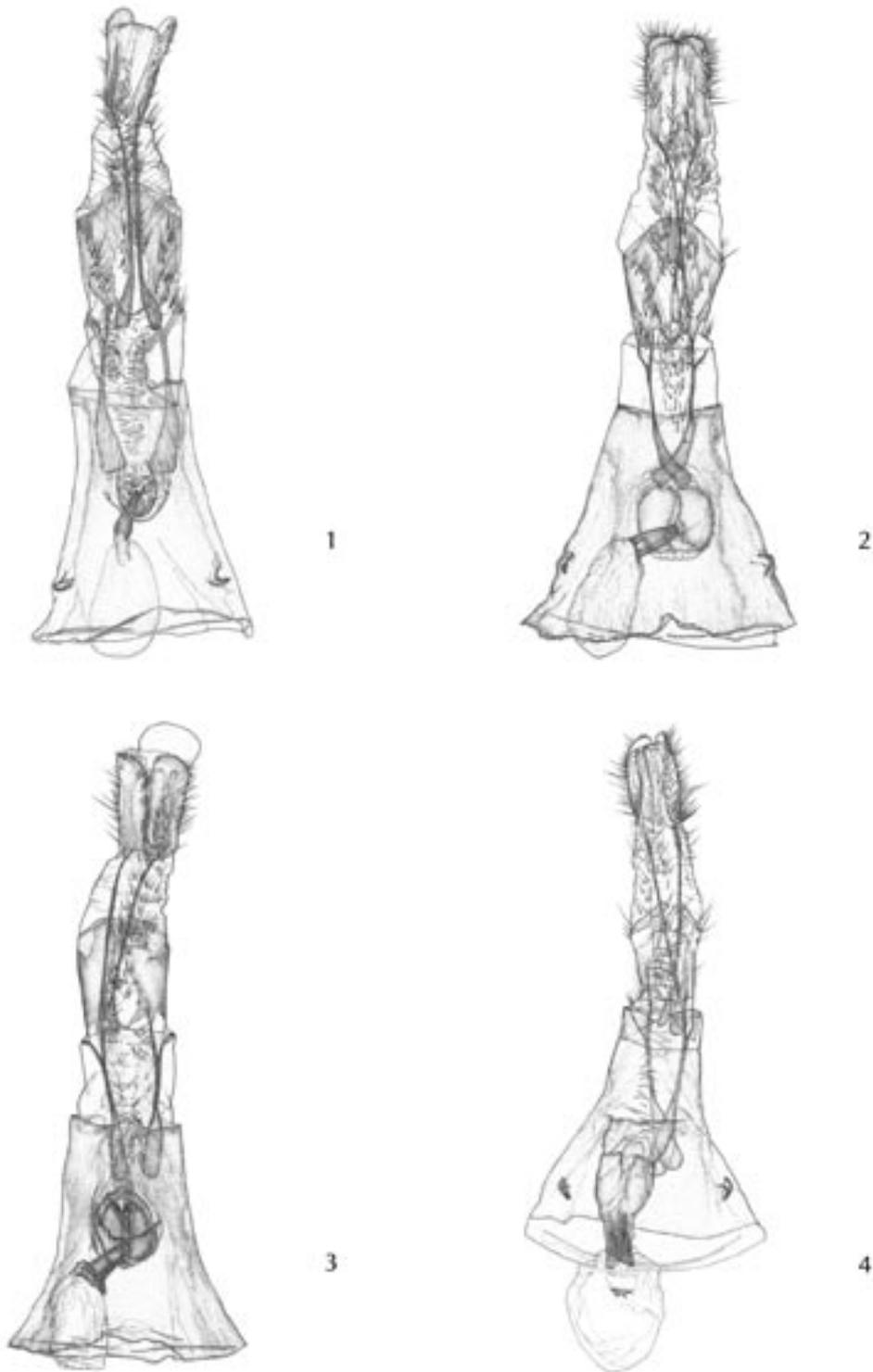


PLATE 27. FEMALE GENITALIA. **Fig. 1.** *Lymantria (Lymantria) monacha*, Europe, genitalia slide USNM 59109. **Fig. 2.** *Lymantria (Lymantria) umbrifera*, Sumatra, Darat, E. Coast, genitalia slide USNM 59124. **Fig. 3.** *Lymantria (Lymantria) dissoluta*, Chinae, Konloon, genitalia slide USNM 59217. **Fig. 4.** *Lymantria (Lymantria) sinica*, China, Kiangsu, near Nanking, genitalia slide DCF 1635 (BMNH).

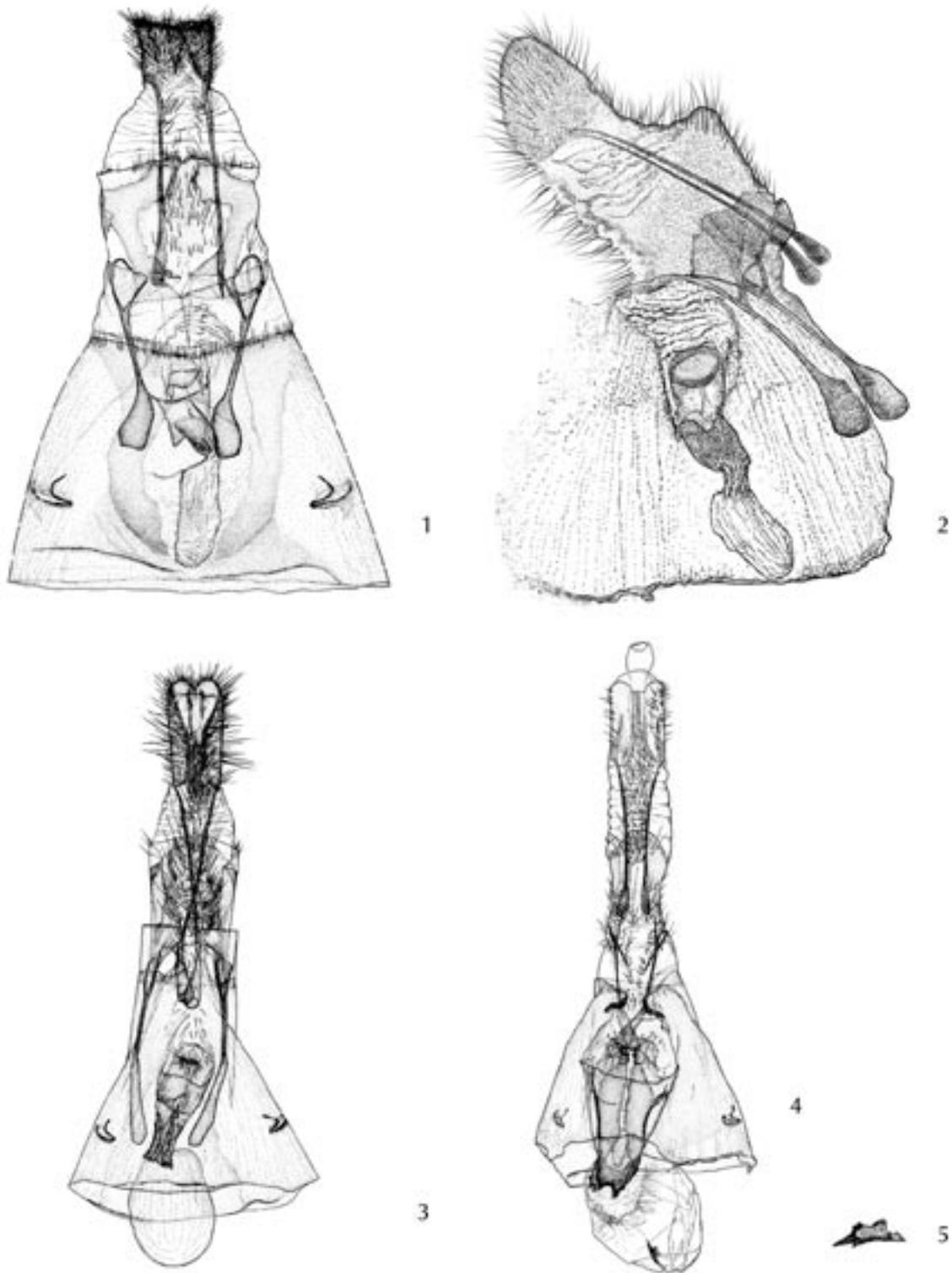


PLATE 28. FEMALE GENITALIA. **Fig. 1.** *Lymantria (Nyctria) mathura* Russia, Siberia, genitalia slide USNM 58970. **Fig. 2.** *Lymantria (Nyctria) flavida*, Japan, Okinawa, Hentona, genitalia slide MGP 1214 (PWS). **Fig. 3.** *Lymantria (Collentria) fumida*, Japan, Takao-san, Tokyo, genitalia slide DCF 1633 (BMNH). **Fig. 4.** *Lymantria (Spinotria) bantaizana*, Japan, Takao-san, Tokyo genitalia slide USNM 59171. **Fig. 5.** Signa from corpus bursae of Fig. 4.



PLATE 29. LARVAE. **Fig. 1.** *Lymantria (Porthetria) dispar dispar*, Spain. **Fig. 2.** *Lymantria (Porthetria) dispar japonica*, Japan, Toyota, on *Castanea* sp. **Fig. 3.** *Lymantria (Porthetria) dispar japonica*, Japan, Honshu, Taiei. **Fig. 4.** *Lymantria (Porthetria) dispar japonica*, Japan, Morioka. **Fig. 5.** *Lymantria (Porthetria) dispar asiatica*, Mongolia, on *Larix* sp. **Fig. 6.** *Lymantria (Porthetria) obfuscata*, India, Kulu Valley.



PLATE 30. LARVAE. **Fig. 1.** *Lymantria (Porthetria) albescens*, Japan, Okinawa. **Fig. 2.** *Lymantria (Porthetria) xylina*, Taiwan, Kuanyin. **Fig. 3.** *Lymantria (Porthetria) xylina*, Taiwan, Quandaoshan. **Fig. 4.** *Lymantria (Porthetria) xylina*, Unknown locality. **Fig. 5.** *Lymantria (Lymantria) monacha*, Japan, Okinawa, lab reared, on *Larix* sp. **Fig. 6.** *Lymantria (Lymantria) minomonis*, Unknown locality.



PLATE 31. LARVAE. **Fig. 1.** *Lymantria (Beatria) atemeles*, Thailand, Nahkon Pathom, Kamphaeng Sean Campus, Kasetsart University, on mango. **Fig. 2.** *Lymantria (Nyctria) mathura*, Japan, Honshu, Nara. **Fig. 3.** *Lymantria (Nyctria) mathura*, Taiwan, Quandaoshan. **Fig. 4.** *Lymantria (Collentria) fumida*, Japan, Morioka. **Fig. 5.** *Lymantria (Spinotria) serva*, Taiwan, Taipei. **Fig. 6.** *Lymantria (Spinotria) bantaizana*, Japan, Iwate Prefecture, Morioka, lab reared.

