อนุกรมวิธานของแมลงปั่นใยในภาคตะวันตกของประเทศไทย

นายพิสิษฐ์ พูลประเสริฐ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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TAXONOMY OF WEBSPINNERS (INSECTA : EMBIIDINA) IN WESTERN THAILAND

Mr. Pisit Poolprasert

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctoral of Philosophy Program in Biological Sciences
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Thesis Title	TAXONOMY OF WEBSPINNERS (INSECTA : EMBIIDINA) IN WESTERN THAILAND
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พิสิษฐ์ พูลประเสริฐ : อนุกรมวิธานของแมลงปั่นใยในภาคตะวันตกของประเทศไทย . (TAXONOMY OF W EBSPINNERS (INSECTA : E MBIIDINA) I N WESTERN THAILAND) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ. จริยา เล็กประยูร, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม : ผศ. ดร. ดวงแข สิทธิเจริญชัย, อ. ดร. บัณฑิกา อารีย์กุล บุทเชอร์, 200 หน้า.

แมลงปั่นใยจัดอยู่ในอันดับ Embiidina หรือ Embioptera มีการกระจายพันธุ์ทั้งในเขตร้อนและเขตอบอุ่น แมลงปั่นใยสามารถผลิตใยจากต่อมผลิตใยซึ่งอยู่บริเวณขาคู่หน้า อาศัยอยู่รวมกันเป็นกลุ่มภายในรัง เส้นใย กินใบไม้แห้ง มอสส์ ไลเคน ส์ และเปลือกไม้เป็นอาหา ร ในปัจจุบันมีรายงานการพบแมลงปั่นใยเพียงไม่กี่ชนิดในประเทศไทย ซึ่งเป็นประเทศที่มีความหลากหลายทางชีวภาพสูง งานวิจัยนี้จึงเน้นกา รศึกษาอนุกรมวิธานของแมลงปั่นใย โดยศึกษาในภาคตะวันตกซึ่งครอบค ลุมพื้นที่ 5 จังหวัด ได้แก่ จังหวัดตาก กาญจนบุรี เพชรบุรี ราชบุรี และประจวบคีรีขันธ์ โดยใช้ลักษณะทางด้านสัณฐานวิทยาภายนอก จากผลการศึกษา พบแมลงปั่นใยทั้งสิ้น 4 วงศ์ 7 สกุล 10 ชนิด และ 7 รูปแบบสัณฐาน วงศ์ Embiidae มี 2 รูปแบบสัณฐาน ได้แก่ *Oedembia* sp.1 และ *Oedembia* sp.2 วงศ์ Notoligotomidae มี 4 รูปแบบสัณฐาน ได้แก่ *Ptilocerembia* sp.1, *Ptilocerembia* sp.2, *Ptilocerembia* sp.3 และ *Ptilocerembia* sp.4 วงศ์ Oligotomidae มี10 ชนิด ได้แก่ *Aposthonia borneensis, A. ceylonica, A. problita, Eosembia auripecta, E. lamunae, E. paradorni, Lobosembia mandibulata, Oligotoma humbertiana, O. nigra* และ *O. saundersii* และ วงศ์ Teratembiidae มี 1 รูปแบบสัณฐาน ได้แก่ *Oligembia* sp.1 และพบแมลงปั่นใย 3 ชนิดในสกุล *Oligotoma* เป็นครั้งแรกในประเทศไทย และ พบ *Aposthonia problita, Eosembia lamunae* และ *E. paradorni* เป็นชนิดใหม่ ทั้งนี้ ได้มีการจัดทำไดโคโตมัสคีย์ และคีย์รูปภาพ ในระดับวงศ์ สกุล และชนิด พร้อมคำบรรยายลักษณะโดยเฉพาะอย่างยิ่ง สามารถใช้ลักษณะของเพศเมียในการจัดจำแนกชนิดของแมลงปั่นใย ซึ่งเหมาะสำหรับการนำไปใช้จำแนกชนิดได้อย่างรวดเร็ว ทั้งการศึกษาในพื้นที่หรือห้องปฏิบัติการ

จากการศึกษาความสัมพันธ์ ระหว่าง จำนวนชนิดของแมลงปั่นใย และถิ่นอาศัยต่างๆ พบว่า ป่าดิบแล้ง ป่าเบญจพรรณ และสวนป่า มีจำนวนชนิดของแมลงปั่นใยสูงสุด (6 ชนิด) ขณะที่จำนวนชนิดของแมลงปั่นใยที่น้อยที่สุด (1 ชนิด) ที่สามารถพบได้ทั้งในสวนสนและป่าชายหาด แมลงปั่นใยทั้ง 3 ชนิดของสกุล *Oligotoma* สามารถพบได้ทั้งในป่าธรรมชาติและพื้นที่ที่ถูกรบกวน โดยเฉพาะสวนป่าตลอดการศึกษา ซึ่งเป็นไปได้ว่า ชนิดเหล่านี้อาจถูกนำเข้ามาในพื้นที่ ในทางตรงกันข้าม *Eosembia lamunae*, *Lobosembia mandibulata*, *Oedembia* sp.2, *Oligembia* sp.1 และ *Ptilocerembia* sp.2 สามารถพบได้เพียงในป่าธรรมชาติ เท่านั้น อาจเป็นไปได้ว่า ชนิดเหล่านี้อาศัยอยู่ในพื้นที่ที่มีความเฉพาะเจาะจง นอกจากนี้ *Eosembia auripecta* สามารถพบได้ทั่วไปทั้งป่าธรรมชาติและพื้นที่ที่ถูกรบกวนโดยมนุษย์

สาขาวิชา วิทยาศาสตร์ชีวภาพ ลายมือชื่อนิสิต .....

ปีการศึกษา 2554 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....

ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

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PISIT POOLPRASERT : TAXONOMY OF WEBSPINNERS (INSECTA : EMBIIDINA) IN WESTERN THAILAND. ADVISOR : ASSOC. PROF. CHARIYA LEKPRAYOON, CO-ADVISOR : ASST. PROF. DUANGKHAE SITTHICHAROENCHAI, Ph.D., BUNTIKA AREEKUL BUTCHER, Ph.D., 200 pp.

Webspinners are small insects order Embiidina or Embioptera with tropical and subtropical distribution. They produce the fine silk in gland situation in the swollen foretarsi and live gregariously within silk galleries. They primarily graze on the outer bark of tree, decomposing leaf litter, mosses and lichens. The biodiversity, taxonomic position of webspinners in Thailand are poorly known. Therefore, the aims of this research were to study taxonomy, the species diversity as well as the distribution of webspinners from different habitat types in western Thailand. All specimens were identified based on morphological characters. A total of ten species and seven morphospecies from seven genera under four families of webspinners were recorded. The family Oligotomidae contained the greatest number of species (10) whereas the dominant genus found in this research was *Ptilocerembia* (4 species) of Notoligotomidae. There are two morphospecies of Embiidae: *Oedembia* sp.1 and *Oedembia* sp. 2, four morphospecies of Notoligotomidae: *Ptilocerembia* sp.1, *Ptilocerembia* sp.2, *Ptilocerembia* sp.3 and *Ptilocerembia* sp.4, ten species of Oligotomidae: *Aposthonia borneensis, A. ceylonica, A. problita, Eosembia auripecta, E. lamunae, E. paradorni, Lobosembia mandibulata, Oligotoma humbertiana, O. nigra* and *O. saundersii,* and one morphospecies of Teratembiidae (*Oligembia* sp.1). Three species of *Oligotoma* were recorded for the first time and three new species; *Aposthonia problita, Eosembia lamunae* and *E. paradorni* were discovered. In addition, the dichotomous and pictorial keys to families, genera and species levels and description of the webspinners from this study are presented, especially the keys to Thai webspinners based on adult females are provided for rapid observation in the field study or in the laboratory examination.

Of all studied habitat characteristic types, the highest number of species (6) occurred in dry evergreen forests, mixed deciduous forests and forest parks, whereas the lowest numbers of species (1) occurred in beach forests and coniferous plantations. Three species of the *Oligotoma* were found only in human exploited areas, particularly in forest parks throughout the study areas, which suggested they might have been introduced to the areas. On the other hand, *Eosembia lamunae, Lobosembia mandibulata*, *Oedembia* sp.2, *Oligembia* sp.1 and *Ptilocerembia* sp.2 were found solely in natural forests. It might be expected that these species may inhabit restricted habitats having specific requirements within these forests. Moreover, the most common species, which was distributed throughout the western Thailand, was *Eosembia auripecta* and was able to be encountered in both human exploited areas and natural forests.

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Student's Signature : .....
Advisor's Signature : .....
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LIST OF ABBREVIATIONS

Institutional symbols

The following institutional abbreviations are used to donate the location of specimens deposited.

CAS	California Academy of Sciences, San Francisco, U.S.A
CUMNH	Chulalongkorn University Museum of Natural History, Bangkok, Thailand
HDE	Hope Department of Entomology, Oxford University, UK
MCZ	Museum of Comparative Zoology, Harvard University, U.S.A
MHN	Museum d'Historie Naturella, Geneva, Switzerland
SZM	Stettiner Zoologisches Museum, Germany

Explanation of terminalia symbols

8 (T8, S8)	Eighth abdominal tergite / sternite
9 (T9, S9)	Ninth abdominal tergite / sternite
10L	Left hemitergites of tenth segment
10R	Right hemitergites of tenth segment
10LP	Left tergal process of tenth segment
10RP	Right tergal process of tenth segment
EP	Epiproct (somite 11)
GON	Gonopophysis internal sclerotic “rods” bordering the apex of the ejaculatory duct
H	Hypandrium (ninth sternite)
HP	Hypandrium process
LC_1	First segment of left cercus
LC_2	Second segment of left cercus
LCB	Left cercus-basipodite
LPPT	Left paraproct
LPPT-P	Process of left paraproct

MF	Medial flap
MS	Medial sclerite of somite 10
RC_1	First segment of right cercus
RC_2	Second segment of right cercus
RCB	Right cercus-basipodite
RPPT	Right paraproct

Head symbol

SMT	Submentum

Leg symbols

fm	femur
tb	tibia
ts	tarsus

Wing symbols

ABS (A)	Anal blood sinus (Anal)
C	Costa
CuA	Anterior cubitus
CuP	Posterior cubitus
CuBS	Cubital blood sinus
MA	Anterior Media
MP	Posterior Media
RA	Anterior radius
RBS	Radial blood sinus
RP	Posterior Radius
ScBS (Sc)	Subcosta blood sinus (Subcosta)

CHAPTER I

GENERAL INTRODUCTION

1.1 Rationale

Webspinners or embiids belong to the order Embiidina (Embioptera), a well characterized and often overlooked insect order with approximately 360 described species (Engel and Grimaldi, 2006). However, Ross (2000a) speculated that the true number was probably closed to 2,000 species worldwide. Typically, very few to no species live on remote islands, but some species have spread to several continents through anthropogenic intervention especially through transport as a result of overseas trade (Ross, 2007; Poolprasert *et al*., 2011a, b). They are readily recognized by their enlarged front tarsi, which contain about a hundred silk glands that are used for silk secretion (Nagashima *et al*., 1991; Ross, 1955, 2000a) for spinning a network of narrow hollow tubes, or galleries.

Because most species are very inconspicuous, spending most of their lives within silk galleries, which function as protection from abiotic and biotic threats such as rain and predators, respectively (Poolprasert and Edgerly, 2011). Webspinners are somewhat rarely observed by humans compared to the majority of the more conspicuous insects (Ross, 2000a), whilst they cause no economic or known ecological impact upon human, because they feed entirely on vegetable matters such as outer barks, dead leaves and lichens (Ross, 1991, 2007). Nonetheless, they are very interesting insects with a unique social behavior and ecology (Edgerly, 1987, 1988), and also have some primitive morphological characteristics.

There are some reports on the species diversity and little biological information of embiids from Thailand. A few taxa from Thailand have been investigated by Ross (2007) and many taxa await description so far. Thailand is a center for biodiversity because it contains flora and fauna from north, south, east and the central part and also the unique fauna in the west. This is an attractive region for biogeography. Because research on Thai embiid fauna quite limited in the number of

species reported is still an underestimate of the total as well as the embiid taxonomists are still scanty.

Thailand contains very different habitats from high mountains to low land including pine forest, deciduous forest, dipterocarp forest, dry evergreen forest, moist evergreen forest and even human exploited area. Because webspinners can be found in several types of forests, it is plausible that a rich fauna still exists in the patchy remnants of the diverse flora of Thailand. It is difficult to do a complete survey. Therefore, the western Thailand, the regionlocated in the biodiversity hotspot of Thailand, was conducted to be representative areas for study species diversity of webspinners.

The western part of Thailand includes five provinces; Tak, Kanchanaburi, Ratchaburi, Petchaburi and Prachuap Khiri Khan. This region has many different habitats including tropical rain-forest, dry evergreen forest, hill evergreen forest, mixed deciduous forest and dry deciduous dipterocarp forest. In addition, each forest type consists of dominant plant species, which is different from each other.

As mentioned above, knowledge of Thai embiid fauna's taxonomy has been too narrowly studies in the past. In order to extend the available information of those insects, this research focused on the species diversity, morphology of the embiids collected from western Thailand, as well as on the production of a dichotomous and pictorial keys to species level identification from the specimens collected in this study and also those already collected within Thailand and deposited in the museum.

1.2 Research objectives

The core objectives for the taxonomic study in the present work were as follows: (1) to describe morphological characters, together with constructing the dichotomous and pictorial keys to the families, genera and species of webspinners in western Thailand. (2) to analyze the species diversity as well as the distribution from various habitats characteristic types of webspinners in western Thailand.

1.3 Anticipated benefits

1. Taxonomic study of webspinners in Thailand will be the first data for the elusive taxa in Thailand, a potential biodiversity hotspot.

2. Data of biology, including behavior, ecology, distribution, diversity and role in ecosystem of webspinners in Thailand will be added greatly to our understand of the taxa.

CHAPTER II

LITERATURE REVIEW

Embiids, also known as webspinners or foot spinners, belong to the order Embiidina Enderlein, 1909 (or Embioptera Shipley, 1904). The Embiidina is classified within the Polyneoptera, which the earwigs, cockroaches, stick insects, mantids, katydids, grasshoppers, crickets and termites are included (Hening, 1981; Terry and Whiting, 2005). Most embiid species are small to medium size, narrow-bodied insects and are easily recognized by the large, bulbous basal tarsomere on each foreleg. They live in silk-lined galleries; the silk is produced by glands and spun when it is ejected through the hollow hair-like structures on the ventral surface of the basal tarsal segment. In general, the distribution of webspinners is restricted to tropicals and subtropic (Ross, 1970, 2000a, 2007), but some representatives are occasionally found in the warm temperate zone, probably as a result of recent artificial (anthropogenic) introduction through commerce (Poolprasert *et al*., 2011a). The order contains approximately 360 species in 14 families (Engel and Grimaldi, 2006; Ross, 1970) of webspinners known worldwide. However, Ross (2000a) estimated that there were at least 2,000 species existing in the world. It is difficult to estimate the embiid number, due to the little known almost every aspects of their biology, including the morphological, physiological, ecological, ethological, geographical and molecular biological characters of webspinners.

2.1 History of classification

The basic classification of webspinners has been historically based on morphology. Embiids are classified in to Phylum Arthropoda, Class Insecta (Hexapoda), Subclass Pterygota and Order Embiidina Enderlein, 1909 (Embioptera Shipley, 1904). Recently there has been some concern over standardizing the order name for webspinners. The two most commonly used during that time has been Embioptera Shipley, 1904 and Embiidina Enderlein, 1909.

Ross (2000a) used Embiidina (Embidina Hagen, 1861), the first group name applied exclusively to embiids, as the order's name in preference to more recent

Embiodea (Kusnezov, 1903) a nd E mbioptera (Shipley, 1904) . E mbiidina ha s had important e arly us e i n monographs a nd is now rapidly s upplanting t he awkward, inappropriate name Embioptera. Grimaldi and Engel (2005) and Engel and Grimaldi (2006) a rgued that E mbioptera, m eaning "lively w ing" in G reek, i s not particularly descriptive. They also point out that the suffix –ina is standard for the rank of subtribe making Embiidina unde sirable a s well. A t present, Mills (2009) us ed E mbioptera as the s tandardized na me f or t his or der because webspinners a re, i n f act, l ively and active i nsects, s o Embioptera is more descriptive than their suggestion, e ven if t hey are not great fliers or even winged in many cases.

Order Embiidina i s one of t he m ore extensively used na mes. I t i s t he more appropriate spelling of the name Embidina introduced by Hagen 1861 (and referred to by Enderlein (1903)), and nowadays us e of t his order n ame mig ht be mo st s uitably attributed to Hagen a s i t i s by R oss (2000a). The first use of this spelling, how ever, was by Enderlein (1909). In 1912, Enderlein attributed the origin of the name (or this particular spelling of the name) to himself (Enderlein, 1903) but in that document he also us ed the s pelling Embidina. Additionally, and m ore significantly, bot h Hagen (1861) a nd Enderlein (1903) used t he na me a t what w ould now be r egarded a s t he family rank, not as an order. Consequently, Embiidina as an ordinal name is properly attributed to Enderlein (1909) as first pointed out by Engel & Grimaldi (2006).

In the past, there were different classifications of Embiidina reported by Davis (1940), R oss (1970, 2000a, 2003a, 2003b) a nd Szumik (2004). Of a ll 17 families o f embiids s o f ar, belonged t o E mbiidina, were r eviewed b y author (Table 2.1) some families w ere described fro m amber f ossil (Burmitembiidae Z herikhin, 1980; Sorellembiidae E ngel and Grimaldi, 2006; Sinembiidae H uang and N el, 2009). Because m any t axa a wait de scription, i t is not pos sible t o de velop a n adequate classification at th is time . S pecies o f th e f amily C lothodidae, c onfined t o S outh America, are the most primitive (Ross, 2000a). The large family, Embiidae is highly diverse a nd r equires di vision i nto subfamilies a nd, pe rhaps, f amilies. A nother large family Anisembiidae is c onfined to the Americas. T ropical A sia has many families, particularly, Oligotomidae, s everal of w hich become w idely d istributed a ccidentally through transportation as a result of commercial. Australia also has many oligotomids, a f ew N otoligotomidae a nd a n a bundance of A ustralembiidae, a f amily c onfined t o

eastern Australia. The large family Teratembiidae is best represented in the Americas and Africa, with only a few Asian species. A number of additional families await description. Strangely, Madagascar does not appear to have endemic embiids. Apparently there are no southern hemisphere origins (Ross, 1970) .

Table 2.1 Comparison of four Classifications of webspinners.

Davis (1940)	**Ross (1970, 2001, 2003a, 2003b)**	**Szumik (2004)**	**Herein (with updates by author)**
Order Embioptera	Order Embiidina	Order Embiodea	Order Embiidina
Suborder Protembioptera	Suborder Embioptera	Family ‘‘Clothodidae’’	Family Andesembiidae Ross, 2003
Family Protembiidae	Family Clothodidae	Suborder Neoembiodea	Family Anisembiidae Davis, 1940
Suborder Euembioptera	Family Embiidae	Family Sorellembiidae	Family Archembiidae Ross, 2001
Family Clothodidae	Subfamily Archembiinae (A)	Family Anisembiidae	Family Australembiidae Ross, 1963
Family Oligembiidae	Subfamily Scelembiinae (B)	Subfamily Anisembiinae	Family Burmitembiidae Zherikhin, 1980
Family Teratembiidae	Subfamily Microembiinae (C)	Subfamily Scolembiinae	Family Clothodidae Enderlein, 1909
Family Oligotomidae	Subfamily Embiinae	Subfamily Aporembiinae	Family Embiidae Burmeister, 1839
Family Notoligotomidae	Subfamily D	Subfamily Chorisembiinae	Family Embonychidae Navás, 1917
Family Anisembiidae	Subfamily E	Subfamily Platyembiinae	Family Notoligotomidae Davis, 1940
Family Embiidae	Subfamily F	Subfamily Cryptembiinae	Family Oligotomidae Enderlein,1909
	Subfamily Pachylembiinae	Subfamily Chelicercinae	Family Paedembiidae Ross, 2006
	Family Notoligotomidae	Family Andesembiidae	Family Sinembiidae Huang and Nel, 2009
	Family Embonychidae	Family ‘‘Oligotomidae’’	Family Sorellembiidae Engel and Grimaldi, 2006
	Family A	Family Teratembiidae	Family Teratembiidae Krauss, 1911
	Family B	Family Archembiidae	Family A*Adelosembiidae Ross
	Family Andesembiidae (C)	Family ‘‘Embiidae’’	Family B* Peltembiidae, Ross
	Family Anisembiidae	Family Embonychidae	Family C* Ptilocerembiidae Ross
	Suborder A	Family Notoligotomidae	
	Family Australembiidae	Subfamily Notoligotominae	
	Family D (Burmitembia)	Subfamily Burmitembiinae	
	Suborder B	Subfamily Australembiinae	
	Family (*Enveja*)		
	Suborder C		
	Family Oligotomidae		
	Family E		
	Family Teratembiidae		

Asterisk (*) indicates treatment will be published by Ross (The Embiidina of Eastern Asia, Part II; Ross, pers comm).

2.2 Zoogeographic range

Embiids are warm-climate-adapted insects whose natural occurrence is almost universal in all suitable environments on any continent, or continental islands, which have a tropical or warm-temperate climate. Distributions of the embiids are given by the following zoogeographical regions (Mill, 2009): Afrotropical, Palaearctic, Nearctic, Neotropical, Australian, Oriental and Oceanic regions (Figure 2.1). Details of distribution of embiids are given below (Figure 2.2).

1**. Afrotropic or Ethiopian** includes Africa, south of the Sahara Desert, the southern and eastern fringes of the Arabian Peninsula, the island of Madagascar, southern Iran and extreme southwestern Pakistan, and the islands of the western Indian Ocean. The webspinners which distributed throughout this zone were Family Embiidae (*Acrosembia*, *Apterembia, Berlandembia*, *Chirembia, Dihybocercus*, *Dinembia, Donaconethis, Electroembia, Embia, Enveja, Leptembia, Machadoembia, Macrembia, Odontembia, Parachirembia* and *Pseudembia*), Family Oligotomidae (*Oligotoma*) and Family Teratembiidae (*Paroligembia*).

2. **Palaearctic** is the largest ecozone. It includes the terrestrial ecoregions of Europe, Asia north of the Himalaya foothills (except India, Pakistan and SE Asia), northern Africa (to Sahara) and the northern and central parts of the Arabian Peninsula. There are four families of embiids that are reported in this region, including Family Embiidae (*Arabembia, Cleomia, Embia*, *Parembia* and *Pseudembia*), Family Oligotomidae (*Aposthonia, Haploembia* and *Oligotoma*), Family Paedembiidae (*Badkhyzembia* and *Paedembia*) and Family Sinembiidae (*Juraembia* and *Sinembia*).

3. **Nearctic** covers most of North America, including Greenland and the highlands of Mexico. Southern Mexico, Southern Florida, Central America, and the Caribbean islands are parts of the Neotropic ecozone, together with South America. The distribution of embiids in this region composes Family Anisembiidae (*Anisembia*, *Chelicerca* and *Dactylocerca*), Family Oligotomidae (*Haploembia* and *Oligotoma*) and Family Teratembiidae (*Diradius* and *Oligembia*).

4. **Neotropic** includes South and Central America, the Mexican lowlands, the Caribbean islands, and southern Florida, because these regions share a large number

of plant and animal groups. The embiids that distributed around this realm consist of Family Andesembiidae (*Andesembia* and *Bryonembia,*), Family Anisembiidae (*Anisembia, Bulbocerca Glyphembia* and *Ectyphocerca, Mesembia, Phallosembia, Stenembia, Poinarembia*, *Exochosembia, Isosembia, Pogonembia, Saussurembia, Aporembia, Brasilembia, Chelicerca, Dactylocerca, Oncosembia, Pelerembia, Schizembia, Chorisembia, Cryptembia, Platyembia* and *Scolembia, Microembia*), Family Archembiidae (*Ambonembia, Archaebia, Biguembia, Calamoclostes, Conicercembia, Dolonembia, Ecuadembia, Embolyntha, Gibocercus, Amazonembia, Gibocercus, Litosembia, Malacosembia, Neorhagadochir, Ochrembia, Pachylembia, Pararhagadochir* and *Xiphosembia*), Family Clothodidae (*Antipaluria, Chromaclothoda, Clothoda* and *Cryptolothoda*), Family Oligotomidae (*Oligotoma*) and Family Teratembiidae (*Diradius, Oligembia* and *Teratembia*).

5. **Australasia** includes Australia, New Guinea, Tasmania, Indonesian Islands east of Wallace's line (Celebes, Timor, etc.) but it does not include New Zealand. Most common Australian embiids which distributed throughout zone are Family Australembiidae (*Australembi* and *Metoligoma*), Family Notoligotomidae (*Noligotoma*) and Family Oligotomidae (*Aposthonia*).

6. **Oriental or Indo-Malaya** extends from Afghanistan and Pakistan through the Indian subcontinent and Southeast Asia to lowland southern China, and through Indonesia as far as Java, Bali and Borneo, east of which lies the Wallace line. Six families of embiids can be found in this area, including Family Burmitembiidae (*Burmitembia*), Family Embiidae (*Embia* and *Oedembia*), Family Embonychidae (*Embonycha*), Family Notoligotomidae (*Ptilocerembia*), Family Oligotomidae (*Aphosthonia, Bulbosembia, Eosembia, Lobosembia* and *Oligotoma*) and Family Sorellembiidae (*Sorellembia*).

7. **Oceania or Pacific** is oceans of the world and truly oceanic, isolated, small islands. A few oligotomids were recorded from this zone particular in the family Oligotomidae (*Oligotoma* and *Aposthonia*). *Aposthonia oceania,* this species has been collected on many islands for instance, Austral Island, Caroline Islands (Kusaie, Lele, Mutunlik, Easter Island, Fanning Island, Hawaiian Islands, Henderson Island, New Caledonia, Marquesas Islands, Rapa, Society Islands). For *Oligotoma,* two species were recorded from this zone. *Oligotoma humbertiana* widespread through man's

commerce has been collected on Tinian and Guam. *Oligotoma saundersii*, an artificially pantropical species, is common in Hawaii where it appears to have been introduced in modern commerce (Ross, 1951).

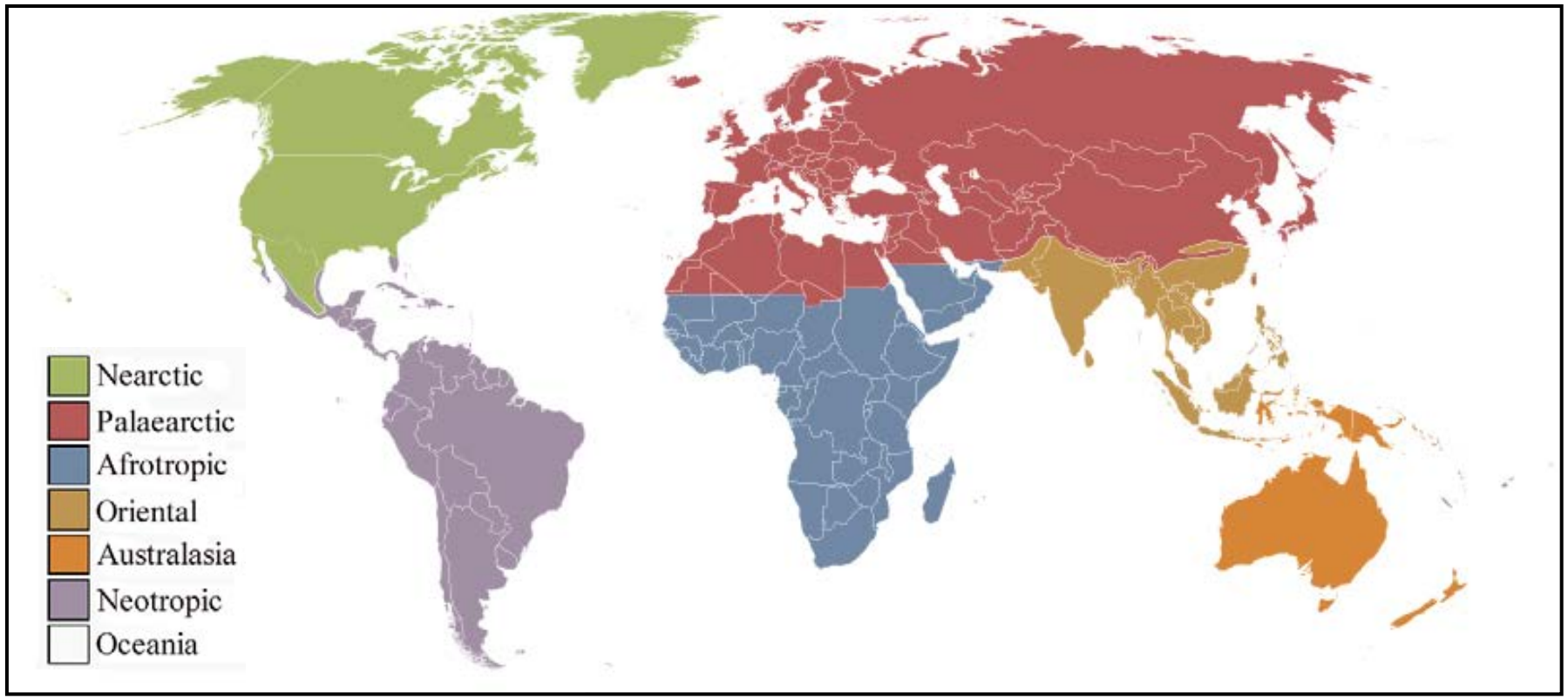


Figure 2.1 Map of zoogeographic regions.

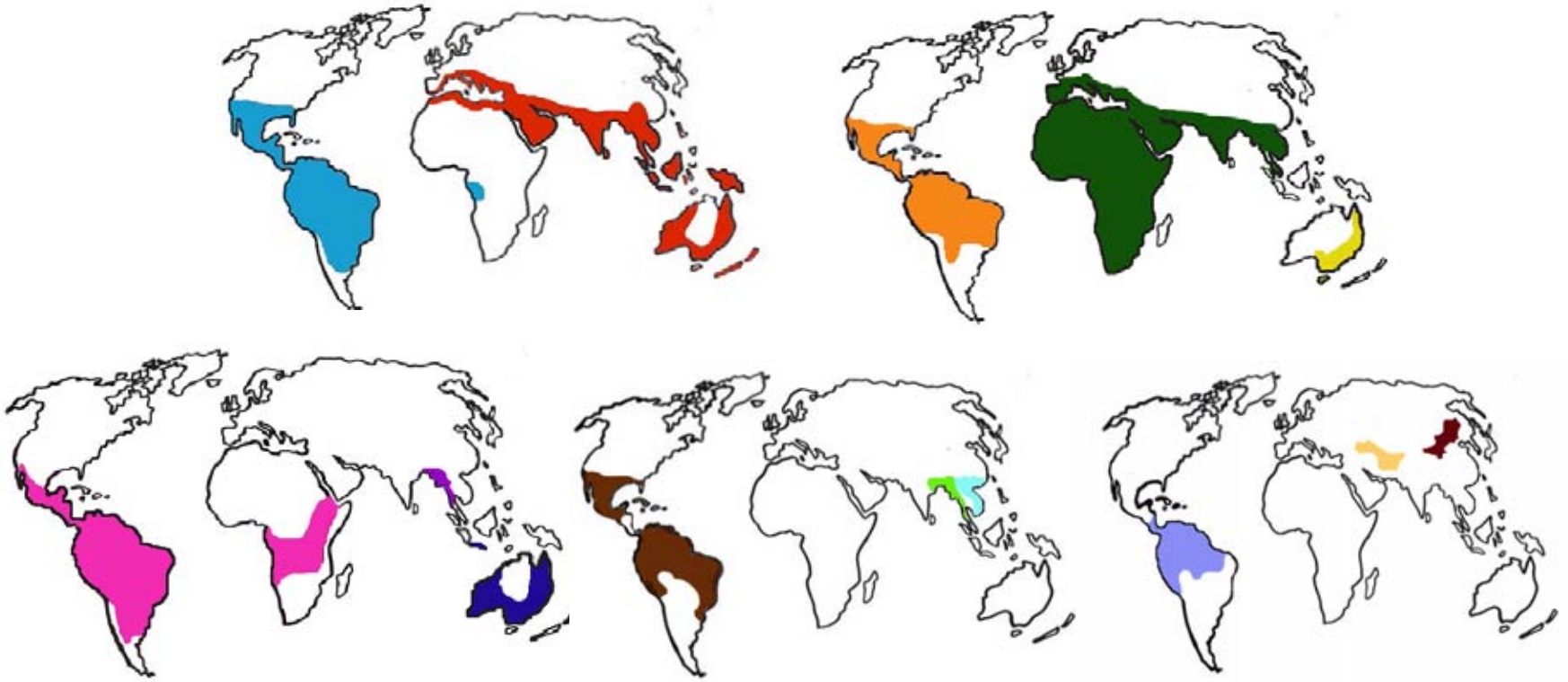


Figure 2.2 Distribution maps of the families in the order Embiidina.

2.3 Knowledge of Embiidina in Eastern Asia and Thailand

Okajima (1926) found *Aposthonia japonica*, which was considered as a new species. The present paper deals so far as he was aware, only with embiids from Japan and Formosa, of which one from three species was new to science. The other species of their embiid-fauna of the family Oligotomidae were *O. latreillei* and *O. saundersii*, respectively.

Ross (1978) collected embiids from China. The results showed embiids collected were in the family Oligotomidae and most of these were introduced invasive species. *Aposthonia varians* (Navás, 1922) was the only native species that was described. Moreover, *Aposthonia borneensis* (Hagen, 1885) was also found in Thailand. This is an anthropogenic "weed" species with a wide distribution in the commercial areas of many localities in Southeast Asia, Indonesia, Laos and Malaysia, and has previously been recorded from Nan Province in Thailand.

Yang (1999) studied oligotomids and found three species, *Aposthonia borneensis, Oligotoma greenniana* and *O. humbertiana.* In this study, he also reported that the last two, from Fujian Province in China, were previously unrecorded.

Ross (2000a) reported on some embiids collected from all over the world, including eastern Asia (China, Indonesia, Japan, Laos, Malaysia, the Philippines, Singapore, Taiwan and Thailand). Most of the embiids were in the family Oligotomidae. For instance, *Aposthonia ceylonica* (Enderlein, 1912) is probably endemic to south India and Sri Lanka. Now, spreading to Mauritius, Madagascar, Malaysia, Laos and Thailand.

Lee *et al*. (2002) studied a species of oligotomids (*Oligotoma saundersii* (Westwood, 1837)), the first record of Korean embiids. This species, the introduced species, was on the bark of an ornamental tree (*Pachira aquatica* Aunl). There are 35 females and 5 males of embiid from the greenhouse used for their morphological and biological studies.

Ross (2007) published a summary of Embiidina of Eastern Asia, Part I. In document he stated that the richest part of the eastern Asia's webspinner fauna was in Thailand. The genus of *Eosembia* was considered to be a new genus for this region.

Of all 12 species, two species were (*Eosembia auripecta* and *E. equicercata*) recorded in Thailand for the first time.

Poolprasert and Edgerly (2011) set out to collect Thai webspinners, while relying on Ross' 2007 reported for descriptions and localities. Indeed, they successfully collected numerous colonies of *Eosembia auripecta* during their work as part of an on-going project in the evolution of this order. In the process, they also discovered a population of similar webspinner but with wingless males. Therefore, they considered that species to be new species (*Eosembia apterosa*).

Before this study, at least seven species in the family Oligotomidae were known from Thailand. They are listed below.

Order Embiidina Enderlein, 1909

Family: Oligotomidae Enderlein, 1909

1. *Aposthonia borneensis* (Hagen, 1885)
2. *Aposthonia ceylonica* (Enderlein, 1912)
3. *Bulbosembia thailandica* Ross, 2007
4. *Eosembia aequicercata* Ross, 2007
5. *Eosembia apterosa* Poolprasert and Edgerly, 2011
6. *Eosembia auripecta* Ross, 2007
7. *Lobosembia mandibulata* Ross, 2007

2.4 Morphology

In general, embiids are typical hemimetabolous insects with gradual metamorphosis that included three stages: egg, nymph and adult. The general morphology and life cycle of webspinners has been reviewed by various authors as below.

External anatomy

Adult

They are small to medium insects, about 0.5 - 20 mm in body length, long and column-like, usually brown or black in color. Segmentation is normally distinct including the head, 3 thoracic, and 10 abdominal segments. Male is alate or pterous while female and some male species are wingless forms (Figure 2.3).

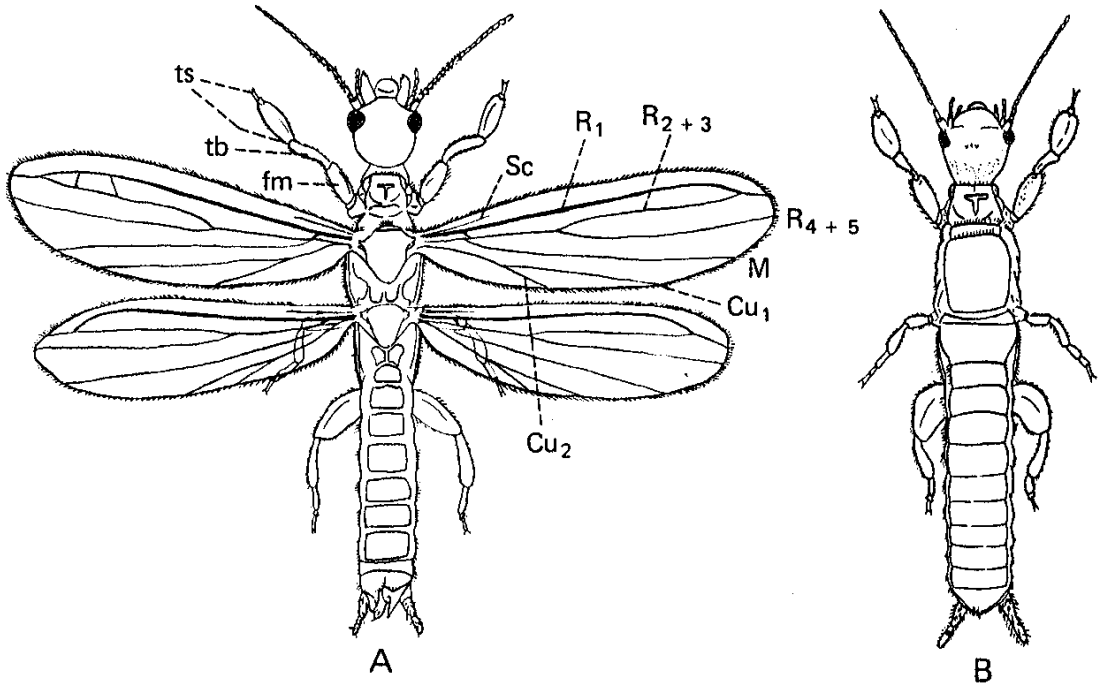


Figure 2.3 Adult embiids, dorsal: (A) winged male (B) wingless female. (Ross, 1991).

1) *Head*: The head is well developed and similar in all stages of each species. Their distinctive heads have mandibulate mouthparts that are directed forward. Antennae, or sense organ (tactile hair and chemoreceptors) (Slifer *et al.*, 1973), of adult female are filiform, 12-32 segments, thickly clothed all over with hairs, and similar throughout the order. However, non-nymphoid adult males show consistent intergeneric and interspecific variation useful in classification. Eyes are normally small, well separated, and often kidney-shaped, ocelli absent. Paired compound eyes of males are bigger than females and nymph in all species. Mandibles of adult males usually flattened, elongate, often with only a few inner-apical dentations. Submentum of males often large, sclerotic, shield-like (Ross, 1991; 2000a).

2) *Thorax*: The prothorax, one of the least specialized parts of the body, is similar in both sexes throughout the order; ventral thoracic sclerites separated by membrane, the prothorax of the alate male simple being less robust. The meso- and metathorax anatomy of adult female typifies that of adult females and nymphs throughout the order, as well as that of fully neotenic (apterous) males. Adult females unquestionably once possessed wings (Ross, 2000a).

2.1 *Leg*: The legs of embiids, remarkably similar in all taxa, are very short relative to body size as best exhibited by nymph, adult females, and neotenic adult males, tarsi 3-segmented. Their legs are easily distinguished from other insects by their large metatarsal gland in the first tarsal segment of the forelegs (Ross, 1991) (Figure 2.4). Over 80 individual silk glands (Figure 2.5) are localized in the enlarged tarsal segment (Nagashima *et al.*, 1991; Ross, 1955, 2000a), each glandular chamber is a globular form bounded by one large multinucleate cell. The inner surface of the gland contains many microvilli. The cuticular lining of the duct is composed of several layers (Nagashima *et al.*, 1991). The spinning organs have been described several times (Alberti and Storck, 1976; Barth, 1954; Melander, 1902; Mukerji, 1927 and Rimsky-Korsakov, 1914). Mid legs relatively small; hind legs with en large femora due to size of tibial depressor muscular (Ross, 1991). Davis (1936) examined the tibial muscles and noted that, unlike saltatorial insect which have large hind tibial extensor or levator muscles, the flexor or depressor muscle is greatly enlarged and

thus accounts for the large size of the femora. The extensor, or levator, muscle is much reduced and fits into a groove atop the flexor.