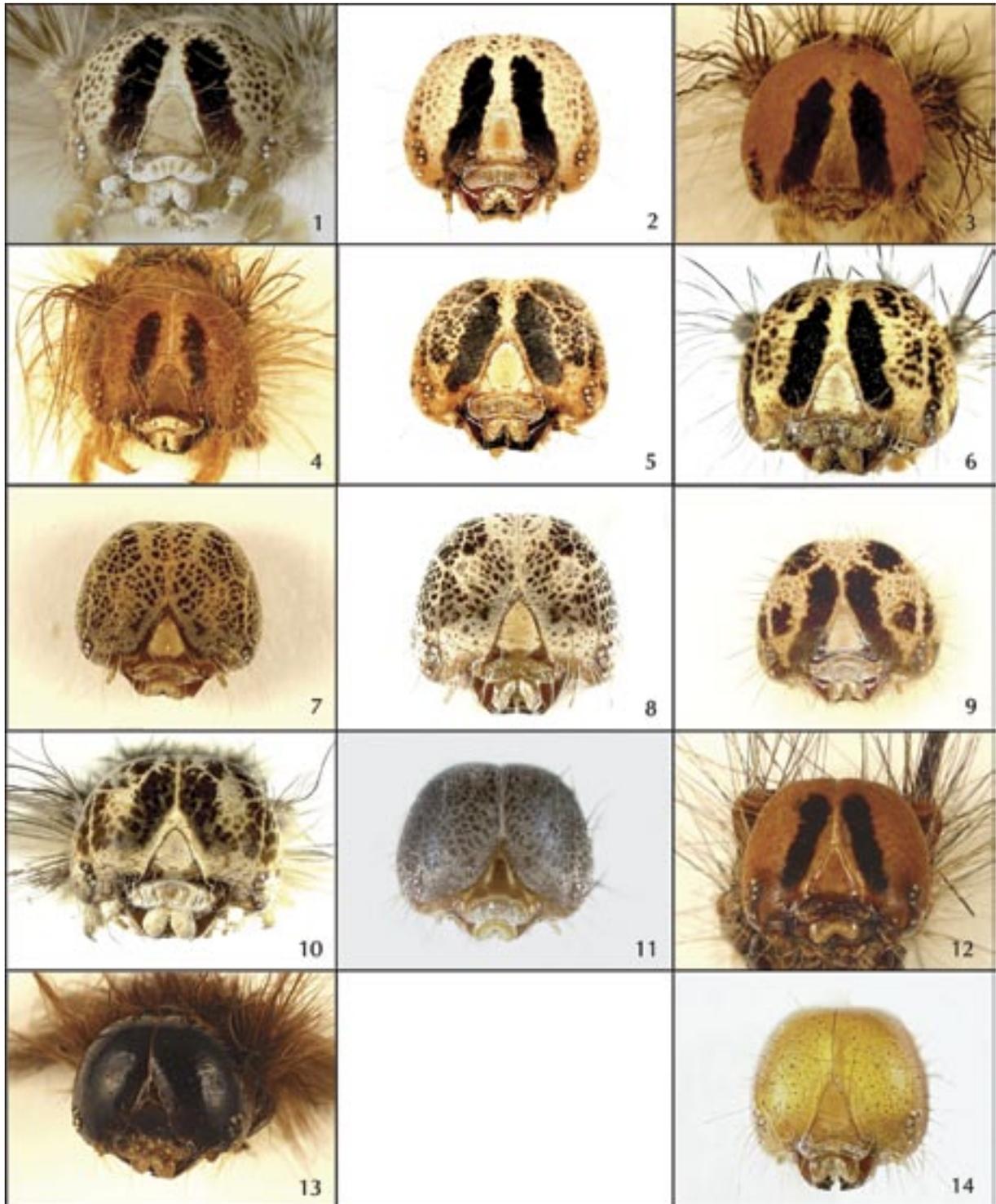


PLATE 32. LAST INSTAR LARVAL HEAD CAPSULES. **Fig. 1.** *Lymantria (Porthetria) dispar dispar*, Maryland, Queen Anne's Co. **Fig. 2.** *Lymantria (Porthetria) dispar asiatica*, Kyrgyz Republic, Karalma, Jergetal. **Fig. 3.** *Lymantria (Porthetria) umbrosa*, Japan, Hokaido, Ashikawa. **Fig. 4.** *Lymantria (Porthetria) obfuscata*, **Fig. 5.** *Lymantria (Porthetria) albescens*, Japan, Okinawa, Naha. **Fig. 6.** *Lymantria (Porthetria) xyliana*, Taiwan, Tashan. **Fig. 7.** *Lymantria (Lymantria) monacha*, Russia, Siberia, Tyumen, reared from *Larix* sp. **Fig. 8.** *Lymantria (Lymantria) minomonis*, Japan, Okinawa, Fungawa, on *Quecus*. **Fig. 9.** *Lymantria (Lymantria) lucescens*, Japan, Honshu, Toyota, Foresta Hills Park. **Fig. 10.** *Lymantria (Beatia) atemeles*, Thailand, Nakhon Pathom, Kamphaeng Saen, Kasetsart University, on mango. **Fig. 11.** *Lymantria (Nyctria) mathura*, Korea, Kyonggi-do, Songchon. **Fig. 12.** *Lymantria (Collentria) fumida*, Japan, Iwate Prefecture, Morioka. **Fig. 13.** *Lymantria (Spinotria) serva*, Taiwan, Taipei. **Fig. 14.** *Lymantria (Spinotria) bantaizana*, Japan, Morioka.

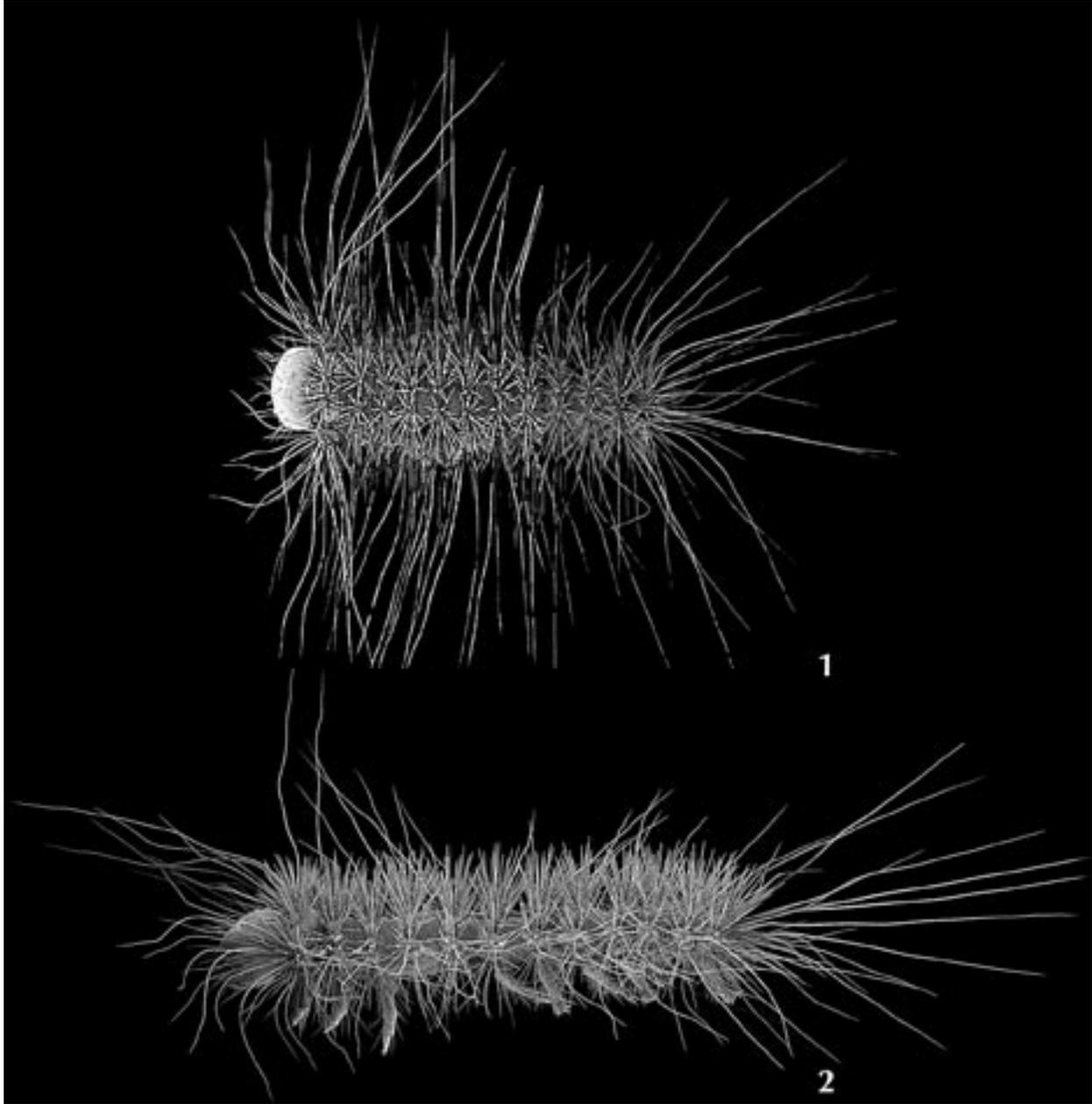


PLATE 33. FIRST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, habitus. **Fig. 1.** Dorsal view; scale=0.5 mm. **Fig. 2.** Lateral view; scale=0.5 mm.

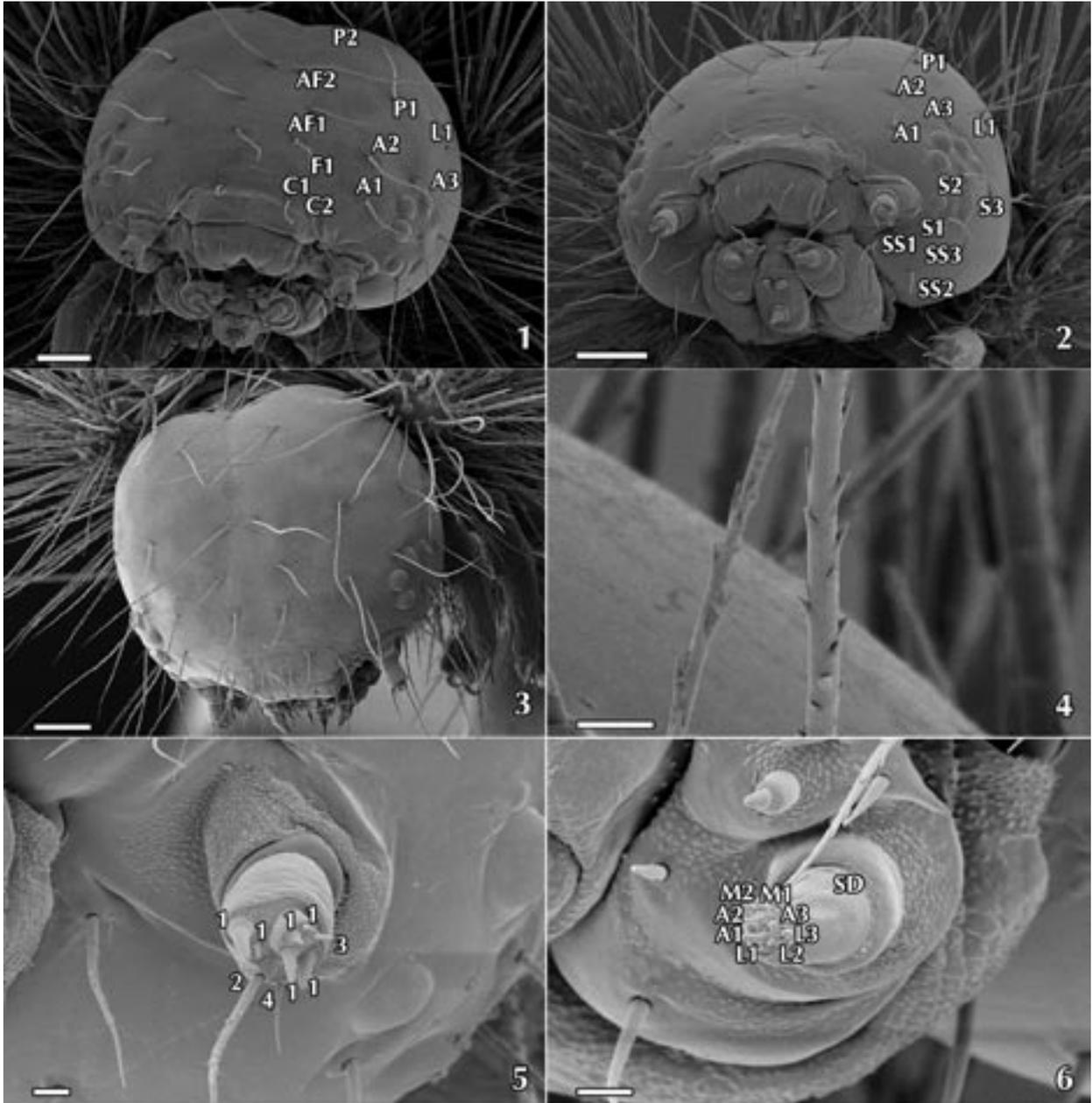


PLATE 34. FIRST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, head. **Fig. 1.** Front view of head; scale=100 μ . **Fig. 2.** Fronto-ventral view showing mouthparts; scale=100 μ . **Fig. 3.** Dorso-frontal view of head=100 μ . **Fig. 4.** Seta AF1; scale=10 μ . **Fig. 5.** Right antenna; scale=10 μ . **Fig. 6.** Left maxillary palpus; scale=10 μ .