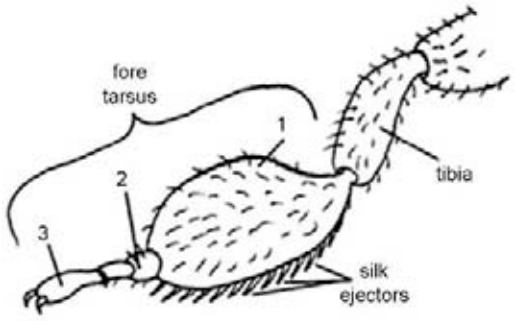


Figure 2.4 External aspects of foretarsus of embiid. (Roos, 2000a)

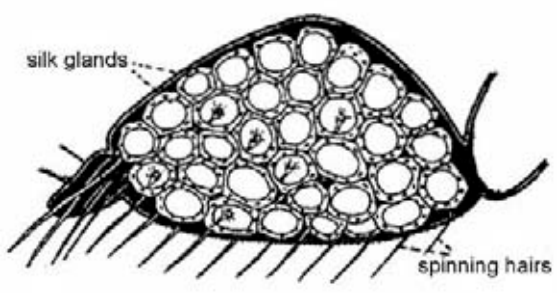


Figure 2.5 Schematic structure of the first segment of embiid foretarsus, showing an arrangement of silk glands and ejectors or spinning hair. (Ross, 1955)

2.2 *Wing*: Both winged and wingless males may occur in the same species. The mainly function of their wings is to disperse from one colony to another for mating purpose, whereas females are always wingless (Ross, 2000a). Two pairs of wings are quite similar in form and structure; elongate, membranous, extremely delicate, subequal; with character, pigmented stripes alternating with hyaline stripes. R1 abroad, inflatable blood sinus (RBS) with granular, pink borders; most other veins normal or represented only by line of setae and pigment stripe; basal half of RP and MA closely parallel, appearing as one vein; cubitus developed as a blood sinus (CuBS) from which emerges CuA; anal blood sinus (ABS) represents the rudimentary anal wing; few cross-veins (Figure 2.6). At rest the wing are held flat to body, overlap and do not extend to tip of abdomen (Ross, 1991).

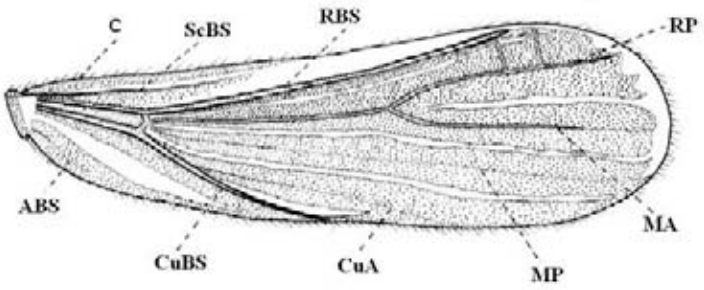


Figure 2.6 Venation of fore wing of embiid. (Mariño and Márquez, 1994)

3) *Abdomen*: The abdomen is slender, with 10 well defined, subequal segments; cylindrical in female, dorso-ventrally flattened in male; usually as long as head and thorax combined, cerci 2 segmented with tiny hair and tactile setae those help to guide their backward movement within the galleries (Ross, 1991). Ten abdominal somites are conspicuous in both sexes but vestiges of the 11th and 12th segments persist. Basic somatization is most apparent in females while that of adult males is confused by complexity of external genitalia, particular in amorphic species (Ross, 2000a).

Male genitalia: Complex, asymmetrical (Figure 2.7 A), 10th tergum cleft, bearing complex processes and flaps; left circus (LC) enhanced by lobes and/or by segment-fusion to better function as a claspers in copulation (Ross, 1991). A fundamental character of terminalia is significant in systematic studies.

Female genitalia: Similar in size (Figure 2.7 B) represented only by slightly modified S 8 and S 9 and rudimentary valvifer lobes (Ross, 1991). Reduction of genitalia is possible because of the simplicity of oviposition. A female attaches eggs to the surface within the galleries, or on silk substrates, therefore the special structures are not required to insert them into the substrate (Ross, 2000a).

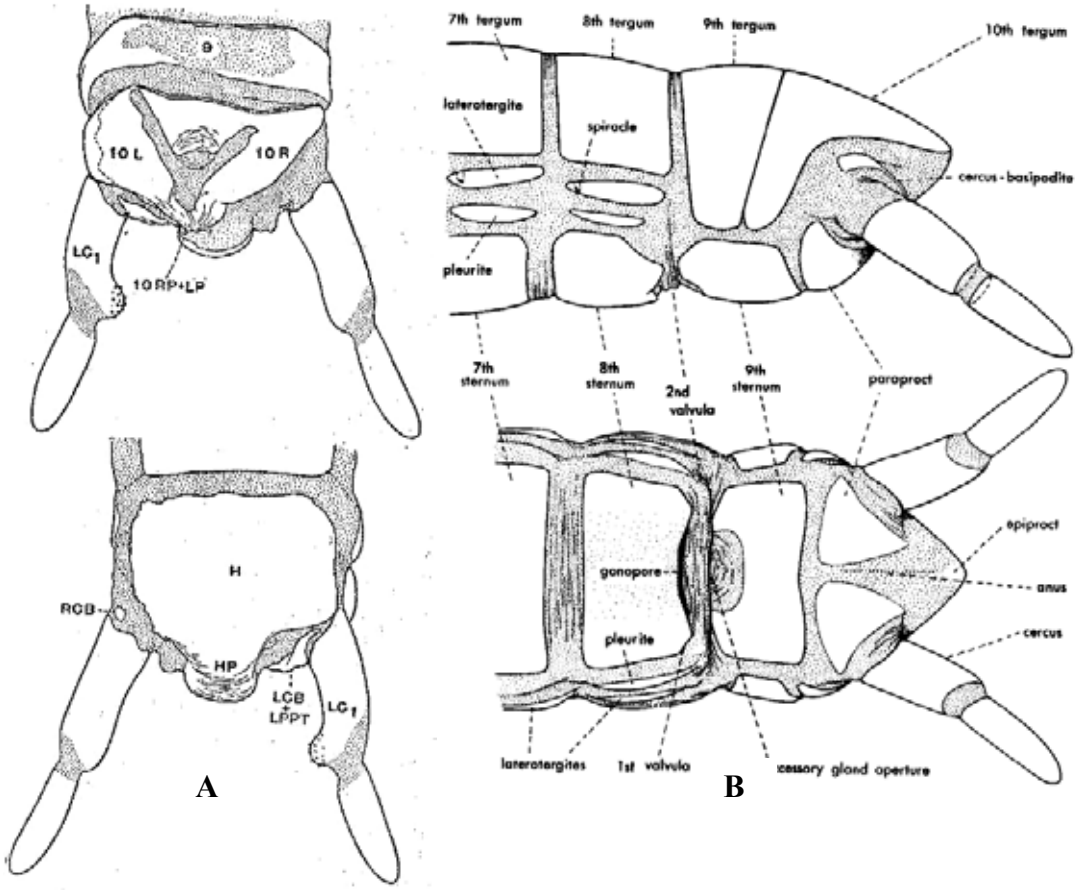


Figure 2.7 Abdominal terminalia of adult male (A) and female (B) of embiids, Upper (A), dorsal aspect, Lower (A), ventral aspect, Upper (B), lateral aspect, Lower (B), ventral aspect. (modified from Ross, 1944 and 2000a)

Nymph

The numbers of nymphal stages are similar among Embiidina. Nymphs undergo five instars before reaching adulthood (Ananthasubramanian, 1957; Ananthasubramanian and Ananthakrishnan, 1960; Bradoo, 1967; Bradoo and Joseph, 1970; Mills, 1932; Szumik, 1999) (Figure 2.8). All nymphal stages take place in the same habitat. Nymphal form is usually elongate and cylindrical or dorsoventrally flattened. The young strongly resemble the adults and gradually develop through a series of molts, or shedding of their exoskeleton. Wing pads develop only in the male nymphs of winged species (McLachlan, 1877, 1879).

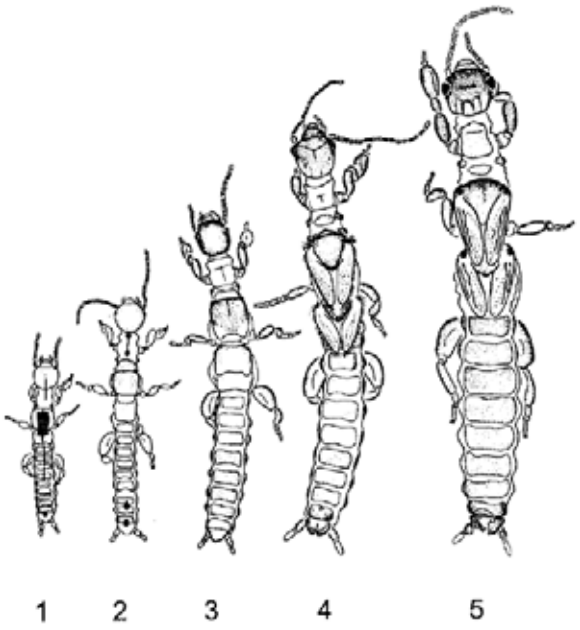


Figure 2.8 Development of embiids (male); 1-5, 1st instar, 2nd instar, 3rd instar, 4th instar and 5th instar, respectively. (Szumik, 1999)

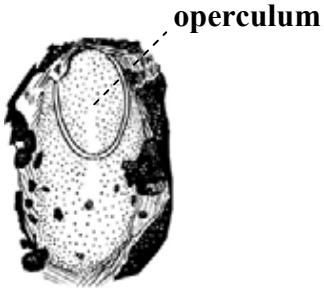


Figure 2.9 The egg of embiid was shown with a thin silk coating here and there and with patches of macerated material. (Edgerly *et al*., 2007)

Egg

Eggs are small and tubular in form, basally rounded, slightly curved, and have a large, slanted, strongly rimmed operculum (Figure 2.9), pale cream-white in color (Melander, 1903 ; Ross, 2000 a). In average size, 1 mm in length and 0.5 mm in diameter (Imms, 1913). Eggs of all species are quite different (Edgerly *et al*., 2007). The surface of the chorion either has polygonal markings, or granules, or both. Eggs

release from the vulva with the operculum inward and are deposited within the galleries, normally attached to a substrate. The larva hatches by breaking a preformed line of weakness between the main body of the shell and the operculum (Stefani, 1956). Frequently, however, eggs are laid in a single-layered cluster and are placed in the hardened paste of habitat material pulverized by female (Ross, 2000a).

Internal anatomy

The digestive system: Alimentary canal is long, simple tube with large salivary glands and 6 large rectal papillae; 20-30 Malpighian tubules in adult (Melender, 1903; Ross, 1991). In nymph the proventriculus is very distinct due to folds which flatten as the structure becomes packed with food (Lacombe, 1965).

The nervous system: It consists of 3 thoracic and 7 discrete abdominal ganglia (Figure 2.10). The abdominal ganglia terminate caudally at 8th abdominal segment, only 5th segment lacking ganglion (Melander, 1903).

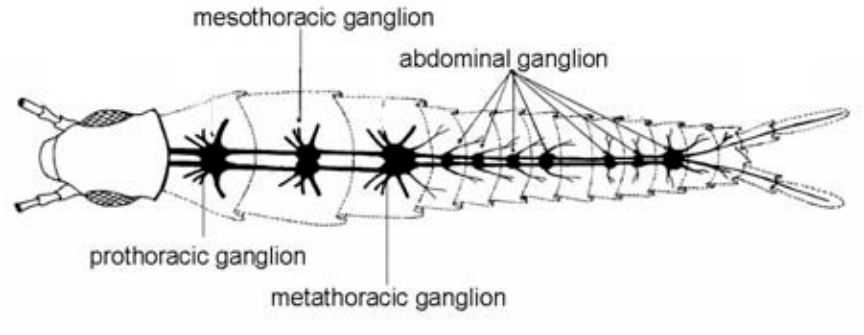


Figure 2.10 Schematic drawing of the nervous system of embiid. (Lacombe, 1971)

The tracheal system: It includes two pairs of thoracic spiracles (meso- and metathorax) and first eight spiracles pairs of abdominal segments. Only the metathoracic spiracles have the air expiration function; all others serve for inspiration. Various structures in the spiracles protect the atrium (Barth and Lacombe, 1955).

The circulatory system: Long, simple dorsal vessel which extends forward from 9th abdominal segment into the cranium. It opens anteriorly near the

circumoesophageal connectives. The dorsal vessel has a pair of ostia and valves corresponding to each thoracic and abdominal segment (Melander, 1903).

The excretory system: This system is represented by Malpighian tubules, pericardial cells, and fat-body. The number and disposition of Malpighian tubules is variable with the order. The pericardial cells are localized around the entire dorsal vessel up to the opening of the aorta in the head (Melander, 1903). The fat-body forms compact layers in the dorsal and ventral regions of the body. In males they are more developed in the abdominal region (Lacombe, 1963).

The reproductive system: Male reproductive system consists of five pairs of testes (Figure 2.11 A) with a metameric disposition, two distinct ducts, two epididymis, and the ejaculatory organs. The accessory gland varies in number and size and opens in the anterior portion of the ejaculatory duct (Lacombe, 1971). The female reproductive organs include five pairs of panoistic ovarioles connecting with each lateral oviduct regularly arranged in the female (Niwa *et al*., 1993; Ross, 2000a) (Figure 2.11 B). Reproduction usually involves with the fusion male and female gametes and fertilized eggs are usually laid in clusters attached to the surface of substrate (Lacombe, 1971).

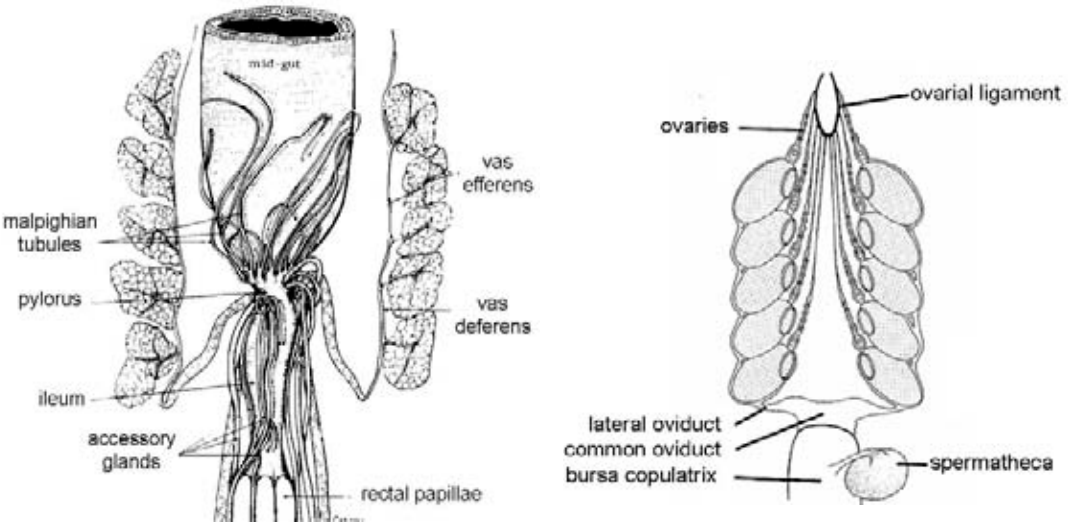


Figure 2.11 Schematic drawing showing the structure of the reproductive systems of the male (A) and female (B). (Lacomb, 1971; Niwa *et al*., 1993)

2.5 Life cycle

The life cycle of webspinners is one of incomplete metamorphosis. Mating takes place within the safety of galleries. Male uses the mouthparts to hold the female's head while mating. Male dies soon afterward. After mating, the female lays a single layer of her eggs within the gallery, where they hatch into nymphs that resemble small, wingless adults (Ross, 2000b). The numbers of eggs depend on each species. Ananthasubramanian and Ananthakrishnan (1960) believed that the numbers of eggs laid in captivity were always very limited (6-15 in *Oligotoma minuscule*, 15-24 in *O. humbertiana*. Bradoo (1967) calculated from the numbers of eggs laid by individual females in its life time varied from 41-74. Total of eggs of *O. greeniana* varied from 77-208 (Bradoo and Joseph, 1970). Besides, Ling (1934a) stated that each females of *O. humbertiana* probably did not produce more than ten eggs.

Females normally deposit their eggs on the silken floor of galleries. Sometimes the females, e. g. *Oligotoma melanura* constructed a larger and more densely spun gallery covered with feces for laying eggs inside (Ross, 1944). The eggs were often coated or embedded in a hardened paste of masticated bark or leaf fragments, presumably glued together with spumaline (Roepke, 1919; Kaltenbach, 1968). Many Embiidina, however, do not cover their eggs but lay them singly or in clusters in the galleries. The female guards such eggs, and in some species moves them from one part of the gallery system to another, according to conditions. The female also often guards the newly hatched larvae, but these soon spin galleries of their own.

After egg hatching, adult females were reported to stay with their nymphs in *Aposthonia ceylonica* (Bradoo, 1967), *Anisembia texana* (Mills, 1932), *Embia major* (Imms, 1913), and *Oligotoma humbertiana* (Ling, 1934a, 1934b). After a brief period of parental care, the nymphs molt four times before reaching adulthood. For the sex ratio, Bradoo and Joseph (1970) reported an overall sex ratio for *Oligotoma greeniana* of 57 males to 46 females from five laboratory cultures. Bradoo (1967) found, for *Aposthonia ceylonica*, seven adult males and 28 adult females collected in the field. Most of the 203 embiids collected were nymphs of *Anisembia texana*, but the data

were not presented. Ananthasubrananian (1957) reared 40 males and 31 females of *Oligotoma humbertiana* in the laboratory.

Adult males never eat, and leave the home colony almost immediately to find a female and mate. In some species, the female then eats the male, but in any event, the male will not survive for long after mating (Ross, 2000a). Embiid life cycles vary from a generation per 2 years up to five generations per year (Table 2.2).

In addition, there are some known cases of parthenogenetic females, in which the young develop from unfertilized eggs, such as *Haploembia solieri* (Rambur, 1842), this species is widely distributed in the Mediterranean basin (Fontana, 2002; Ross, 1957, 1960). Females typically guard their eggs and youngs. In some species, females coat their eggs with their own waste and chewed up bits of vegetable materials, whilst others move the eggs inside the galleries for protection (Edgerly, 1987, 1988, 2002; Poolprasert and Edgerly, 2011; Ross, 2000b).

Table 2.2 The numbers of generation per 1 or 2 years were reported in the literature for six species of embiids.

Species name	Generations per year (/y)					
	Location	1 /2y's	1 /y	2 /y	4-5 /y	Reference
Anisembia texana	Texas		X			Mills, 1932 Melander, 1903
*Aposthonia ceylonica**	India				X	Bradoo, 1967
Aposthonia japonica	Japan			X		Okajima, 1926
*Embia major***	India		X			Imms, 1913
Embia taurica	Crimea	X				Kusnezov, 1904
*Eosembia aequicercata****	Thailand		X			Ross, 2007
*Eosembia auripecta****	Thailand		X			Ross, 2007

* Each life cycle was completed within a maximum of 27 days

** Females live up to 6 ½ months after oviposition

*** The following year adults began maturing as early as February but peak maturity period was in April through June.

2.6 Biological habitats

Webspinners can be found in various types of forest i.e. tropical evergreen forests, tropical cloud forests, seasonally-dry grassy wood land, semi-arid (open grassland), desert areas, and human habitats (Ross, 2000b). They build their silk galleries on exposed bark, on rock surfaces and branches in the more humid regions and under rock, bark, or logs in the drier parts of their areas. Galleries are also found on hanging moss in mountain rainforests. (Ross, 1970).

The east Asian "weed species" of *Oligotoma*: *O. humbertiana, O. nigra* and *O. saundersii* can be found from the bark of trees in both forests and human exploited areas. The habitats of *O. humbertiana* have been rather extensively described (Ling 1934a, 1934b; Ananthasubramanian, 1957; Edgerly, 1977). *Oligotoma nigra* was found on the bark of ornamental and appeared to prefer dry areas (Ross, 2006). *Oligotoma saundersii* are able, at least temporary, to be come e stablished in greenhouses. Moreover, this species was found to disappear into crevices, under the bark of trees and other humid and shady places.

In Thailand, many webspinners dwell in leaf litter during the dry season but when moisture is available, they move from extensive silk galleries to bark on lichens where they feed. Humidity from nearby creeks or irrigated habitats around homes seemed enough to stimulate webspinners to move out of litter and onto trees. In contrast, in drier places, webspinners appear to wait for the rains within isolated tubes of silk within leaf litter. Poolprasert and Edgerly (2011) found dozens of mature webspinners during their fieldwork in northern Thailand, seemingly gravid females of a variety of species sitting in leaf litter within tubes of silk near the bases of trees (some of which showed off empty silk galleries from the previous season). Only females of *Eosembia apterosa* were found to be reproducing while in the leaf litter. No evidence of silk on tree bark found in the evergreen forest type locality, indicating that young may develop within this microhabitat rather than on bark. Because of the limited numbers collected, however, further exploration is needed to verify that this habit characterizes this species.

2.7 Feeding

They primarily graze on the outer bark of tree, decomposing leaf litter, mosses and lichens on bark, rocks, termite mounds and soils in their nature (Edgerly, 2004; Ross, 1970, 2000b). Undoubtedly, many old substrates are coated or permeated with live microorganism, such as algae, which are also nutritious. However, Males of most species do not feed after reaching maturity and die soon after mating (Ross, 2000a). Embiids rarely leave their silken tunnels, the growth of colony is done by expanding the tunnel system to new food sources. Adult males do not feed. There is not any evidence that digestion depends on symbiotic intestinal organism (Ross, 1970, 2000a). Ross successfully reared the webspinner species collected throughout the range of order, by using a diet of dead oak leaves and lettuce (Ross, 2000a).

2.8 Mating

Mating occurs within galleries. When a male located a gallery containing a receptive female, he bit an opening, entered, and approached the female head-on, rapidly jerking his body and vibrating his antennae. Mandibles of males were modified in some species and apparently used to grasp the females by the back of head (Ross, 1970). If the female was unreceptive, her reaction, perhaps varying according to species, would be antagonistic and dangerous. In some encounters, a female attempted to eat, or at least bit an approaching male. She lunged toward the male with the same motions used in defending eggs, or young brood. There were often antagonisms or fighting between males (Ross, 2000a).

2.9 Social behavior

All embiids were categorized as subsocial but division of labor was not found (Ross, 1991). Some were also communal (Edgerly, 1987a, b, 1988), with reproductive adult females of the same generation, each with her own egg mass, sharing a commonly constructed silk gallery system (Ross, 1970, 2000b). Females generally exhibited simple parental care, licking the eggs and occasionally moving them (Edgerly, 1987a, b, 1988). Early nymph instars usually congregated near their mother and perhaps got the benefit from her presence for at least two instars (Ross, 2000a).

Males are not known to exhibit parental care, although such behavior cannot be ruled out.

Apparent maternal care has been recorded for many species of embiids. The adult females of *Anisembia texana* (Mills, 1932), *Antipaluria urichi* (Edgerly, 1987), *Oligotoma greeniana* (Bradoo and Joseph, 1970), *Aposthonia ceylonica* (Bradoo, 1967), *Embia major* (Imms, 1913), and *Oligotoma humbertiana* (Ananthasubramanian, 1957) showed their bodies over cluster eggs but the function of this behavior was not investigated for any of these species. Colonies of Embiids collected in the field vary from solitary females (*O. humbertiana* and *Embia major*) with their offsprings to populations that included both solitary and communal groups (*Aposthonia ceylonica* and *O. saundersii*) to strictly communal (*Anisembia texana* and *Antipaluria urichi*).

2.10 Natural enemies

Specialized parasites are associated with webspinners. The Sclerogibbidae is a family of aculeate Hymenoptera, all species of which are ectoparasites of embiids nymph (Callan, 1939; Krombein, 1979; Shelter, 1973). Scelinoid wasps (*Embiodia* sp.) parasitize the eggs. A tachinid fly (*Perumbyia embiaphaga*) was discovered parasitizing a species of *Clothoda* (Clothodidae) from Peru (Arnaud, 1963). Shaw and Edgerly (1985) found a new genus of braconids wasp parasitizing *Clothoda urichi* adult females in Trinidad. Disease organism such as gregarines (*Gregarina marteli, Diplocystic cleric;* (Stefani, 1959, 1960) and coccida (*Adelea transita*) (Denis, 1949) also attacked the embiids.

Predation is also a source of mortality for embiids, both within and outside of silk. Edgerly (1994) observed a wolf spiders (Lycosidae), a jumping spider (Salticidae), a gecko (*Gonotodes vittatatus*) and a neuropteran larva (Ascalaphidae) killing *Clothoda urichi* wandering outside of their silk. Webspinners are the prey of asilid fly (Asilidae) (Callan, 1952). Other predators, which reached the embiids by cutting through silk, pulling off sheet of silk or piercing through it were ants, birds and harvestmen, respectively. Additionally, embiophiles (mirid-like, Plokiophilidae), which act as predators on embiids or other insects and mites within the gallery. (Carayon, 1974; Ross, 2000b).

2.11 Economic importance

They are never considered as pests because they fed on smattering of dead vegetable and lichens (Poolprasert *et al*., 2011a, b), thus the webspinners are not listed as endangered or threatened for the conservation status (Ross, 1970, 1991, 2000b). Although only occasional minor economic recorded such as the webbing of galleries and feeding on buds and incipient fruits of the avocado trees (*Persea americana*), together with much excrement, caused the drying of young growth and fruit in western Negev, Israel (Argaman and Mendel, 1991), a few species, especially Indian species (weed species) of *Oligotoma*, were widespread through ancient and modern trade (Ross, 1991, 2007).

CHAPTER III

MATERIALS AND METHODS

3.1 Surveys and collection

1) Study site

The study of webspinners was conducted from 2008 to 2010 for both wet (May to September) and dry (October to April) seasons. The specimen collecting was taken by encounter from various ecosystem types from highly degraded anthropogenic places to native forests in western Thailand, consisting of Tak, Kanchanaburi, Ratchaburi, Petchaburi and Prachuap Khiri Khan provinces from north to south, respectively (Figure 3.1). Detail backgrounds of these provinces were given below.

1.1) Kanchanaburi covers a total area of approximately 19,483 km². Topographically, it is covered with mixed deciduous, lower mountain. The province covers the source valleys of the Kwae Yai and Kwae Noi rivers ("River Kwai"), which merge at the city Kanchanaburi and form the Mae Klong River there.

1.2) Phetchaburi is located at the northern end of the Malay Peninsula, with the Gulf of Thailand to the East and the Tanao Sri mountain range forming the boundary to Myanmar. A total area covers 6,225 km^2. Except these border mountains, most of the province is a flat plain area. With an area of about 3000 km², the Kaeng Krachan National Park is the largest national park of Thailand, covering nearly half of the province. It protects mostly rainforests in the mountains along the boundary to Myanmar, but also the Kaeng Krachan reservoir is part of the park. The Phetchaburi River is only the important river of the province.

1.3) Prachuap Khiri Khan covers an area of 6,367 km². The province is located on the Kra Isthmus, the narrow land bridge connecting the Malay Peninsula with mainland Asia. The province contains the narrowest part of Thailand - directly south of the capital, it is just 13 kilometers from the coast of the Gulf of Thailand to the border with Myanmar. Physiographically Prachuap Khiri Khan is moderately plain area with altitude varying from 0-1200 meters above mean sea level. The

maximum altitude can be reached in the north eastern and central west regions, which makes approximately 30% of the area.

1.4) Ratchaburi covers about 5,196 km^2. The east part of the province contains the flat river plains of the Mae Klong river, intersected by many canals. The west of the province is more mountainous, and includes the Tanao sri mountain range. As the mountains are made mostly of limestone, with several caves containing stalactites there. The main river of the west part is the Phachi River.

1.5) Tak covers a total areas of about 16,406 km^2, is situated on the Ping river basin. To the west, the border touches on Myanmar demarcated by mountain ranges and the Moei River. There has the Bhumibol Dam, which stops the river Ping, one of the two sources of the Chao Phraya river. The largest artificial lake in Thailand with an area of 300 km^2 is created in this province. Thungyai Naresuan wildlife sanctuary, shares half of the lake front with Kanchanaburi and Huai Kha Khaeng wildlife sanctuary at the border with Uthai Thani where are World Heritage Sites.

2) Field collecting

The habitat types for webspinner collection in western Thailand from natural habitats (7) to human exploited areas (3), consisting of dry dipterocarp forest (DDF), dry evergreen forest (DEF), hill evergreen forest (HEF), mixed deciduous forest (MDF), beach forest (BF), tropical rain forest (TRF), coniferous plantation (CP), forest park (FP), rubber plantation (RP) and mango plantation (MP) (Figure 3.2). The classification of forest types was followed by Marod and Kudin in 2009. Collecting site descriptions are also shown in Table 3.1

In each representative area, each habitat type was divided into 3 sampling units. For each sampling unit, the length of the line transect sampling is 1 kilometer. Within the sampling trail, the possible shelter habitats or foraging sites of webspinners i.e. on and under bark of the trees, under or in crevices of rocks, and under leaf litter were observed to find the specimens. The specimen collection was conducted by hands, aspirator, forceps, paint brush, chisel and then kept them in the plastic box containers. In addition, the characteristic of the galleries, ecological habitats, altitude and GPS (Global Positioning System) from each collecting site were recorded.

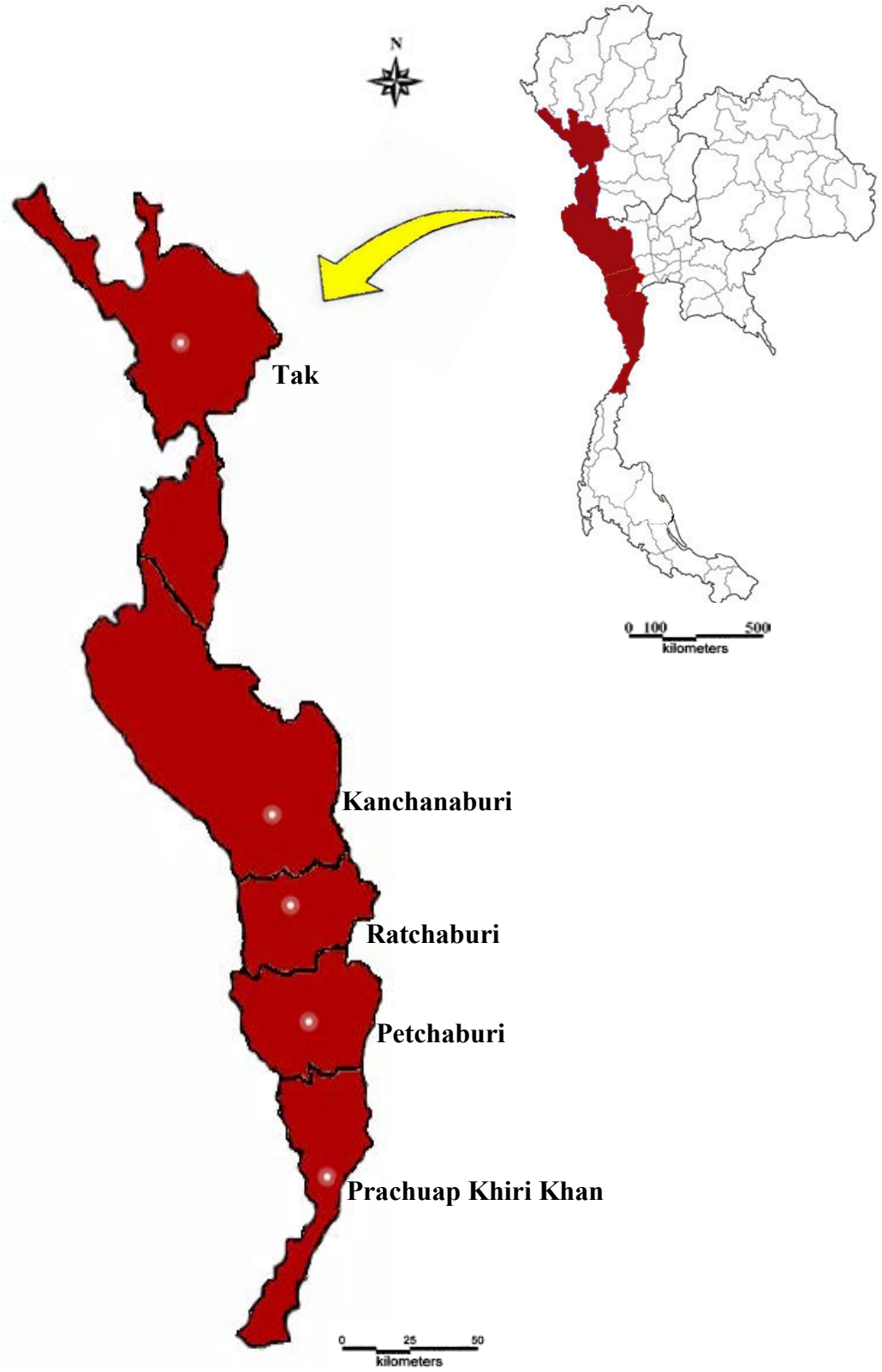


Figure 3.1 The map shows the study sites with provinces.

Figure 3.2 Habitat ty pes f or w ebspinner c ollection i n w estern T hailand. A: dry dipterocarp fo rest (D DF), B: dry e vergreen forest (D EF), C: hill ev ergreen forest (HEF), D: mixed deciduous forest (MDF), E: beach forest (BF), F: tropical rain forest (TRF), G: coniferous pl antation (CP), H: forest p ark (FP), I: rubber plantation (RP) and J: mango plantation (MP).

Table 3.1 Collection locality data for webspinners in western Thailand.

Locality		Collection data	
Province	**District**	**GPS**	**Habitats type**
Tak,	Mae Ramat	16º58'N, 98º31'E	Dry evergreen forest
	Mae Sod	16º45'N, 98º31'E	Hill evergreen forest
	Mae Sod	16º42'N, 98º34'E	Forest park
	Mas Sod	16º45'N, 98º53'E	Dry dipterocarp forest
	Mae Sod	16º45'N, 98º54'E	Mixed deciduous forest
	Mae Sod	16º45'N, 98º57'E	Coniferous plantation
	Mueang	16º42'N, 98º31'E	Mango plantation
	Mueang	16º46'N, 98º00'E	Mixed deciduous forest
	Mueang	16º46'N, 98º00'E	Forest park
Kanchanaburi	Bo Phloi	14º39'N, 99º18'E	Dry evergreen forest
	Mueang	14º02'N, 99º31'E	Mango plantation
	Thong Pha Phum	14º44'N, 98º37'E	Mixed deciduous forest
	Thong Pha Phum	14º43'N, 98º35'E	Rubber plantation
Ratchaburi	Pak Tho	13º16'N, 99º29'E	Mixed deciduous forest
	Saun Phueng	13º32'N, 99º20'E	Mixed deciduous forest
	Saun Phueng	13º32'N, 99º20'E	Forest park
Petchaburi	Ban Lad	13º02'N, 99º53'E	Mango plantation
	Kaeng Krachan	12º45'N, 99º36'E	Dry evergreen forest
Prachuap Khiri Khan	Bang Saphan	11º19'N, 99º24'E	Rubber plantation
	Bang Saphan	11º19'N, 99º24'E	Forest park
	Bang Saphan	11º19'N, 99º24'E	Tropical rain forest
	Mueang	11º48'N, 99º47'E	Forest park
	Mueang	11º48'N, 99º47'E	Beach forest
	Thap Sakae	11º37'N, 99º36'E	Dry evergreen forest

3) Laboratory rearing

3.1) Egg clusters were collected along with the bark of their host plants and reared in the laboratory. Nymphal stages were reared in plastic containers, with natural food (crumbs of bark supplemented with water soaked in cotton wool and kept in the cultural jars) or fresh lettuce leaves are provided (Figure 3.3, arrow). Fresh lettuce should be added about three times a week.

The number of specimens collected was enough for further male identification. Further studies of the specimens, sample analyses and rearing were carried out at the insect laboratory, Department of Biology, Faculty of Science, Chulalongkorn University.

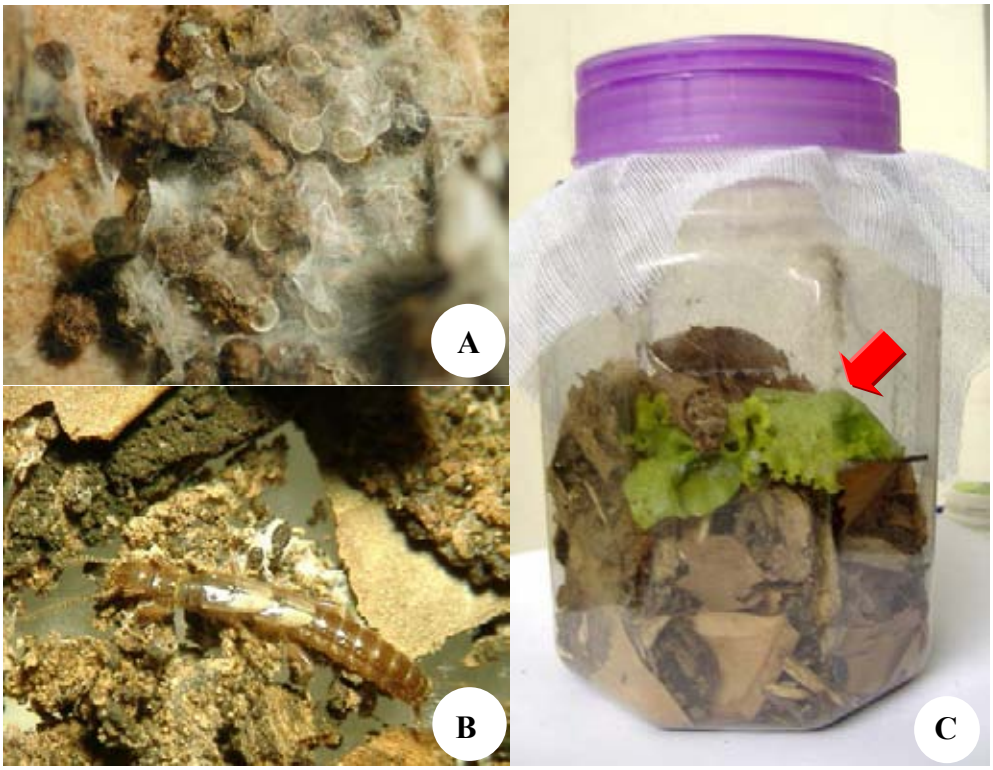


Figure 3.3 Cultures of embiids: Eggs (A) and nymph (B), container with lettuce leaves used as food (C).

3.2) Taxonomic study

1) Preservation and slide preparation of the specimens

The adult specimens were preserved in the vials with 70% (v/v) ethyl alcohol for genitalia dissection. The specimens were boiled in a crucible 10% KOH until the body tissues were liquefied. Then the cleared genitalia were pulled out from the abdomen and placed them in glycerin on the slide. Observation was undertaken by stereomicroscopy. Finally, the male terminalia were illustrated and described.

2) Examination of materials

Identification and measurement of the specimens were made with a handheld Digital Microscope (AM-413T-FVW Dino-Lite Pro White) and the DinoCapture Program for measurement. The characters of genitalia, wing pattern of male and papilla or papillae of basitarsus of hind leg, including color of the head, thorax and abdomen were used for identification. The morphological study based on descriptions and the keys constructed by Ross (2007). Descriptions of families, genera and species levels were presented. Some specimens were verified by Dr. Edward Ross, California, USA. New species and new record were described and illustrated. Scientific names of the new spcies were provided, according to the rules of the International Commission of Zoological Nomenclature (ICZN) in 1999.

3) Drawing and photography

Digital images were generated using a Samsung Digimax in the field and a stereoscopic microscope (by Olympus) in the laboratory. Illustration of genitalia and other important characters were drawn using the stereomicroscope with drawing tube attachment. Finally, Adobe Photoshop CS4 was used to generate photographic plates.

4) Data management

All specimens were given the accession numbers. The specimens were deposited in the insect collection of the Chulalongkorn University Museum of Natural History (CUMMH), Bangkok, Thailand. Checklist of the webspinners collected from the western part of Thailand was presented.

5) Construction of the dichotomous and pictorial keys

Dichotomous and pictorial keys to family -, genera - and species - levels were constructed from this study.

3.3) Data analyses

1) The taxonomic diversity index

The taxonomic diversity (species per genera S/G ratio) was calculated for each area and overall value for two habitat types. A low value for S/G implies a higher overall taxonomic diversity than a high value due to a biotic in which the species are divided among several genera is intuitively more 'diversity' than one in which most species belong to only a few genera. Classification of forest types follows Marod and Kudin (2009).