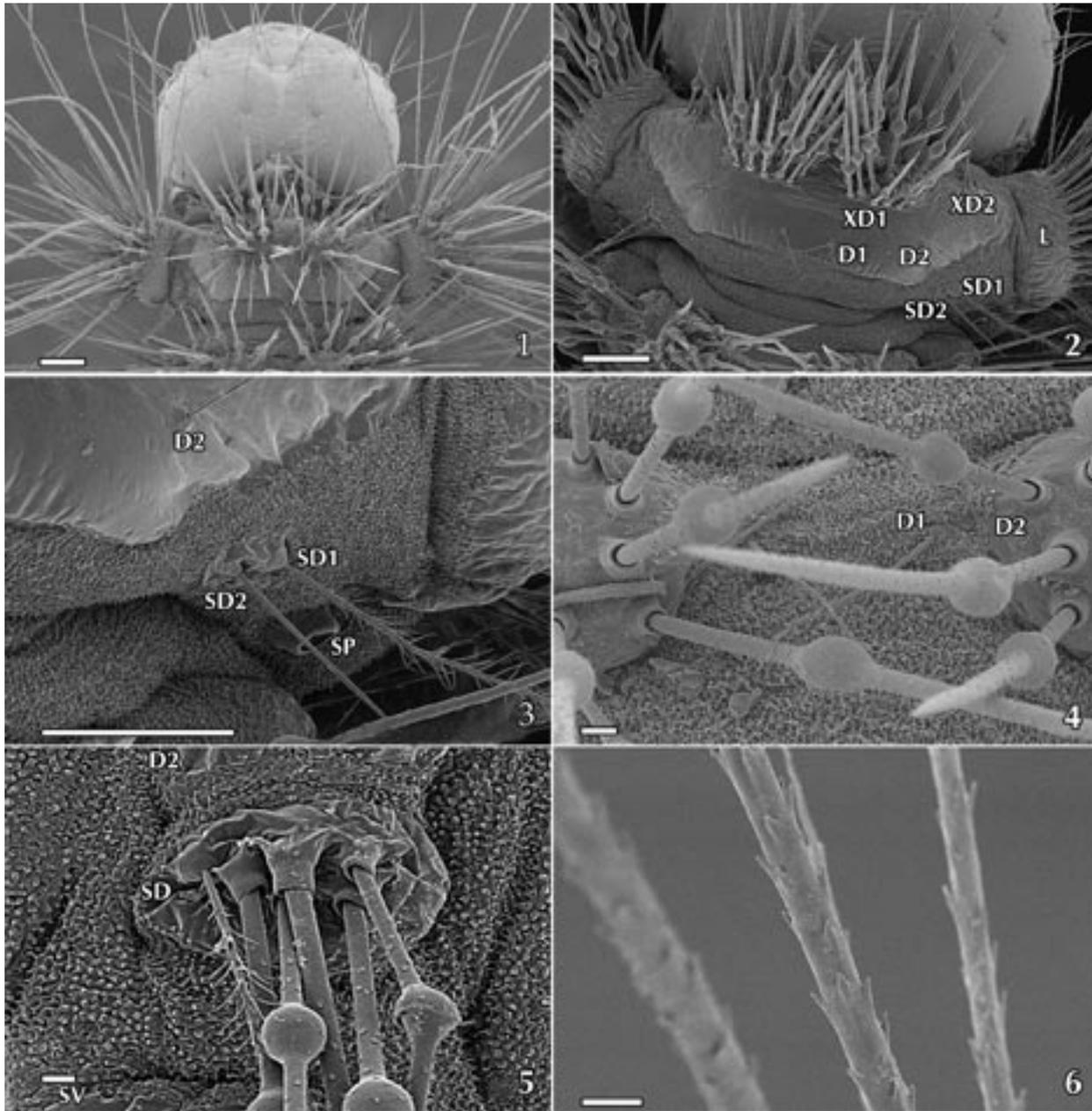


PLATE 35. FIRST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, thorax. **Fig. 1.** Dorsal view of head and T1; scale=100 μ . **Fig. 2.** T1, dorsal view; scale=100 μ . **Fig. 3.** T1, SD1-2, and spiracle; scale=100 μ . **Fig. 4.** T3, D1 seta and D2 verruca; scale=10 μ . **Fig. 5.** T3, SD verruca; scale=10 μ . **Fig. 6.** T1, L verruca setae; scale=10 μ .

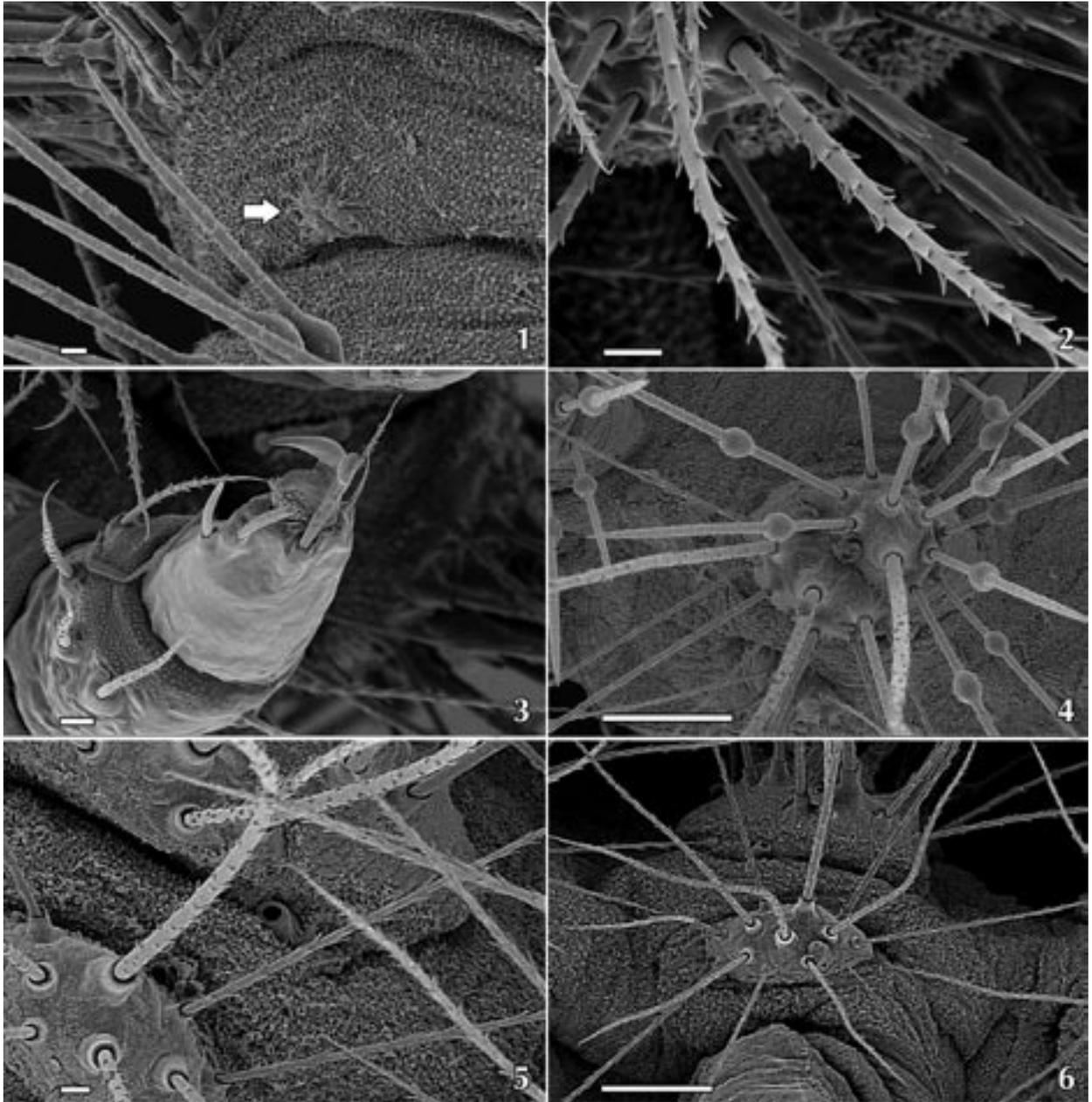


PLATE 36. FIRST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, thorax and abdomen. **Fig. 1.** Dorsal gland near posterior margin on T2; scale=10 μ . **Fig. 2.** T1, SV verruca setae; scale=10 μ . **Fig. 3.** T3 leg; scale=10 μ . **Fig. 4.** A1: SD, L, and SV verrucae; scale=100 μ . **Fig. 5.** A5: SD, L, and SV verrucae and spiracle; scale=10 μ . **Fig. 6.** A5: SV verruca setae; scale=100 μ .

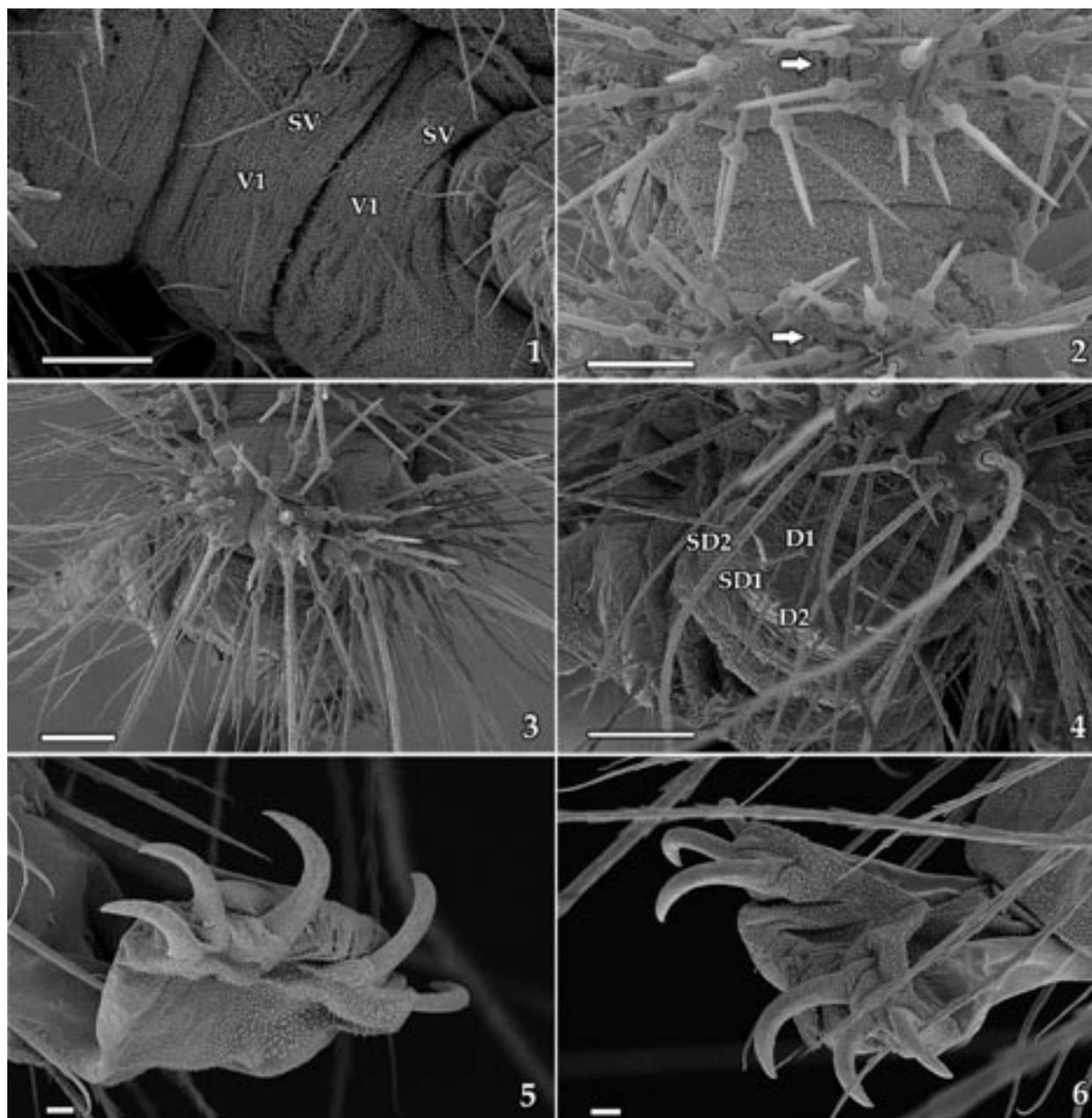


PLATE 37. FIRST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, abdomen. **Fig. 1.** Ventral view of A7–9; scale=100 μ . **Fig. 2.** Dorsal view of A6–7, arrows points to mid-dorsal glands between D2 verrucae; scale=100 μ . **Fig. 3.** Dorsal view of A9–10; scale=100 μ . **Fig. 4.** Dorsal view of A10; scale=100 μ . **Fig. 5.** A5 left proleg, 3 crochets anteriorly, 2 crochets posteriorly; scale=10 μ . **Fig. 6.** A10 right proleg, 3 crochets anteriorly, 3 crochets posteriorly; scale=10 μ .

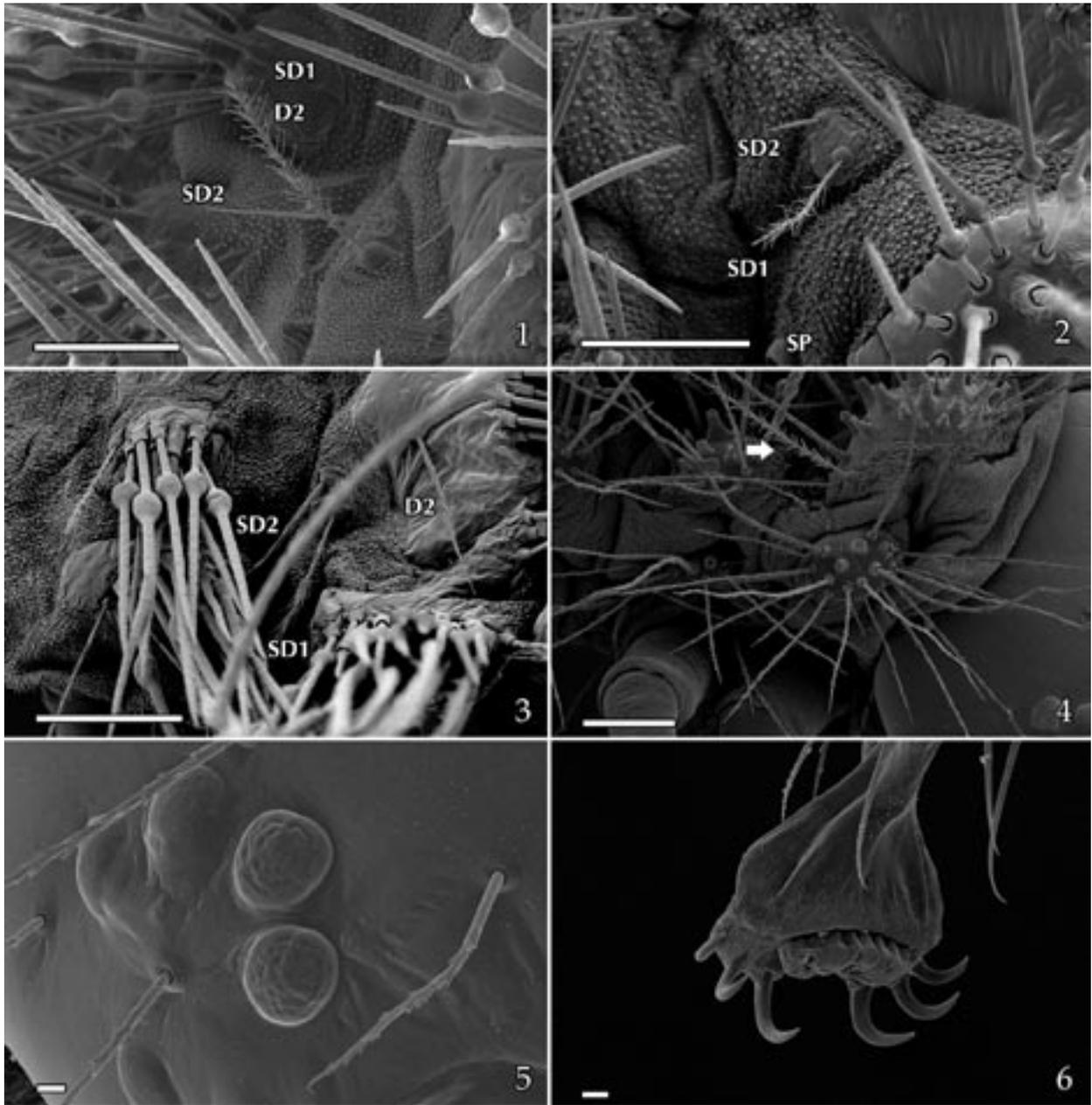


PLATE 38. FIRST INSTAR LARVA. **Fig. 1.** *Lymantria (Porthetria) dispar asiatica*, dorso-lateral view of T1, SD1, SD2, and spiracle; scale=100 μ . **Fig. 2.** *Lymantria (Nyctria) mathura*, T1 SD1, SD2, and spiracle; scale=100 μ . **Fig. 3.** *Lymantria (Lymantria) monacha*, T1 SD1 and SD2; scale=100 μ . **Fig. 4.** *Lymantria (Porthetria) obfuscata*, T1 SD1 and SD2; scale=100 μ (arrow pointing to SD1). **Fig. 5.** *Lymantria (Porthetria) obfuscata*, stemma 3 and 4, tripartite; scale=10 μ . **Fig. 6.** *Lymantria (Porthetria) obfuscata*, A3 right proleg; scale=10 μ .

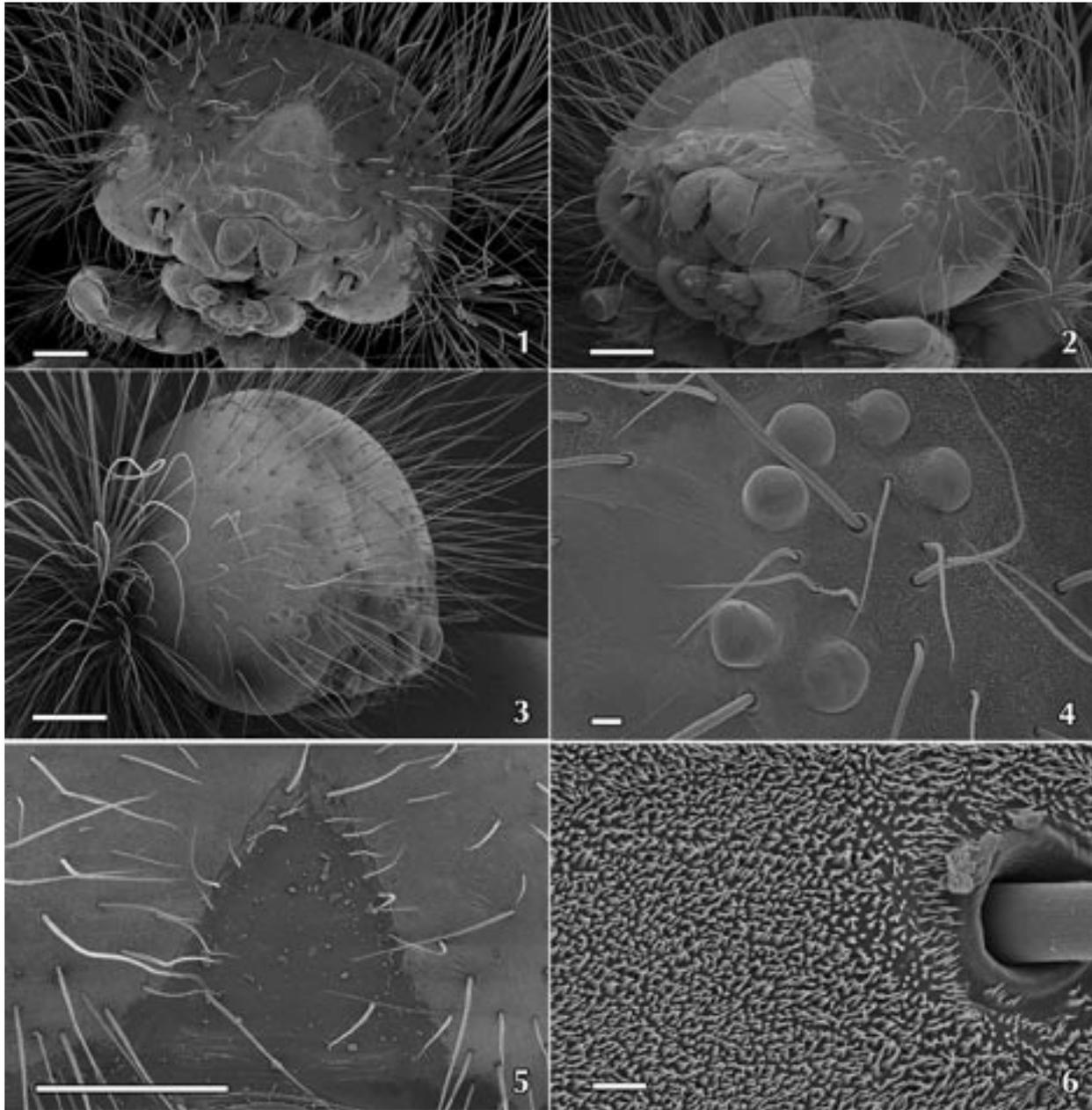


PLATE 39. LAST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, head. **Fig. 1.** Frontal view; scale=1 mm. **Fig. 2.** Fronto-lateral view; scale=1 mm. **Fig. 3.** Dorso-lateral view; scale=1 mm. **Fig. 4.** Stemmata; scale=10 μ . **Fig. 5.** Frons and adfrontal area; scale=1 mm. **Fig. 6.** Microspicules near AF2; scale=10 μ .

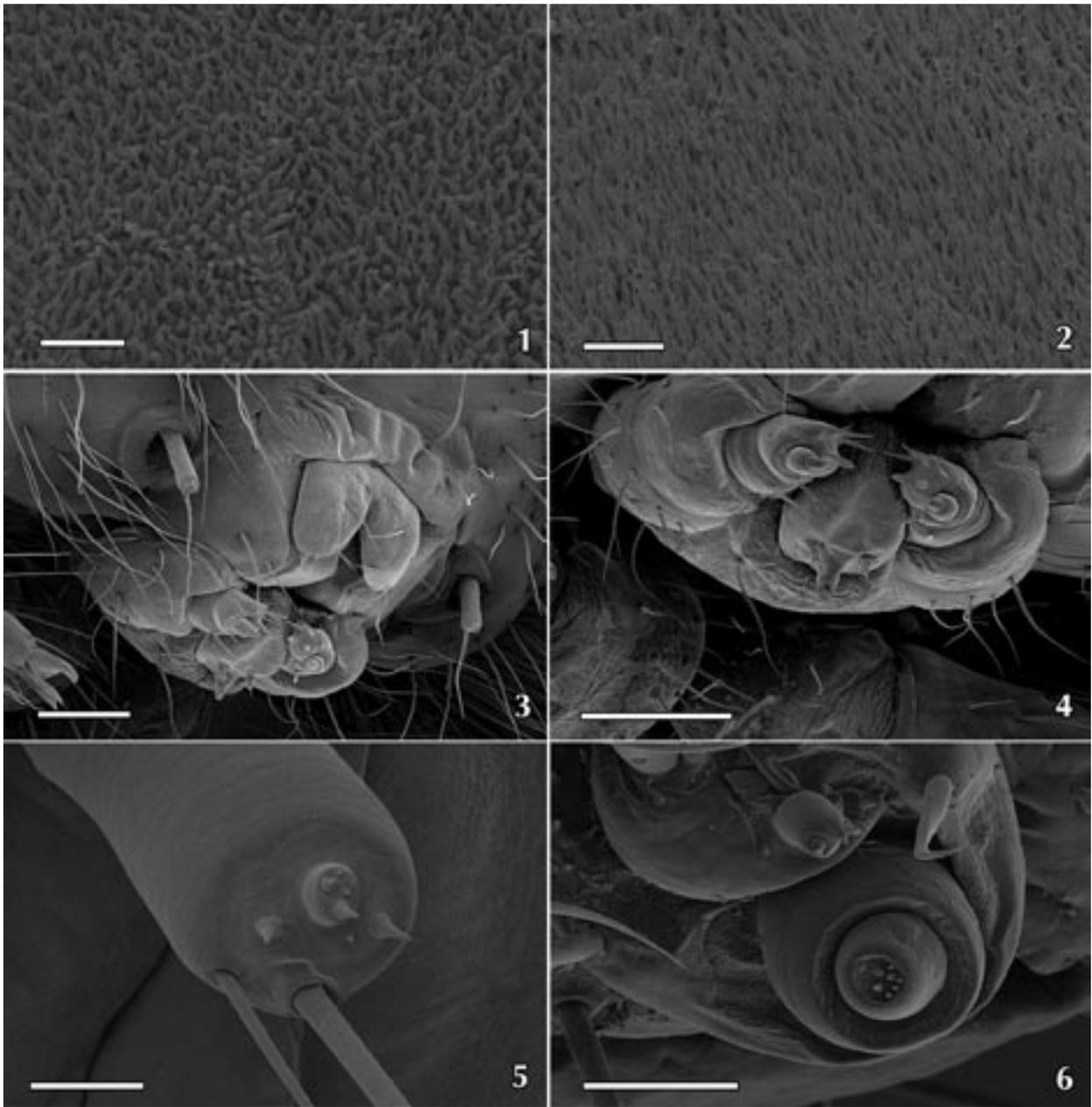


PLATE 40. LAST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, head. **Fig. 1.** Microspicules on black stripe; scale=10 μ . **Fig. 2.** Microspicules on remainder of head; scale=10 μ . **Fig. 3.** Mouthparts; scale=1 mm. **Fig. 4.** Labium and spinneret; scale=1 mm. **Fig. 5.** Right antenna; scale=100 μ . **Fig. 6.** Left maxillary palpus; scale=100 μ .