2) Sorensen's similarity coefficient index

Sorensen's similarity coefficient (S_s) index was calculated for all possible pair-wise combination of various habitat characteristic types and different level of elevation considered. The coefficient of Sorensen (Krebs, 1999) was used, calculated as follows:

$$S_s = \frac{2a}{2a + b + c}$$

Where S_s = Sorensen's similarity coefficient

a = number of species in sample A and sample B (joint occurrences)

b = number of species in sample B but not in sample A

c = number of species in sample A but not in sample B

The S_s values range between 0 (when the dataset being compared share no species in common) and 1.0 (all species are present in both datasets).

The relative similarities of webspinners present in the different both habitats and elevation level were determined by cluster analysis and a cladogram was also produced using PC-ORD version 5.10 (McCune and Mefford, 2006).

CHAPTER IV

RESULTS

4.1 Embiid taxonomy and description

Ten species and seven morphospecies of webspinners, belonging to seven genera under four families, were found during a 2008-2010 survey on both wet and dry seasons at each habitat types of western part of Thailand. Out of 17, ten described species, including three new species (*Aposthonia problita, Eosembia lamunae* and *E. paradorni*), three new records (*Oligotoma humbertiana, O. nigra* and *O. saundersii*), and seven morphospecies (*Oedembia* sp.1, *Oedembia* sp.2, *Ptilocerembia* sp.1, *Ptilocerembia* sp.2, *Ptilocerembia* sp.3, *Ptilocerembia* sp.4, and *Ptilocerembia* and *Oligembia* sp.1) were encountered. The following analysis was based on morphological characters of adult males and females.

Check list of webspinners of western Thailand

Family Embiidae Burmeister, 1836

Genus ***Oedembia*** Ross, 2007

1. *Oedembia* sp.1
2. *Oedembia* sp.2

Family Notoligotomidae Davis, 1940

Genus ***Ptilocerembia*** Friederichs, 1923

3. *Ptilocerembia* sp.1
4. *Ptilocerembia* sp.2
5. *Ptilocerembia* sp.3
6. *Ptilocerembia* sp.4

Family Oligotomidae Enderlein, 1909

Genus ***Aposthonia*** Krauss, 1911

7. *Aposthonia borneensis* (Hagen, 1885)
8. *Aposthonia ceylonica* (Enderlein, 1912)
9. *Aposthonia problita* Poolprasert, Sitthicharoenchai, Butcher & Lekprayoon, 2011

Genus ***Eosembia*** Ross, 2007

10. *Eosembia auripecta* Ross, 2007
11. *Eosembia lamunae* Poolprasert, Sitthicharoenchai, Lekprayoon & Butcher, 2011
12. *Eosembia paradorni* Poolprasert, Sitthicharoenchai, Lekprayoon & Butcher, 2011

Genus ***Lobosembia*** Ross, 2007

13. *Lobosembia mandibulata* Ross, 2007

Genus ***Oligotoma*** Westwood, 1837.

14. *Oligotoma humbertiana* (Saussure, 1896)
15. *Oligotoma nigra* (Hagen, 1885)
16. *Oligotoma saundersii* (Westwood, 1837)

Family Teratembiidae Krauss, 1911

Genus ***Oligembia*** Davis, 1939

17. *Oligembia* sp.1

Key to embiid families of western Thailand (Adult males)

1. MA not forked (Fig. 4.1A). LC_2 not fused to LC_1 (Figs 4.1E-H). MS fused to 10L and 10R (Fig. 4.1H). Hind basitarsus with 1-2 ventral papillae (Figs 4.1L&M) .....Oligotomidae
- MA forked (Figs 4.1B-D).....2
2. LC_2 at least partly fused to LC_1, the composite segment with echinulates on inner areas or lobes (Fig 4.1K). MS not fused to 10L and 10R, broad and short (Fig. 4.1K). Hind basitarsus with 1 ventral papilla (Fig. 4.1P) ..... Notoligotomidae
- LC_2 not fused to LC_1 (Figs. 4.1I&J) 3
3. LC_1 without echinulate on its inner surface (Fig. 4.1I). MS fused to 10L and 10R (Fig. 4.1I). Hind basitarsus with 1 ventral papilla (Fig. 4.1N) ..... Teratembiidae
- LC_1 with echinulates in inner side, these usually located on an inner apical nodule (Fig. 4.1J). MS not fused to 10L and 10R, broad and long (Fig. 4.1I). Hind basitarsus with 1 ventral papilla (Fig. 4.1O)..... Embiidae

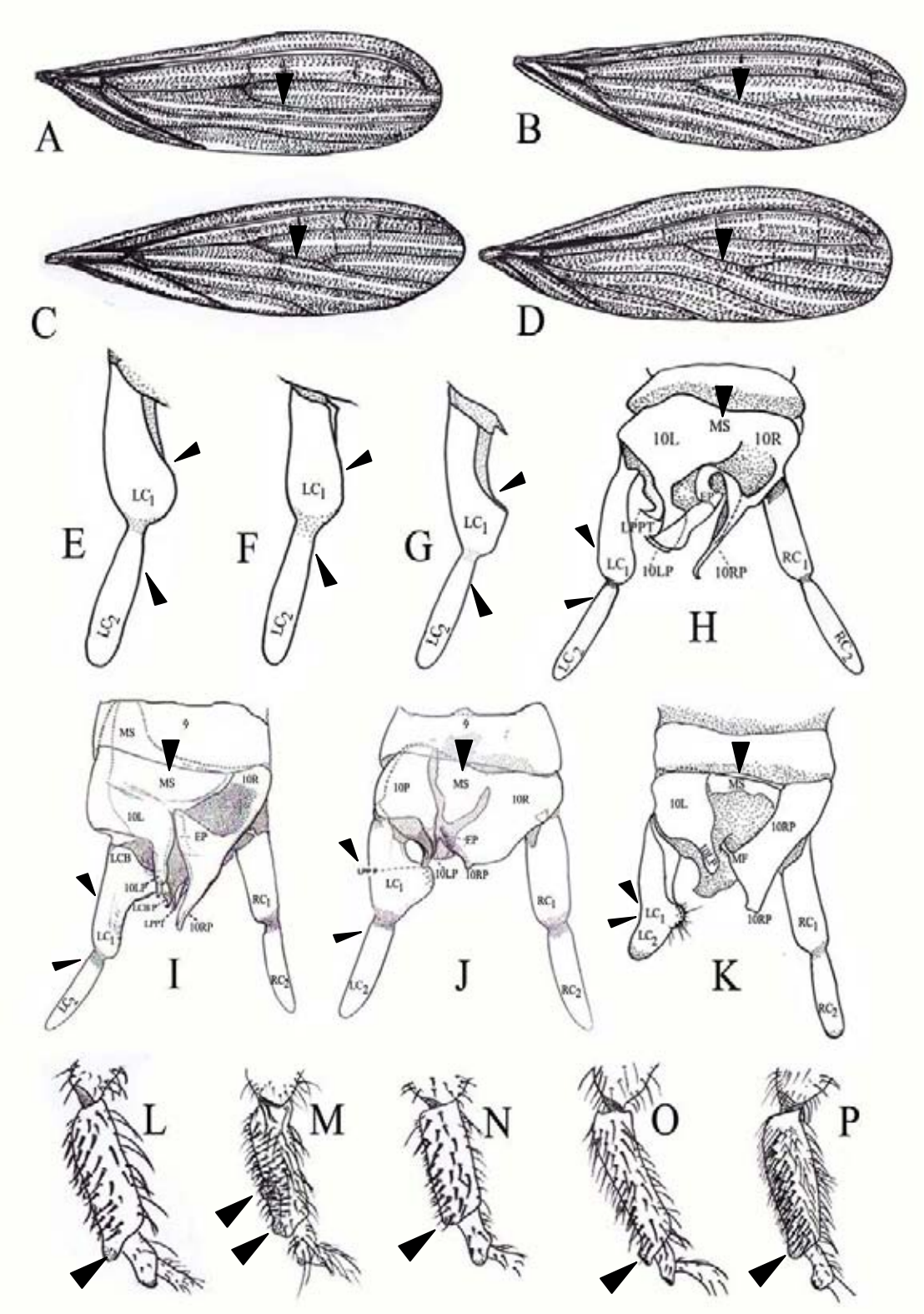


Figure 4.1 Important characters of embiid families. MA not forked (A); MA forked (B-D); LC_2 not fused to LC_1 (E-J); LC_2 at least partly fused to LC_1 (K); MS fused to 10L and 10R (H-I); MS not fused to 10L and 10R (J-K) Hind basitarsus with 1 ventral papilla (L,N,O,P); Hind basitarsus with 2 ventral papillae (M).

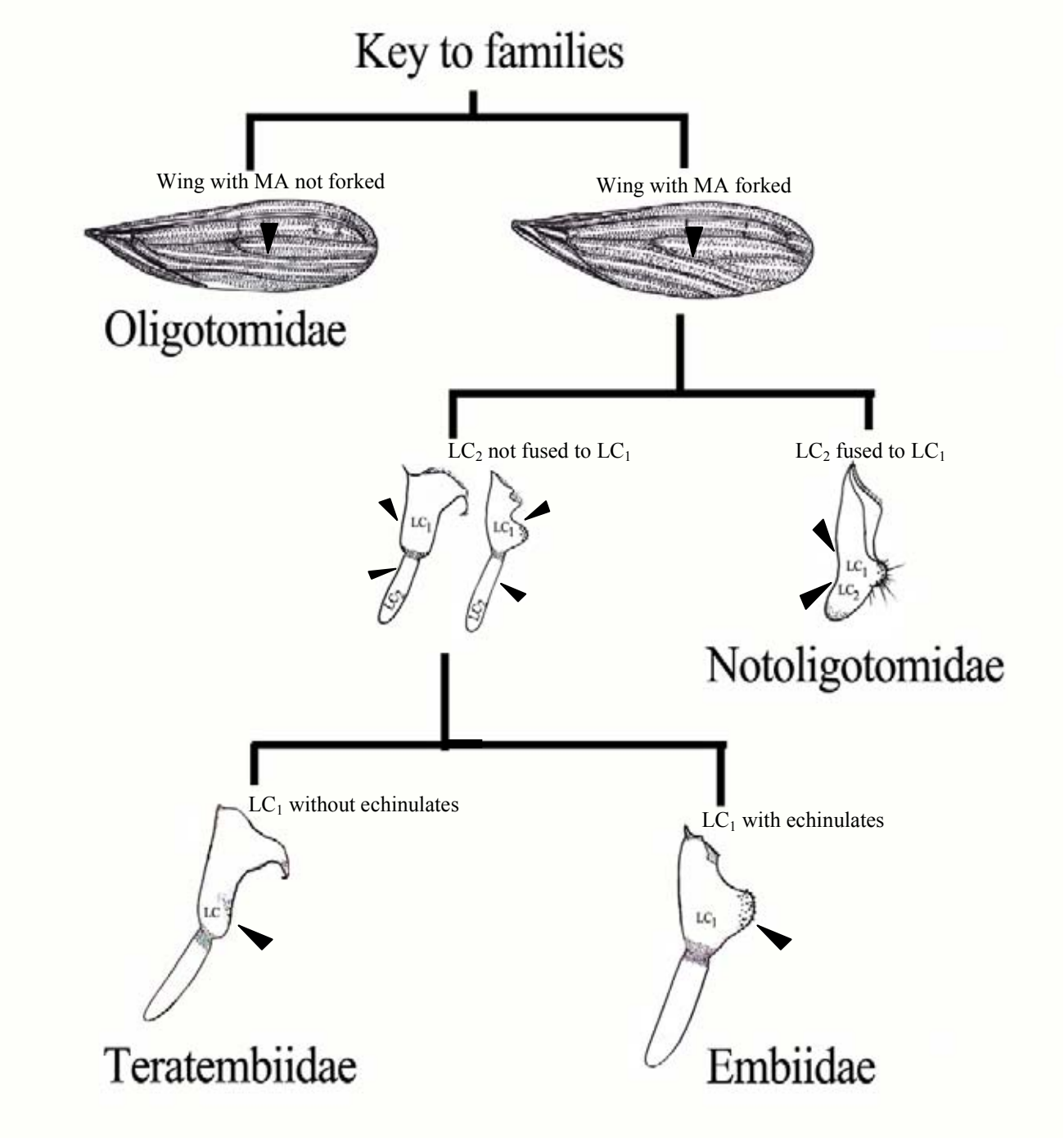


Figure 4.2 Pictorial key to families for adult male webspinners from western Thailand.

Family Embiidae Burmeister, 1836

Diagnosis. Alate male: Body length averaging 12 mm, monochromatic brown but some species are bicolorous with darker head than thorax and abdomen. Head longer than wide, eyes small to moderate. Mandibles are elongate with three apical dentations on the right, two on the left. Antennal setae short. Wing vein MA always forked. Hind basitarsus with one or two papillae. Terminalia with hemitergites narrowly spaced; MS conspicuous. A flap-like projection (MF) partly extends over epiproct. Cerci two-segmented, LC_1 always echinulated on inner side and sometime strongly lobed. Apterous female: Body length average 12 mm, similar coloration to male, eyes smaller than male. Hind basitarsi short, with one or two medial papillae.

Distribution. Africa, Central America, Circum-Mediterranean, India and South America.

Genus ***Oedembia*** Ross, 2007

Oedembia Ross, 2007: 576

Type species. *Oedembia dilatamenta* Ross, 2007: 576, fig. 1, by original designation.

Diagnosis. Alate male with basic characters of Embiidae, but the submentum is swollen. The lobe of LC_1 is usually large, triangular, with a dorsal, horizontal fold. 10RP is very long, sharp, folded forward beneath caudal margin of 10R. Both paraprocts and the hypandrium lobe, short, sclerotized. Hind basitarsus short with one papilla. Apterous female without distinctive characters.

Distribution. India, Myanmar, Nepal, Pakistan and Thailand

Oedembia sp.1
(Figs. 4.3, 4.4, 4.8, 4.9, 4.10)

Material examined. 1♂, 1♀ (CUMZ-EMB-Emb.2010.439-440), **Thailand,** Tak Province, Mae Ramat District, Dry evergreen forest, 16°58.331'N, 098°32.213'E, 213 m, 04. IV. 2008; 2♂♂, 3♀♀ (CUMZ-EMB-Emb.2010.441-445) Mae Sod District, Hill evergreen forest, 16°45.837'N 098°54.533'E, 788 m, 26. VI. 2009. All collected by P. Poolprasert.

Other specimens examined. 1♂, 3♀♀ (CUMZ-EMB-Emb.2010.446-449), **Thailand**, Chiang Mai Province, Sanpatong District, Hill evergreen forest, 18°32.608'N, 098 °31.521'E, 1237 m, 02. III. 2008; 1♂ (CUMZ-EMB-Emb.2010.450), Fang District, Mixed deciduous forest, 20°04.499'N 099°14.616'E, 615 m, 31. III. 2008. All collected by P. Poolprasert.

Distribution. Western and northern Thailand

Description. Alate male (n = 3), mean (range)): Head width x length 1.6 (1.5-1.8) x 1.9 (1.8-2.1) mm, body length 14.2 (13.8-15.2) mm, width 2.1 (2.0-2.3) mm, forewing length 11.3 (11.2-11.4) mm, hindwing length 10.3 (10.1-10.8) mm.

Head: Capsule as broad as long, blackish. Eyes entirely dark, large prominent subreniform. Submentum quadrate, darkish. Antennae darkish throughout, 20 segmented.

Thorax: Yellowish to orange throughout. Wings with MA forked, blackish with hyaline inter-ventral lines. All legs darkish. Hind leg with only one basitarsal papilla.

Abdomen: Brown throughout, paler ventrally, tenth abdominal tergite diagonally cleft leftward to its base. Terminalia with hemitergites separated basally by plate of MS. 10L smaller and shorter than 10R. 10LP medium long, broad basally then evenly tapered to apex. 10RP very short, blunt distally. EP sclerotized. HP dull blackish brown. LPPT slender, sclerotized, slightly arced leftward, fused to HP. LC_1 thick with a finely and densely echinulate, globose, subapical lobe.

Apterous female (n = 7, mean (range) ± SD): Head width x length 1.8 (1.7-2.1) ± 0.34 x 2.2 (2.0-2.4) ± 0.16 mm, body length 16.4 (14.7-17.3) ± 0.23 mm, width 2.2 (2.1-2.3) ± 0.72 mm.

Head: Capsule as broad as long, sides short, parallel broadly arcuated caudally, brown. Eyes dark, smaller and less kidney-shaped than in male. Submentum trapezoidal. Antennae entirely brown without white tip except for few basal segments paler, 18 segmented.

Thorax: Purplish brown throughout, paler at sides and ventrally. All legs concolorous with thorax except for femorotibial joints pale in color. Hind leg with only one basitarsal papilla.

Abdomen: Concolorous thorax with cream stripe lateral plate. Cerci brownish. Sternite 8 medially inset into the plate as trapezoid whereas sternite 9 without a distinct pattern.

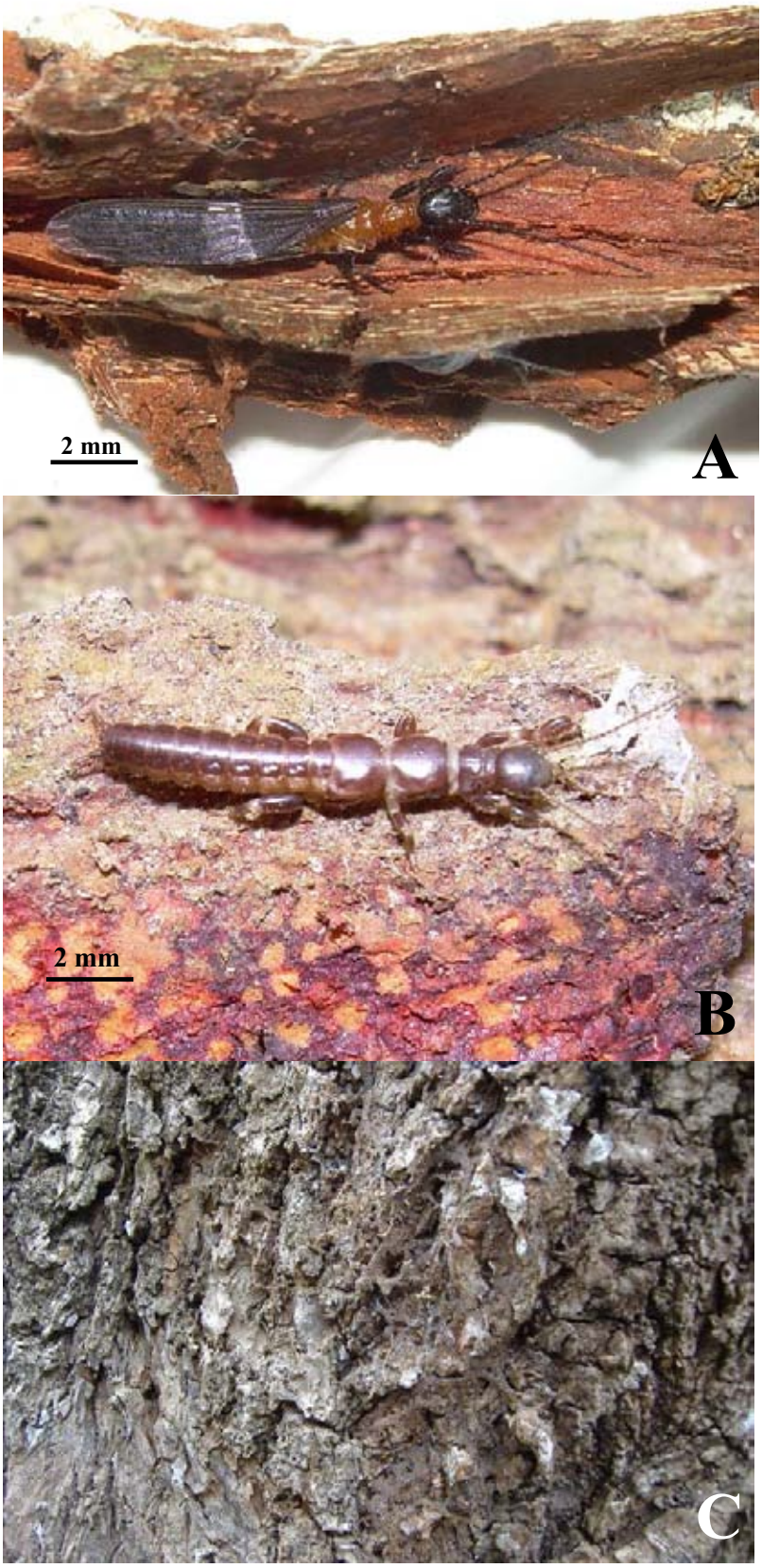


Figure 4.3 *Odembia* sp. 1 (A) male, (B) female and (C) silk gallery.

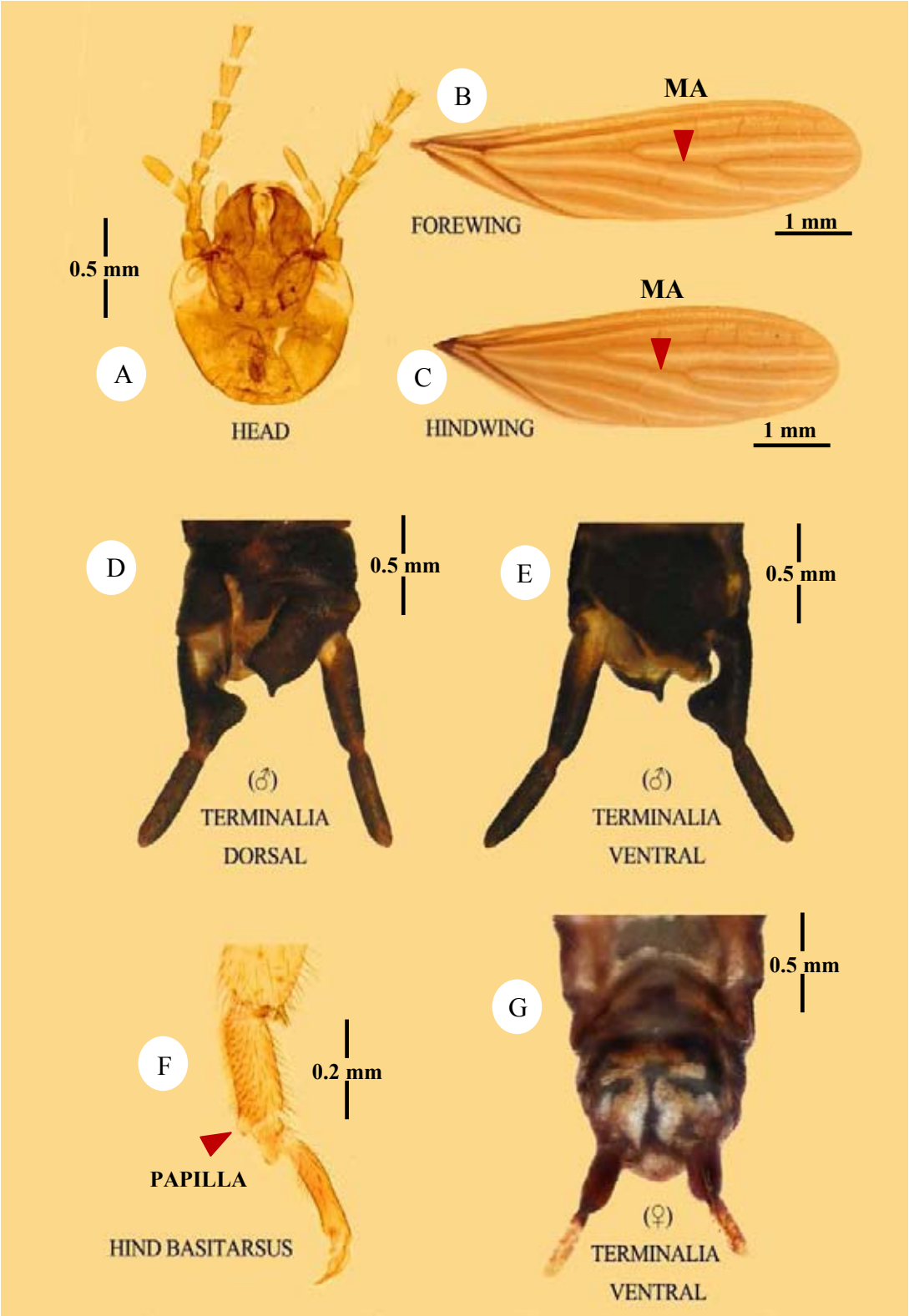


Figure 4.4 Important characters of male (A-F) and female (G) of *Oedembia* sp.1.

Oedembia sp.2

(Figs. 4.5, 4.6, 4.8, 4.9, 4.10)

Material examined. 1♂, 4♀♀ (CUMZ-EMB-Emb.2010.451-456), **Thailand**, Ratchaburi Province, Pak Tho District, Mixed deciduous forest, 13°15.267' N, 099°31.839'E, 265 m, 09. II. 2010. All collected by P. Poolprasert.

Distribution. This species is known from Pak Tho District, Ratchaburi Province, Thailand.

Description. Alate male (n = 1): Head width x length 1.8 x 2.2 mm, body length 16.6 mm, width 2.2 mm, forewing length 14.5 mm, hindwing length 12.2 mm.

Head: Capsule elongate-oval (longer than broad), sides convergent, blackish. Eyes entirely dark. Submentum trapezoidal, darkish. Antennae, very long, blackish except for white-tipped antennae, 28 segmented.

Throrax: Yellowish throughout. Wings with MA forked, blackish with hyaline inter-venal lines. All legs concolorous except for femoral-tibial joints brown, strongly contrasted by the darkish femora tibia and tarsi. Hind leg with only one basitarsal papilla.

Abdomen: Concolorous with thorax except for terminalia darkish. Tenth abdominal tergite diagonally cleft leftward to its base. Terminalia with hemitergites separated basally by plate of MS. 10L broader and shorter than 10R. 10L P long, slightly arched leftward then tapered terminally. 10R P very short, obtuse caudally. MF flap without hook. HP dull blackish. LPPT slender, sclerotized, gradually arced leftward, fused to HP. LC_1 distally expanded as angulate lobe, entire inner face coarsely echinulated.

Apterous female (n = 4, mean (range) ± SD): Head width x length 1.8 (1.7-2.0) ± 0.45 x 1.9 (1.8-2.0) ± 0.21 mm, body length 17.4 (16.5-18.8) ± 0.03 mm, width 2.2 (2.1-2.4) ± 0.02 mm.

Head: Capsule as broad as long, sides short, parallel broadly arcuated posteriorly, darkish brown, the posterior becoming light brown, Eyes dark, smaller and less reniform than in male. Submentum trapezoidal. Antennae short, entirely brownish, 22 segmented.

Thorax: Redish brown throughout, created a pale band between the thoracic somites. All legs concolorous with thorax except for femorotibial joints pale in color. Hind leg with only one basitarsal papilla.

Abdomen: Mostly reddish brown to brown, paler at sides and ventrally except terminal three abdominal segments, cerci darkish brown. Sternite 8 with broadly unpigmented area, becoming darker at the lateral sides. Sternite 9 deeply insetted on the body.

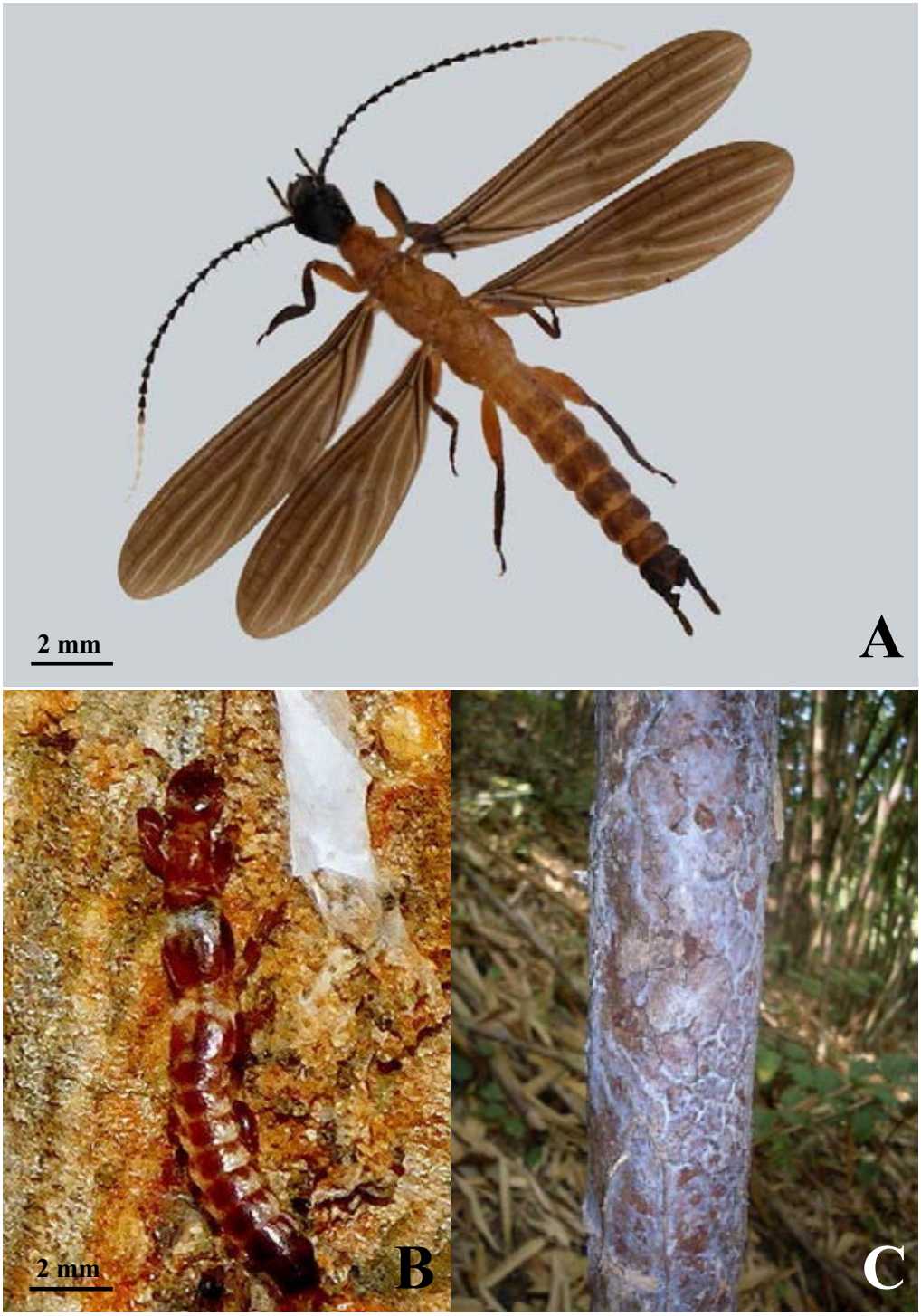


Figure 4.5 *Odembia* sp.2 (A) male, (B) female and (C) silk gallery**.**

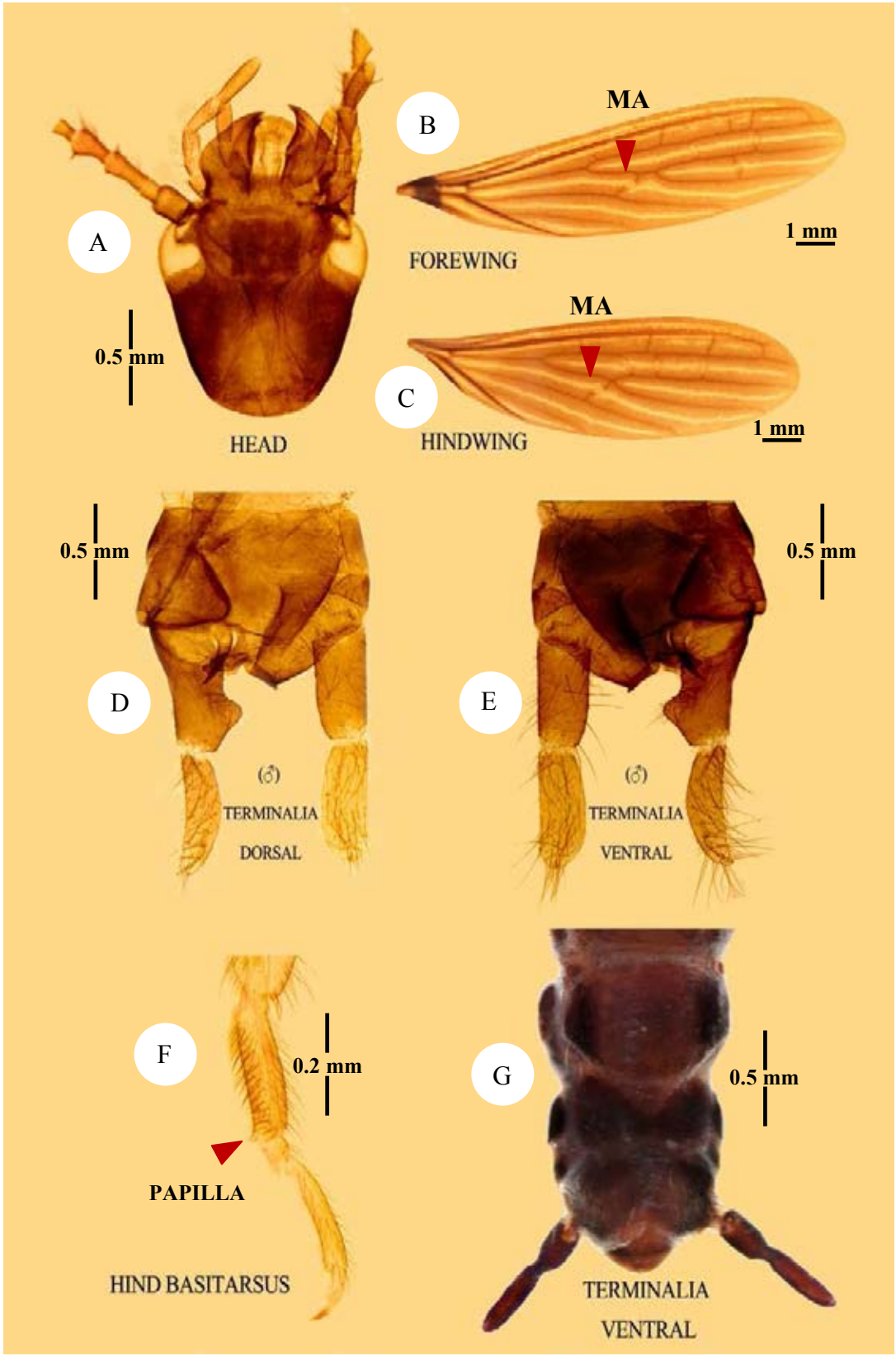


Figure 4.6 Important characters of male (A-F) and female (G) of *Oedembia* sp.2.

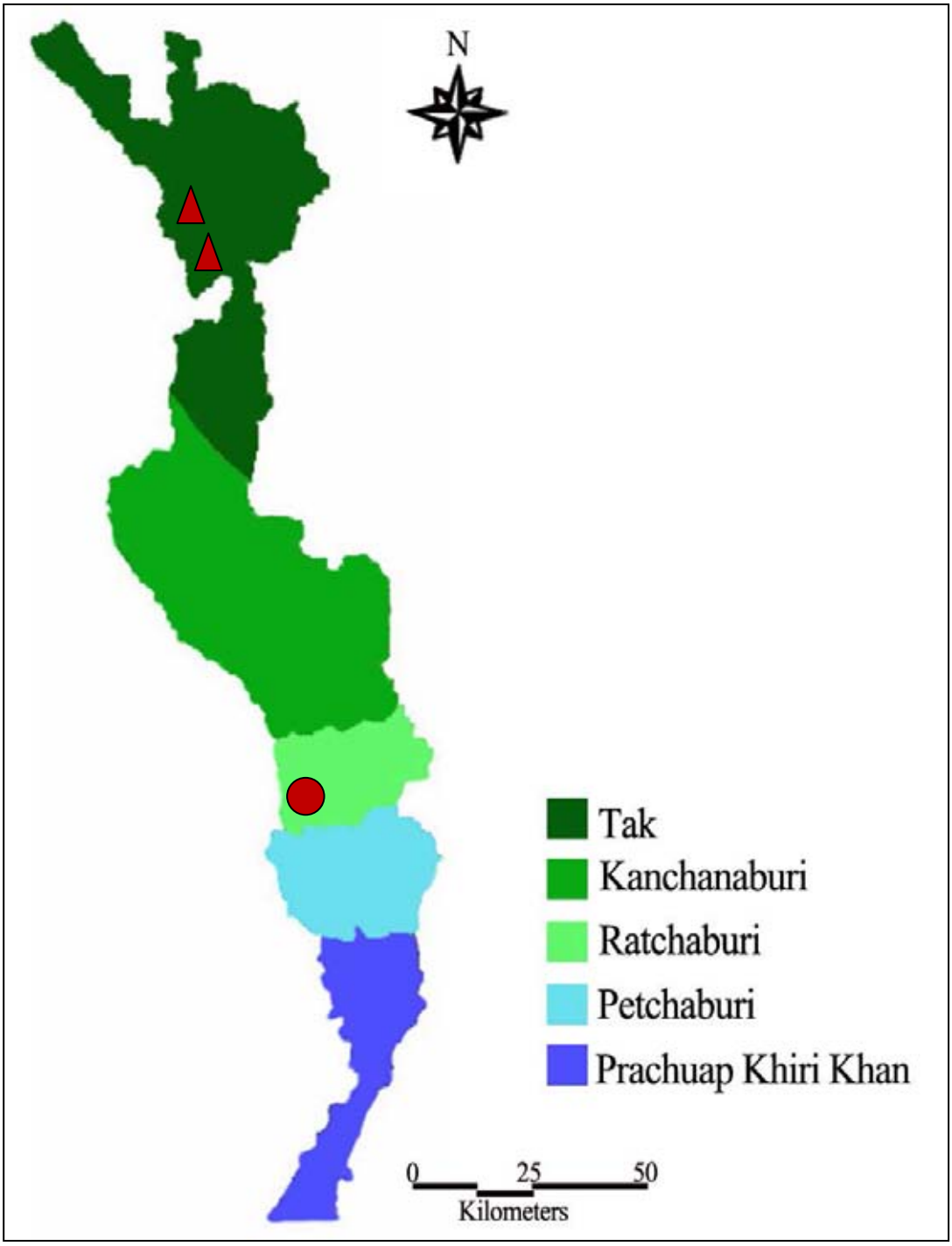


Figure 4.7 Distribution of the genus *Oedembia* (F. Embiidae) found in western Thailand.

▲ *Oedembia* sp.1 ● *Oedembia* sp. 2

Key to species of the genus *Oedembia* (Adult males)

1. LC_1 slender, thick with a finely and densely echinulate, globose, subapical lobe; 10LP medium long, broad basally then evenly tapered to apex .....*Oedembia* sp.1
- LC_1 distally expanded as an gulate lobe, entire inner face coarsely echinulated; 10LP long, slightly arched leftward then tapered terminally.....*Oedembia* sp.2

Key to species of the genus *Oedembia* (Adult females)

1. Sternite 8 medially inset into the plate as trapezoid; sternite 9 without a distinct pattern .....*Oedembia* sp.1
- Sternite 8 with broadly unpigment area, becoming darker at the lateral sides; sternite 9 deeply inset on the body.....*Oedembia* sp.2

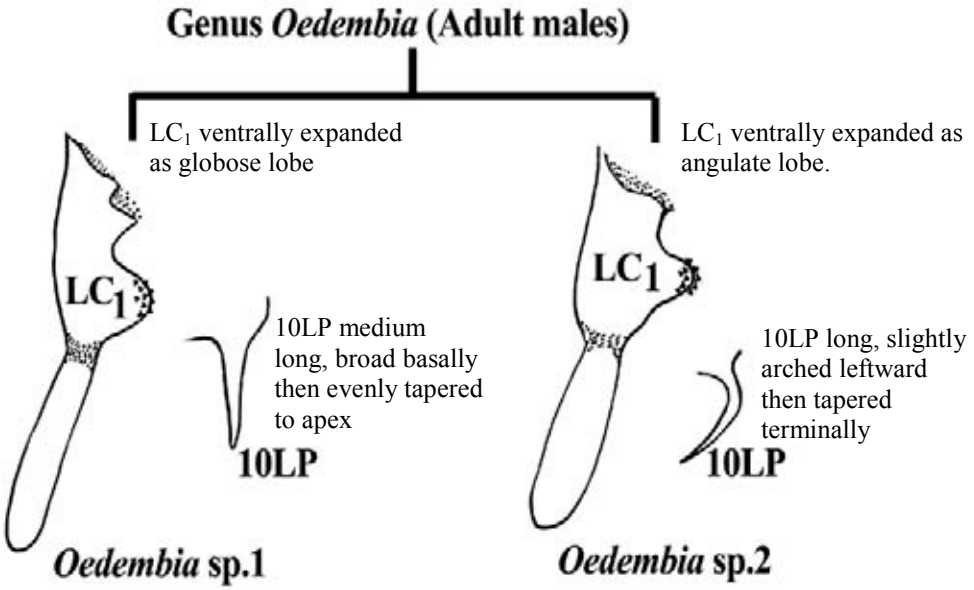


Figure 4.8 Pictorial key to species 1 and 2 for adult males of the genus *Oedembia* from western Thailand.