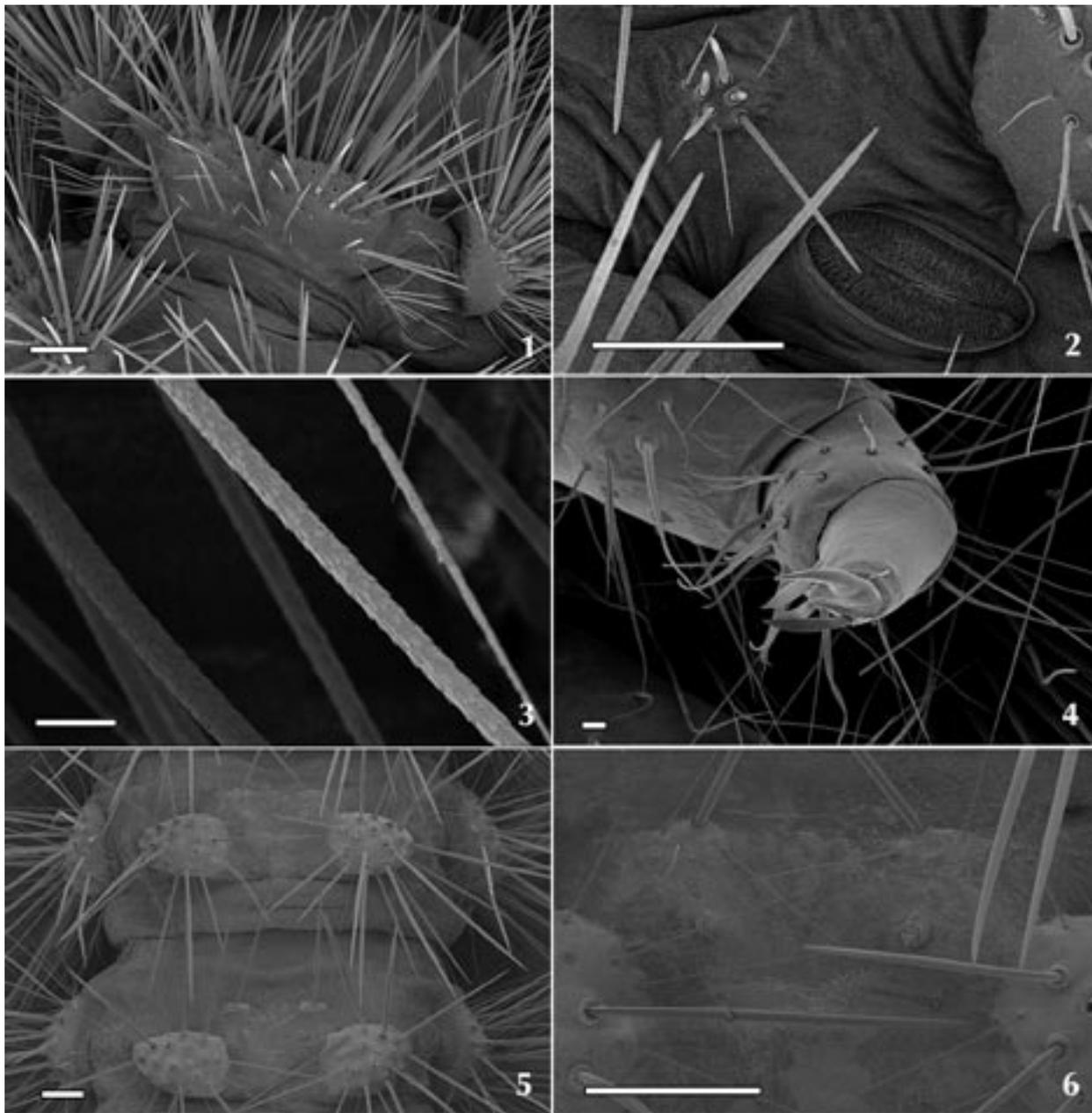


PLATE 41. LAST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, thorax and abdomen. **Fig. 1.** Dorsal view of T1; scale=1 mm. **Fig. 2.** Lateral view of T1, SD1, SD2 verruca, and spiracle; scale=1 mm. **Fig. 3.** T2, L verruca seta; scale=100 μ . **Fig. 4.** T1 left tarsal claw; scale=100 μ . **Fig. 5.** Dorsal view of A3–4; scale=1 mm. **Fig. 6.** Dorsal view of A3 with D1 and D2 verrucae and paired dorsal glands; scale=1 mm.

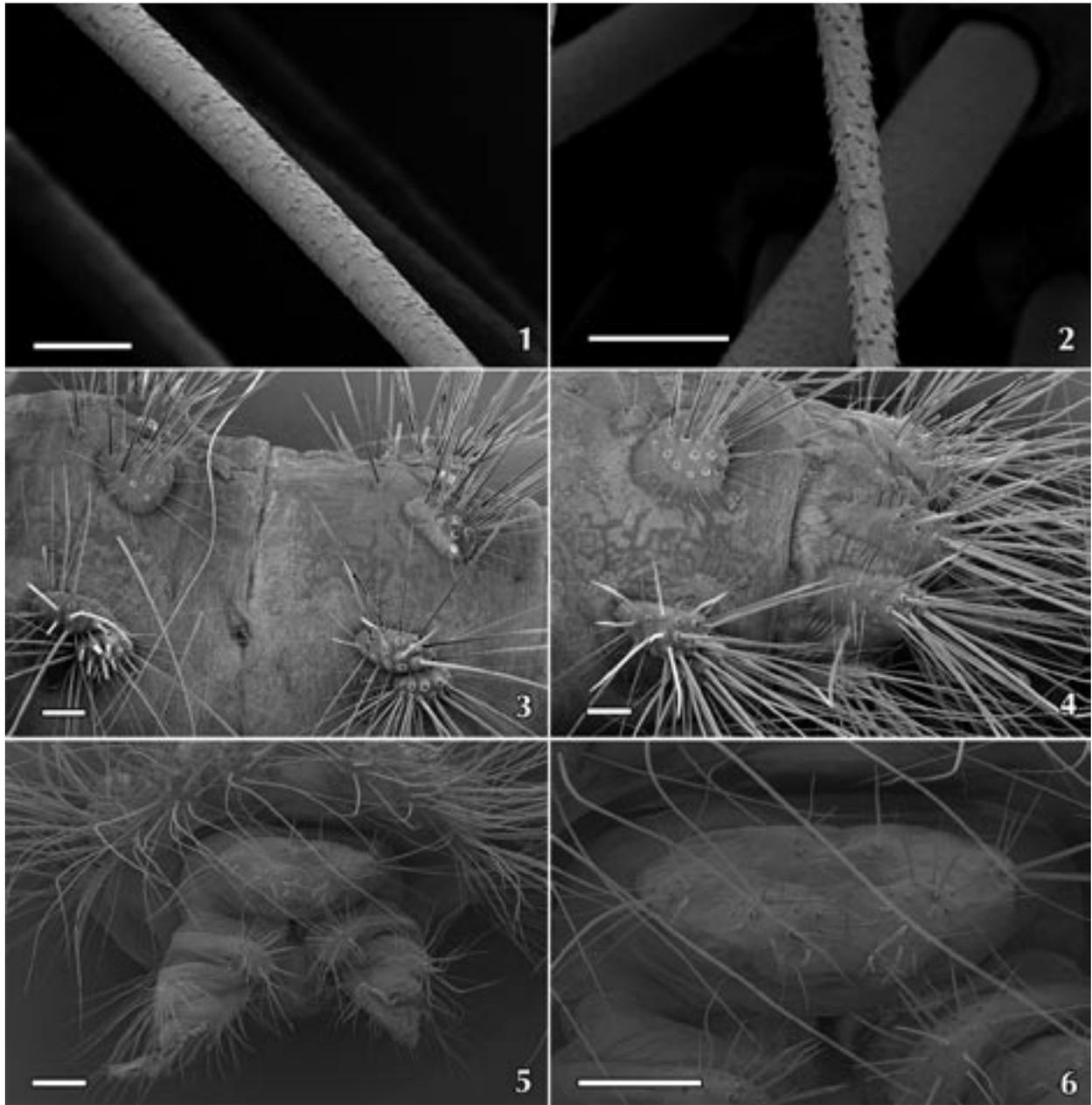


PLATE 42. LAST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, abdomen. **Fig. 1.** A2, L verruca seta; scale=100 μ . **Fig. 2.** A2, SD verruca seta; scale=100 μ . **Fig. 3.** Dorso-lateral view of A6–7; scale=1 mm. **Fig. 4.** Dorso-lateral view of A8–9; scale=1 mm. **Fig. 5.** Caudal view of A10; scale=1 mm. **Fig. 6.** Anal plate; scale=1 mm.



PLATE 43. LAST INSTAR LARVA. *Lymantria (Porthetria) dispar dispar*, habitus. Fig. 1. Dorsal view. Fig. 2. Lateral view.

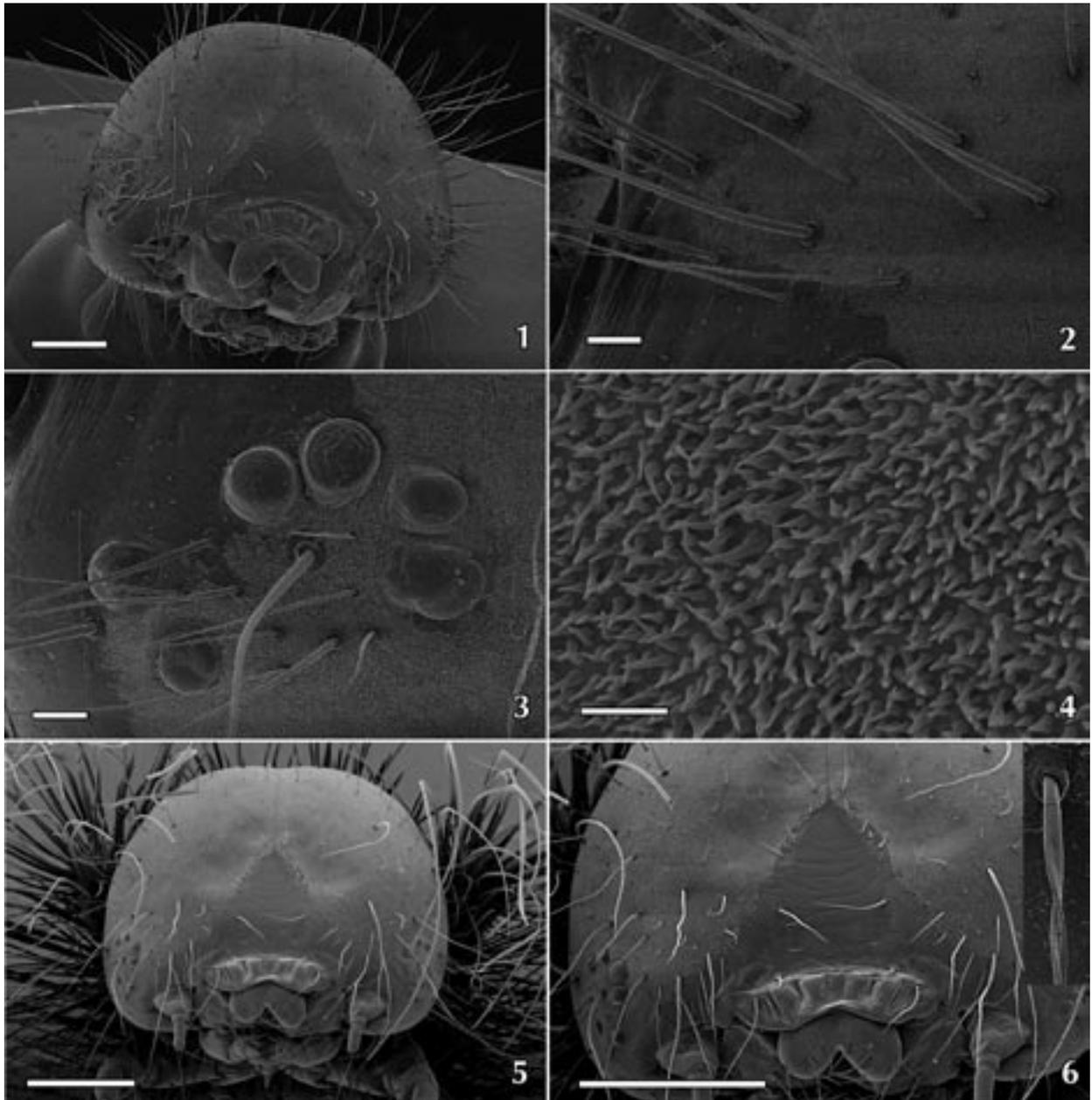


PLATE 44. LAST INSTAR LARVA. Head. **Fig. 1.** *Lymantria (Porthetria) dispar asiatica*, frontal view; scale=1 mm. **Fig. 2.** *Lymantria (Porthetria) dispar asiatica*, twisted and slightly barbed setae dorsal to stemma area; scale=100 μ . **Fig. 3.** *Lymantria (Porthetria) dispar asiatica* stemma area; scale=100 μ . **Fig. 4.** *Lymantria (Porthetria) dispar asiatica*, microspinules in black stripe; scale=10 μ . **Fig. 5.** *Lymantria (Porthetria) umbrosa*, frontal view; scale=1 mm. **Fig. 6.** *Lymantria (Porthetria) umbrosa*, frons, clypeus, and labrum; inset showing twisted seta on head; scale=1 mm.