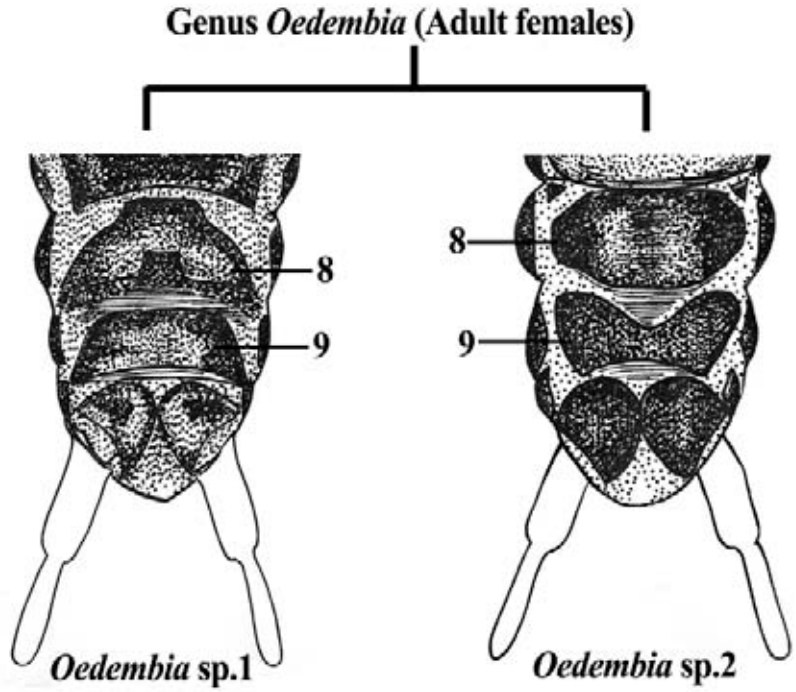


Figure 4.9 Pictorial key to species 1 and 2 for adult females of the genus *Oligotoma* from western Thailand, showing the pattern of abdominal segment 8th and 9th, ventrally.

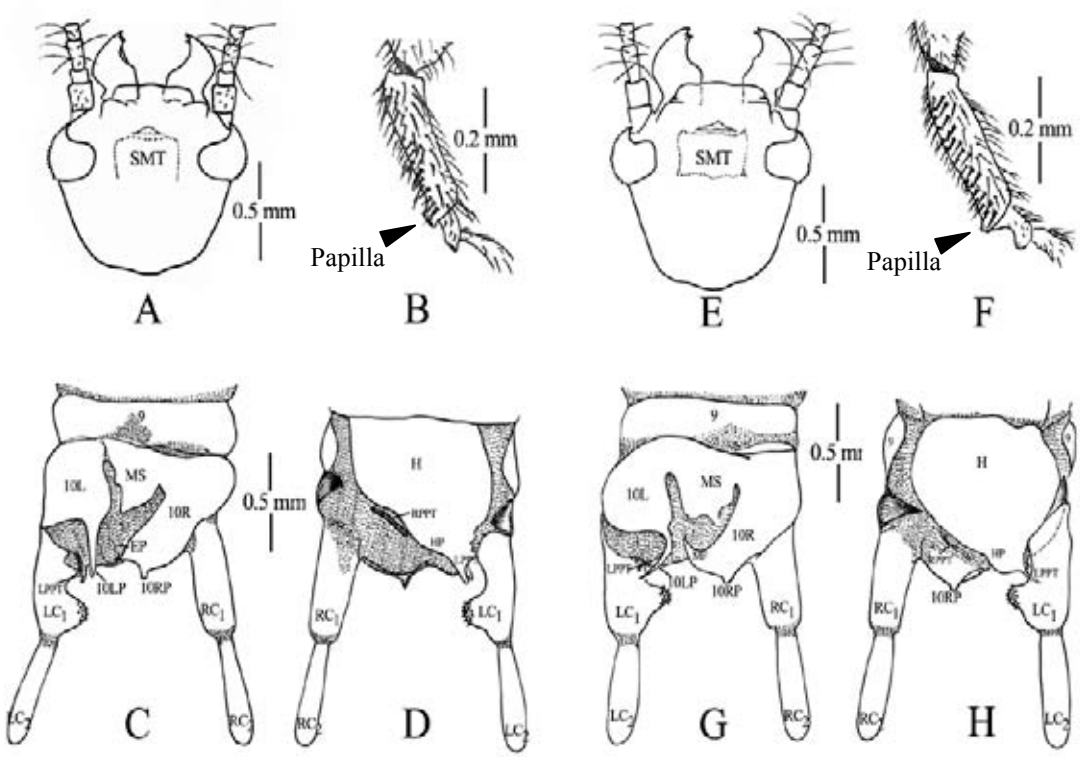


Figure 4.10 Illustrations of male *Oedembia* sp.1 (A–D), *Oedembia* sp.2 (E–H). A, E) Head. B, F) Hind basitarsus. C, G) Dorsal views of terminalia. D, H) Ventral views of terminalia.

Family Notoligotomidae Davis, 1940

Description. Apterous or alate male: Body length average 14 mm. Wing vein MA always forked. Antennae with a profusion of long, wavy setae on most antennal segments. Hind basitarsus with one or two papillae. Terminalia with MS broad and short, not fused to 10L and 10R, MF not flap but variable hook apparently which in some species, subtended with a small echinulated nodule. LC_2 fused with LC_1 partly or completely. The composite segment with one or more echinulate inner areas or lobes. Apterous female: Body length average 18 mm, diverse coloration in male. Eyes smaller than male. The hind basitarsi with one or two ventral papillae.

Distribution. Australia and south-eastern Asia

Genus ***Ptilocerembia*** Friederichs, 1923

Ptilocerembia Friederichs, 1923: 24; 1924: 422; Davis, 1940: 526; 1940: 535 (after Friederichs); Ross, 1963; 123.

Type genus.-*Ptilocerembia roepkei* Friederichs, 1923: 24, figs. 5-7, by original designation.

Diagnosis. Alate male: Body length 18-22 mm, forewing length 10.0 mm, width average 2.0 mm, entirely black except for white-tipped antennae. Capsule large, sides slightly convergent, caudal arcuation shallow. Eyes relatively small. Antennae prominent, 33 segmented; most antennal segments broader at base than sub-basally, apices flaring, rounded and clothed with very long erect setae which decrease in prominence toward antennal apex; distal five segments very small, microsetose, white. Mandibles triangulate, apically tapped; outer margins straight with subapical incurvature; apical teeth prominent, acutely pointed. Submentum quadrate, not strongly sclerotized, anterior margins weak. Hind basitarsi elongate with only one papilla; plantar setae long, very dense. Wing with MA forked. MS broad and short, posterior margin becoming membranous. 10L with weak inner and caudal margins;

medial surface at t imes abruptly v aulted, cau dal m argin often ex tended as an arcuation over base of LC_1; 10LP broad base, short, with a rounded dorsal lobe and a ventral acute poi nt. 10R P with pos tero-latero ma rgin broadly in curved; a t time coarsely s peculated i n s ubapical ed ge; cau dally-tapered t o f orm a bl unt, non - constricted 10RP; i nner m argins c onvergent m esad a nd te rminated a s a s mall, sclerotic hook (MF). E P a nd i ts s clerite obsolete. L PPT s imilar b ut th e e chinulated ridge, shorter and abruptly terminated caudally; inner angle continued as a short, non-echinulated r idge caudal l obe. RPPT i rregularly elongated; paralleling, but not fused to s ide of H. LC_1 basally cylindrical, t hen abruptly, i nwardly l obe and e chinulate a t apex; ap ical segment s hort, br oadly f used t o ba sal s egment, a t time s lin e o f f usion invisible. R C_1 very elongate a nd c ylindrical, its s clerotization e ven throughout. Apterous female: Body length 20-23 m m, width a veraging 2.0 mm, m ore di verse in coloration than males. Most species, in thorax and abdomen typically contrasting pale segmental and in tersegmental a reas, with a t le ast abdominal te rgites 4-7 conspicuously pale m edially. Antenna c ontrastingly white. H ind basitarsi w ith onl y one papilla. The genitalia sclerites lack noteworthy generic characters.

Distribution. South-eastern Asia.

Ptilocerembia sp.1
(Figs. 4.11, 4.12, 4.20, 4.21, 4.22)

Material examined. 1♂, 1♀ (CUMZ-EMB-Not.2010.322-323), **Thailand**, T ak Province, Mae Ramat District, Dry evergreen forest, 16°58.591″N, 98°31.012’E, 353 m, 20. I II. 2008; 2♀♀, (CUMZ-EMB-Not.2010.324-325) M ae S od D istrict, Hill evergreen f orest, 16°45.83 7’N 098 °54.533’E, 804 m, 26. V I. 2009. 2♀♀, (CUMZ-EMB-Not.2010.326), Mae S od D istrict, Deciduous dipterocarp forest, 16°45.233’ N 098°53.113’E, 213 m, 26. VI. 2009. All collected by P. Poolprasert.

Other s pecimens ex amined. 1♂, 3♀♀ (CUMZ-EMB-Not.2010.327-330), Thailand, Chiang M ai Province, M ueang D istrict, Huay K aeo Arboretum, 18°48.348’N 098°57.585’E, 336 m, 01. II. 2008. 2♀♀ (CUMZ-EMB-Not.2010.331-

332), Loei Province, Phu Kradueng District, orchard, 16°53.315'N 101°53.140'E, 227 m, 26. II. 2007. 12♀♀ (CUMZ-EMB-Not.2010.333-345), Nong Bua Lam Phu Province, Na Klang District, Mixed deciduous forest, 17°25.044' N, 102°10.944' E, 376 m, 07.VII.2010. 1♀ (CUMZ-EMB-Not.2010.346), Petchabun Province, Lom Sak District, Dry evergreen forest, 16°46.462'N, 101°14.323' E, 129 m, 04.IV.2008. 1♂ (CUMZ-EMB-Not.2010.347), Phisanulok Province, Nakhon Thai District, Dry evergreen forest, 17°61.174'N, 100°50.156'E, 321 m, 14.III.2008. All collected by P. Poolprasert.

Distribution. Thailand

Description. Alate male (n = 3), mean (range)): Head width x length 1.8 (1.7-1.9) x 2.3 (2.1-2.4) mm, body length 15.3 (14.9-15.8) mm, width 2.2 (2.1-2.3) mm, forewing length 12.5 (12.1-13.2) mm, hindwing length 11.8 (10.5-12.3) mm.

Head: Capsule elongate-oval (longer than broad), sides convergent. Eyes entirely dark, large prominent subreniform, sides behind eyes narrowed. Submentum trapezoidal. Antennae, 36 segmented, darkish with long perpendicular hairs and 6 white antennal apically.

Throrax: Darkish throughout. Wings with MA forked, brown with hyaline inter-venal lines. All legs darkish. Hind leg with only one basitarsal papilla, plantar surface of basitarsus densely setose.

Abdomen: Very dark brown, paler ventrally, terminalia with tenth abdominal tergite completely cleft, hemitergites separated basally by a trapezoidal plate. 10R transverse, inner margin ending posteriorly in a blunt 10RP, anteriorly in a dorsal hook curving forward. 10L with inner margin produced backward to an elongate 10LP, medially slightly expanded, terminally subacute. LPPT, broad, sclerotized, slightly arced leftward. Right cercus with two subcylindrical segments (RC_1 and RC_2). LC_1 excavated inner side in basal half, dilated terminal with a finely echinulated nodule. LC_2 shorter, subconical, firmly set in first segment outside and inner dilation distally.

Apterous female (n = 23, mean (range) ± SD): Head width x length 1.9 (1.7-2.0) ± 1.32 x 2.3 (2.0-2.5) ± 0.11 mm, body length 17.4 (14.5-19.9) ± 0.43 mm, width 2.2 (2.0-2.4) ± 0.51 mm.

Head: Capsule as broad as long, sides short, parallel broadly arcuated caudally, darkish, eyes dark, smaller and less kidney-shaped than in male. Submentum trapezoidal. Antennae entirely black except for 6 white antennal apices, 34 segmented.

Thorax: Darkish throughout. All legs concolorous with thorax except for coxae and trochanters whitish, strongly contrasted by the dark femora tibia and tarsi. Hind leg with only one basitarsal papilla, plantar surface of basitarsae densely setose.

Abdomen: Mostly darkish with white stripe lateral plate, basal three abdominal terga blackish in contrast with the next four brown terga; terminal three abdominal segments darkish brown. Cerci medium brown.

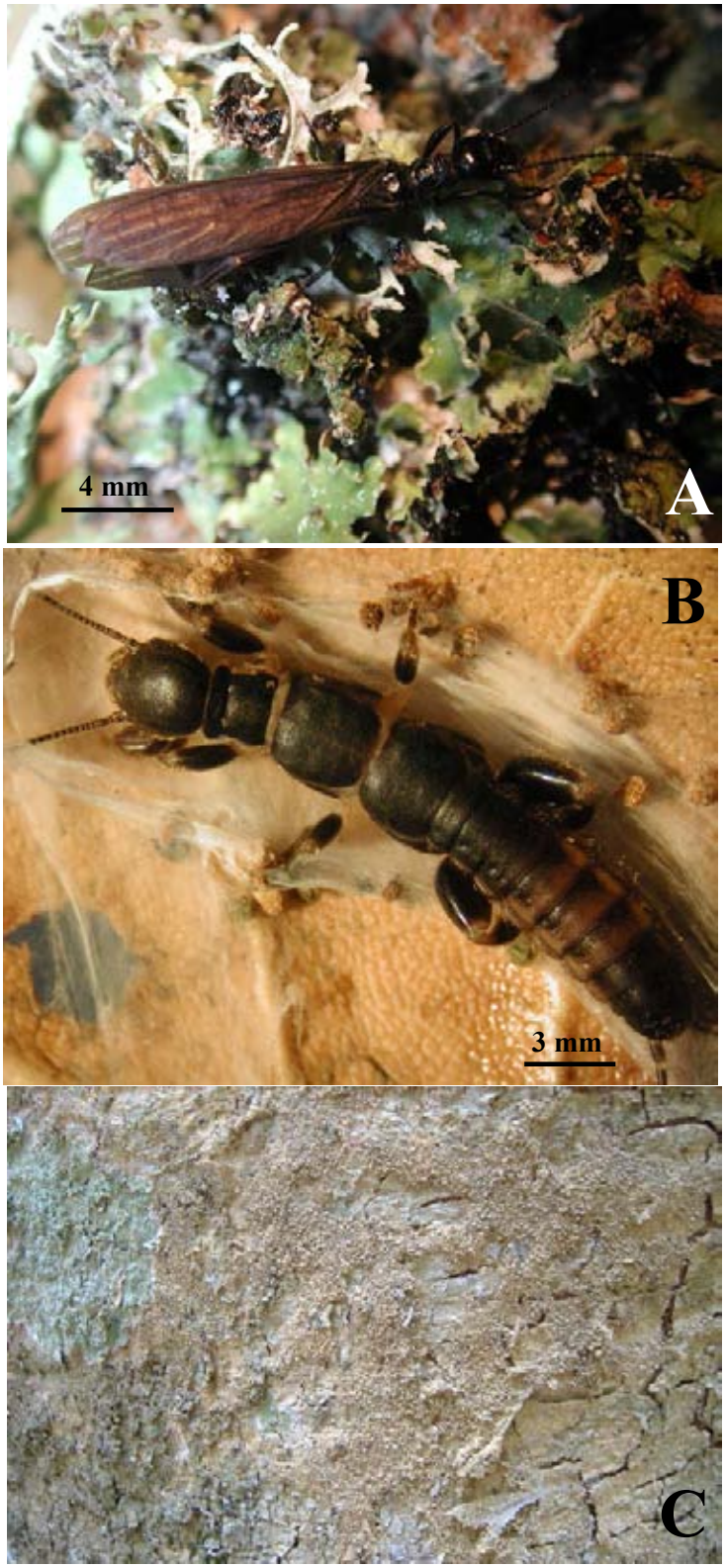


Figure 4.11 *Ptilocerembia* sp.1 (A) male, (B) female and (C) silk gallery.

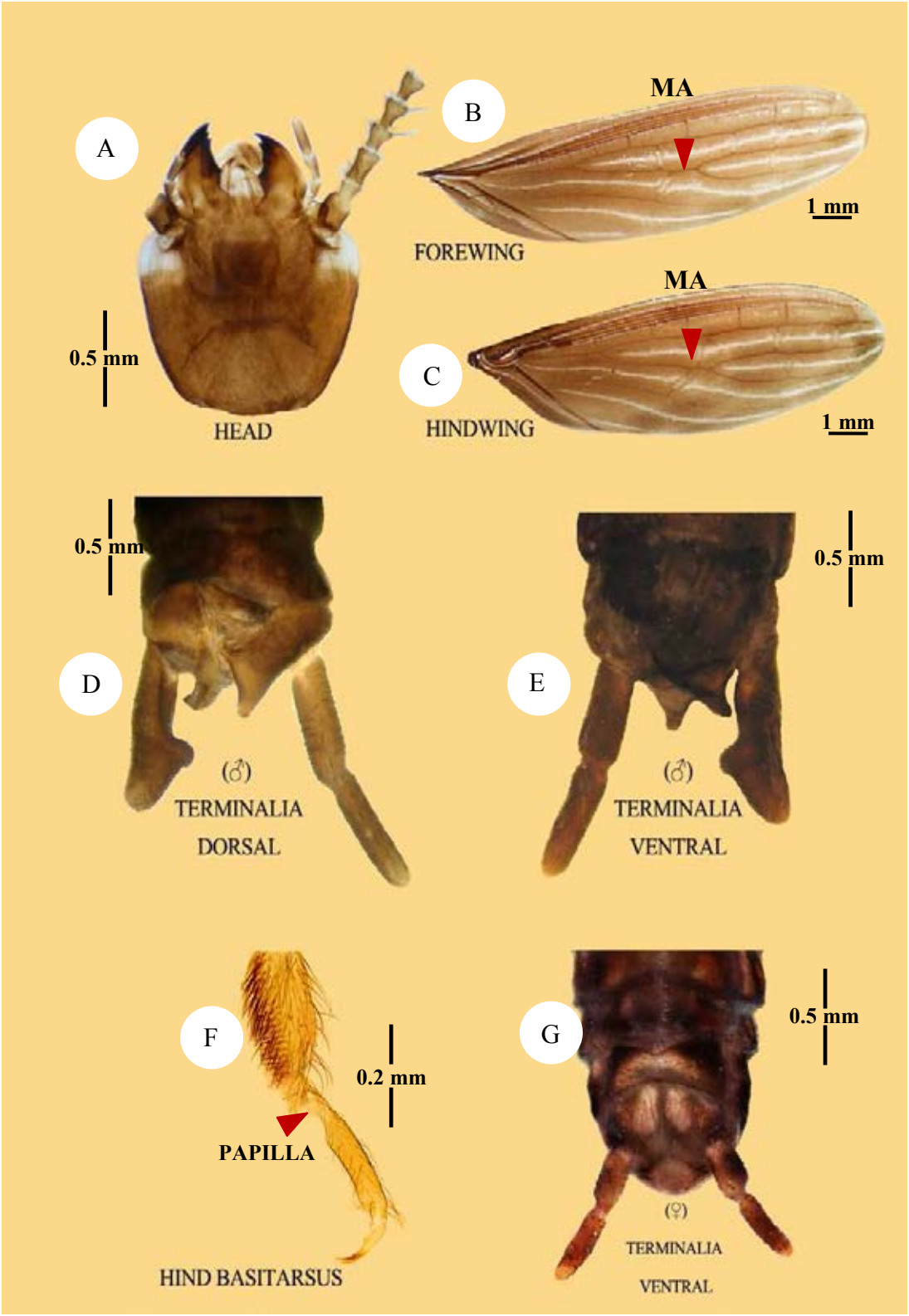


Figure 4.12 Important characters of male (A-F) and female (G) of *Ptilocerembia* sp.1

Ptilocerembia sp.2
(Figs 4.13, 4.14, 4.20, 4.21, 4.22)

Material examined. 20♀♀ (CUMZ-EMB-Not.2010.348-367), **Thailand**, Ratchaburi Province, Pak Tho District, Mixed deciduous forest, 13°16.628'N 099°29.800'E, 483 m, 09.V.2009; 2♂, 12♀♀ (CUMZ-EMB-Not.2010.368-381), 04.II.2010. All collected by P. Poolprasert.

Distribution. This species is known only from Pak Tho District, Ratchaburi Province, Thailand.

Description. Alate male (n = 2, mean (range)): Head width x length 1.7 (1.6-1.8) x 1.8 (1.7-1.9) mm; body length 12.5 (12.3-12.9) mm, width 2.2 (2.1-2.3) mm; forewing length 8.8 (8.8-8.9) mm; hindwing length 8.1 (7.8-8.3) mm.

Head: Capsule as broad as long, sides short, parallel broadly arcuated caudally, dorsally basically darkish. Eyes lavender black, narrowly outlined with dark amber. Submentum trapezoidal. Antennae dark brown with 6 white antennal segments apically, 36 segmented.

Thorax: Prothorax basically chestnut brown but with dark mahogany pattern. Pterothorax pale tan dorsally but clouded with mahogany brown. All legs various shades of darkish brown. Wing with MA forked, medium brown with metallic purple luster. All legs entirely blackish. Hind basitarsi with only one papilla, plantar surface of basitarsi densely setose.

Abdomen: Mottled dark purple; terminalia more darkly mottled over a basic color of chestnut brown; apices of cerci tan. 10L slightly vaulted, this surface setose; basically and apically non-setose. 10L P slender; apex abruptly pointed and rugose. 10R with a strong inner margin, the medial portion (MF) which bears blunt sickle-shaped hook (EP), elevated nodule. LPPT produced as a sclerotic, sharp LPPT-P extended to LC_1. LC_1 medium long, gradually lobed, entire inner surface coarsely echinulated. LC_2 shorter, subconical, line of fusion with LC_1 membranous, diagonal.

Apterous female (n = 32, mean (range) ± SD): Head width x length 1.5 (14-1.6) ± 2.23 x 1.6 (1.4-1.7) ± 1.03 mm; body length 14.0 (13.8-16.7) ± 1.43 mm, width 1.9 (1.8-2.3) ± 0.73 mm.

Head: Capsule about as long as broad caudal margin broadly arcuate; sides short, parallel, glossy piceous dorsally with faint pattern; ventrally chestnut brown. Mandibles dark chestnut brown with piceous margins; other mouthparts various shades of chestnut brown. Submentum trapezoidal. Antennae dark brown with 24 segments basal half brown, apical half white; distal segments (25 to 29) pure white,

Thorax: Yellowish with two longitudinal brown bars. Coxae and trochanter of all legs concolorous with thorax, femora and tibia blackish brown except for short basal and terminal yellow area, as darkly colored as tarsi. Hind leg with only one basitarsal papilla, plantar surface of basitarsi densely setose.

Abdomen: Dark purplish brown, paler at sides and ventrally; cerci brownish but with apical segment becoming yellowish at apex. Basal two abdominal terga darkish brown, the third tergum in contrast with the fouth tergum with widely pale colored on dark area; medial three terga (segments 4-6) yellowish and terminal three abdominal segments (segments 7-10) darkish brown.

Figure 4.13 *Ptilocerembia* sp.2 (A) male, (B) female and (C) silk gallery.

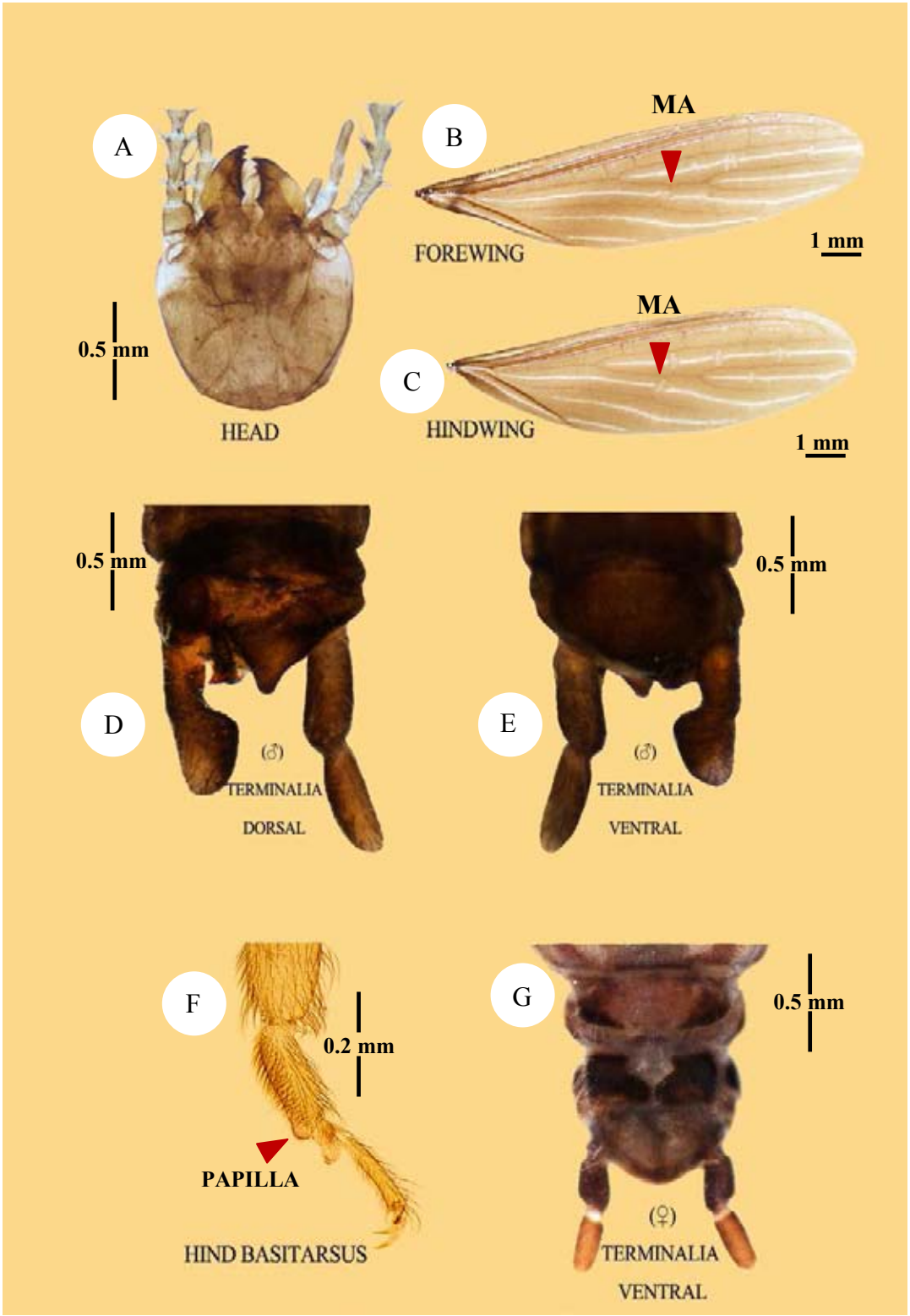


Figure 4.14 Important characters of male (A-F) and female (G) of *Ptilocerembia* sp.2.

Ptilocerembia sp.3
(Figs. 4.15, 4.16, 4.20, 4.21, 4.22)

Material examined. 2♂♂, 2♀♀ (CUMZ-EMB-Not.2010.382-385), **Thailand,** Tak Province, Mae Ramat District, Dry evergreen forest, 16°58.591'N, 98°31.012'E, 363 m, 20. III. 2008 ; 2♀♀ (CUMZ-EMB-Not.2010.386-387), Mae Sod District, Hill evergreen forest, 16°45.377'N, 98°31.012'E, 811 m, 20.III.2008; 1♀ (CUMZ-EMB-Not.2010.388), Mae Sod District, Pine forest, 16°45.370'N, 98°57.056'E, 518 m 27. VI. 2009. 1♀ (CUMZ-EMB-Not.2010.389), Mae Sod District, Pine forest, 16°45.241'N, 98°56.124'E, 443 m 13. VIII. 2009. All collected by P. Poolprasert.

Other specimens examined. 1♂, 1♀ (CUMZ-EMB-Not.2010.390-391), **Thailand**, Chiang Mai Province, Sanpatong District, Hill evergreen forest, 18°32.608'N, 098 °31.521'E, 1237 m , 02. III. 2008; 2♂♂, 3 ♀♀ (CUMZ-EMB-Not.2010.392-396), Fang District, Mixed deciduous forest, 20°04.499'N 099°14.616'E, 615 m , 31. III. 2008; 3♂♂, 4 ♀♀ (CUMZ-EMB.Not.397-403) Mae Taeng District, Hill every green forest, 19°18.917'N, 098°36.348'E, 1597 m, 31. III. 2008. 1♀ (CUMZ-EMB-Not.2010.404), Nan Province, Wiang Sa District, Dry evergreen forest, 18°10.803'N, 100°58.928'E, 417 m, 22. XII. 2009. All collected by P. Poolprasert.

Distribution. Thailand.

Description. Alate male (n = 8, mean (range) ± SD): Head width x length 2.0 (1.9-2.3) ± 0.15 x 1.8 (1.6-1.9) ± 0.11 mm; body length 16.6 (15.7-17.5) ± 0.64 mm, width 2.2 (2.0-2.4) ± 0.12 mm; forewing length 5.6 (4.8-6.1) ± 0.34 mm; hindwing length 10.5 (10.2-11.5) ± 0.32 mm.

Head: Capsule as broad as long, blackish brown. Eyes grayish purple, paler than cranium. Preclypeal and labral membranes lavender, sclerites dark brown; mandible dark amber, sclerotized portions of the other mouthparts dark purple, appearing concolorous to the naked eyes. Molar angles of mandibles deeply notched. Submentum trapezoidal. Antennae black from base through segment 26, segments 27 to 30 (the apex) white, 30 segemented.

Thorax: Blackish throughout. Wings with MA forked, black with purple iridescence except for narrow, white intervenal stripes; margins of costa, radial blood vein and cross-veins are pink. All legs entirely blackish. Hind basitarsi with only one papilla, plantar surface of basitarsi densely setose.

Abdomen: Darkish throughout, terminalia with 10LP, broad, separate from 10R, 10LP broad basally, gradually arced leftward, evenly taperd to a pex. 10R transverse, inner margin ending posteriorly in a blunt, 10RP, anteriorly in a dorsal sharp hook backward. EP, process long, narrow, overlapping apex of an echinulated projection. LPPT, somewhat long, sclerotized. Right cercus with two subcylindrical segments (RC_1 and RC_2). LC_1 very short, distally echinulate expanded and lobed. LC_2 shorter, subconical, fused to LC_1.

Apterous female (n = 15, mean (range) ± SD): Head width x length 2.1 (2.0-2.3) ± 0.19 x 1.9 (1.8-2.0) ± 0.07 mm; body length 17.8 (16.5-18.3) ± 0.33 mm, width 2.3 (2.1-2.4) ± 0.53 mm.

Head: Capsule mostly blackish brown, faintly transversely clouded reddish brown between eyes. Submentum trapezoidal. Antennae with basal three antennal segments golden, all other segments dark brown, distal five segments white, 26 segmented.

Thorax: Prothorax dorsally glossy dark brown, its legs with basal three-fourth dark brown; apex and entire tibia golden brown, tarsi mostly dark brown; meso-and meta-thorax and its legs similar in color but their tarsi are only partially medium yellowish; membranous areas between thoracic segments tan. Hind basitarsi with only one papilla, plantar surface of basitarsi densely setose.

Abdomen: Abdominal te rga almost a ll black, f aintly clouded me dially w ith golden br own; pl eura creamy w hite f orming a l ateral b and o n each s ide o f the abdomen; cer ci en tirely black; m embranous areas o f v enter of p rothorax creamy white; venter of m eso a nd m eta-thorax a nd a bdomen m ottled da rk br own; g enital sternites glossy black.

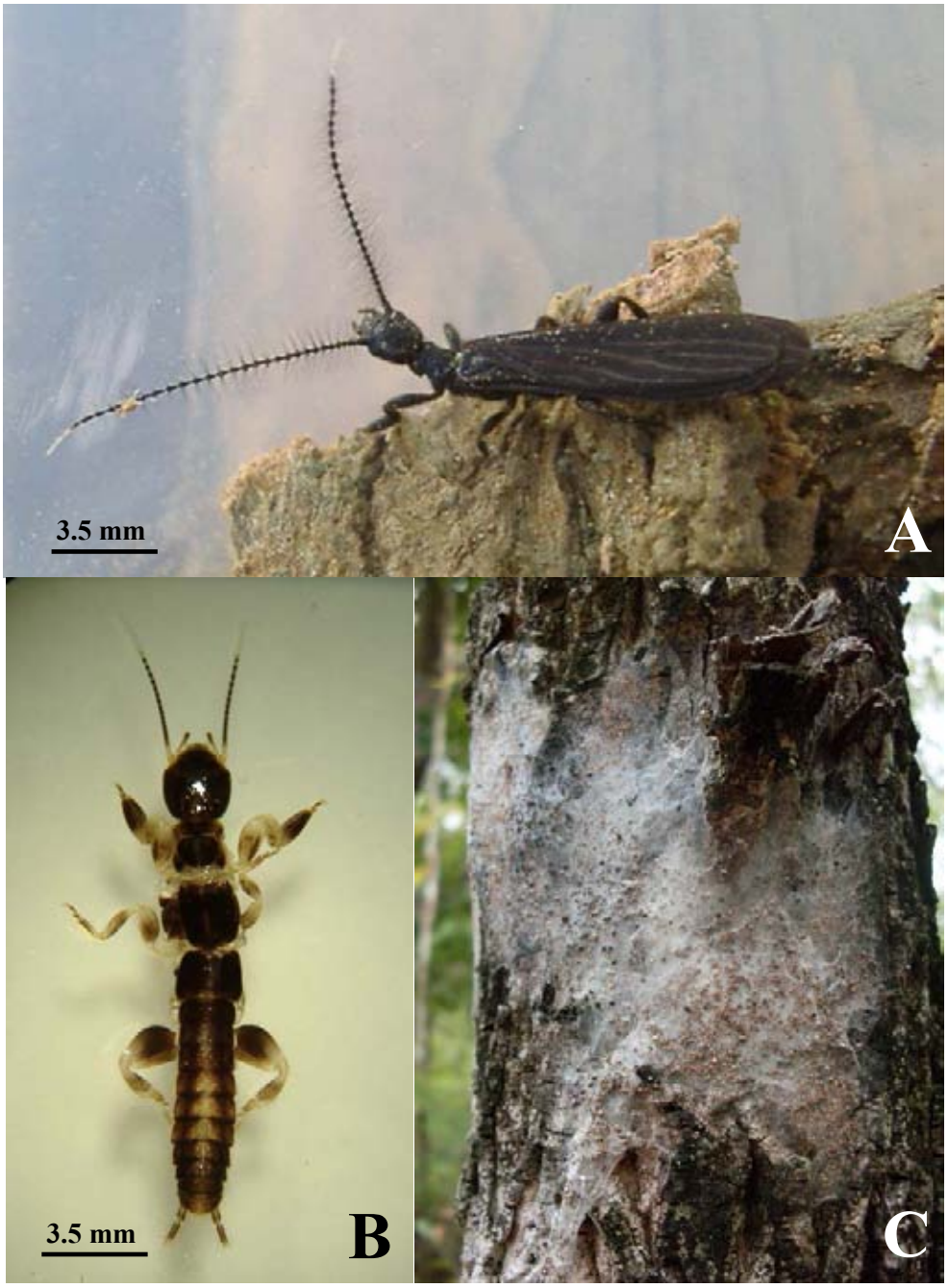


Figure 4.15 *Ptilocerembia* sp.3 (A) male, (B) female and (C) silk gallery.

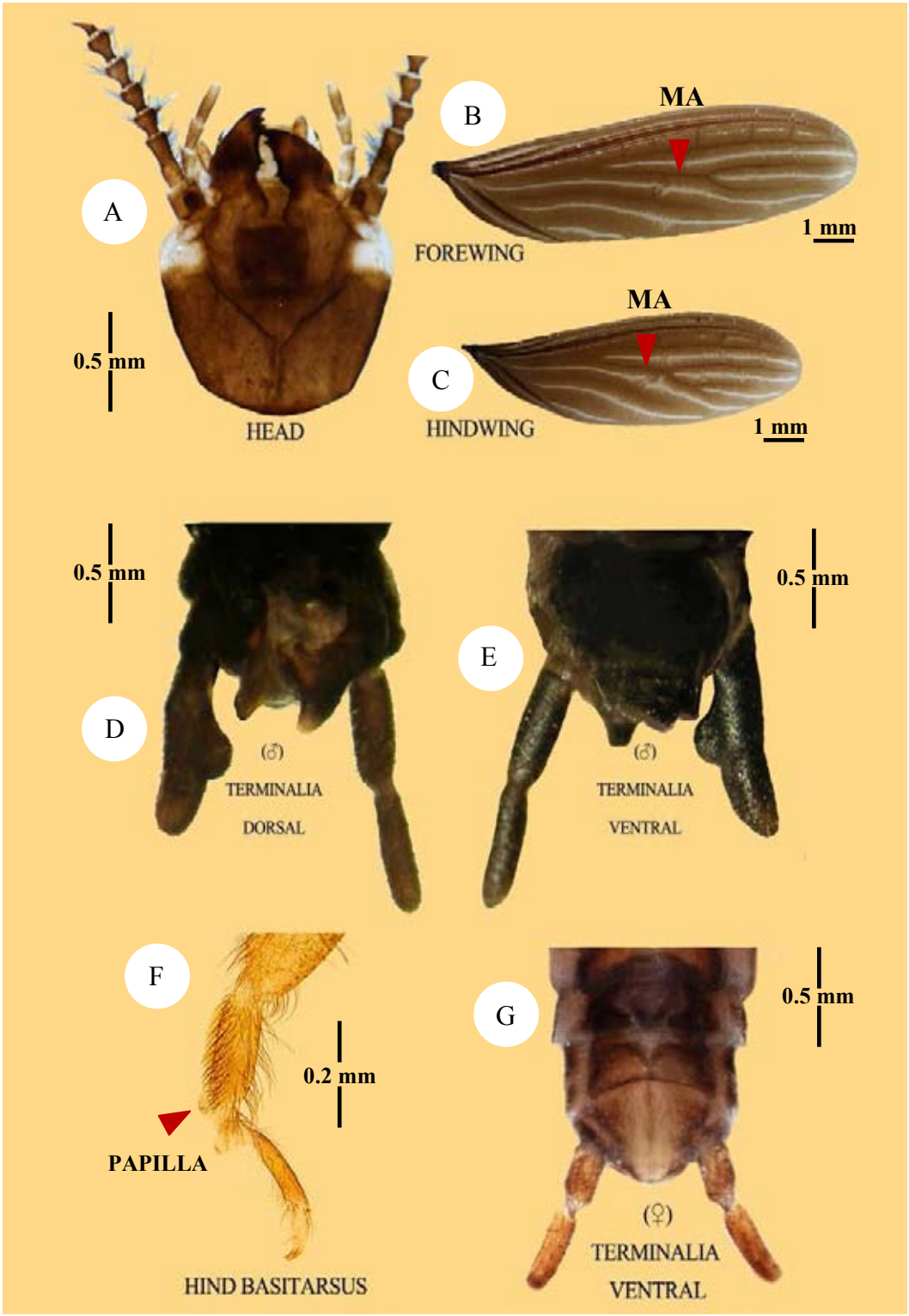


Figure 4.16 Important characters of male (A-F) and female (G) of *Ptilocerembia* sp.3.

Ptilocerembia sp.4
(Figs. 4.17, 4.18, 4.20, 4.21, 4.22)

Material examined. 1♂, 2 ♀♀ (CUMZ-EMB-Not.2010.405-407), **Thailand**, Prachuap Khiri Khan, Ban Saphan District, Rubber plantation, 11°19.124'N 99°24.422'E, 105 m, 16. IV.2009; 4♀♀ (CUMZ-EMB-Not.2010.408-411), Prachuap Khiri Khan, Ban Saphan District, Rubber plantation, 11°19.342'N 99°24.536'E, 78 m, 03. IX. 2009. All collected by P. Poolprasert.

Other specimens examined. 5♀♀ (CUMZ-EMB-Not.2010.412-416), **Thailand**, Chantaburi Province, Soi Dao District, Tropical rain forest, 13°06.184'N, 102°11.496'E, 113 m, 08. VIII. 2009; 1♀ (CUMZ-EMB-Not.2010.417), Klung District, Rubber plantation, 12°30.742'N 102°10.562'E, 50 m, 28. XI. 2009. 3♂♂, 5♀♀ (CUMZ-EMB-Not.2010.418-425), Nakhon Si Thammarat Province, Thung Song District, Rubber plantation, 08°10.340'N 99°44.505'E, 103 m, 06. II. 2010.; 1♂ (CUMZ-EMB-Not.2010.426), 01. V. 2008; 4♀♀ (CUMZ-EMB-Not.2010.427-430), 25. VI. 2008. 7♀♀ (CUMZ-EMB-Not.2010.431-437), Satun Province, La-ngu District, Beach forest, 06°32.502'N 099°16.411'E, 3 m, 21. X. 2008. 1♀ (CUMZ-EMB-Not.2010.438), Trang Province, Mueang District, Tropical rain forest, 07°33.423'N, 099°36.653'E, 34 m, 02. XII. 2010. All collected by P. Poolprasert.

Distribution. Thailand.

Description. Alate male (n = 5, mean (range) ± SD): Head width x length 1.4 (1.2-1.5) ± 0.25 x 1.6 (1.4-1.7) ± 0.42 mm; body length 12.5 (12.3-15.5) ± 0.41 mm, width 1.9 (1.8-2.1) ± 0.03 mm; forewing length 9.2 (9.1-9.5) ± 0.73 mm; hindwing length 8.8 (8.5.9.0) ± 0.16 mm.

Head: Capsule about as broad as long, sides behind eyes strongly convergent and roundcaudally; eyes rather large. Molar area of mandibles sharply pointed. Antennae uniformly brown except for five white distal antennal segments, 29 segmented.

Thorax: Darkish brown but dark patterned with mahogany. Wing with MA forked, medium brown with metallic purple luster. All legs concolorous with throrax. Hind basitarsi with only one papilla, plantar surface of basitarsi densely setose.

Abdomen: Darkish brown then caudally dark. Terminalia with 10L small, not vaulted; 10LP slender constrict basally then tapered distally, pointed. 10L broad. MF almost obsolete, merely a long sickle-shaped hook, raised nodule. LPPT limited to a dark, sclerotic caudal rim, sharp LPPT-P, curved leftward, pointed to LC_1. Basal portion of left cercus (LC_1) tubular, half length of cercus elongate, its echinulate lobe rather small, gradually formed its caudal width equally to that of atrophied base of LC_2.

Apterous female (n = 29, mean (range) ± SD): Head width x length 1.5 (1.3-1.6) ± 0.11 x 1.7 (1.3-1.8) ± 0.81 mm; body length 14.6 (14.2-17.1) ± 0.23 mm, width 2.1 (1.9-2.5) ± 0.46 mm.

Head: Capsule medium brown. Eyes, darkish brown, less kidney form than in male. Antennae darker except for eight white distal segments, 35 segmented.

Thorax: Prothorax and acrotergite yellowish, mottled with medium brown. Meso-and meta-tergites and pleurites blackish brown. All legs pale yellow. Hind basitarsi with only one papilla, plantar surface of basitarsi densely setose.

Abdomen: Basal three abdominal terga blackish brown in sharp contrast with the next four golden terga (mottled with medium brown); terminal three abdominal segments and cerci medium brown.

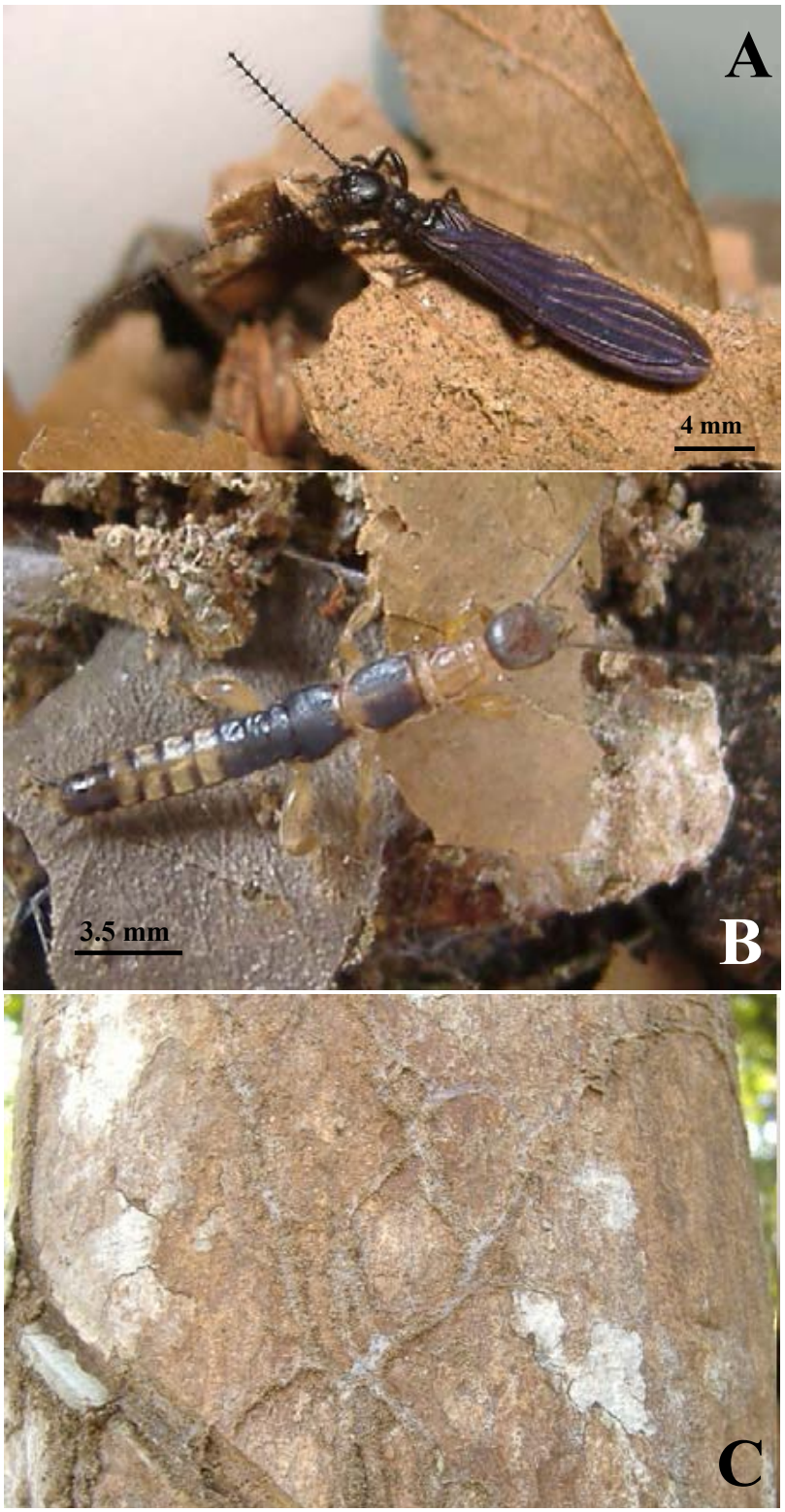


Figure 4.17 *Ptilocerembia* sp.4 (A) male, (B) female and (C) silk gallery.

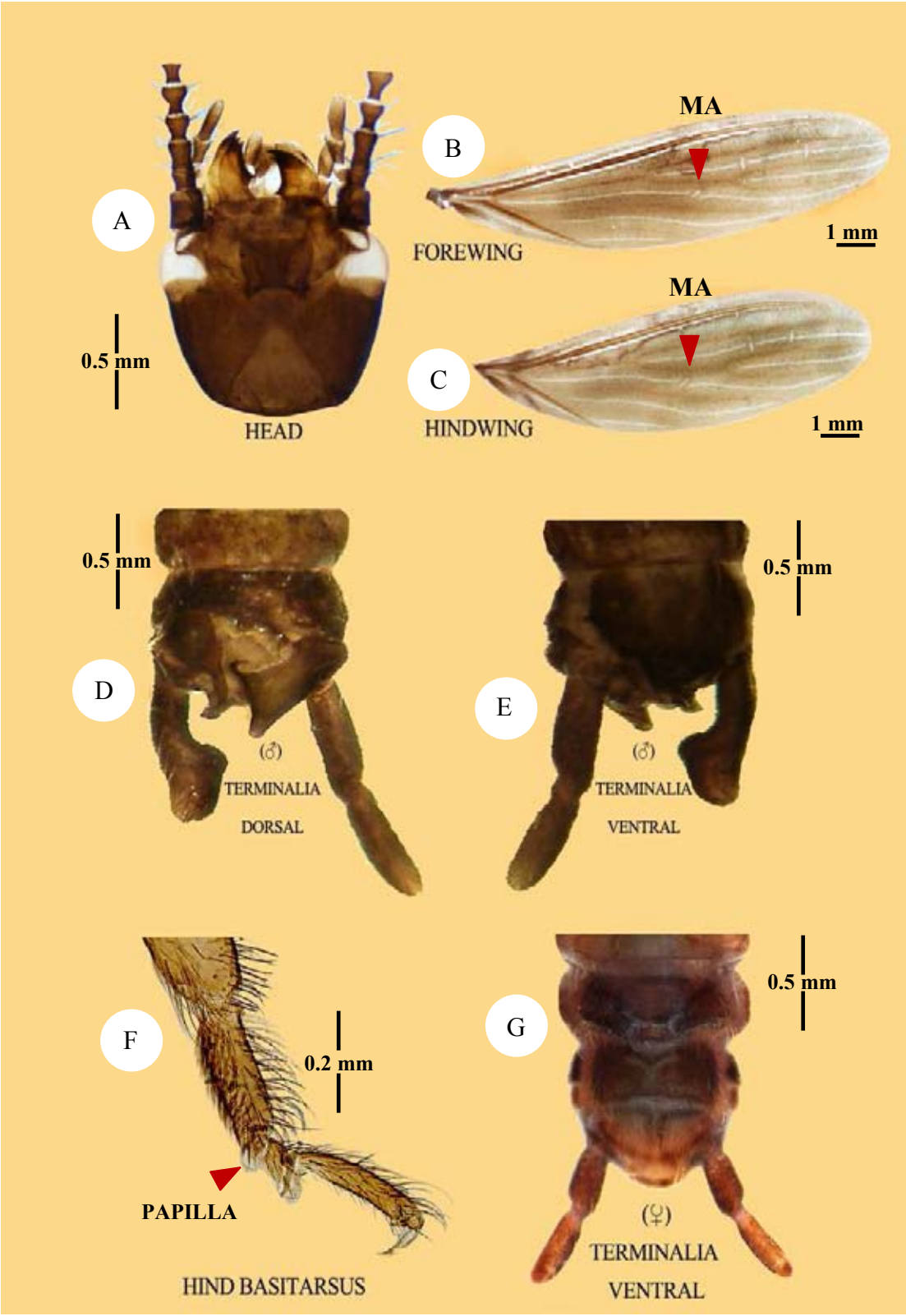


Figure 4.18 Important characters of male (A-F) and female (G) of *Ptilocerembia* sp.4.

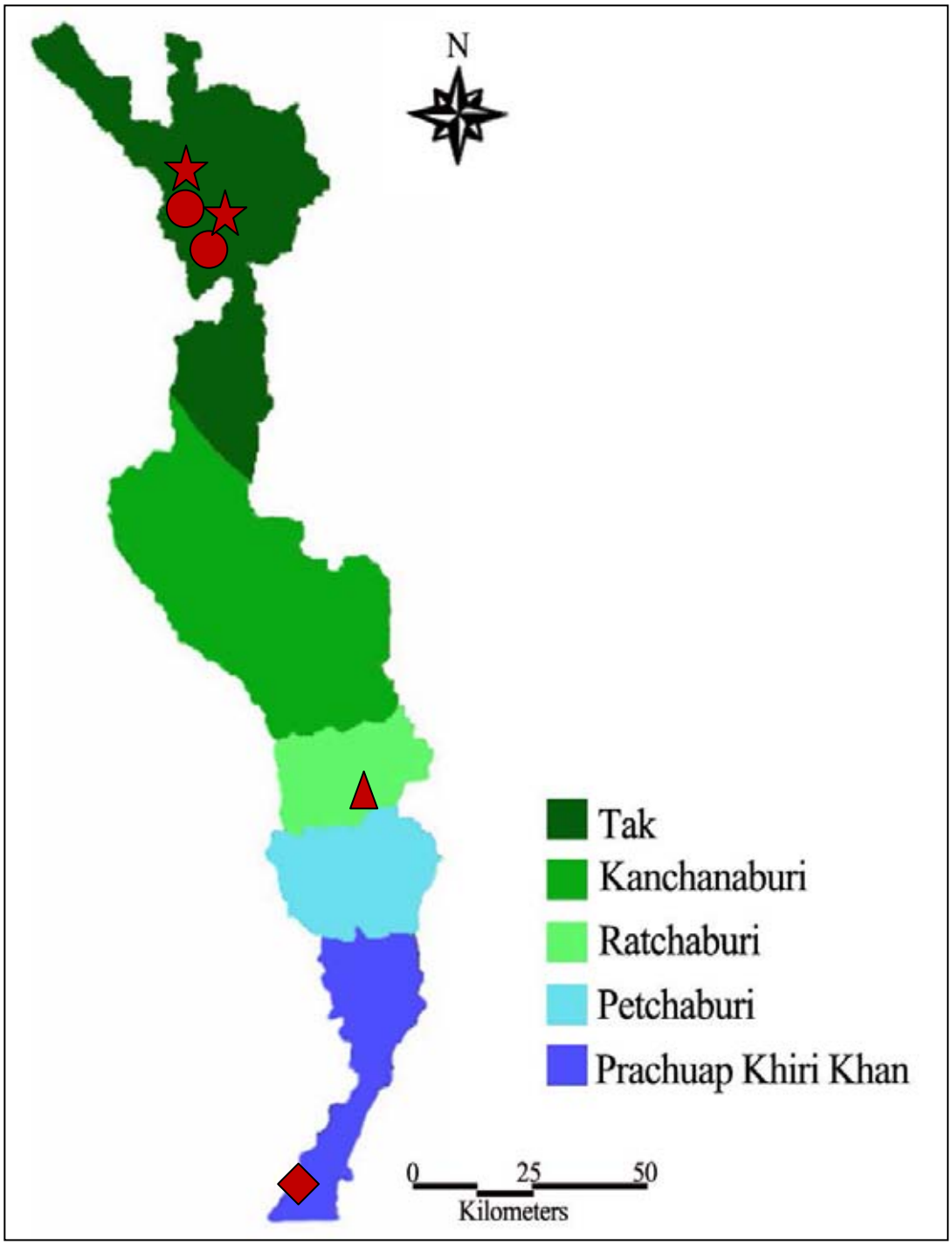


Figure 4.19 Distribution of the genus *Ptilocerembia* (F.Notoligotomidae) found in western Thailand.

Ptilocerembia sp.1 *Ptilocerembia* sp.2 *Ptilocerembia* sp.3

Ptilocerembia sp.4

Key to species of the *Ptilocerembia* (Adult males)

1. LC_1 short, distally large echinulate expanded and lobed; LC_2 shorter, subconical, fused to LC_1; 10LP gradually arced leftward, evenly tapered to apex; MF with a sharp hook. ..... *Ptilocerembia* sp.3
- LC_1 basally subcylindrical, distally expanded and lobed 2
2. LC_1 excavated inner side in basal half, dilated terminal with a finely echinulated nodule; LC_2 short, subconical; 10LP medially slightly expanded, terminally subacute; MF with a dorsal hook curving forward ..... *Ptilocerembia* sp.1
- LC_1 clavate 3
3. MF with a long sickle-shaped hook, elevated nodule; 10 LP slender constrict basally then tapered distally; basal portion of left cercus tubular, elongate half length of cercus, its echinulate lober rather small, gradually formed its caudal width equally to that of atrophied base of LC_2. ..... *Ptilocerembia* sp.4
- MF with a short sickle-shaped hook, elevated nodule; 10LP slender, apex abruptly pointed; basal portion of left cercus subcylindrical, gradually lobed distally, entire inner face coarsely echinulated; LC_2 shorter, subconical, firmly set in basal segment outside completely ..... .*Ptilocerembia* sp.2

Key to species of the *Ptilocerembia* (Adult females)

1. Head concolorous with prothorax *2*
- Head not concolorous with prothorax 3
2. Head, thorax darkish; abdomen mostly darkish with white stripe lateral plate, basal three abdominal terga blackish in contrast with the next four brown terga; terminal three abdominal segments darkish brown; coxae and trochanters whitish, strongly contrasted by the dark femora tibia and tarsi ..... *Ptilocerembia* sp.1
- Head and thorax darkish; abdomen with white stripe lateral plate and conspicuous pale longitudinal mark on a dark background; tibia and tarsi darker than other part of legs ..... *Ptilocerembia* sp.3

3. Head light brown; prothorax yellowish; meso and metathorax brown to dark; legs largely yellow; abdomen, terga 1-3 darkish, terga 4-7 yellowish, and terga 8-10 darkish brown..... *Ptilocerembia* sp.4
- Head dark brown; prothorax yellowish with two longitudinal brown bars; coxae and throchanters yellowish; femora and tibia, except for short basal and terminal yellow area, as darkly colored as tarsi; abdomen, terga 1-2 dark, tergum 3 widely pale colored on dark area, terga 4-6 yellowish, and terga 7-10 darkish brown ..... *Ptilocerembia* sp.2

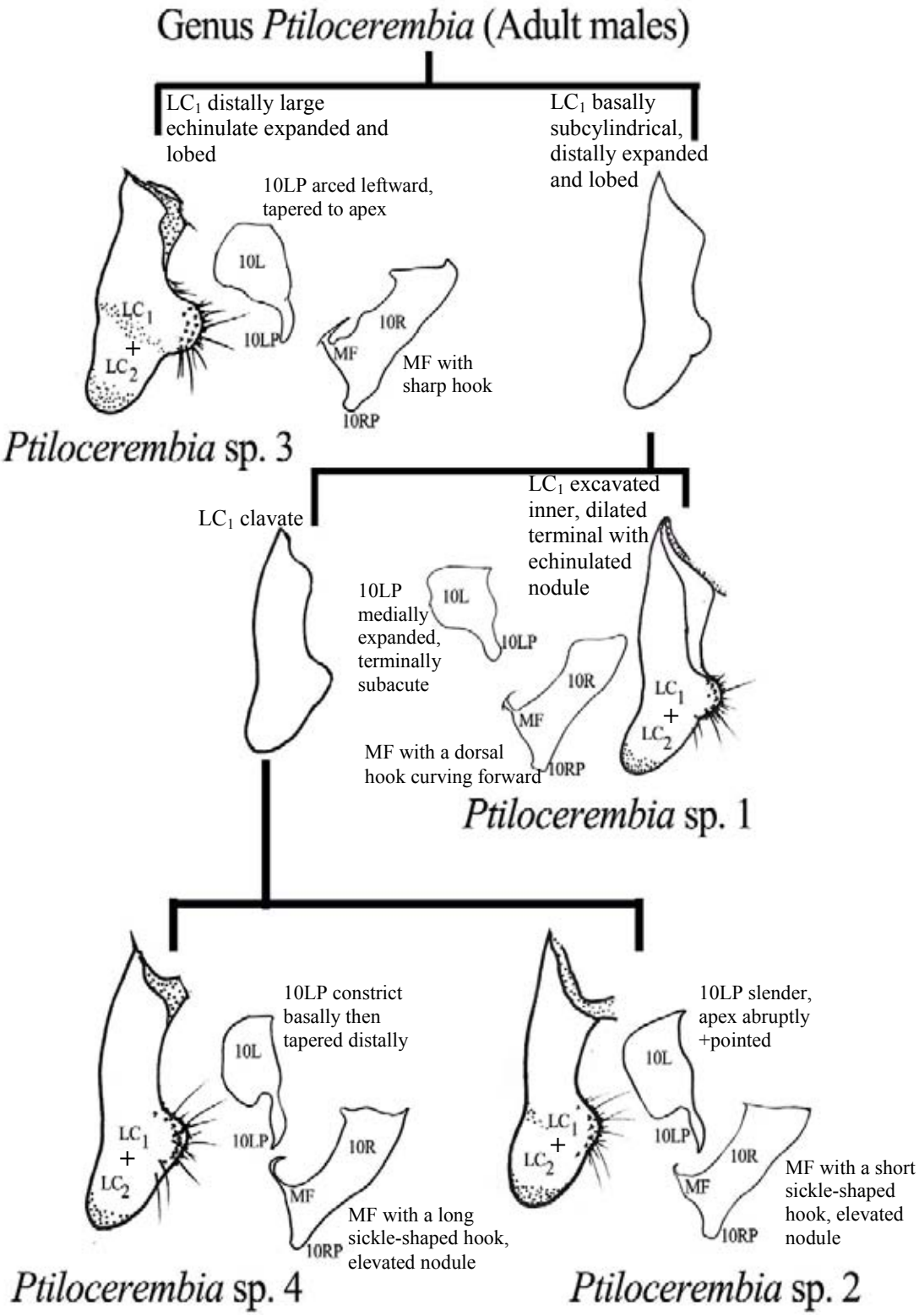


Figure 4.20 Pictorial key to morphospecies for adult males of genus *Ptilocerembia* from western Thailand.

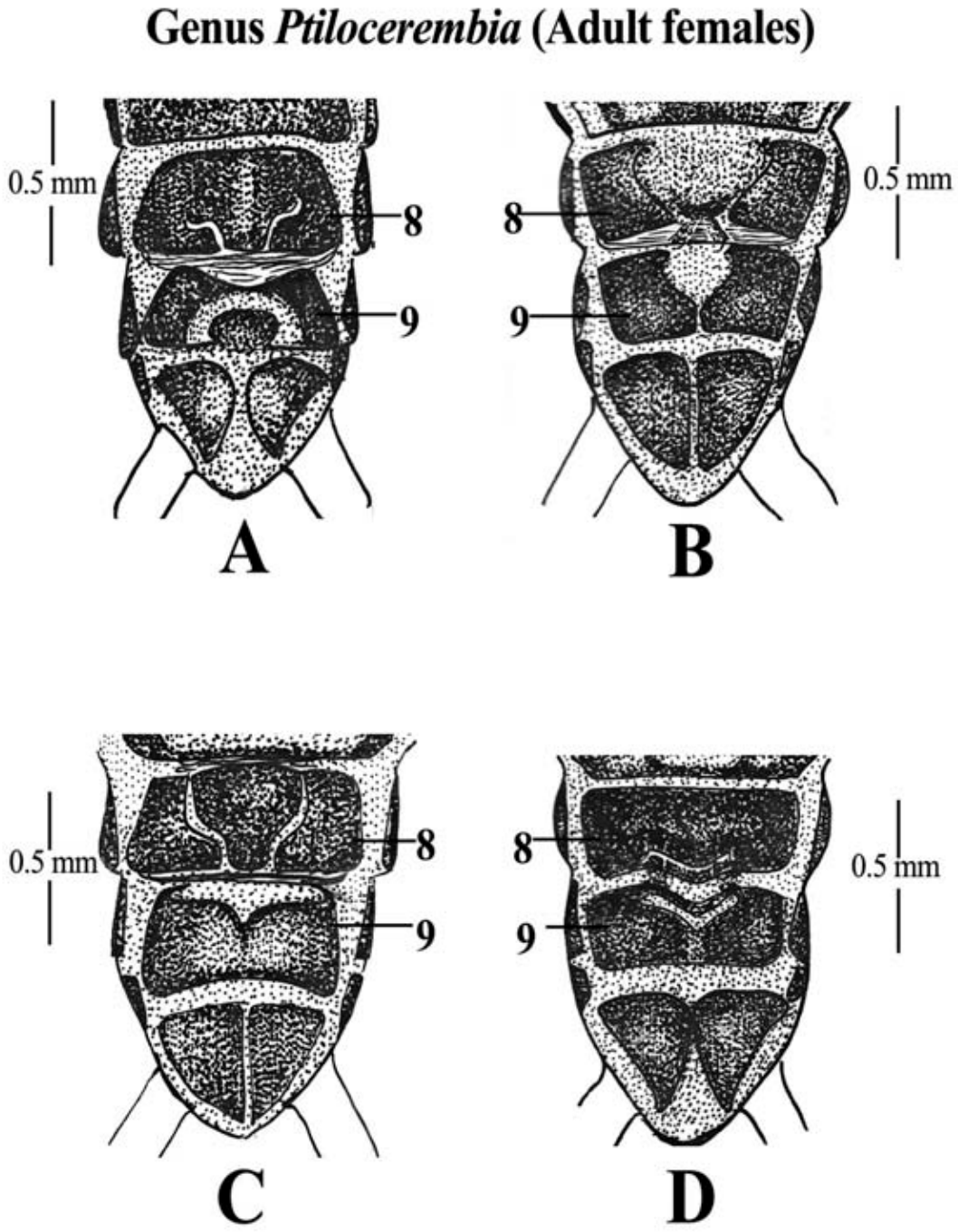


Figure 4.21 Illustrations of sternites, especially on 8th and 9th abdominal segments of female *Ptilocerembia* sp.1 (A), *Ptilocerembia* sp. 2 (B), *Ptilocerembia* sp. 3 (C) and *Ptilocerembia* sp. 4.

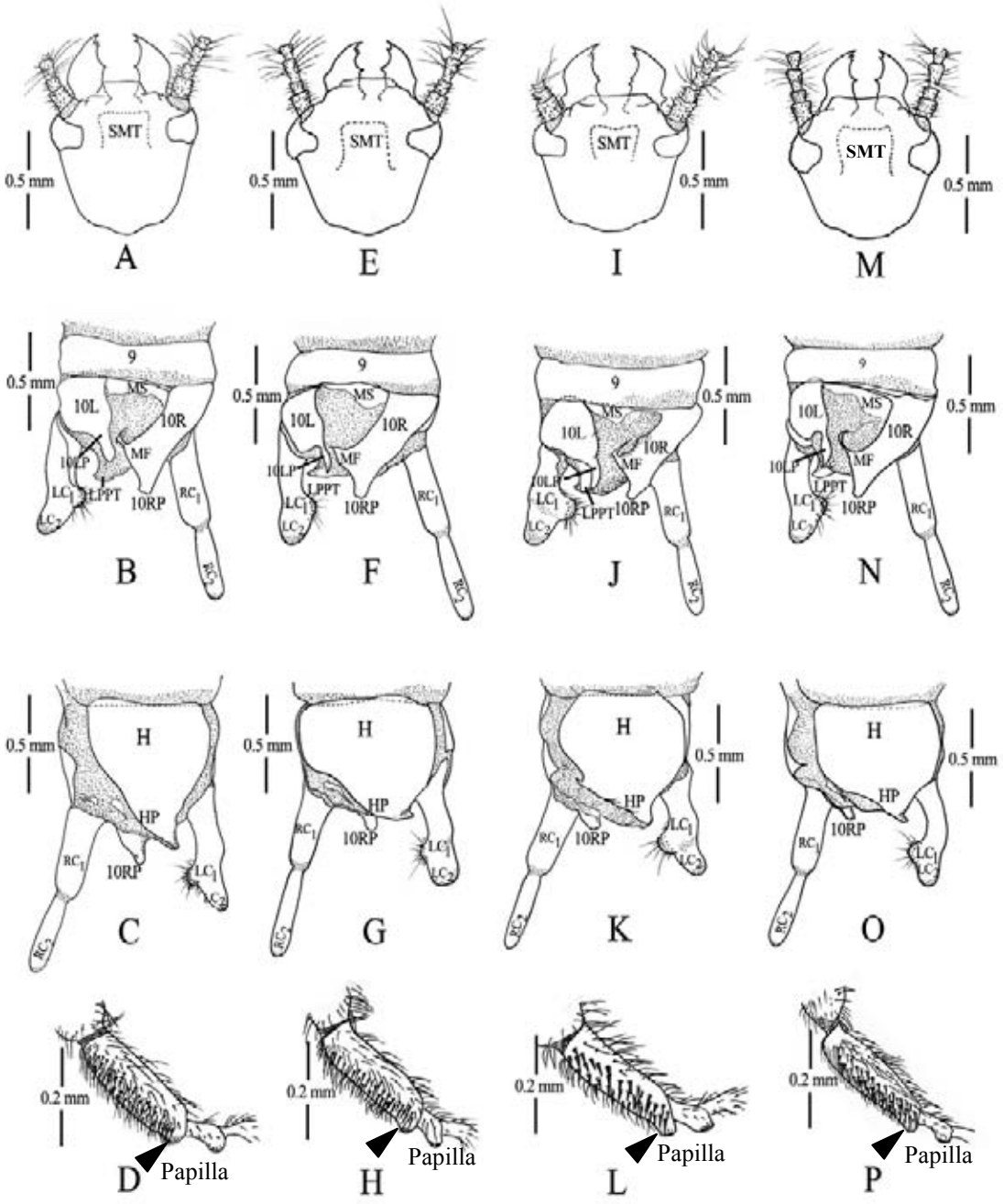


Figure 4.22 Important characters of male *Ptilocerembia* sp.1 (A–D), *Ptilocerembia* sp.2 (E–H) *Ptilocerembia* sp.3 (I–L) and *Ptilocerembia* sp.4 (M-P). A, E, I, M) Head. B, F, J, N) Dorsal views of terminalia. C, G, K, O) Ventral views of terminalia. D, H, L, P) Hind basitarsus.

Oligotomidae Enderlein, 1909

Diagnosis. Apterous or alate male: Body length 5-20 mm. Wings with MA unforked. Hind basitarsus with one or two papillae. Terminalia with MF separated from 10R by an extensive membranous area which then projects caudally as though it is a process of the right hemitergite, but actually it appears to be MF rotated caudally. LC_1 lobed or unlobed, never echinulated. Apterous female: Body length 5-22 mm, without distinctive characters.

Distribution. Mediterranean, Middle East, Indian region, Southeastern Asia, and Australia.

Key to genera of Oilgotomidae (Adult males)

1. LC_1 completely encircled by LCB which projects mesad as a lobe ..... *Oligotoma*
- LC_1 with only an outer flange, which never completely encircles the cercus base and never lobed 2
2. HP somewhat simple, short; 10LP slender, aedeagus not conspicuous; LC_1 slender, never bulbous ..... *Aposthonia*
- HP long 3
3. HP very long, arising broadly from a narrow H, is very long and somewhat twisted; 10LP unusually small, straight, tapered caudally; LC_1 expanded dorsomesad as angular lobe ..... *Lobosembia*
- HP shorter often trough-like, twisted leftward; 10 LP usually broad, aedeagus usually sclerotic and broadened caudally; LC_1 varying from a simple cylindrical form to distally-expanded and lobed. ..... *Eosembia*

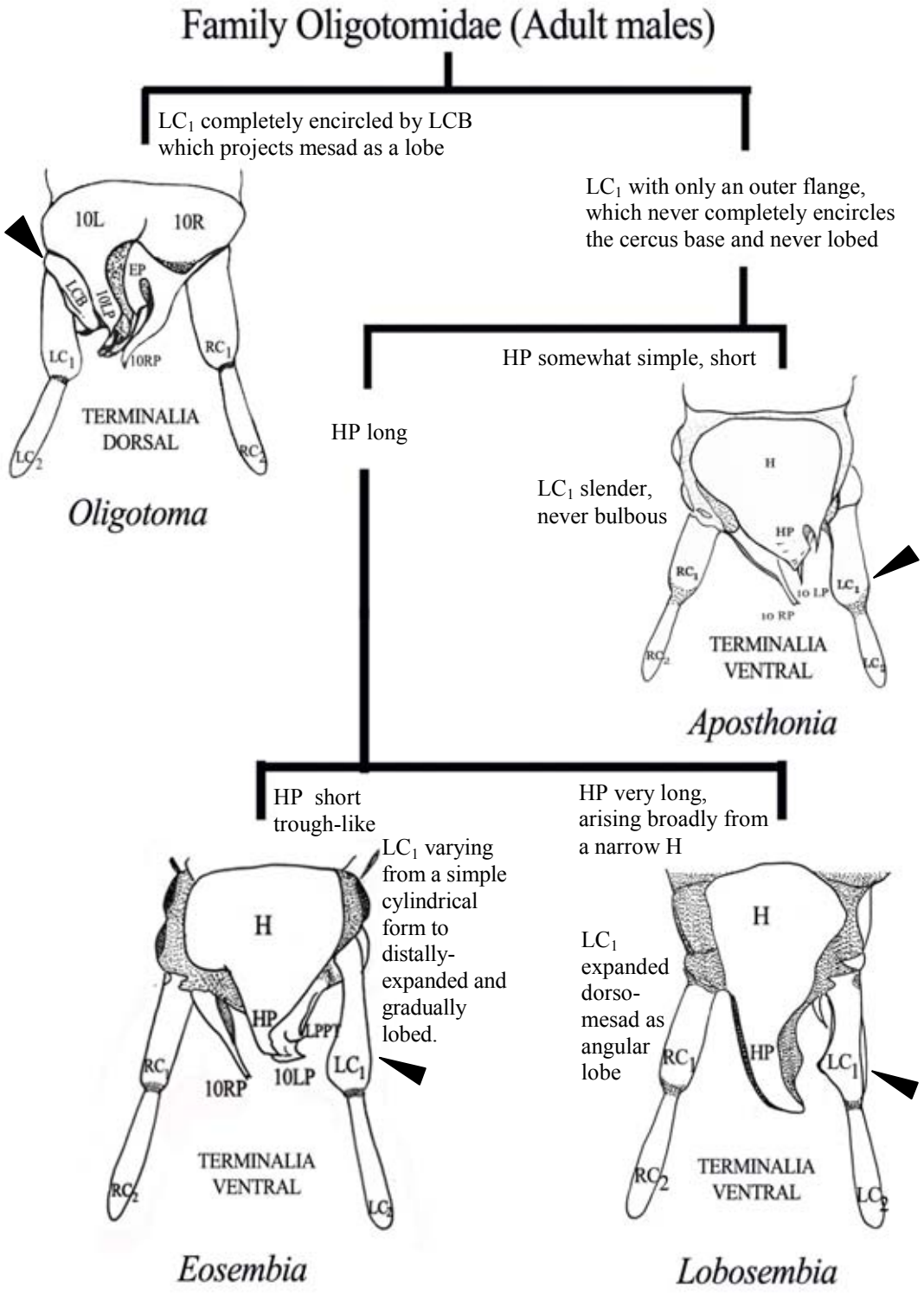


Figure 4.23 Pictorial key to genera for adult males of family Oligotomidae of western Thailand.

Genus ***Aposthonia*** Krauss, 1911

Aposthonia Krauss, 1911: 48; Enderlein, 1912: 100 (as syn. of *Oligotoma* Westwood); Davis, 1936: 233; Davis, 1940b: 363 (as syn. of *Oligotoma*); Ross, 1956b: 316 (as valid genus); Ross, 1963: 135; Ross, 2007: 592; Mill, 2009: 15; Poolprasert *et al.*, 2011: 4.

Oligotoma (*Aposthonia*) Krauss. Ross, 1955: 2.

Type species.-*Aposthonia vosseleri* Krauss, 1911: 48, fig. 14a-g (=*Oligotoma borneensis* Hagen), by original designation.

Diagnosis. Apterous or alate male: Body length 5-12 mm; coloration diverse, never with antennal apices white, or body and legs brightly pigmented. Wing without specific venational features, MA not forked. Hind basitarsi never with more than one papilla. Terminalia basically but never with prominent internal phallic sclerotization, absence of mesal lobing of LCB and simplicity of LPPT. Apterous female: Body length 8-15 mm. Absence of white apical segments of the antennae and lack of a second hind basitarsal papilla.

Distribution. Tropical Asia, northt o southern Japan; Indonesia, Melanesia, and throughout Australia. A few species spread by man to Oceania, New Caledonia, Madagascar and east African coasts. Absent in Afrotropical region and the Americas.

***Aposthonia borneensis* (Hagen, 1885)**
(Figs. 4.24, 4.25, 4.31, 4.32, 4.33)

Oligotoma borneënsis Hagen, 1885: 146 (as "*O. saundersii* Westwood"); Krauss, 1911: 39 (= "*O. saundersii* Westwood"); Davis, 1940: 371, figs. 23-27; Ross, 1943: 102, figs. 6-8; Davis, 1948: 100, fig. 1

Aposthonia vosseleri Krauss, 1911: 48, pl. II, fig. 14; Friederichs, 1934: 409, 410 (v. *vosseleri*), 427 (female); Davis, 1948: 373 (= *borneënsis* Hagen)

Oligotoma vosseleri (Krauss). Enderlein, 1912: 101, fig. 65; Silvestri, 1912: 334, fig. 6.

Aposthonia vosseleri intermedia Friederichs, 1934: 410 (as a form); Davis, 1940: 374 (= *borneënsis* Hagen)

Aposthonia vosseleri obscura Friederichs, 1934: 412; Davis, 1940: 375 (= *borneënsis* Hagen)

Oligotoma jacobsoni Silvestri, 1912: 334; Davis, 1940: 373 (= *borneënsis* Hagen)

Aposthonia vosseleri jacobsoni (Silvestri). Friederichs, 1934: 411

Oligotoma maerens Roepke, 1919: 5, figs. 1-12; Davis, 1940: 374 (= *borneënsis* Hagen)

Oligotoma nana Roepke, 1919: 20, figs. 13-15; Davis, 1940: 374 (= *borneënsis* Hagen)

Aposthonia vosseleri nana (Roepke). Friederichs, 1934: 412

Oligotoma masi Navás, 1923: 39; Navás, 1932: 923; Davis, 1940: 374, fig. 32 (= *borneënsis,* Hagen, see reference to *masi* type)

Aposthonia borneensis (Hagen). Ross, 1978: 5, fig. 2; Ross, 2000b: 30; Ross, 2007: 592, fig. 14; Yang, 1999: 66, fig. 18-1c; Poolprasert *et al.*, 2011a: 4, figs. 2a-c, 3a.

Diagnosis. Males of *A. borneensis* can be distinguished from congeners by the basal region of the left cercus being distally expanded and lobed, and by the presence of an outcurved hook on the left cercus-basipodite. The female is chestnut brown with blackish brown cranium, golden prothorax and brown legs except for the pale femoral-tibial joints.

Lectotype. ♂ Museum of Comparative Zoology (MCZ), U.S.A.

Type locality. Malaysia (Borneo).

Material ex amined. 2♂♂, 3♀♀ (CUMZ-EMB-Oli.2010.28-32), **Thailand**, Kanchanaburi Province, Mueang District, Orchard, 14°02.278' N 99°31.770' E, 36 m, 22. V III. 2009. 1♂, 3♀♀ (CUMZ-EMB-Oli.2010.42-45), T ak P rovince, Mueang District, Orchard, 16°46.545'N 99°00.456'E, 123 m , 30. V II. 2009. All collected by P. Poolprasert.

Other specimens examined. 1♂, 1♀ (CUMZ-EMB-Oli.2010.01-02), **Thailand**, B angkok Province, P athumwan D istrict, Lumpini P ark, 13°45.575 'N 100°32.304'E, 7 m, 05. I II. 2008 . 1♂ (CUMZ-EMB-Oli.2010.07), N akhon N ayok Province, Mueang District, p lantation, 14°12.109'N 101°12.480' E, 189 m , 09. X. 2007. 1♂ (CUMZ-EMB-Oli.2010.35), Loei Province, Phu Kradueng District, orchard, 16°53.315'N 101°53.1 40'E, 227 m, 03. III. 2007. 2♂♂, 8♀♀ (CUMZ-EMB-Oli.2010.14-23), Nakhon S i T hammarat P rovince, Thung S ong D istrict, r ubber plantation, 08°10.340'N 99°44.505'E, 103 m , 06. II. 2010. 1♂, 3♀♀ (CUMZ-EMB-Oli.2010.24-27), N an P rovince, Tha W ang P ha District, P lantation, 19°10.953'N 100°54.934'E, 271 m , 23. X II. 2009. 1♂, 1♀ (CUMZ-EMB-Oli.2010.33-34), Phitsanulok Province, Mueang District, orchard, 16°49.290'N 100°15.345'E, 123 m , 21. X I. 2008 . 1♂ (CUMZ-EMB-Oli.2010.36), S akon Nakhon P rovince, P hu Phan District, p lantation, 17°14.010'N 103°58.105' E, 254 m, 02. V III. 2007. 1♂, 2♀♀ (CUMZ-EMB-Oli.2010.37-39), C haiyaphum P rovince, Mueang District, p lantation, 15°58.916'N 102°02.248'E, 217 m, 09. IX. 2007. 1♂, 1♀ (CUMZ-EMB-Oli.2010.40-41), Satun Province, Mueang District, beach forest, 06°32.145'N 100°04.001'E, 6 m, 19. X . 2008. 2♂♂, 4♀♀ (CUMZ-EMB-Oli.2010.08-13), S isaket P rovince, Uthumphon P hisai D istrict, forest p ark, 15°06.083'N 104°07.643'E, 143 m, 20. IX. 2009. 1♂ (CUMZ-EMB-Oli.2010.46), U bon Ratchathani, Mueang District, p ublic park, 1 5°13.443'N 104°51.151.E , 123 m , 03. I II. 2007. 1♂, 3♀♀ (CUMZ-EMB-Oli.2010.03-06), U ttaradit P rovince, P hichai D istrict, or chard, 17°17.085'N 100°01.209'E, 63 m, 06. II. 2010. All collected by P. Poolprasert.

Distribution. China (Canton, Hainan), Hong Kong, Indonesia (Java, Sumatra), Laos, Malaysia (Borneo), Papua New Guinea, Vietnam and Thailand.

Description. Alate male (n = 17, mean (range) ± SD): Head width x length 1.1 (0.9-1.2) ± 0.11 x 1.5 (1.3-1.6) ± 0.10 mm; body length 8.2 (7.6-8.6) ± 0.23 mm, width 1.5 (1.3-1.6) ± 0.12 mm; forewing length 6.5 (5.9-6.8) ± 0.26 mm; hindwing length 5.7 (5.3-6.2) ± 0.22 mm.