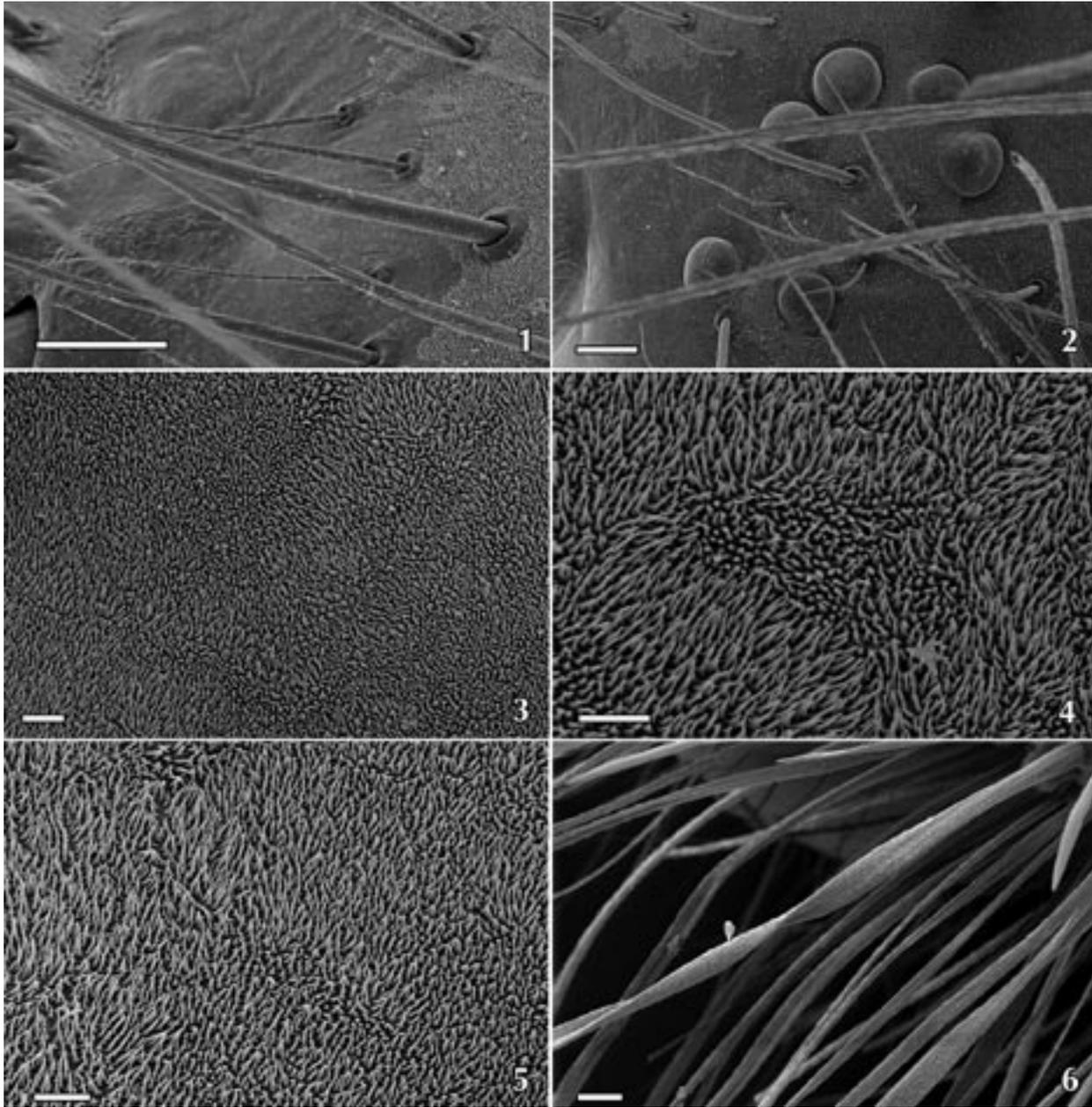


PLATE 45. LAST INSTAR LARVA. *Lymantria (Porthetria) umbrosa*, head and thorax. **Fig. 1.** Twisted setae dorsal to stemma area; scale=100 μ . **Fig. 2.** stemma area; scale=100 μ . **Fig. 3.** Microspinules in black stripe; scale=10 μ . **Fig. 4.** Microspinules and tonofibular platelets adjacent to black stripe; scale=10 μ . **Fig. 5.** Microspinules in black stripe (right) and adjacent to black stripe (left); scale=10 μ . **Fig. 6.** T1, L verruca showing twisted and microbarbed setae; scale=100 μ .

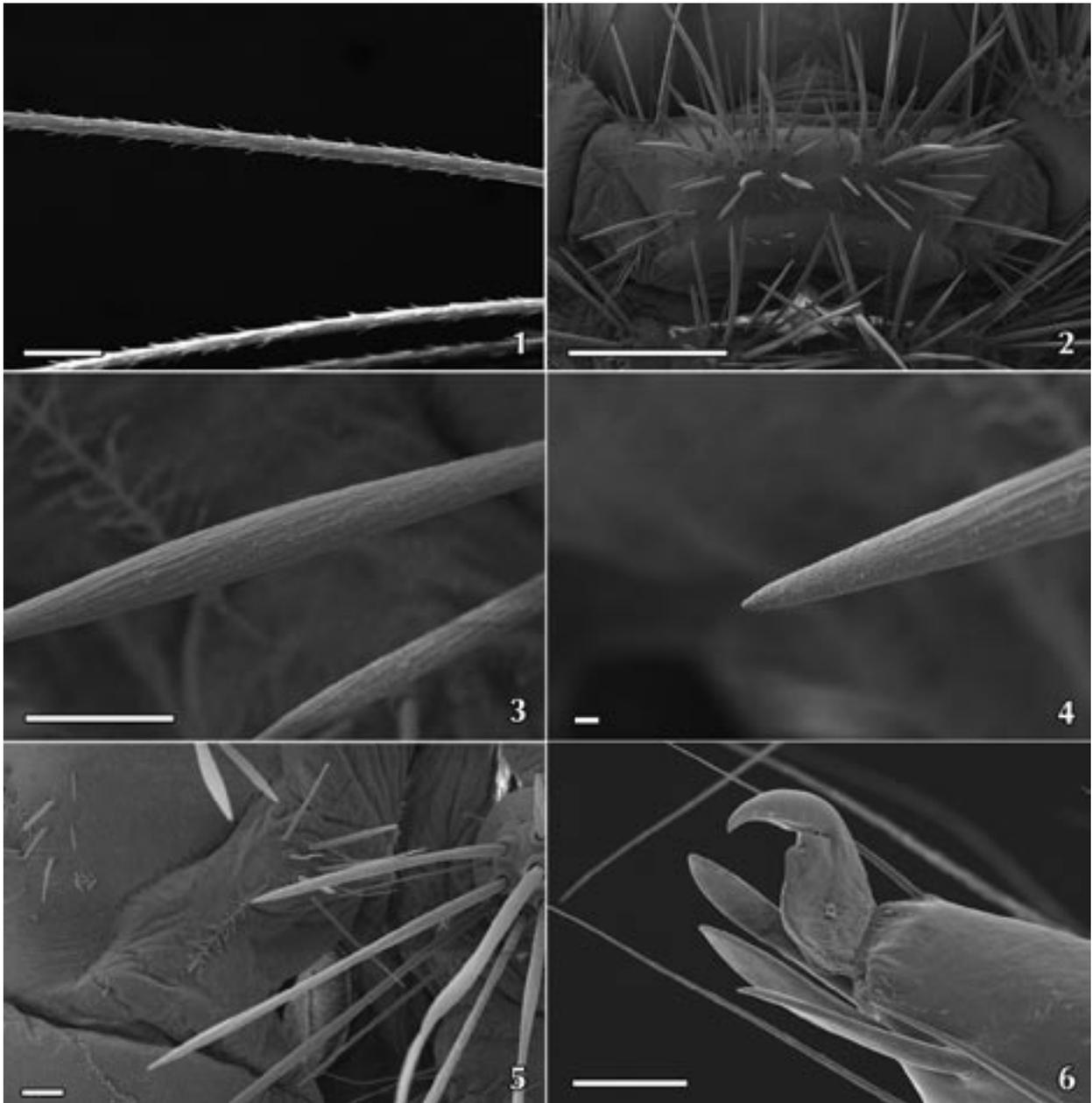


PLATE 46. LAST INSTAR LARVA. *Lymantria (Porthetria) umbrosa*, thorax. **Fig. 1.** T1, L verruca round microbarbed seta; scale=100 μ . **Fig. 2.** dorsal view of T1 prothoracic shield; scale=1 mm. **Fig. 3.** T1, D2 verruca seta; scale=100 μ . **Fig. 4.** T1, D2 verruca seta apex with micropores; scale=10 μ . **Fig. 5.** T1, SD1 seta and SD2 verrucae; scale=100 μ . **Fig. 6.** T1, claw and associated setae of right leg; scale=100 μ .