Head: Capsule brownish, slightly longer than broad with large, prominent, kidney-shaped eyes, sides behind eyes rounded, converging posteriorly. Clypeus pale, labrum pale, with large brown middle spot, maxillary palpi brown, labial palpi similar in color. Submentum trapezoidal with medial concave anterior margin, blackish. Mandible dark. Antennae brownish throughout, 19 segmented.

Thorax: Prothorax yellowish, much narrower than head, longer than broad, meso- and metathorax generally dark fuscous, with paler articulations. Wings medium brown throughout; MA not forked. All legs fuscous except the articulations, tarsi of the front legs pale. Hind leg with only one basitarsal papilla.

Abdomen: Grayish brown throughout with terminalia darker. Terminalia with 10L and 10R of equal width. 10LP elongate, slender, narrowly rounded distally, 10RP greatly elongated, narrow, membranous inner side, with small outer hook at the apex. HP simple, rounded. LPPT narrow, sclerotized, hooked outward and upward terminally and acutely pointed. LCB represented by a blackish plate at base of left cercus. LC_1 dilated distally and lobed without echinulation.

Apterous female (n = 26, mean (range) ± SD): Head width x length 1.2 (1.0-1.3) ± 0.09 x 1.8 (1.3-19) ± 0.13 mm; body length 9.9 (9.3-10.3) ± 0.29 mm, width 1.5 (1.3-16) ± 0.05 mm.

Head: Capsule blackish brown, convex, longer than broad. Eyes dark, smaller and less kidney-shaped than in male. Antennae brown throughout without white tips, 16 segmented.

Thorax: Prothorax golden, cream-white intersegmental banding anterior and posterior to mesoscutum. All legs brown, whitish mid and hind coxae and trochanters. Hind leg with only one basitarsal papilla.

Abdomen: Chestnut-brown throughout. Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.

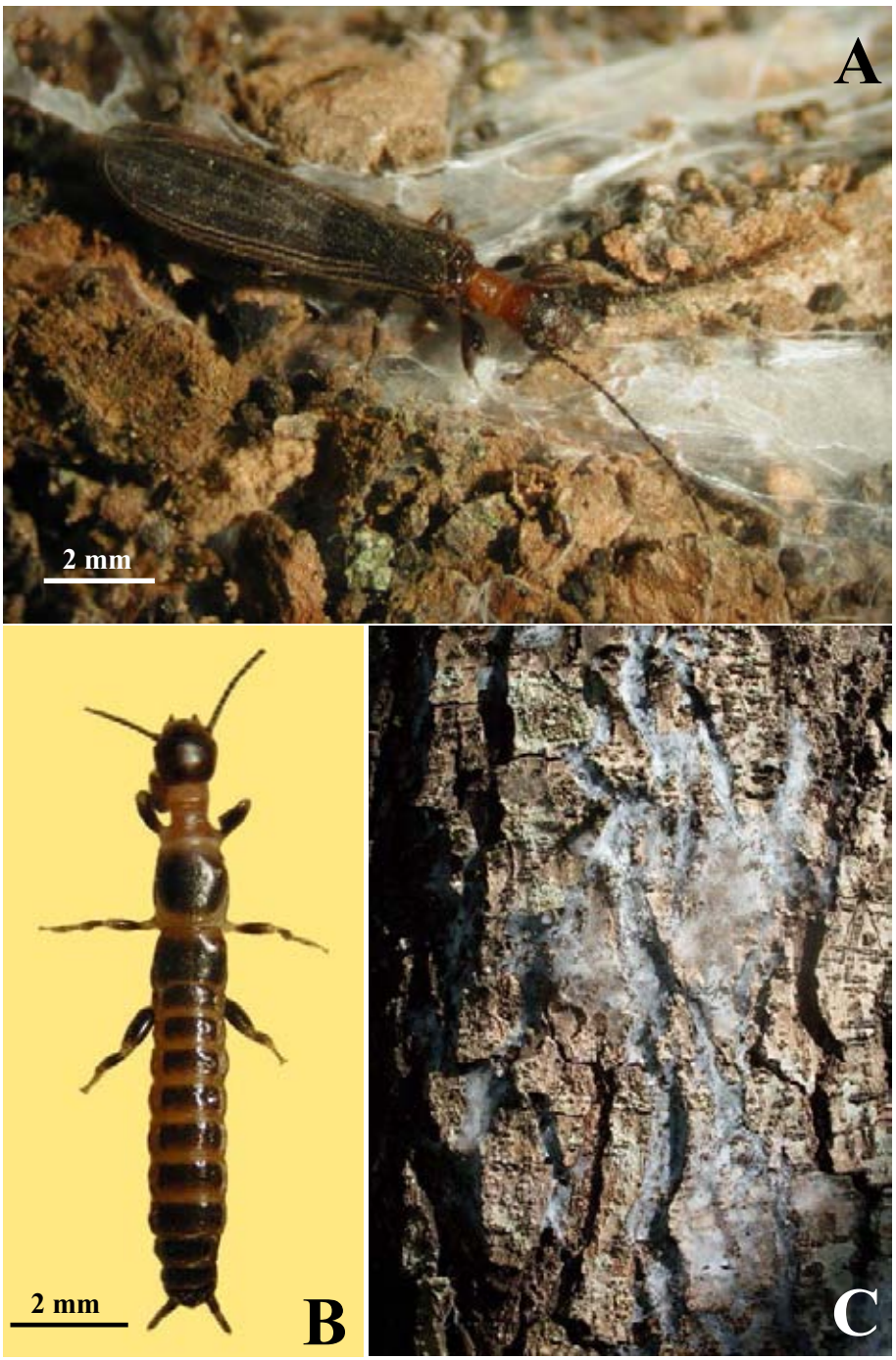


Figure 4.24 *Aposthonis borneensis* (A) male, (B) female and (C) silk gallery.

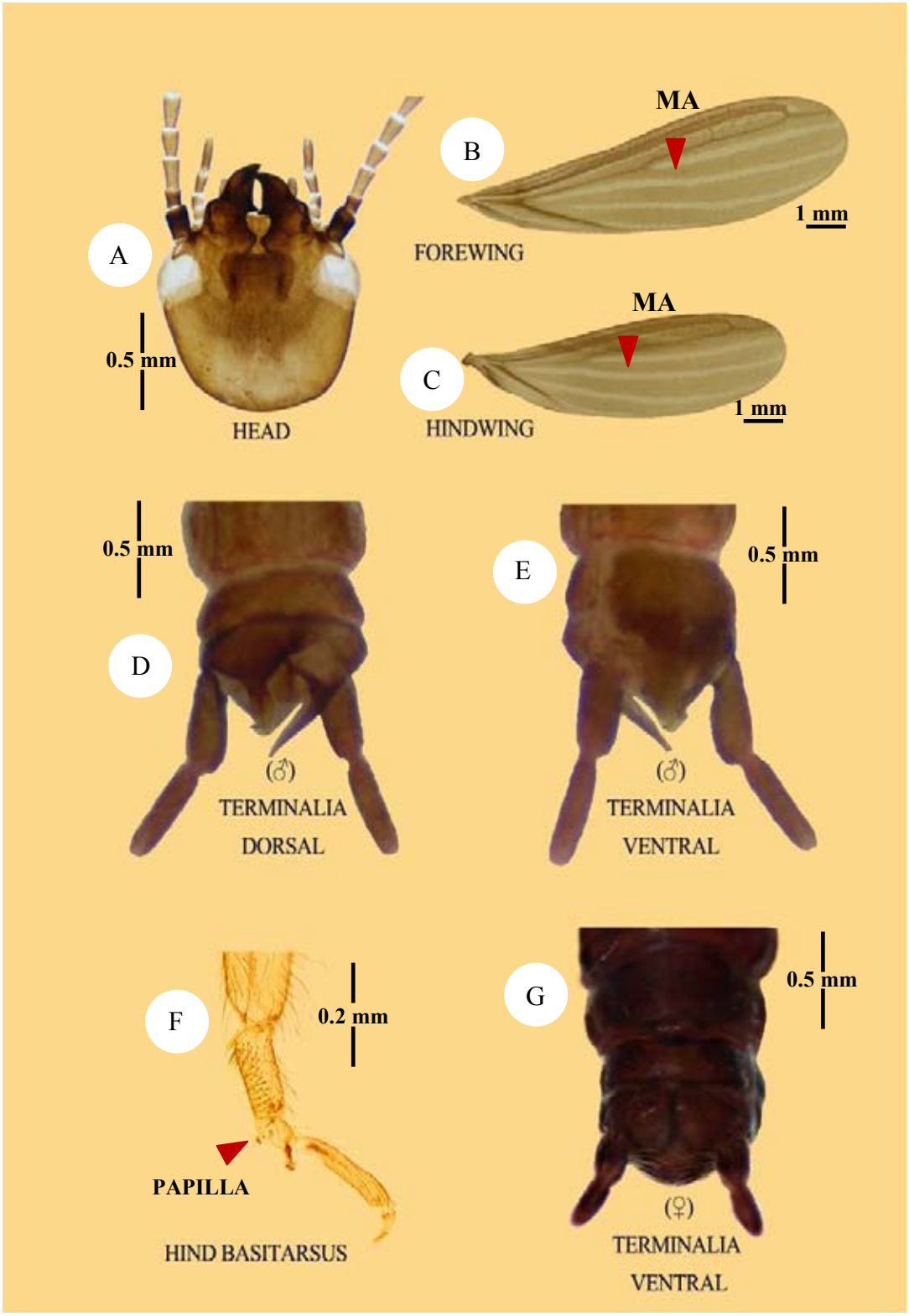


Figure 4 .25 Important ch aracters of m ale (A-1F) an d female (G) o f *Aposthonia borneensis*.

Aposthonia ceylonica (Enderlein, 1912)
(Figs. 4.26, 4.27, 4.31, 4.32, 4.33)

Oligotoma ceylonica Enderlein, 1912: 83, fig. 56.

Oligotoma ceylonica ceylonica Enderlein. Davis, 1940: 378, figs. 51-56; Kapur & Kripalani, 1957: 126; Bradoo, 1967: 447, figs. 1-11.

Oligotoma ceylonica var. *variegata* Mukerji, 1935: 4, fig. 2 a-k; Menon & George, 1936: 91, pl. ii, Figs. 1a-b, 2a-b.

Aposthonia ceylonica (Enderlein). Ross, 2000b: 30; Poolprasert *et al*., 2011a: 6, figs. 2d-f, 3b.

Diagnosis. The male of *A. ceylonica* is distinguished from its relatives by the basal segment of the left cercus being less excavate in the basal three quarters and by the absence of an outcurved spine on the left cercus-basipodite. The female is brownish with light brown head, brown prothorax and forelegs, and dark brown middle and hind legs, except that the femoral-tibial joints are pale.

Holotype. ♂ Stettiner Zoologisches Museum (SZM), Germany.
Type locality. Sri Lanka (Ceylon)

Material examined. 2♂♂, 1 ♀ (CUMZ-EMB-Oli.2010.52-54), **Thailand**, Kanchanaburi Province, Sangkhla Buri District, rubber plantation, 15°18.267'N 098°23.656'E, 297 m, 21. VII. 2008. 1♂, 2 ♀♀ (CUMZ-EMB-Oli.2010.70-72), Prachuap Khiri Khan Province, Mueang District, forest park, 11°48.613'N 99°47.329'E, 7 m, 19. X. 2008. 1♂ (CUMZ-EMB-Oli.2010.73) beach forest 11°48.553'N 99°47.313'E, 3 m, 19. X. 2008. 1♂, 2♀♀ (CUMZ-EMB-Oli.2010.74-76), Ratchaburi Province, Saun Phung District, forest park, 13°32.805'N 99°20.126'E, 137 m, 22. VIII. 2009. 1♂ (CUMZ-EMB-Oli.2010.93), Tak Province, Mueang District, mixed deciduous forest, 16°46.661'N 99°00.245'E, 306 m, 04. III. 2009. All collected by P. Poolprasert.

Other specimens examined. 4♂♂ (CUMZ-EMB-Oli.2010.47-50), **Thailand**, Chiang Mai Province, Mueang District, Huay Kaeo Arboretum, 18°48.348'N 098°57.585'E, 336 m, 01. II. 2008. 1♂ (CUMZ-EMB-Oli.2010.51), Chonburi Province, Sri Racha District, forest park, 18°48.348'N 098°57.585' E, 18m, 20.IV.2008. 8♂♂, 7♀♀ (CUMZ-EMB-Oli.2010.55-69), Satun Province, Mueang District, beach forest, 06°33.181'N 99°16.513'E, 9 m, 19. X. 2008. 3♂♂, 13♀♀ (CUMZ-EMB-Oli.2010.77-92), Surin Province, Samrong Thap District, dry evergreen forest, 15°03.533'N 103°56.566'E, 139 m, 09. V. 2008. 3♂♂, 1♀ (CUMZ-EMB-Oli.2010.94-97), Bangkok Province, Pathumwan District, Lumpini Park, 13°45.575'N 100°32.304'E, 7 m, 05. III. 2008. All collected by P. Poolprasert.

Distribution. India, Laos, Madagascar, Malaysia, Mauritius, Sri Lanka and Thailand.

Description. Alate male (n = 25, mean (range) ± SD): Head width x length 1.0 (0.9-1.4) ± 0.15 x 1.3 (1.0-1.5) ± 0.10 mm; body length 6.6 (5.7-7.5) ± 0.51 mm, width 1.2 (1.1-1.4) ± 0.07 mm; forewing length 5.6 (4.8-6.1) ± 0.42 mm; hindwing length 4.5 (3.7-5.4) ± 0.52 mm.

Head: Capsule pale brown, longer than broad, sides convergent behind eyes. Eye dark and moderately large. Labrum light brown, mandibles brownish, slender. Submentum trapezoidal with medial concave anterior margin, brownish. Antennae dark chocolate-brown, 17- segmented.

Thorax: Medium brown throughout, pleurites darker. Wings grayish brown, anterior medial vein (MA) not forked. All legs medium brown throughout except for pale joints. Hind leg with only one basitarsal papilla.

Abdomen: Similar in color to thorax. Terminalia with 10L same width as 10R. 10LP slender, evenly narrowed to simple round tip. 10RP greatly elongated, membranous inner margin with a hooked apex. H produced back anteriorly to an obtuse HP, reaching as far as 10LP. LPPT weakly developed but distinct. LC_1 strongly excavate in the basal three-quarters.

Apterous female (n = 26, mean (range) ± SD): Head width x length 1.2 (1.0-1.4) ± 0.13 x 1.3 (1.2-1.6) ± 0.10 mm; body length 6.7 (5.8-7.5) ± 0.51 mm, width 1.3 (1.2-1.5) ± 0.09 mm.

Head: Capsule light brown, weakly convex, longer than broad. Eyes dark, smaller than in male. Antennae 15-segmented with basal 3 segments medium brown, other segments dark brown.

Thorax: Prothorax mostly brown except the anterior becoming light brown. Meso- and metathoracic sclerites dark brown. Forelegs concolorous with pronotum, middle and hind legs entirely dark brown except for pale femoral-tibial joints. Hind leg with only one basitarsal papilla.

Abdomen: Brownish with tergum of segments 3-6 more reddish brown, tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.

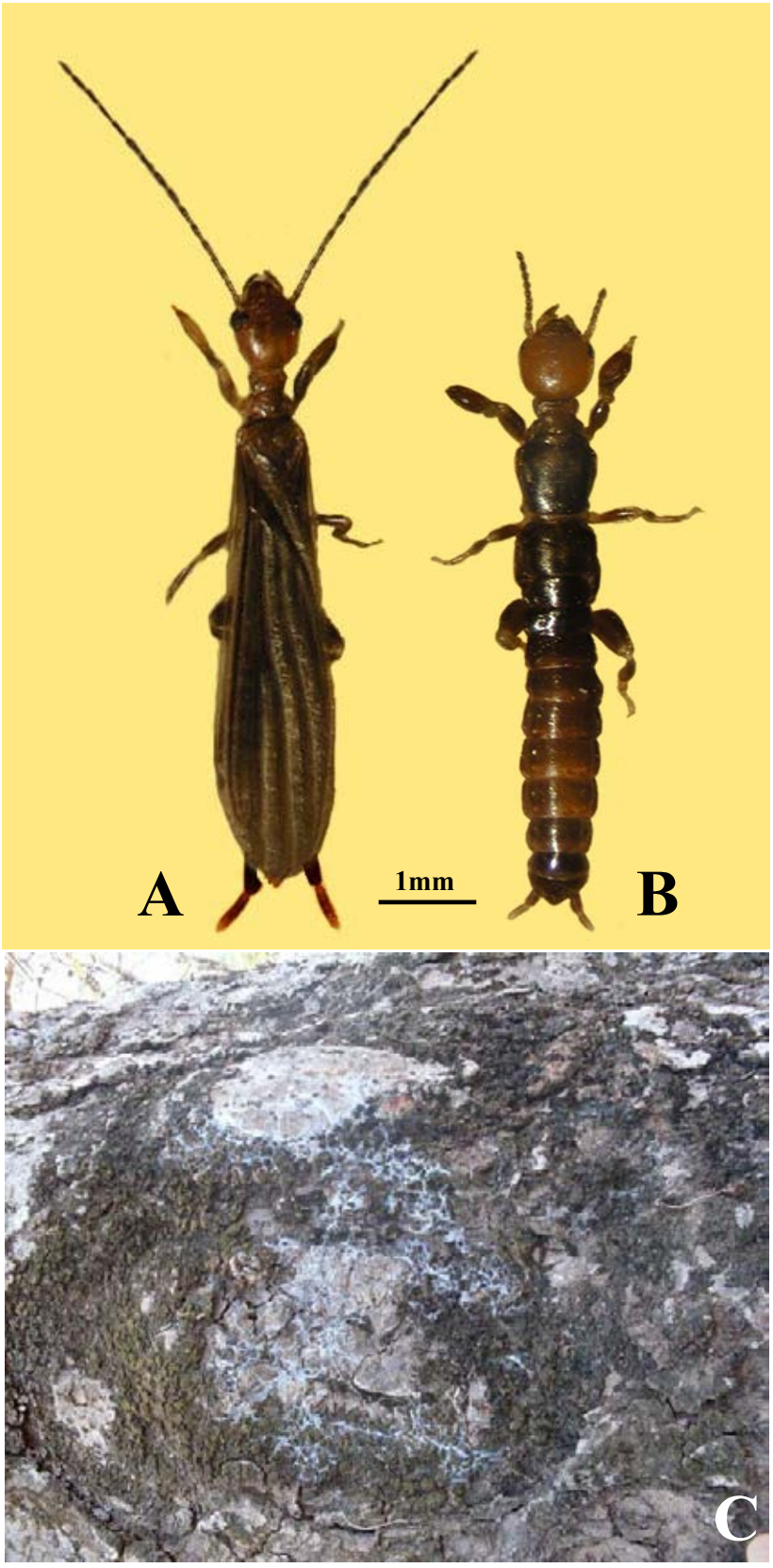


Figure 4.26 *Aposthonia ceylonica* (A) male, (B) female and (C) silk gallery.

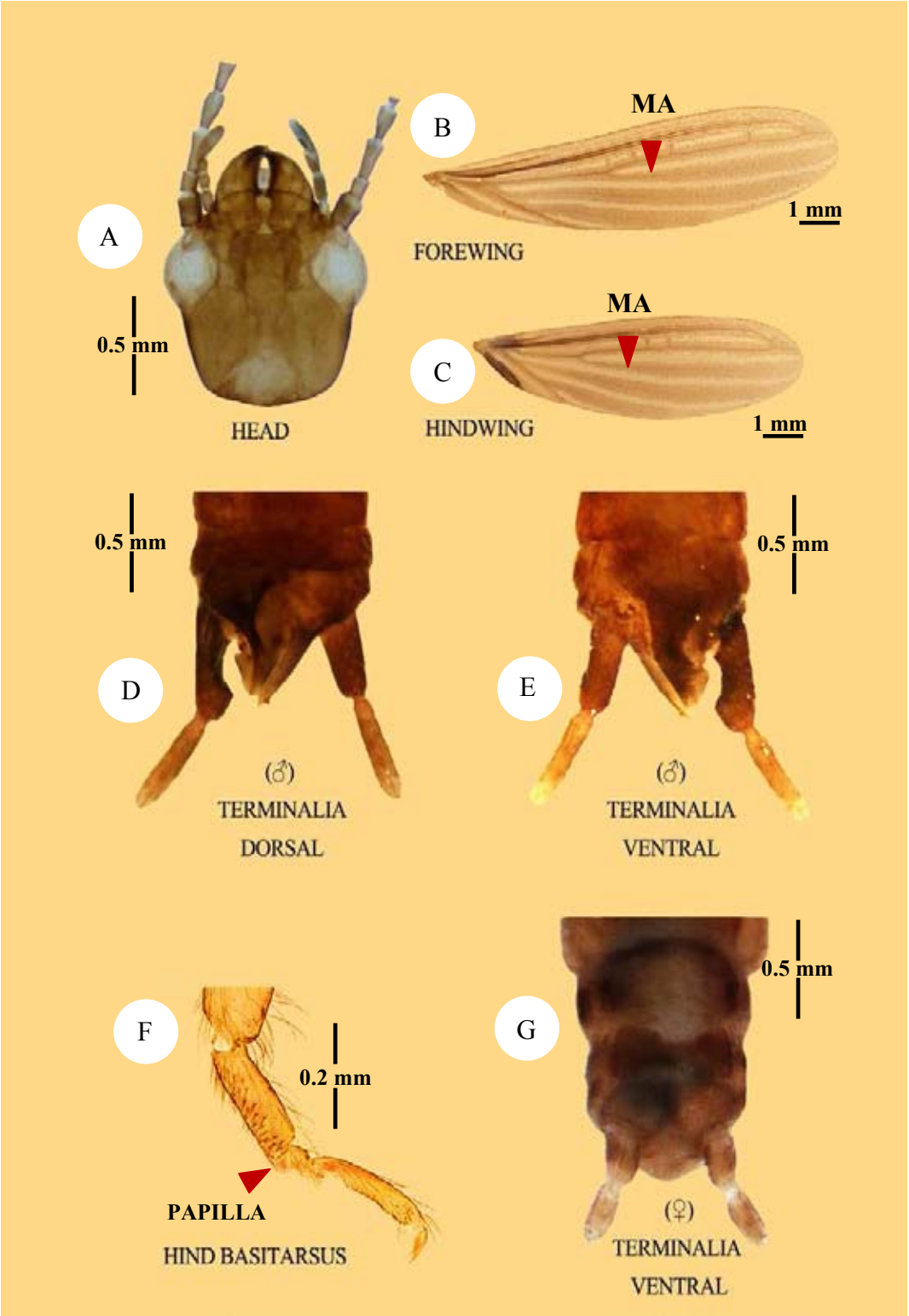


Figure 4.27 Important characters of male (A-F) and female (G) of *Aposthonia ceylonica*.

***Aposthonia problita* Poolprasert, Sitthicharoenchai, Butcher & Leprayoon, 2011**
(Figs 4.28, 4.29, 4.31, 4.32, 4.33)

Aposthonia problita Poolprasert *et al*, 2011a: 7, figs.2g-1, 3c, by original designation.

Diagnosis. The male of *A. problita* is distinguished from congeners by the basal segment of the left cercus being gradually distally expanded but not abruptly lobed, and the absence of an outcurved hook on the left cercus-basipodite. The female body is very dark and shiny except for pale femoral-tibial joints.

Holotype. ♂ (CUMNH), **Thailand**, Nakhon Si Thammarat Province, Thung Song District, tropical rain forest, 08°10.340'N 99°44'505'E, 103 m, 26.VII.2008.

Material examined. 1♂, 2 ♀♀ (CUMZ-EMB-Oli.2010.106-108), Prachuap Khiri Khan, Bang Saphan District, rubber plantation, 11°19.124' N 99°24.422' E, 63 m, 03.VIII.2009. All collected by P. Poolprasert.

Other specimens examined. 2♂♂, 6♀♀ (CUMZ-EMB-Oli.2010.98-105), **Thailand**, Nakhon Si Thammarat Province, Thung Song District, tropical rain forest, 08°10.340'N 99°44.505'E, 103 m, 26.VII.2008. 4♀♀ (CUMZ-EMB-Oli.2010.109-112), Ranong Province, Mueang District, tropical rain forest, 09°58' 200"N 098°38.250'E, 63 m, 22.III.2009. 2♀♀ (CUMZ-EMB-Oli.2010.113-114), Sa Kaeo Province, Mueang District, tropical rain forest, 13°59.633' N 102°12.395' E, 157 m, 03.VII.2010. All collected by P. Poolprasert.

Distribution. This species is found from four localities in Thailand; Nakhon Si Thammarat, Ranong, Prachuap Khiri Khan and Sa Kaeo Provinces.

Etymology. The species is named *Aposthonia problita* (Greek *problita* = jet) referring to the rich, deep black color, particularly in females.

Description. Alate male (n = 3, mean (range)): Head width x length 0.5 (0.5-0.6) x 0.7 (0.7-0.8) mm; body length 5.2 (5.13-5.33) mm, width 0.5 (0.52-0.55) mm; forewing length 4.0 (3.9-4.2); hindwing length 3.7 (3.6-3.9) mm.

Head: Capsule blackish, longer than broad, sides caudally convergent. Eyes dark, rather small. Labrum brown. Mandibles brown with apical teeth and inner margins brownish. Submentum trapezoidal with medial concave anterior margin, blackish. Antennae with basal 3 segments brownish, remaining segments becoming increasingly lighter brown distally, 16-segmented.

Thorax: same color as head. All legs blackish throughout except for pale color of joints. Wing light brown with MA not forked. Hind leg with only one basitarsal papilla.

Abdomen: blackish brown throughout with cerci paler. Terminalia with 10L broader than 10R. 10LP slender, narrow, evenly tapered to apex; 10RP greatly elongated, narrow, membranous inner side with small outer hook at tip. H broad basally, slightly narrowed caudally, forming a broad HP directed gradually toward left cercus and beneath 10LP. Right cercus with two subcylindrical segments (RC_1 and RC_2). Left cercus with segments (LC_1 and LC_2) subequal to corresponding segments of right cercus; LC_1 gradually expanded distally but not abruptly lobed.

Apterous female (n = 14, mean (range) ± SD): Head width x length 0.6 (0.5-0.6) ±0.04 x 0.7 (0.6-0.8) ± 0.04 mm; body length 6.1 (5.6-6.6) ± 0.35 mm, width 0.6 (0.5-0.6) ± 0.03 mm.

Head: Capsule dark, convex, longer than broad. Eyes dark, smaller and less reniform than in male. Antennae blackish throughout, 15-segmented.

Thorax: Entirely dark, somewhat shining. All legs concolorous with thorax except for pale femoral-tibial joints. Hind leg with only one basitarsal papilla.

Abdomen: Very glossy, dark. Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely pale.

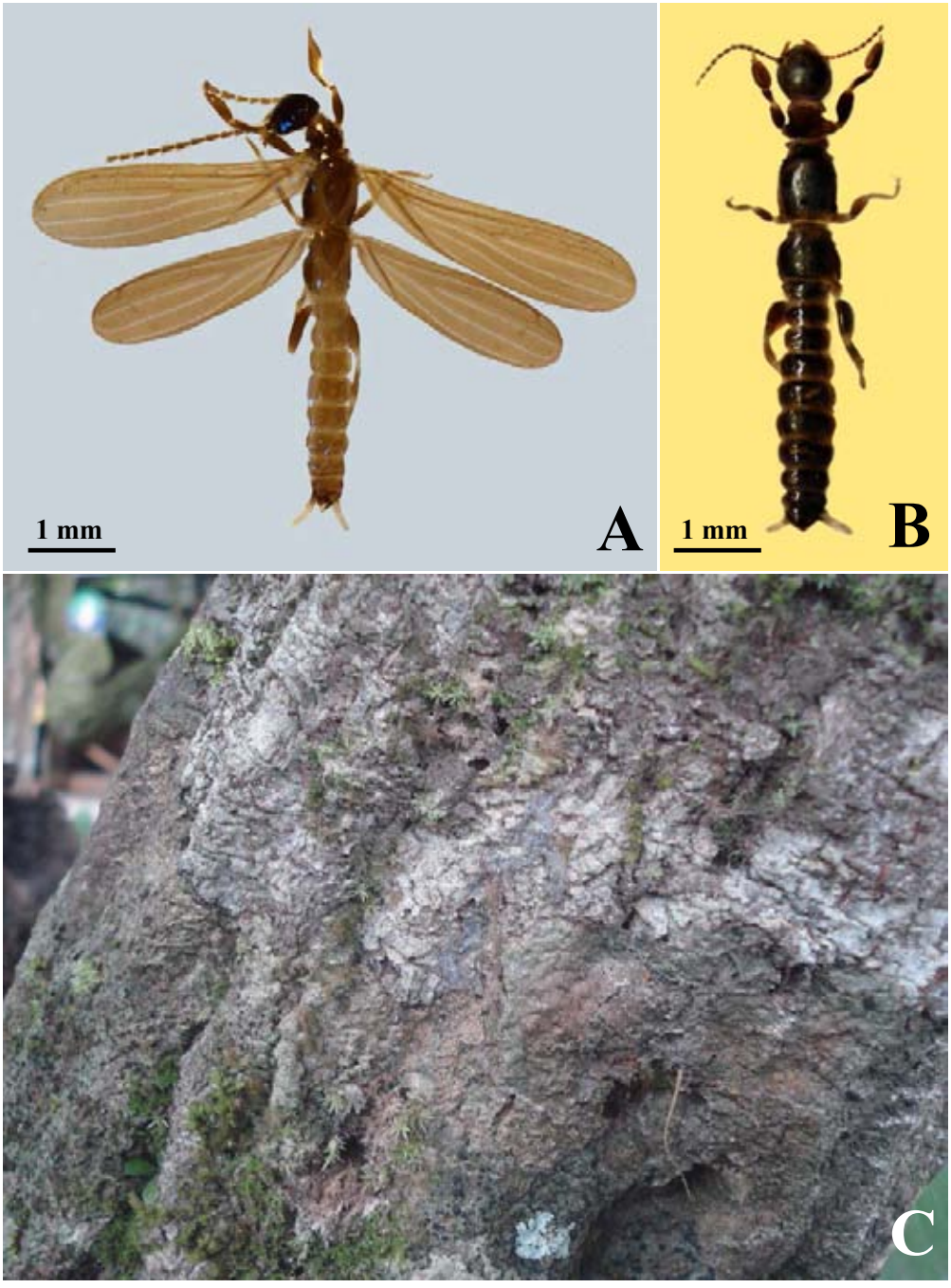


Figure 4.28 *Aposthonia problita* (A) male, (B) female and (C) silk gallery.

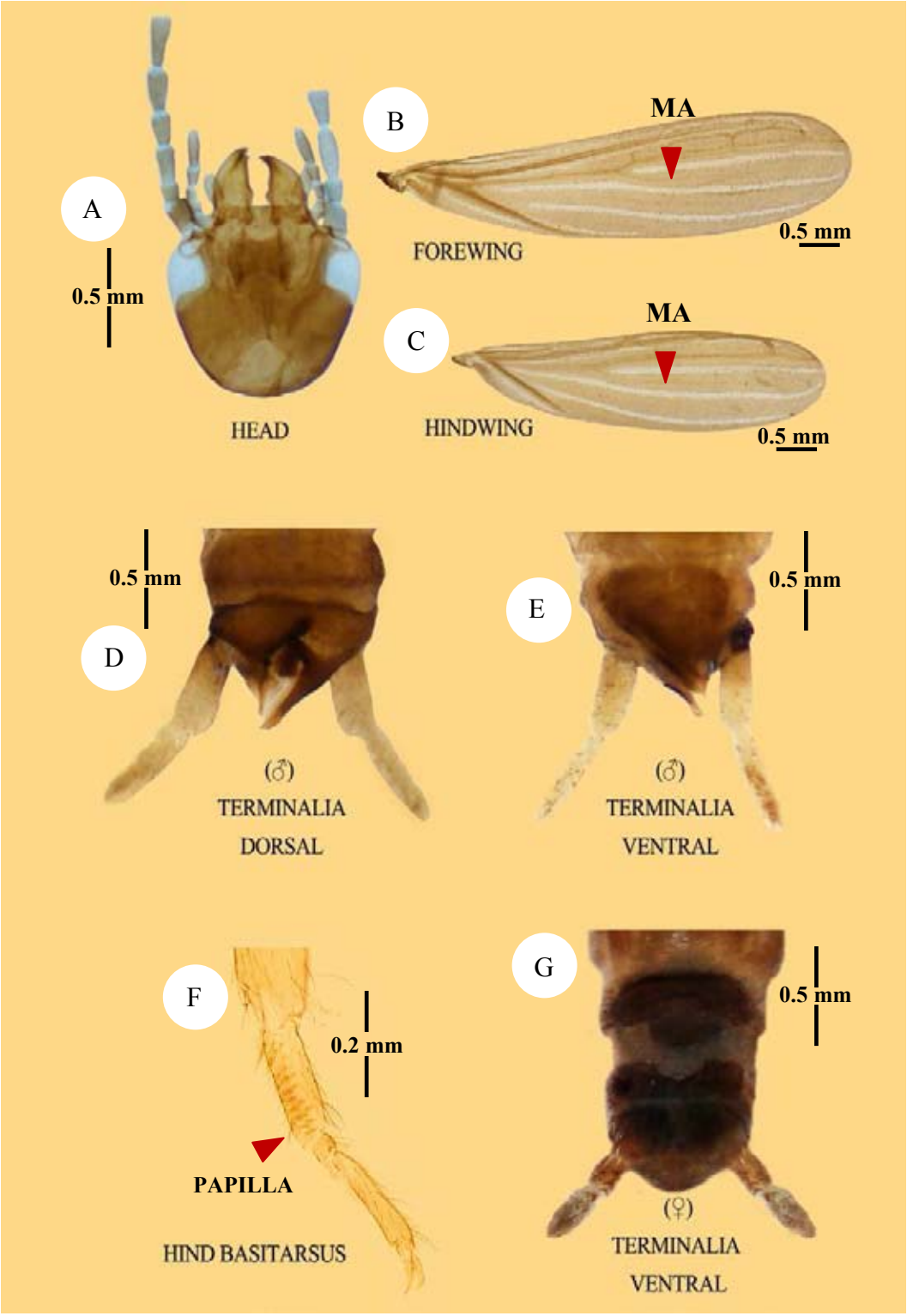


Figure 4.29 Important characters of male (A-F) and female (G) of *Aposthonia problita*.

Key to species of genus *Aposthonia* Krauss, 1911 (Adult male)

1. LC_1 distally expanded and lobed; 10LP slender, narrowly rounded distad; 10RP greatly elongated, narrow, membranous on inner margin with a small outer hook at the apex; LPPT narrow, sclerotic, hooked outward and upward terminally and acutely pointed ..... *A. borneensis*
- LC_1 not abruptly lobed 2
2. LC_1 strongly excavate in the basal three-quarters; 10LP slender, evenly narrowed to simple round tip; 10RP greatly elongated, membranous on inner margin with hooked apex ..... *A. ceylonica*
- LC_1 short, gradually expanded distally; 10 LP slender, narrow, evenly tapered to apex; 10RP elongated, somewhat straight, membranous on inner margin with a small outer hook at tip..... *A. proplita*

Key to species of genus *Aposthonia* Krauss, 1911 (Adult female)

1. Head light brown; prothorax brown, meso- and metathorax dark brown; forelegs concolorous with pronotum, middle and hind legs entirely dark brown; abdomen brownish with terga of segments 3-6 somewhat reddish brown; cerci entirely medium brown ..... *A.ceylonica*
- Head dark brown or black..... 2
2. Head dark brown; prothorax light brown or ange, cream-white in tersegmental banding anterior and posterior to mesoscutum; all legs brown, except middle and hind coxae and trochanters whitish; abdomen chestnut-brown throughout; cerci entirely medium brown ..... *A. borneensis*
- Head black; thorax entirely dark; all legs concolorous with thorax; abdomen very glossy, dark; cerci pale..... *A. problita*

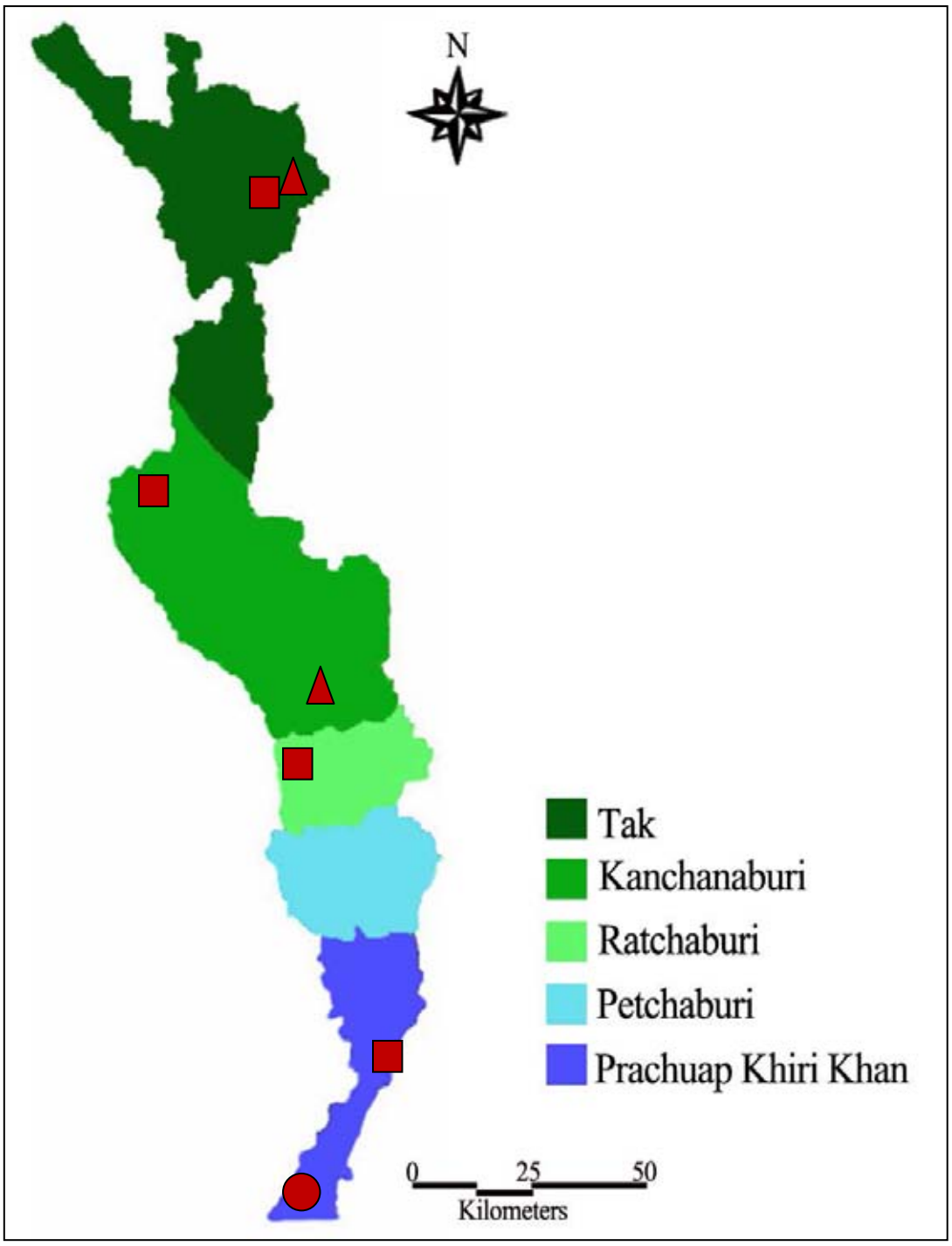


Figure 4.30 Distribution of the genus *Aposthonia* (F. Oligotomidae) found in western Thailand.

▲ *Aposthonia borneensis* ■ *A. ceylonica* ● *A proplita*

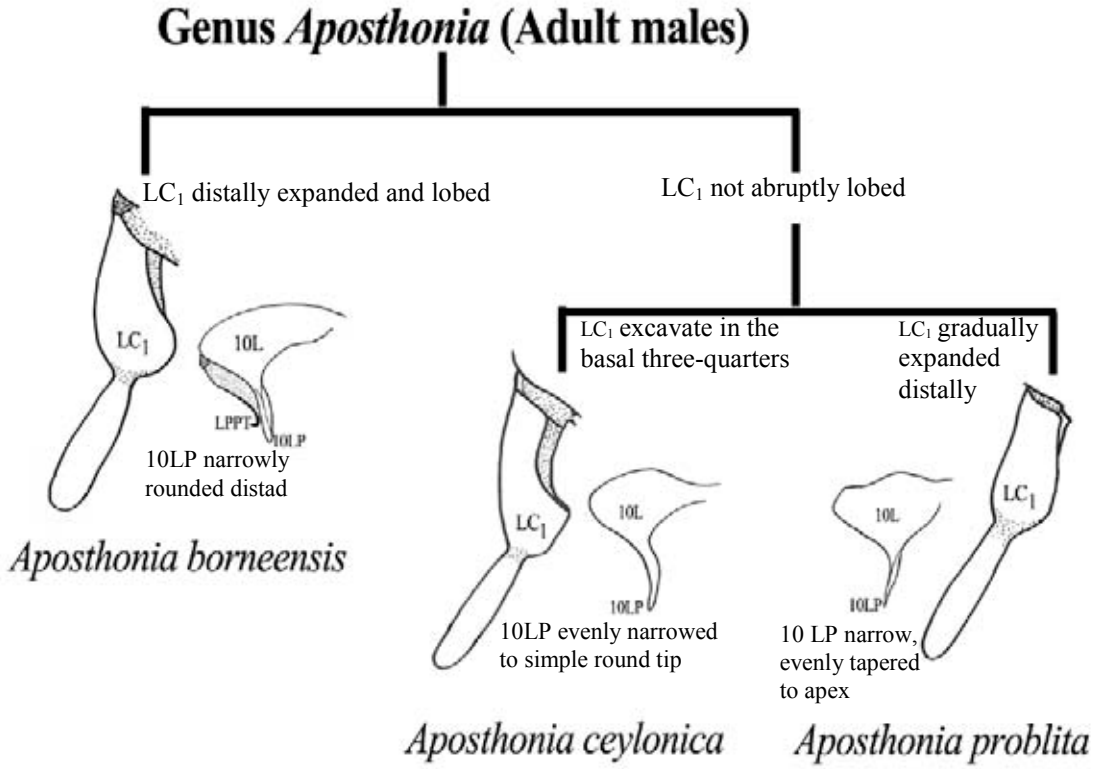


Figure 4 .31 Pictorial k ey to s pecies f or adult ma les o f the genus *Aposthonia* of western Thailand.

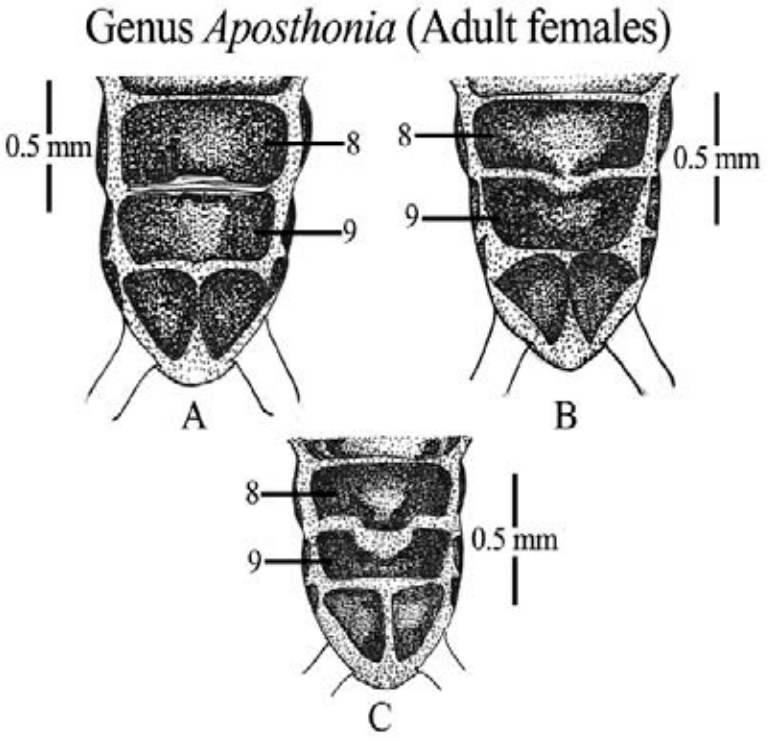


Figure 4.32 Illustrations of sternites, especially on 8th and 9th abdominal segments of female *Aposthonia borneensis* (A), *A. ceylonica* (B) and *A. problita* (C).

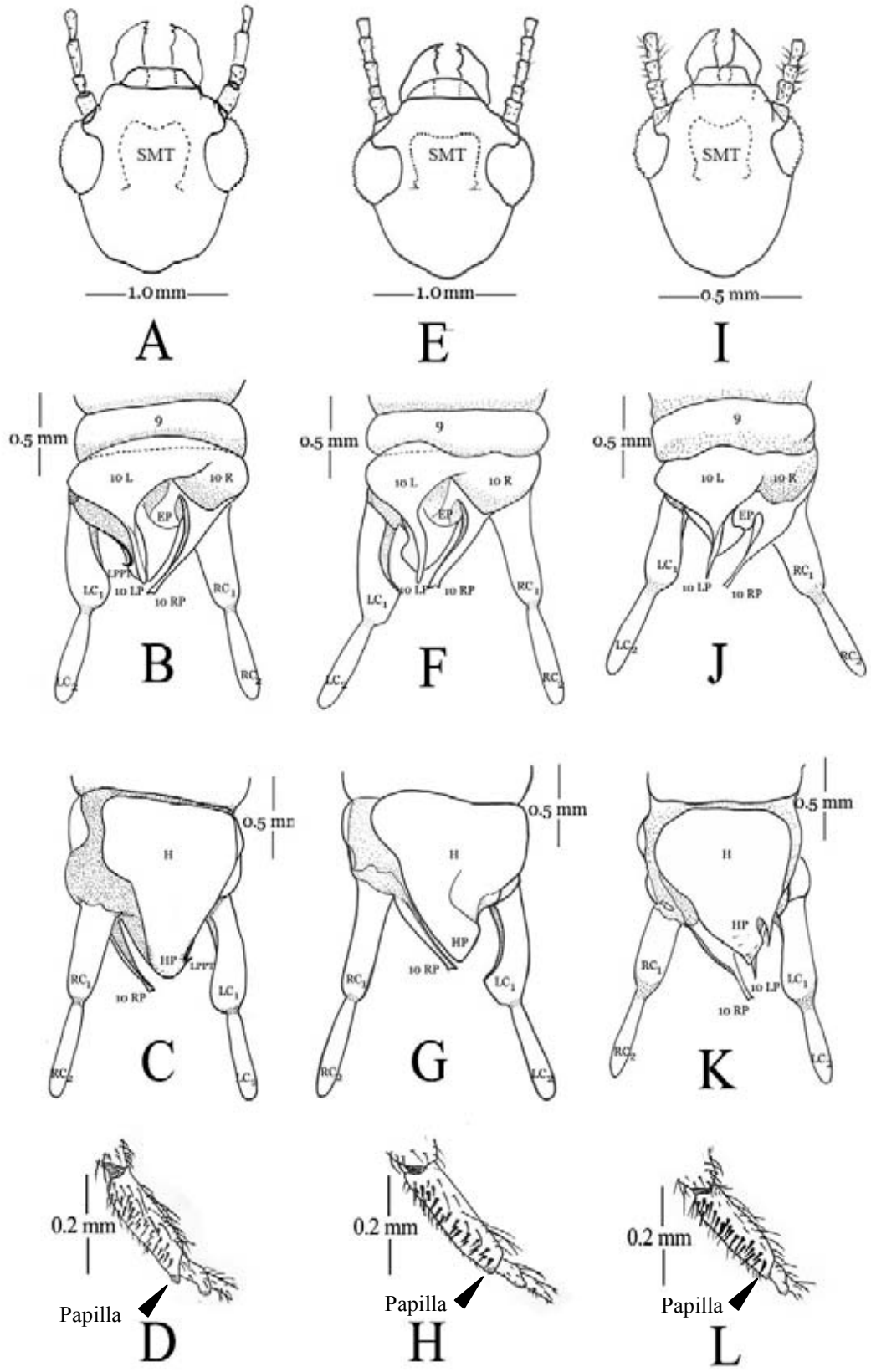


Figure 4.33 Important characters of male *Aposthonia borneensis* (A-D), *A. ceylonica* (E-H) and *A. problita* (I-L). A, E, I) Head. B, F, J) Dorsal views of terminalia. C, G, K) Ventral views of terminalia. D, H, L) Hind basitarsus.

Genus ***Eosembia*** Ross, 2007

Eosembia Ross, 2007 : 578; Mill, 2009: 15; Poolprasert & E dgerly, 2011: 12; Poolprasert *et al*., 2011b: 3.

Type species. *Eosembia nepalica* Ross, 2007: 578, fig 3, by original designation.

Diagnosis. Apterous o r al ate male of *Eosembia* generally di stinguished f rom ot her genera in th e family O ligotomidae b y MA not being br anched i n the f orewing a nd hindwing, the basal segment of the left cercus is slender and never lobed and the tenth abdominal tergite i s c ompletely di vided. I t i s of ten s trongly bi colorous, be ing basically blackish brown except for, typically, a bright orange prothorax and bases of the forelegs. Distal segments o f the an tennae are commonly abruptly w hite, s etae ar e usually l onger t han t he bearing s egment. T erminalia with 10L P us ually broad, aedeagus usually sclerotic and broadened caudally. Hind basitarsi lengthened, second papilla ve ry s mall or a bsent. Alate f emale is l arge, s trong and r ichly pigmented. Distal a ntennal s egments a re usually a bruptly w hite. The pr othorax a nd c ertain leg segments in some species are bright orange, but entirely dark in others. Intersegmental areas o f thorax, coxae and trochanters ar e whitish. Hind basitarsi are often w ith two ventral papillae.

Distribution: Northeastern India and southeastern Asia.

Eosembia auripecta **Ross, 2007**
(Figs 4.34, 4.35, 4.41, 4.42, 4.43)

Eosembia auripecta Ross, 2007:583, figs. 6-7.

Diagnosis. Male of *E. auripecta* can be recognized from congeners by the process 10LP is spatulate with a sharp obtuse outer-apical angle and by the basal segment of left cercus is elongated, gradually lobe distad. Female can be readily regcognized by the cervical and prothorax orange, associated membranes frayish cream, forlegs concolour with pronotum except for dark mahogany brown basitarsi.

Holotype. ♂ (CAS), USA.
Type locality. Thailand, Lamphun Province, Li District, 13 mi SE of Li, 500 m, 07. IV. 1963 (E.S. Ross).

Material examined. 3♂♂, 2 ♀♀ (CUMZ-EMB-Oli.2010.134-138), **Thailand**, Kanchanaburi Provice, Thong Pha Phum District, mixed deciduous forest, 14°44.452'N, 98° 37.303'E, 487 m, 27 .IV.2009. 1♂, 2♀♀ (CUMZ-EMB-Oli.2010.139-141) rubber plantation, 14°43.241'N, 98° 35.123'E, 432m, 27.IV.2009. 21♂, 3♀♀ (CUMZ-EMB-Oli.2010.142-145), Petchaburi Provice, Kaeng Krachan District, dry evergreen forest, 12°45.021'N, 99°36.104' E, 316 m, 19.III.2008. 2♂♂ (CUMZ-EMB-Oli.2010.146-147), Prachuap Khiri Khan Provice, Thap Sakae District, dry evergreen forest, 11°60.502'N, 99°67.214' E, 347 m, 18.III.2009. 1♀ (CUMZ-EMB-Oli.2010.148) 11°60.433'N, 99°65.112 'E, 87 m, 18. III. 2009. 3♂♂, 7♀♀ (CUMZ-EMB-Oli.2010.149-158), Ratchaburi Province, Saun Phueng, forest park, mixed deciduous forest, 13°32.805'N 099°20.126' E, 134 m, 10.X.2009. 1♂, 2♀♀ (CUMZ-EMB-Oli.2010.159-161), Tak Provice, Mueang District, orchard, 16°42.475'N 98°34.291'E, 196 m, 04.IV.2008; 2♂♂, 9♀♀ (CUMZ-EMB-Oli.2010.162-172), Mae Sot District, hill evergreen forest, 16°45.370'N 099°57.056'E, 518 m, 27.VI.2009. All collected by P. Poolprasert.

Other specimens examined. 1♂, 4♀♀ (CUMZ-EMB-Oli.2010.173-177), Chachoengsao Province, Tha Takiap District, dry evergreen forest, 13°26.410'N, 101°36.402'E, 133 m, 04.III. 2007. 1♂ (CUMZ-EMB-Oli.2010.178), Chantaburi Province, Khlung District, dry evergreen forest, 12°27.175'N, 102°13.171'E, 176 m, 04.XII.2009. 3♂♂ (CUMZ-EMB-Oli.2010.179-181), Chiang Mai Provice, Mueang, Huay Kaeo Arboretum, 18°48.348' N 098°57.585' E, 336 m, 01. III. 2008. 1♂, 1♀

(CUMZ-EMB-Oli.2010.182-183), Lampang Province, Ngao Disrtict, mixed deciduous forest, 18°46.361'N 99°58.123' E, 412 m, 12.XII.2008. 5♀♀ (CUMZ-EMB-Oli.2010.184-188), Nakhon Ratchasima Province, Pak Chong District, deciduous dipterocarp forest, 14°25.881'N 101°22.269' E, 767 m, 01.I.2010. 3♀♀ (CUMZ-EMB-Oli.2010.189-191), Nong Bua Lam Phu Province, Na Klang District, Dry evergreen forest, 17°25.044'N, 102°10.944' E, 376 m, 07.VIII.2010. 2♂♂, 1♀ (CUMZ-EMB-Oli.2010.192-194), Petchabun Province, Lom Sak District, 16°46.462'N, 101°14.323' E, 129 m, 04.IV.2008. 1♂, 5♀♀ (CUMZ-EMB-Oli.2010.195-200), Phisanulok Province, Nakhon Thai District, plantation, 17°61.174'N, 100°50.156' E, 59 m, 14.III.2008. 4♂♂, 2♀♀ (CUMZ-EMB-Oli.2010.201-206), Ranong Province, Mueang, tropical rain forest, 13°43.292'N, 100°33.322'E, 403 m, 22.III.2009. 7♀♀ (CUMZ-EMB-Oli.2010.207-213), Sisaket Province, Mueang, forest park, 15°71.141'N, 104°19.202'E, 657 m, 20.XI.2009.

Distribution. Thailand

Description. Alate male (n = 26), mean (range) ± SD): Head width x length 1.8 (1.7-1.9) ± 0.24 x 2.3 (2.1-2.4) ± 1.21 mm, body length 17.3 (15.6-19.2) ± 0.33 mm, width 2.2 (2.1-2.3) ± 0.12 mm, forewing length 9.5 (9.3-9.6) ± 1.14 mm, hindwing length 8.7 (8.5-8.8) ± 1.23 mm.

Head: Capsule blackish brown dorsally, ventral surface clear amber. Eye dark lavender, narrowly rimmed with gold. Mandible concolorous with cranium. Submentum partially dark amber. Antennae very long, almost as dark as cranium except for two distal white segments tinged with tan, 30 segmented.

Thorax: Prothorax bright gold, all membranes dark creamy white but not strongly contrasting with sclerites. Meso- and metathorax chestnut brown. Wings very dark brown with MA not forked. Forelegs bright gold except foretarsi and tibiae blackish brown. Mid legs chestnut brown except tarsi and tibiae mahogany brown. Hind legs dark mahogany brown. Hind leg with two basitarsal papillae.

Abdomen: Blackish brown throughout. Terminalia with 10L as broad as 10R. 10LP becoming bright straw yellow distally, narrowly rimmed with reddish amber, broad, spatulate with a sharp obtuse outer-apical angle. 10RP slender, broadly membranous on inner margin, apex with small outer hook. H broad basally gradually narrow caudally. L PPT produced caudally as a hook directed leftward. LC_1 long, slender, slightly lobed.

Apterous female: (n = 54, mean (range) ± SD) Head width x length 1.8 (1.6-1.9) ± 0.35 x 2.1 (1.9-2.2) ± 1.51 mm, body length 21.5 (18.9-22.1) ± 1.45 mm, width 2.5 (2.3-2.6) ± 0.13 mm.

Head: Capsule dark chocolate brown. Eyes dark. Antennae uniformly dark chocolate brown except for 6 white distal segments, 28 segmented.

Thorax: Prothorax orange throughout. Meso- and metathoracic sclerites very dark mahogany brown. Forelegs concolorous with pronotum except for dark mahogany brown basitarsi. Mid legs entirely orange, hind legs entirely dark mahogany brown except for golden femorotibial joint. Hind leg with two basitarsal papillae.

Abdomen: Concolorous with prothorax, dorso-pleural and intersegmental membranes contrastingly white. Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci dark brown.

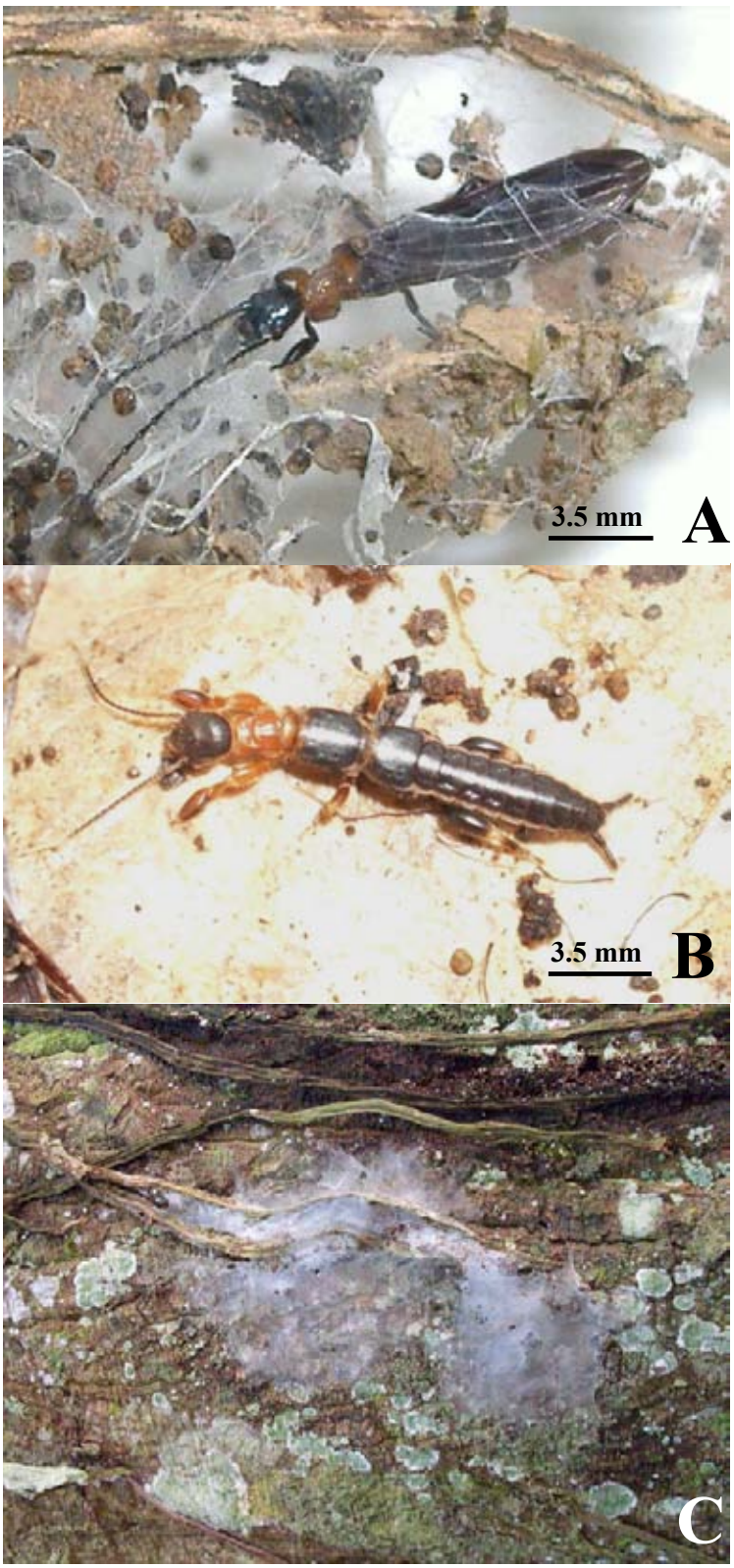


Figure 4.34 *Eosembia auripecta* (A) male, (B) female, (C) silk gallery.

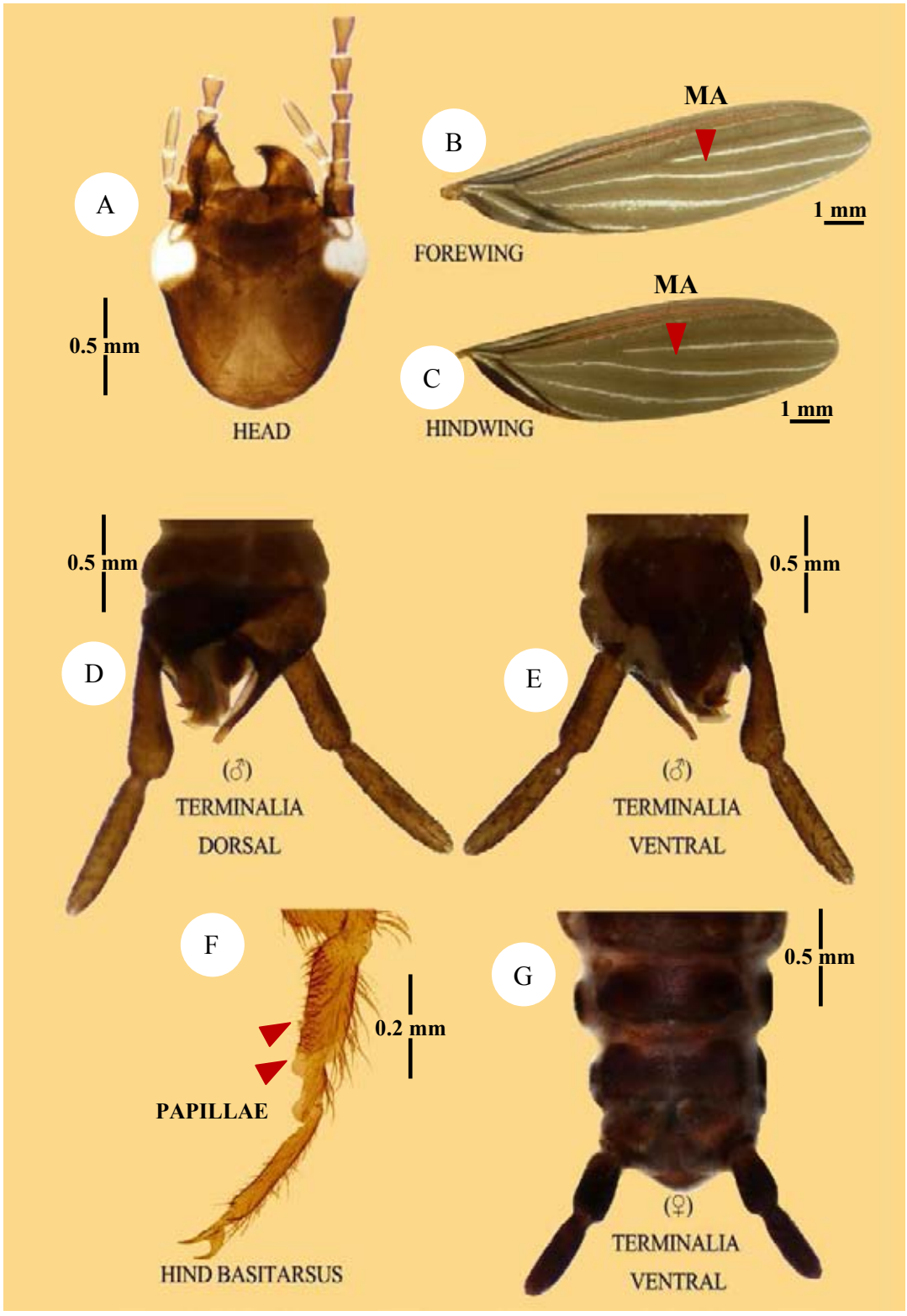


Figure 4 .35 Important ch aracter o f m ale (A-F) an d f emale (G) o f *Eosembia auripecta.*

***Eosembia lamunae* Poolprasert, Sitthicharoenchai, Lekprayoon & Butcher, 2011**
(Figs. 4.36, 4.37, 4.41, 4.42, 4.43)

Eosembia lamunae Poolprasert et al., 2011b: 3, figs. 1, 2.

Diagnosis. Male of *E. lamunae* can be readily distinguished from congeners in the especially LPPT which is produced caudad as a sharp hook directed leftward and by LC_1 which is club-like, slightly dilated distad but not lobed. Female can be easily recognized by cervical, prothoracic sclerites and all legs of this new species are bright orange throughout.

Holotype. ♂ (CUMNH), Thailand, Prachuap Khiri Khan Province, Thap Sakae District, dry evergreen forest, 11°37.564'N 099°36.867'E, 61 m, 17.III.2009.

Material examined. Holotype male (CUMZ-EMB-Oli.2010.115), paratypes 2 ♂♂, 2 ♀♀ (CUMZ-EMB-Oli.2010.116-119), same data as holotype, all collected by P. Poolprasert.

Distribution. This species is known only from Thap Sakae District, Prachuap Khiri Khan Province, Thailand.

Etymology. This species is named after the late Lamun Poolprasert, mother of the first author.

Description. Alate male (n = 3, mean (range)): Head width × length 1.2 (1.1 -1.2) × 1.6 (1.5 - 1.6) mm, body length 13.5 (13.2 - 14.1) mm, width 1.9 (1.8 - 1.9) mm, forewing length 9.2 (9.1 - 9.2) mm, hindwing length 8.3 (8.2 - 8.3) mm.

Head: Capsule darkish brown, longer than broad, sides caudally convergent. Eyes entirely dark. Anterior margin of labrum blackish brown and equally rounded. Submentum trapezoidal with shallow medial concave anterior margin, blackish. Mandible dark and slender. Antennae long, dark throughout, 29 segmented.

Thorax: Prothorax bright orange. Meso- and metathorax darkish brown in color, dorsally and slightly paler ventrally. All legs bright orange throughout from coxae to femurs, except for a darkish color of tibiae and tarsi. Wings dark brown with MA not forked. Hind leg with two basitarsal papillae.

Abdomen: darkish brown throughout with darker terminalia. Terminalia with 10L broader than 10R. 10L P becoming yellowish distally, broad, spatulate with a sharp outer-apical angle; 10R P long, lengthy membranous inner margin, gradually arced rightward with a small outer hook at the apex. H broad basally, gradually narrowing caudally, forming a broad H P directed slightly towards left cercus and beneath 10LP. LPPT produced caudally as a sharp hook directed leftwards. LC_1 long, slightly dilated distally but not lobed.

Apterous female (n = 2, mean (range)): Head width × length 1.3 (1.2 - 1.4) × 1.8 (1.7 - 1.9) mm, Body length 17.9 (17.5 - 18.3) mm, width 2.3 (2.3 - 2.4) mm.

Head: Capsule blackish brown, convex, longer than broad. Eyes dark. Antennae, 25 segmented with white-tips.

Thorax: Prothorax bright orange, cream-white intersegmental banding anterior and posterior to mesoscutum. Meso- and metathoracic sclerites darkish brown. Forelegs concolorous with pronotum except for bright brown basitarsi. Mid and hind legs entirely bright orange throughout. Hind leg with two basitarsal papillae.

Abdomen: Blackish concolorous with metathoracic, lateral plate cream-white stripe throughout. Ninth sternum medial inset in the body with three inner lobes at the base (Fig. 4.37E). Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely brown.

Remarks. This species was collected during the dry season (March) in a dry evergreen forest. Colonies take place on the surface of lichen covered rocks. The silk gallery is large and conspicuous (Fig. 4.36C).

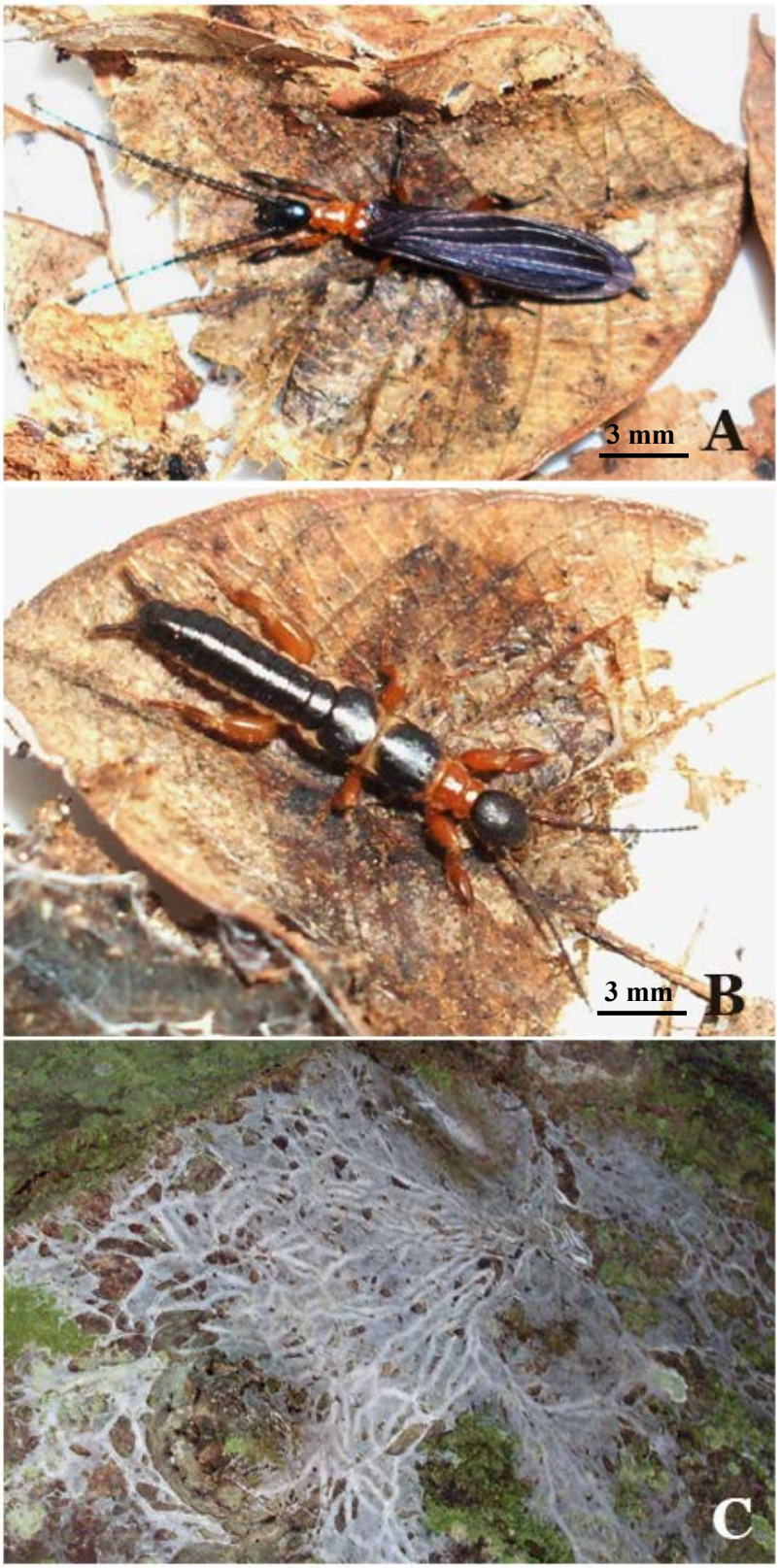


Figure 4.36 *Eosembia lamunae* (A) male, (B) female, (C) silk gallery.

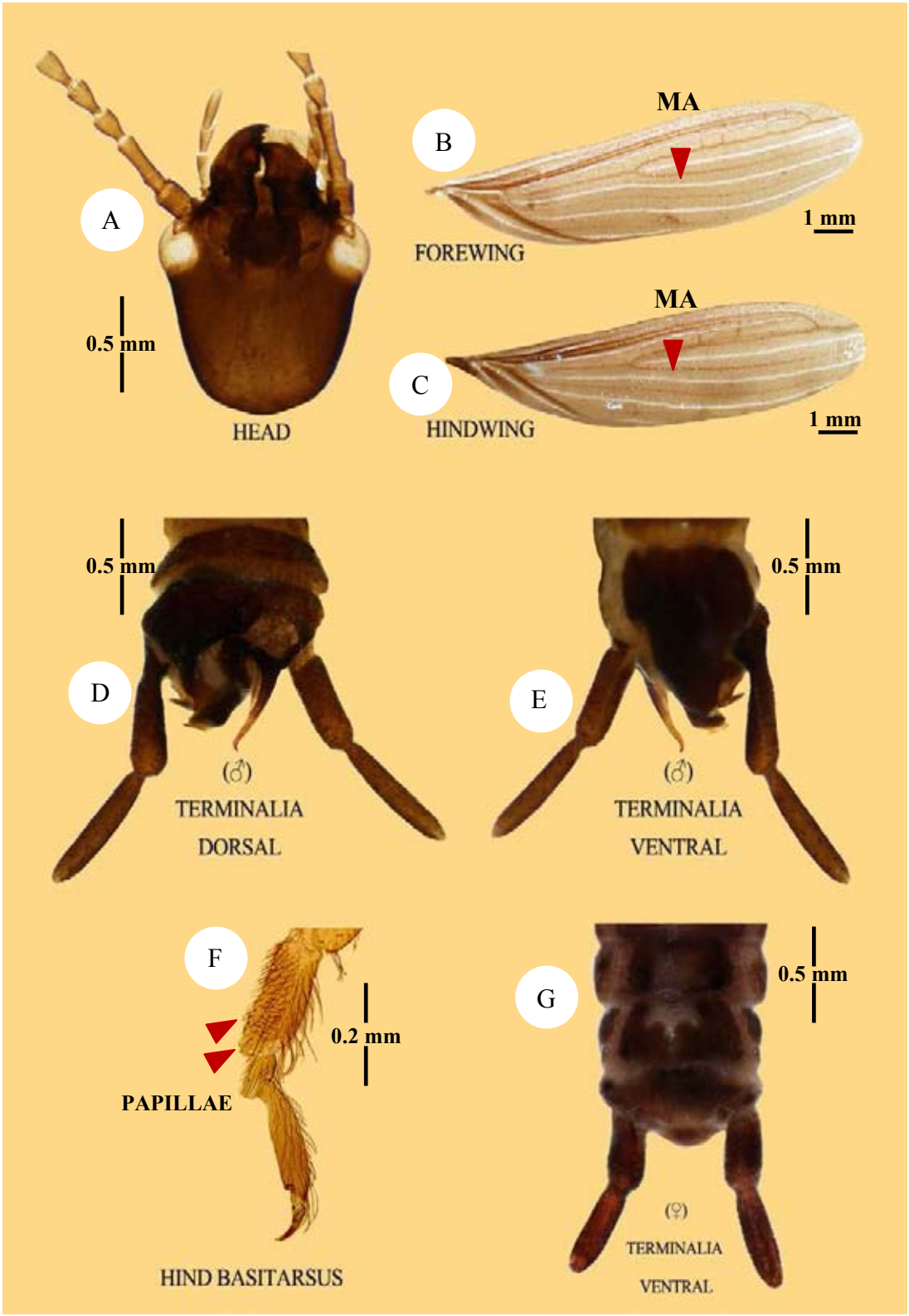


Figure 4.37 Important characters of male (A-F) and female (G) of *Eosembia lamunae*.

***Eosembia paradorni* Poolprasert, Sitthicharoenchai, Lekprayoon &Butcher, 2011**
(Figs. 4.38, 4.39, 4.41, 4.42, 4.43)

Eosembia paradorni Poolprasert *et al*., 2011b: 8, figs. 3, 4, by original designation.

Diagnosis. The male of *E. paradorni* can be readily distinguished from congeners by the very long H, basally extensively boarded caudally and by the elongated basal segment of the left cercus, which is scoop-like and at the inner side evenly arcuate. The females are very similar to those of *E. auripecta* but differ from *E. auripecta* by the yellowish prothorax.

Holotype. ♂ (CUMNH), Thailand, Kanchanaburi Province, Bo Phloi District, dry evergreen forest, 14°39.334'N 099°18.181'E, 223 m, 31.III.2008.

Materail examined. Holotype ♂ (CUMZ-EMB-Oli.2010.120), paratypes 3♂♂, 10♀♀ (CUMZ-EMB-Oli.2010.121-133), same data as holotype, all collected by P. Poolprasert.

Distribution. This species is known only from Bo Phloi District, Kanchanaburi Province, Thailand.

Etymology. This species is named after Paradorn Dokchan, companion, friend, and colleague, in honour of his considerable contribution to collecting.

Description. Alate male (n = 4, mean (range) ± SD): Head width × length 1.2 (1.1 - 1.2) ± 0.04 × 1.6 (1.6 - 1.8) ± 0.08 mm, body length 14.4 (14.0 – 15.1) ± 0.47 mm, width 1.8 (1.9 - 1.8) ± 0.11 mm, forewing length 9.3 (9.2 - 9.4) ± 0.09 mm, hind wing 8.3 (8.2 - 8.4) ± 0.07 mm.

Head: Capsule blackish brown, longer than broad, sides caudally convergent. Eye darkish and well developed. Anterior margin of labrum blackish brown. Submentum trapezoidal with medial concave anterior margin, blackish. Mandible dark and slender. Antennae long, dark throughout with white-tips, 30 segmented.

Thorax: Prothorax yellowish throughout, dorsally and slightly paler ventrally. Meso- and metathoracic sclerites darkish brown. All legs entirely blackish. Wings dark brown with MA not forked. Hind leg with two basitarsal papillae.

Abdomen: Blackish throughout with pale stripe lateral. Terminalia darker with 10L rather broader than 10R. 10LP long, broad, spatulate a sharp-edged obtuse outer-apical angle; 10R P very slender, narrow with a small hook at the apex, mostly membranous inner margin. Hver y long, extensively basally broadened caudally, forming a broad HP directed towards left cercus and beneath 10LP. Basal segment of LC_1 elongated and incurved but not lobed.

Apterous female (n = 10, mean (range) ± SD): Head width × length 1.7 (1.6 - 1.8) ± 0.1 × 2.1 (2.0 - 2.3) ± 0.18 mm, Body length 18.6 (17.9 - 19.2) ± 0.53 mm, width 2.3 (2.1 - 2.5) ± 0.14 mm.

Head: Capsule blackish brown, convex, longer than broad. Eyes almost concolorous with cranium, smaller and less reniform than in male. Antennae dark chocolate brown with white apex, 28 segmented

Thorax: Prothorax yellowish. Meso- and metathoracic sclerites darkish brown. Forelegs concolorous with pronotum except for chestnut brown basitarsi, mid yellowish. Hind legs entirely dark brown except for femortibial joint pale in color. Hind leg with two basitarsal papillae.

Abdomen: Blackish brown, dorsally and slightly paler ventrally. Sternites brownish throughout, membranous areas and posterior margins of tergites rufous brown. Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.

Remarks. This species is very common on tree trunks which are large and conspicuous white silk gallery (Fig. 4.38C) in dry evergreen forest, or secondary growth. At the time of encounter, adult female with their egg masses and early instar nymphs were found in March.

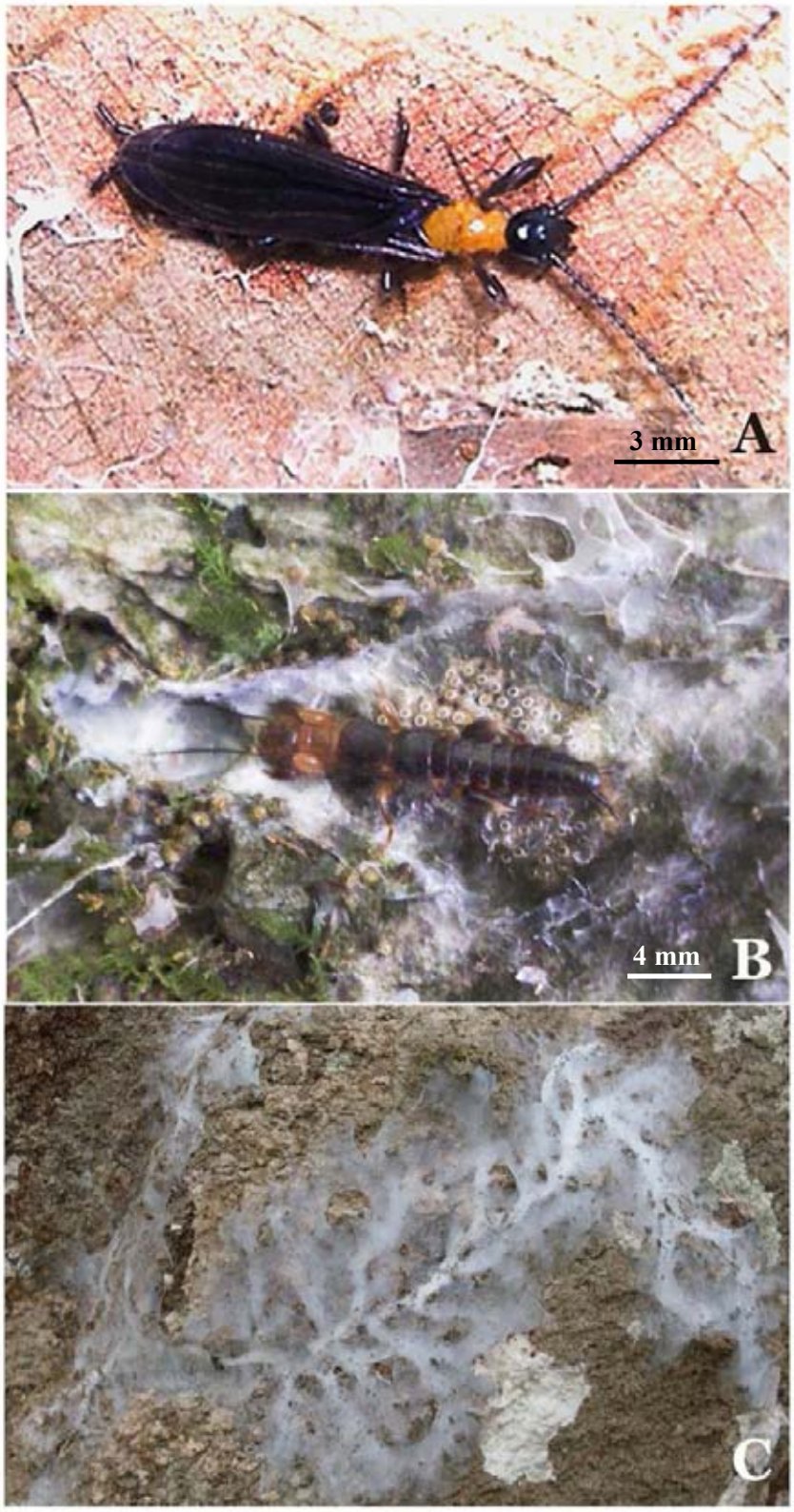


Figure 4.38 *Eosembia paradorni* (A) male, (B) female with eggs, (C) silk gallery.