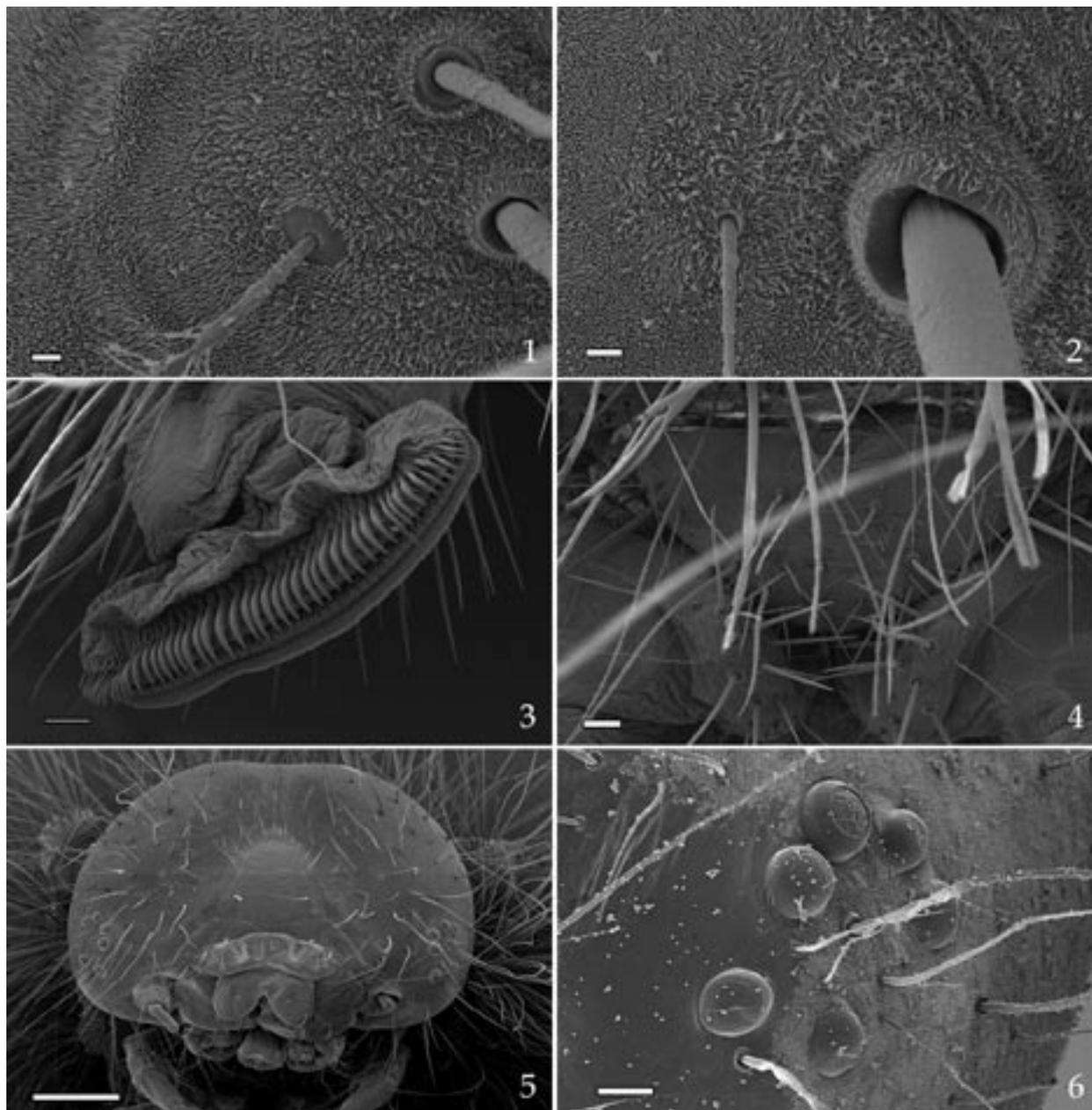


PLATE 47. LAST INSTAR LARVA. Thorax and abdomen. **Fig. 1.** *Lymantria (Porthetria) umbrosa*, T1, pinnaculum bearing SD1–2 verrucae covered with microspicules; scale=10 μ . **Fig. 2.** *Lymantria (Porthetria) umbrosa*, T1, D2 verruca covered with microspicules; scale=10 μ . **Fig. 3.** *Lymantria (Porthetria) umbrosa*, A10, left proleg; scale=100 μ . **Fig. 4.** *Lymantria (Porthetria) umbrosa*, A10, dorsal view; scale=100 μ . **Fig. 5.** *Lymantria (Porthetria) albescens*, frontal view; scale=1 mm. **Fig. 6.** *Lymantria (Porthetria) albescens*, stemma area; scale=100 μ .

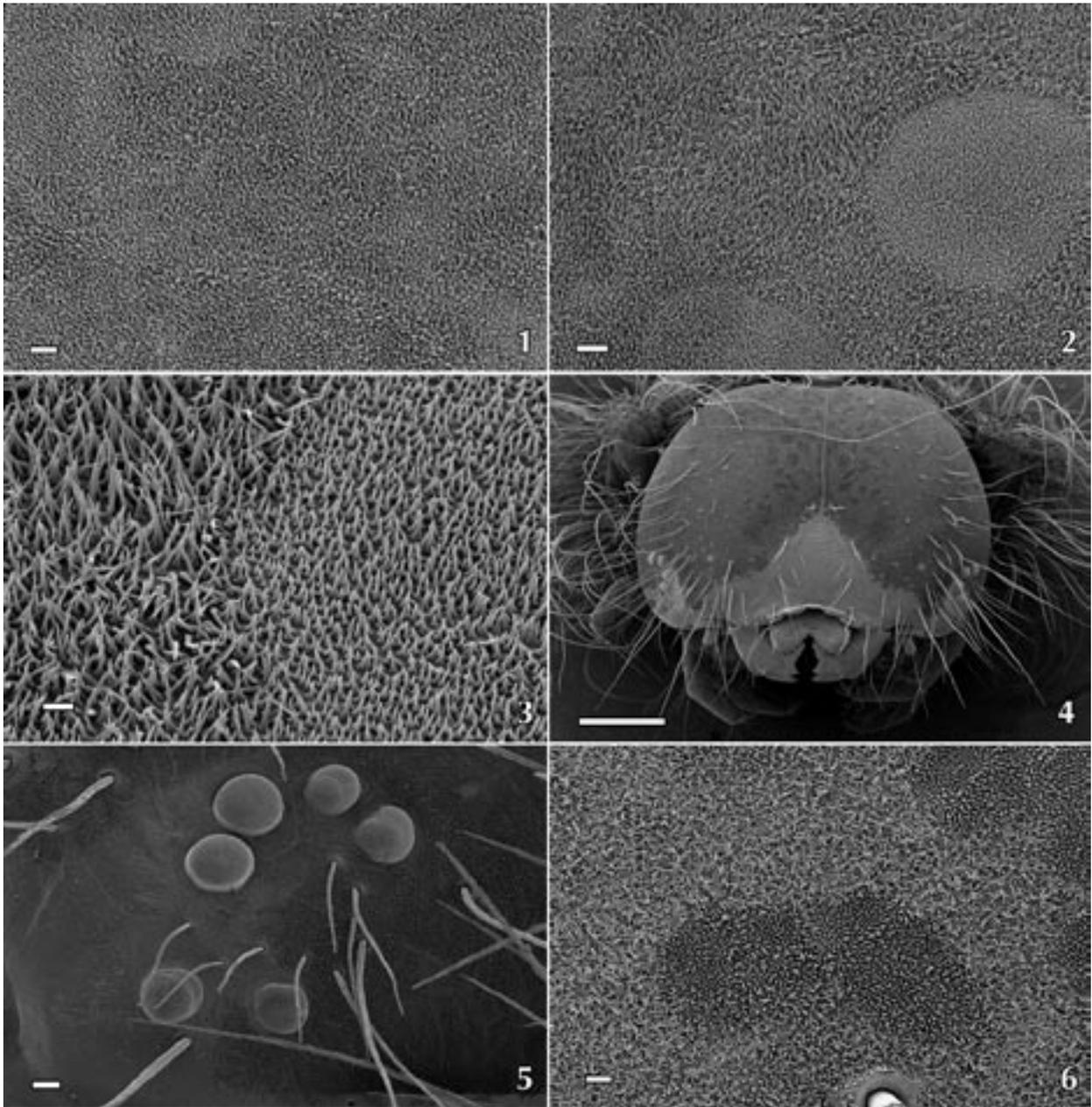


PLATE 48. LAST INSTAR LARVA. Head. **Fig. 1.** *Lymantria (Porthetria) albescens*, microspinules in black stripe; scale=10 μ . **Fig. 2.** *Lymantria (Porthetria) albescens*, microspinules and tonofibulary platelets adjacent to black stripe; scale=10 μ . **Fig. 3.** *Lymantria (Porthetria) albescens*, detail of microspinules and tonofibulary platelets adjacent to black stripe; scale=10 μ . **Fig. 4.** *Lymantria (Porthetria) xyliina*, frontal view; scale=1 mm. **Fig. 5.** *Lymantria (Porthetria) xyliina*, stemma area; scale=100 μ . **Fig. 6.** *Lymantria (Porthetria) xyliina*, microspinules and tonofibulary platelets adjacent to black stripe; scale=10 μ .

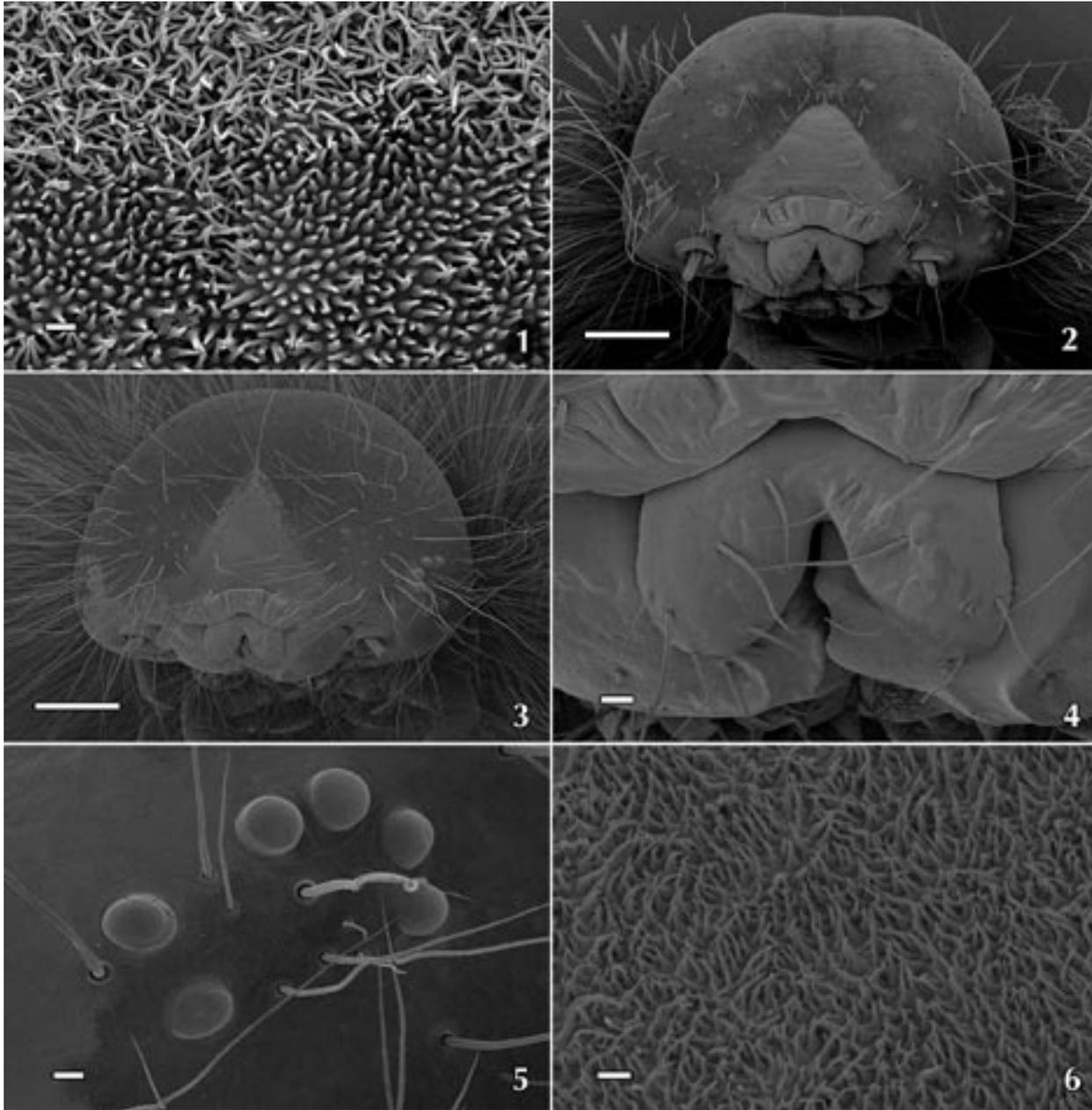


PLATE 49. LAST INSTAR LARVA. Head. **Fig. 1.** *Lymantria (Porthetria) xyline*, detail of microspinules and tonofibular platelets adjacent to black stripe; scale=10 μ . **Fig. 2.** *Lymantria (Lymantria) monacha*, frontal view; scale=1 mm. **Fig. 3.** *Lymantria (Lymantria) lucescens*, frontal view; scale=1 mm. **Fig. 4.** *Lymantria (Lymantria) lucescens*, clypeus; scale=10 μ . **Fig. 5.** *Lymantria (Lymantria) lucescens*, stemma area; scale=10 μ . **Fig. 6.** *Lymantria (Lymantria) lucescens*, microspinules in black stripe; scale=10 μ .

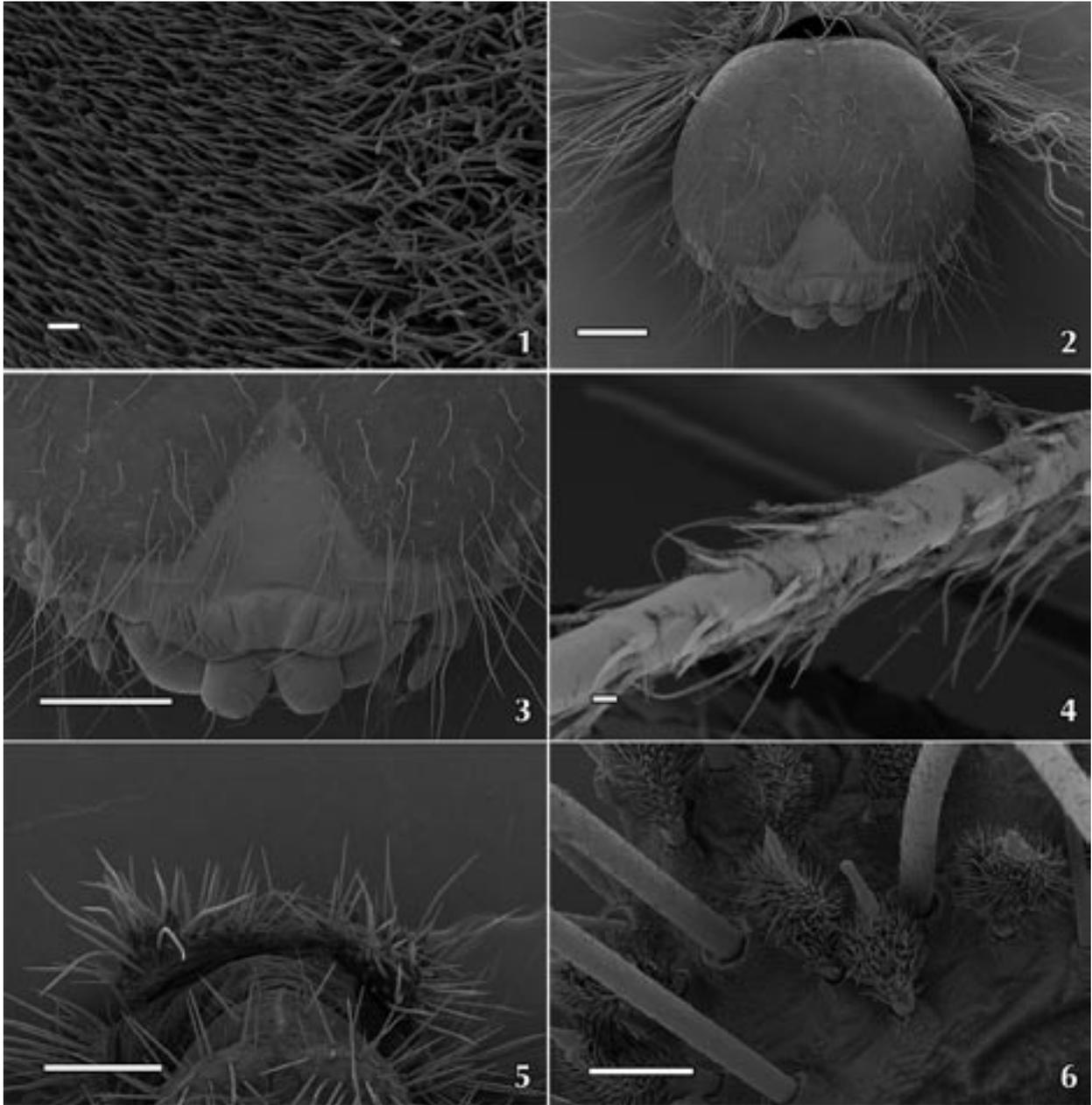


PLATE 50. LAST INSTAR LARVA. Head and thorax. **Fig. 1.** *Lymantria (Lymantria) lucescens*, microspinules in black stripe (left, shorter) and adjacent to black stripe (right, longer); scale=10 μ . **Fig. 2.** *Lymantria (Beatrìa) atemeles*, frontal view; scale=1 mm. **Fig. 3.** *Lymantria (Beatrìa) atemeles*, frons and clypeus; scale 1=mm. **Fig. 4.** *Lymantria (Beatrìa) atemeles*, T1, L verruca seta; scale=10 μ . **Fig. 5.** *Lymantria (Beatrìa) atemeles*, T2, specialized setae on dorsum of prothoracic shield; scale=1 mm. **Fig. 6.** *Lymantria (Beatrìa) atemeles*, T2, detail of specialized setae on dorsum of prothoracic shield; scale=100 μ .

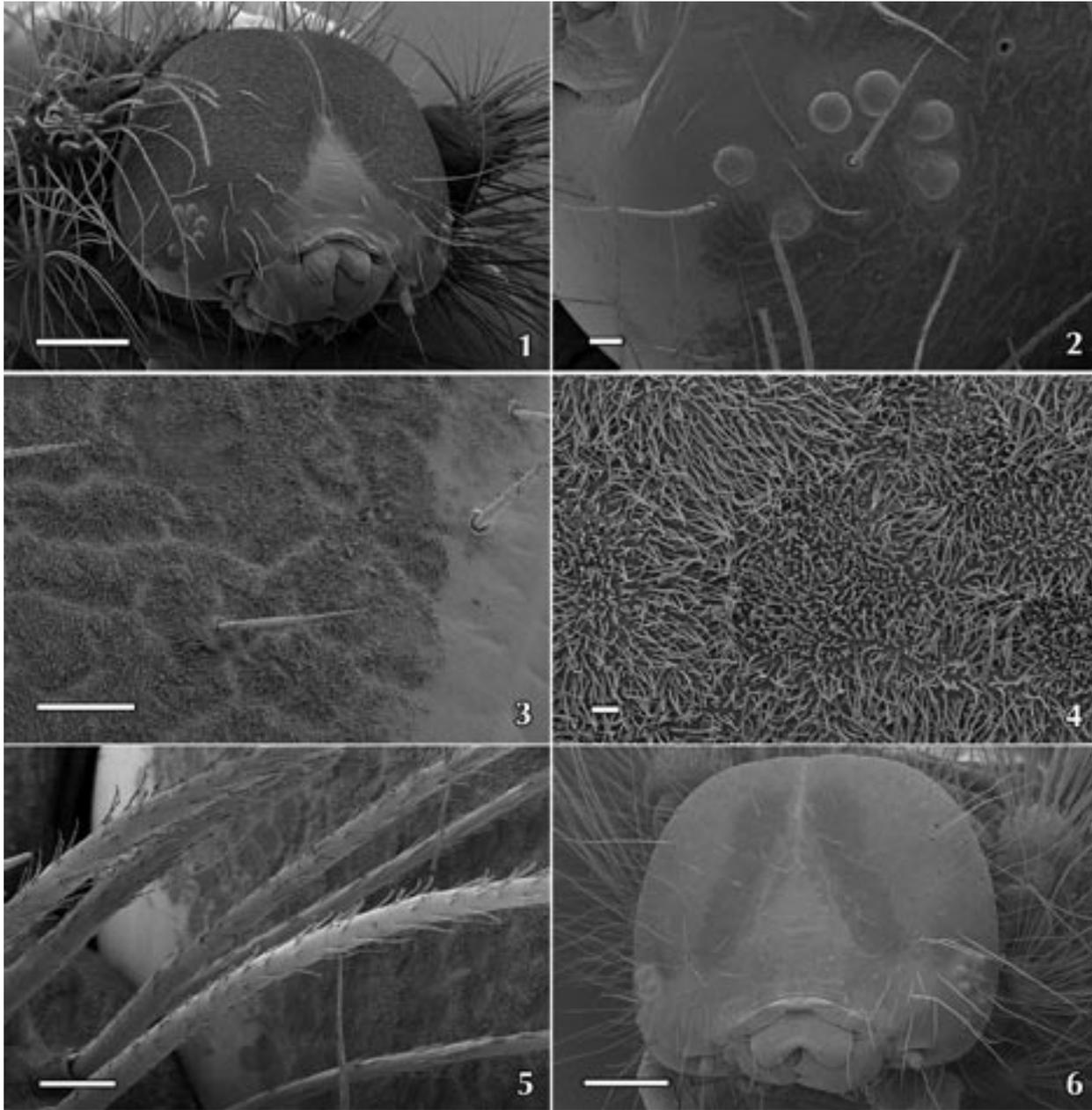


PLATE 51. LAST INSTAR LARVA. Head and thorax. **Fig. 1.** *Lymantria (Nyctria) mathura*, fronto-lateral view; scale 1 mm. **Fig. 2.** *Lymantria (Nyctria) mathura*, stemma area; scale=100 μ . **Fig. 3.** *Lymantria (Nyctria) mathura*, microspinules adjacent to frons; scale=100 μ . **Fig. 4.** *Lymantria (Nyctria) mathura*, detail of microspinules and tonofibular platelets adjacent to frons; scale=10 μ . **Fig. 5.** *Lymantria (Nyctria) mathura*, T1, L verruca setae; scale=100 μ . **Fig. 6.** *Lymantria (Collentria) fumida*, frontal view; scale=1 mm.

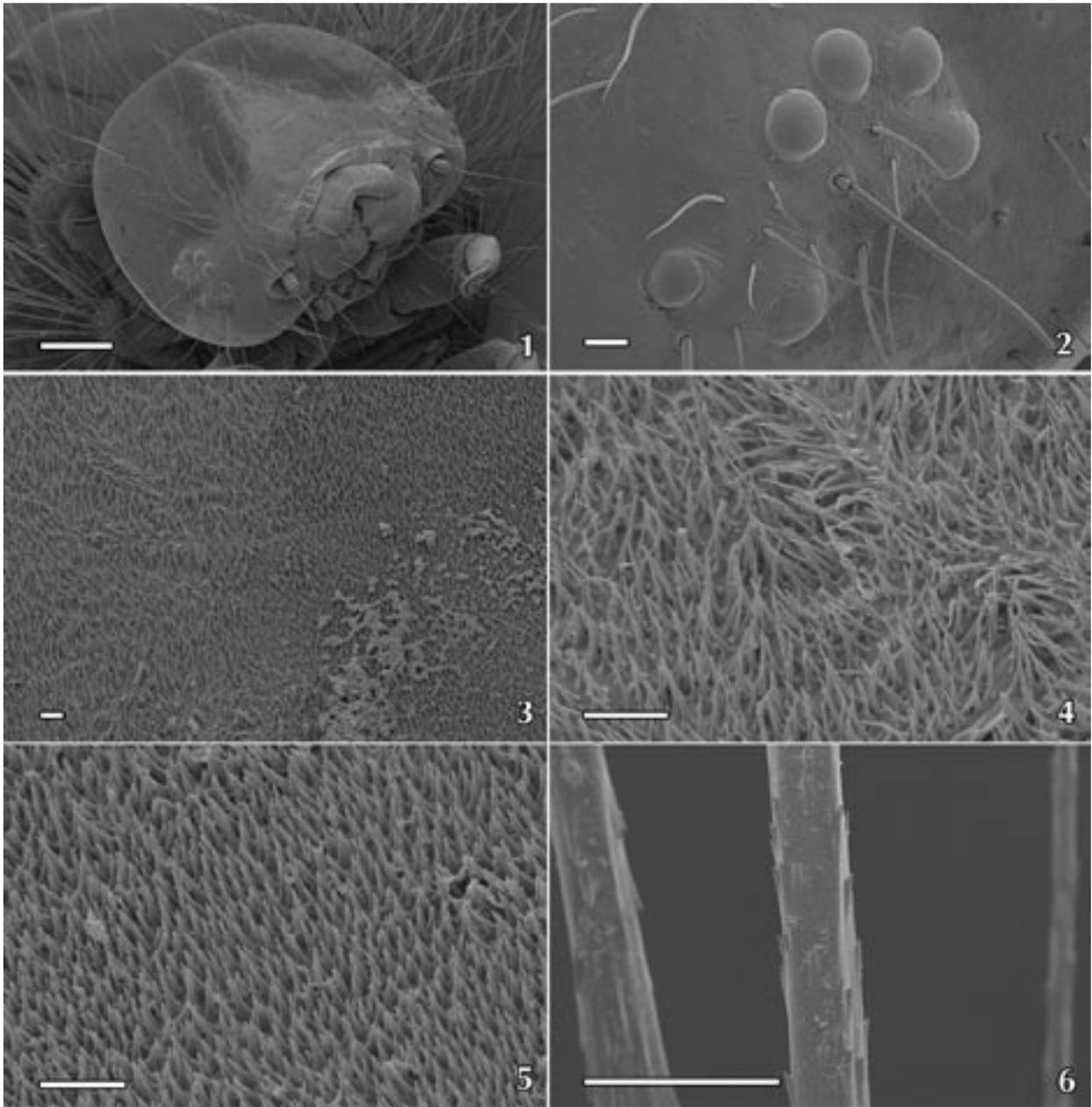


PLATE 52. LAST INSTAR LARVA. *Lymantria (Collentria) fumida*, head and thorax. **Fig. 1.** Head, fronto-lateral view; scale=1 mm. **Fig. 2.** Stemma area; scale=100 μ . **Fig. 3.** Microspinules in black stripe (right, shorter) and adjacent to black stripe (left, longer); scale=10 μ . **Fig. 4.** Detail of microspinules adjacent to black stripe; scale=10 μ . **Fig. 5.** Detail of microspinules in black stripe; scale=10 μ . **Fig. 6.** T1, L verruca seta; scale=100 μ .

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COMMON NAMES

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