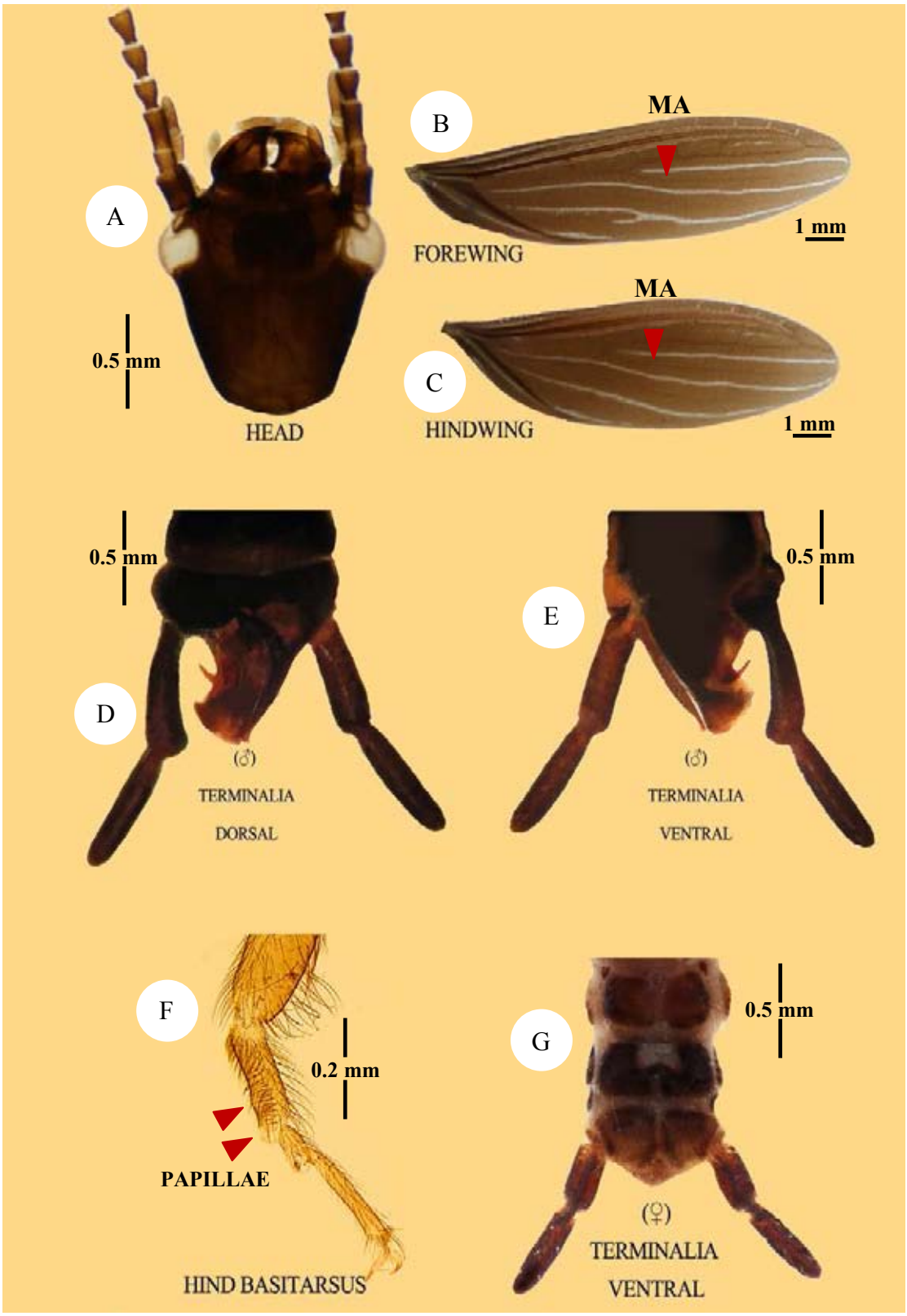


Figure 4.3 9 Important ch aracters of male (A-F) an d female (G) o f *Eosembia paradorni*.

Key to species of genus *Eosembia* Ross, 2007 (Adult male)

1. LC_1 slender, distally expanded and lobed; 10LP spatulate with a sharp obtuse outer-apical angle; 10RP long, broadly membranous on inner, apex with small outer hook ..... *E. auripecta*
- LC_1 not abruptly lobed 2
2. LC_1 long slightly dilated distad; 10LP broad, spatulate with a sharp outer-apical angle; 10 RP long, lengthy membranous inner margin, gradually arced rightward with a small outer hook at the apex ..... *E. lamunae*
- LC_1 elongated and incurved but not lobed; 10 LP long, broad, spatulate with a sharp-edged obtuse outer-apical angle; very slender, narrow with a small hook at the apex, mostly membranous on inner margin ..... *E. paradorni*

Key to species of genus *Eosembia* Ross, 2007 (Adult female)

1. All legs entirely blackish; prothorax yellowish throughout, dorsally and slightly paler ventrally; meso- and metathorax darkish brown..... *E. paradorni*
- All legs partly blackish 2
2. All legs bright orange throughout from coxae to femurs, except for a darkish color of tibias and tarsi; prothorax bright orange; meso- and metathorax dorsally darkish brown, and slightly paler ventrally. ..... *E. lamunae*
- Fore and mid legs largely orange, hind legs entirelty dark mahogany brown except for golden femorotibial joint; prothorax golden; meso- and metathorax dark mahogany brown..... *E. auripecta*

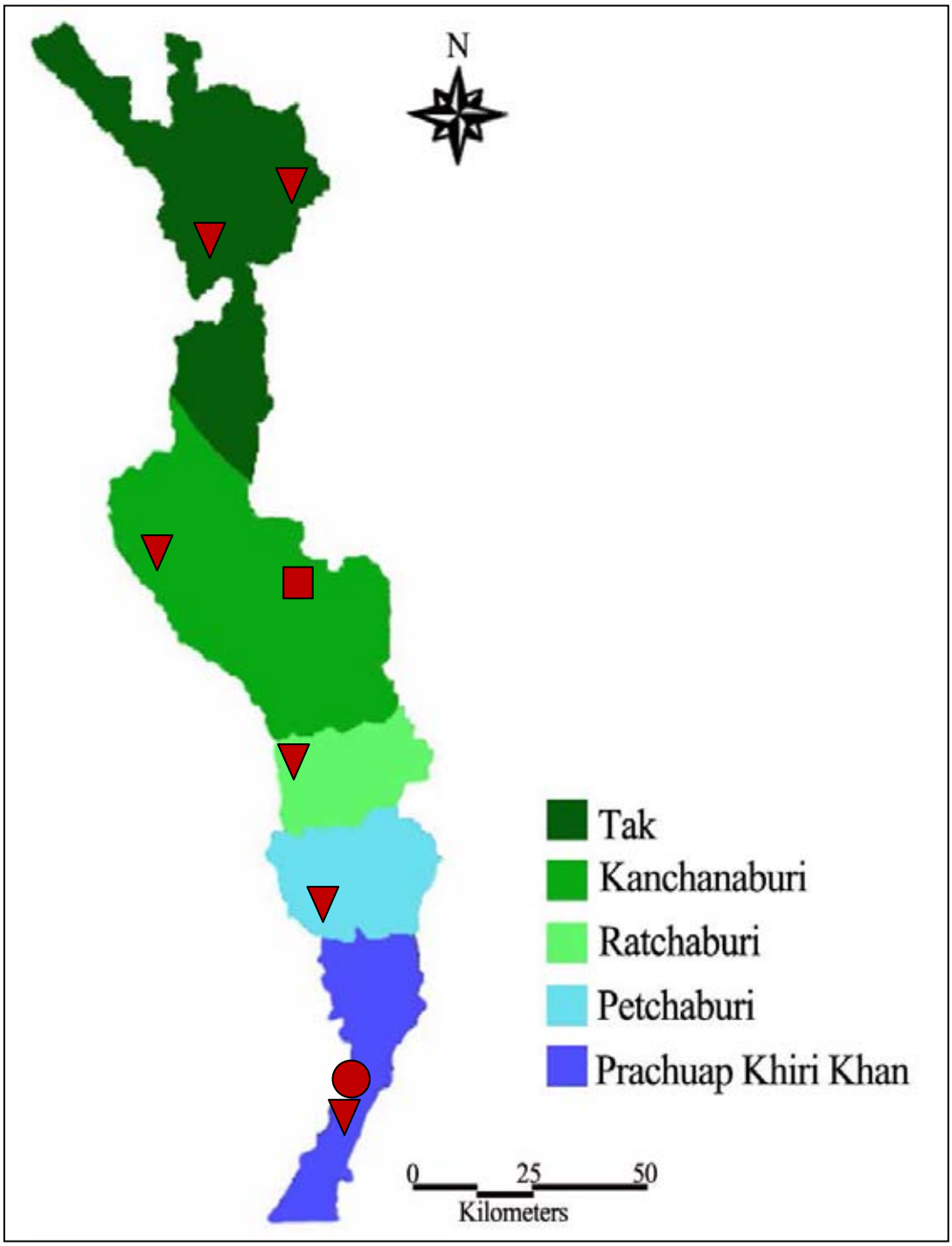


Figure 4.40 Distribution of the genus *Eosembia* (F. Oligotomidae) found in western Thailand.

▼ *Eosembia auripecta* ● *E. lamunae* ■ *E. paradorni*

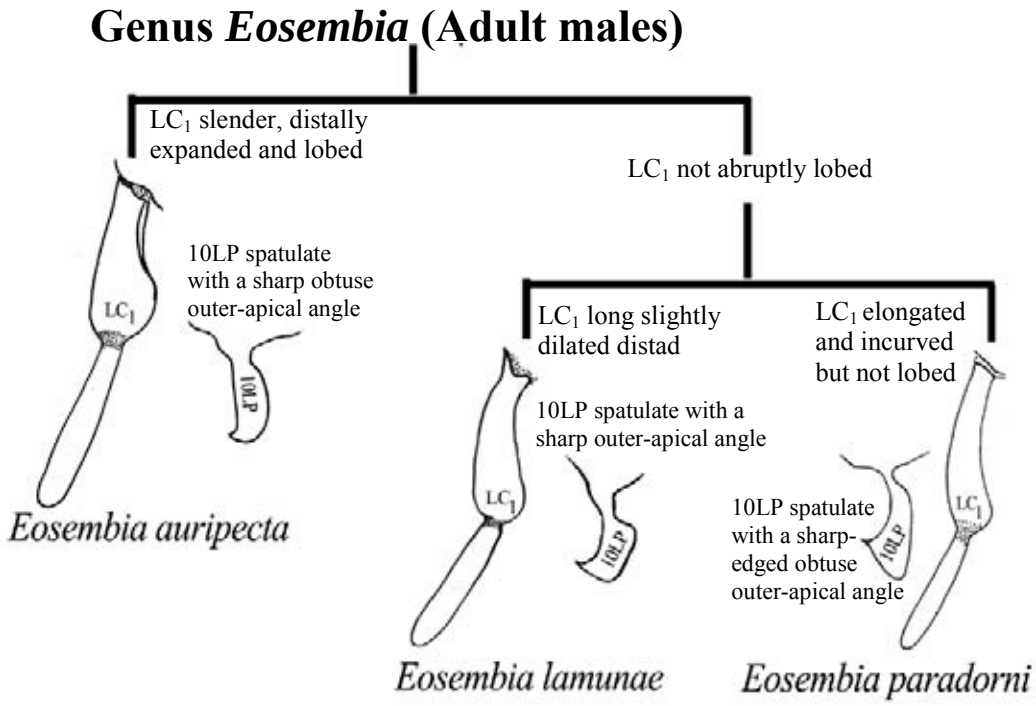


Figure 4.41 Pictorial key to species for adult males of the genus *Eosembia* of western Thailand.

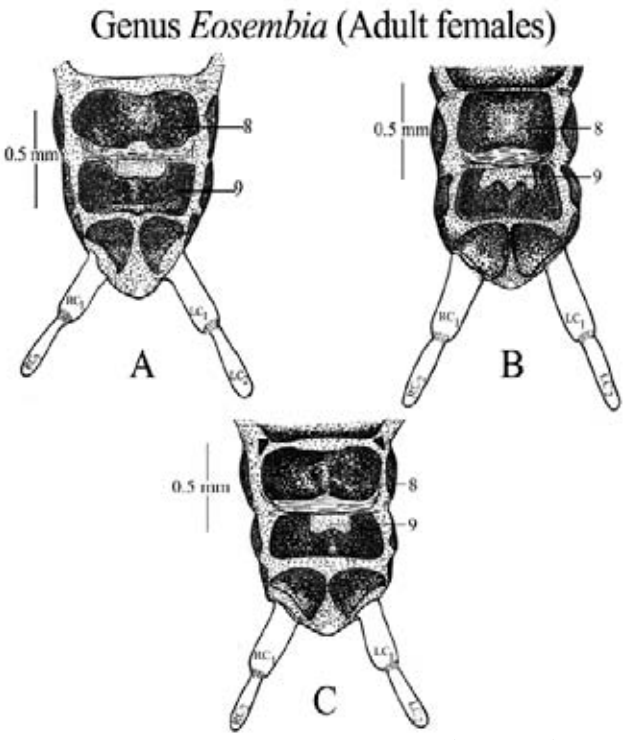


Figure 4.42 Illustrations of sternites, especially on 8th and 9th abdominal segments of female *Eosembia auripecta* (A), *E. lamunae* (B) and *E. paradorni* (C).

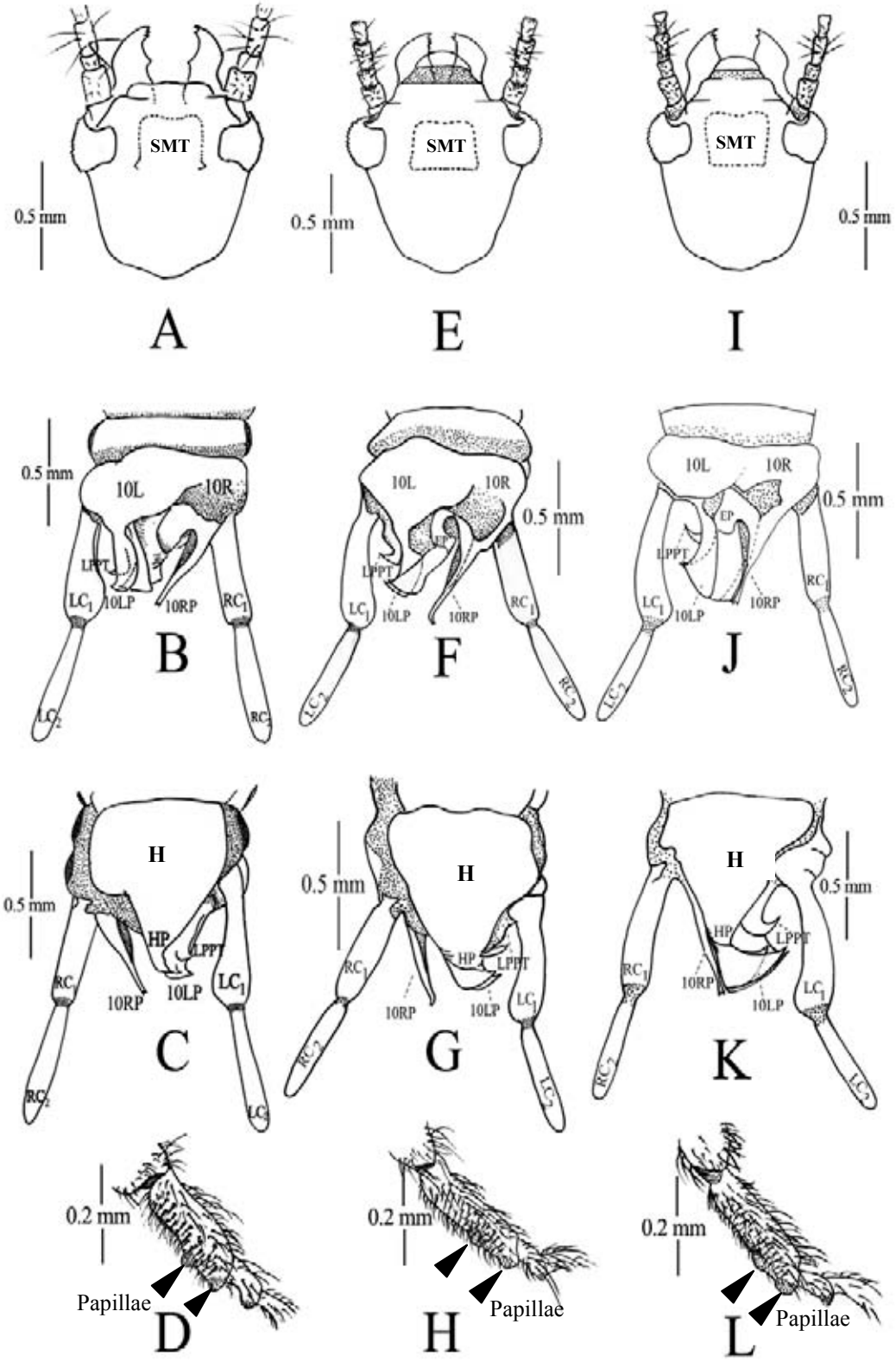


Figure 4.43 Important characters of male *Eosembia auripecta* (A-D), *E. lamunae* (E-H) and *E. paradorni* (I-L). A, E, I) Head. B, F, J) Dorsal views of terminalia. C, G, K) Ventral views of terminalia. D, H, L) Hind basitarsus.

Genus ***Lobosembia*** Ross, 2007

Lobosembia Ross, 2007: 596; Mill, 2009: 15.

Type species.- *Lobosembia mandibulata* Ross, 2007: 597, figs. 17-19, by original designation.

Diagnosis. Alate male: Body length 14-16 mm; width 2.5 mm. Wings with MA unforked, Head broad, almost quadrate; clypeal margin sclerotic and inflexed, unicolorous. Eyes relatively small. Mandibles broad-based, then arcuated around labrum with an unusually elongate incisor lobe, submentum darkly sclerotized, inflexed sides project forward beyond anterior margin as incurved, knob-like lobes, anterior margin not otherwise inflexed. Hind basitarsus elongate, with only one papilla. Terminalia with 10L short, caudally margin not lobed, its 10LP unusually small, straight, tapered caudad; HP arising broadly from a narrow H, is very long and somewhat twisted, its apex lying partially beneath inner lobe of LC_1 which it equals in length; apical third somewhat flared and dorsally sclerotized. LPPT fused to HP. LCB represented only as a sclerotic flange fused to outer basal edge of LC_1, which is slender basally, then broadly expanded dorso-mesad as an angulate lobe which inserts into a mesodorsal depression on the inner apex of the LPPT. Apterous female: Body length 17 mm; width 2.5 mm, chestnut brown anteriorly, abdomen and legs dark chocolate brown, thoracic intersegments creamy white; mid and hind coxae, trochanters, and tibial bases also creamy white; antennae and cerci entirely dark. Hind leg with only one basitarsal papilla.

Distribution. Northern and western Thailand: Mixed tropical forest. Probably also ranges into Laos, eastern Myanmar, and southwestern China.

Lobosembia mandibulata Ross, 2007
(Figs 4.44, 4.45, 4.46)

Lobosembia mandibulata Ross, 2007: 597, figs. 17-19.

Diagnosis. Male of *L. mandibulata* is probably most closely related to *Aposthonia* Krauss, but can be distinguished from this genus and all other oligotomids by the mandibles is broad based, then arcuated around labrum with unusually long incisor lobe, H is broad, very long and rather twisted with LPPT fused to HP and by LC_1 is elongate, gradually expanded caudally on inner side but not abruptly lobed. Female is without significant features. Its color is mostly chestnut brown anteriorly with abdomen and legs are dark chocolate brown.

Holotype. ♂ (CAS), USA.
Type localtity. Thailand (Chiang Mai), East slope of Doi Suthep, near Chiang Mai, 560 m, 15. IV. 1963 (E.S. Ross).

Material examined. 2♂♂, 2♀♀ (CUMZ-EMB-Oli.2010.214-217), **Thailand**, Tak Province, Mae Sot District, mixed deciduous forest, 16°45.377'N 098°54.533'E, 718 m, 27. II. 2009. All collected by P. Poolprasert.

Other specimens examined. 1♂, 3♀♀ (CUMZ-EMB-Oli.2010.218-221), **Thailand**, Chiang Mai Province, Fang District, mixed deciduous forest, 20°04.499'N 099°14.616'E, 615 m, 31. III. 2008. All collected by P. Poolprasert & J.S Edgerly.

Distribution. China (Southwestern), Laos, Myanmar (Eastern) and Thailand.

Description. Alate male (n = 3, mean (range)): Head width × length 1.5 (1.4 -1.6) × 1.9 (1.8 - 2.0) mm, body length 16.0 (15.5 – 16.5) mm, width 2.3 (2.2 – 2.4) mm, forewing length 8.5 (8.3 - 8.7) mm, hindwing length 7.8 (7.6 -7.9) mm.

Head: Capsule dark chocolate brown, little longer than broad. Eye gray. Mandibles broad-based, then arcuated a round labrum with an unusually elongate incisor lobe, dark amber with dorso-basal lobes chocolate brown. Submentum and palpi concolorous with cranium. Antennae long, 1 and 2 mahogany brown, remaining segments medium brown blending to tan distally, 27 segmented.

Thorax: Prothorax dark chocolate brown, dorsally and slightly paler ventrally. Meso- and metathoracic sclerites brown. All legs concolorous with prothorax except for yellowish brown tibial bases, coxae, and trochanters. Wing dark brown with MA not forked. Hind leg with only one basitarsal papilla.

Abdomen: darkish brown with terminalia darker. Terminalia with 10L as broad as 10R. 10LP short, evenly tapered to apex. 10RP slender, rather straight, gradually narrowed caudally, mostly membranous on inner margin. H broad basally gradually narrowed caudally, forming a broad HP directed slightly toward left cercus and beneath 10LP. LPPT fused to HP. LC_1 long, gradually expanded caudally on inner side then broadly expanded dorso-mesad as an angulate.

Apterous female (n = 5, mean (range) ± SD): Head width x length 1.5 (1.3-1.7) ± 0.32 x 2.1 (2.0-2.2) ± 0.12 mm, body length 17.0 (1.6-1.8) ± 1.02 mm, width 2.5 (2.4-2.6) ± 1.15 mm.

Head: Capsule darkish brown interiorly. Eyes grayish dark, Antennae with basal 2 segments brownish, segments 3-4 yellowish tan, the remaining segments becoming dark brown, 25 segmented.

Thorax: Prothorax dark chestnut brown. Meso and metathorax chestnut brown, basisterna largely yellowish brown. Forelegs concolorous with prothorax except for creamy white fermorotibial joint, mid and hind legs brownish except for creamy white coxae, trochanters, and femorotibial joints. Hind leg with only one basitarsal papilla.

Abdomen: Concolorous with metathorax, sternites 1 and 2 creamy white, the remaining segments dark chocolate brown. Tenth sternum symmetrically divided longitudinally into two lateral plates.Cerci chocolate brown with purple membranes. Cerci entirely medium brown.

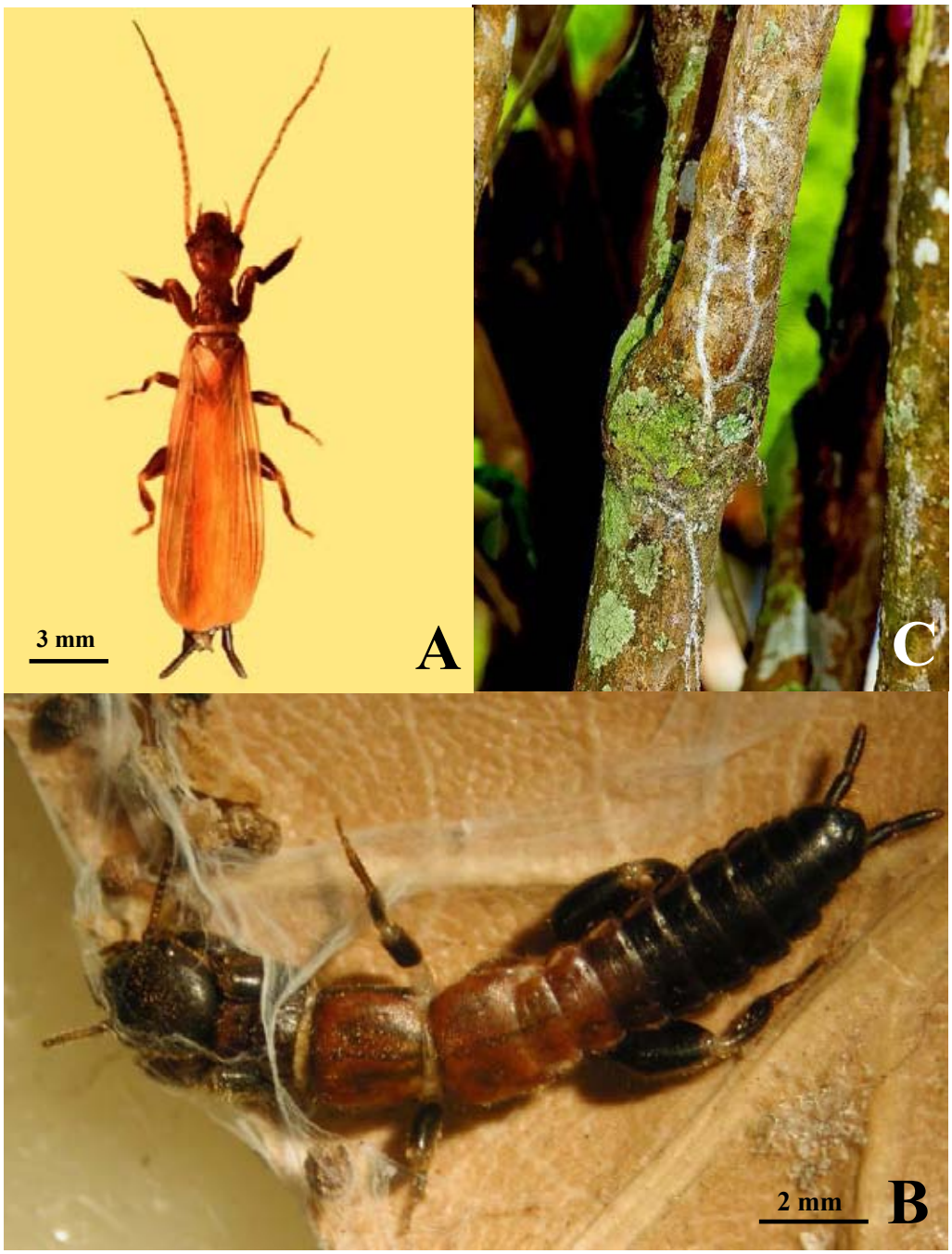


Figure 4 .44 *Lobosembia mandibulata* (A) ma le, (B) f emale w ith eggs, (C) silk gallery.

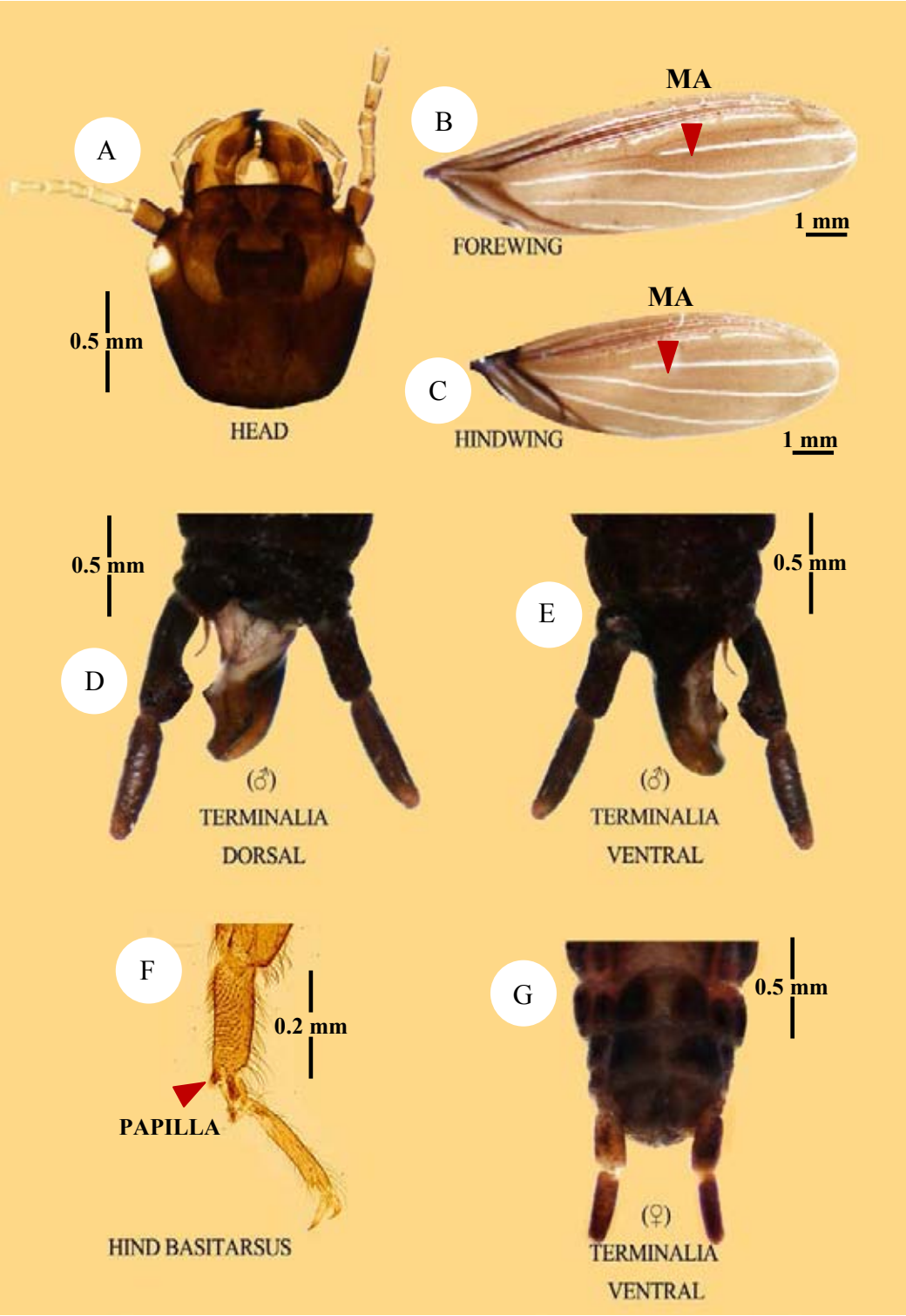


Figure 4 .45 Important ch aracters of male (A-F) an d f emale (G) o f *Lobosembia mandibulata.*

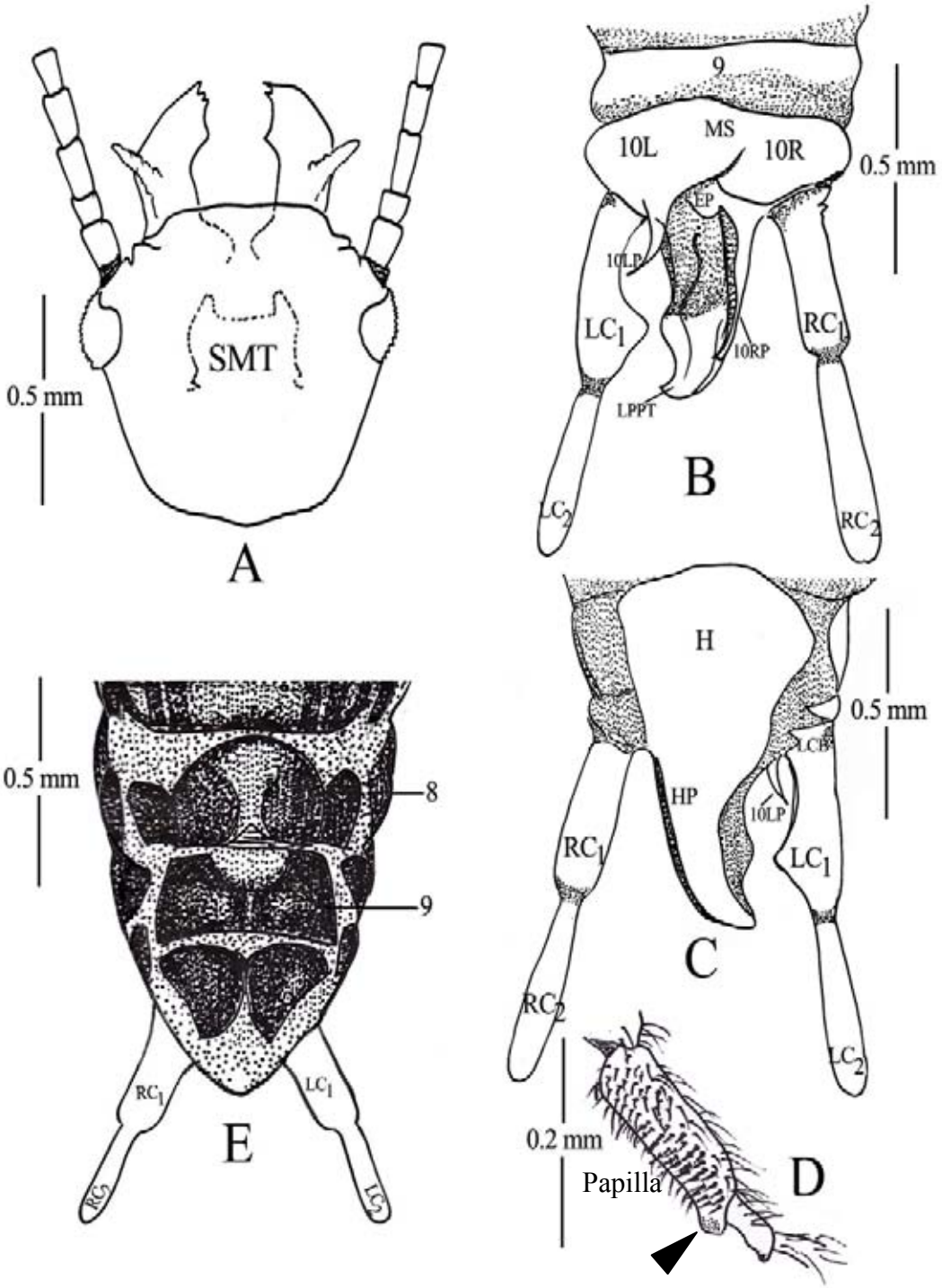


Figure 4 .46 Illustrations o f *Lobosembia mandibulata* (A) H ead o f m ale, (B) Terminalia (dorsal) of male, (C) Terminalia (ventral) of male, (D) Hind basitarsus of male and (E) Sternites of female.

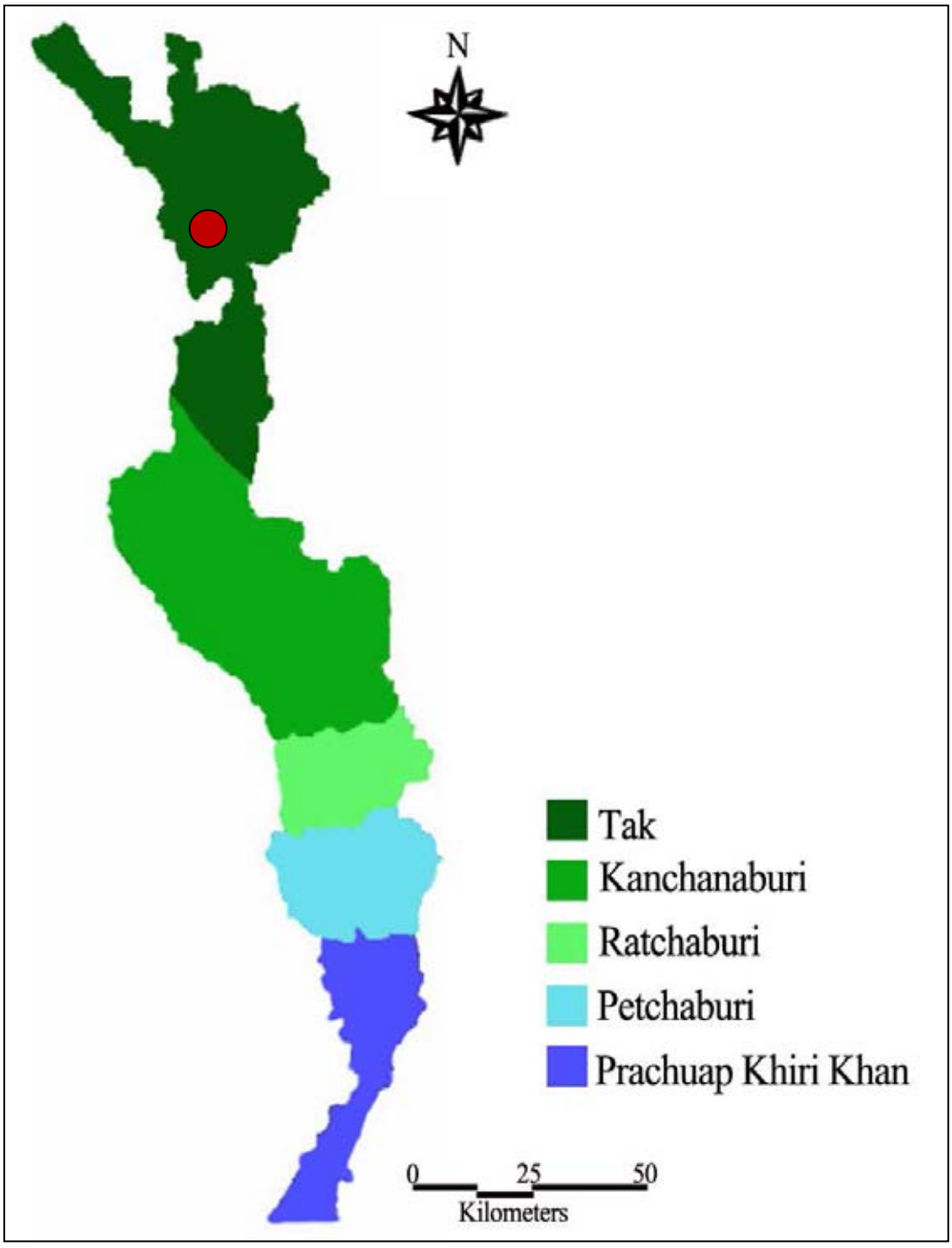


Figure 4.47 Distribution of the genus *Lobosembia* (F. Oligotomidae) found in western Thailand.

● *Lobosembia mandibulata*

Genus ***Oligotoma*** Westwood, 1837.

Embia (Oligotma) Westwood, 1837: 17:373, fig. 2-2f.

Oligotoma Westwood, Burmeister, 1839: 2: 770.-Davis, 1940: 65: 362; Ross, 1940: 33:667; Ross, 1944: 94: 494; Kapur and Kripalani, 1957; 3: 113; Mill, 2009:16.

Aposthonia Krauss, 1911: 23:48.

Type species.-*Embia* (*Oligotoma*) *saundersii* Westwood, 1837: 17:373, fig. 2-2f, by original designation.

Diagnosis. Apterous or alate male: Body length 12 mm; forewing length 6.5 mm, width 2.0 mm, yellowish brown to blackish brown. Head with eyes large, inflated; mandible elongate, the right with 3 inner apical dentations, the left with 2. Basitarsi of hind legs elongate with only one ventral bladder situated terminally. Terminalia with the tergite 10 divided submedially by a suture which is usually obsolescent anteriorly, sometimes continued to tergite 9 as a groove; hemitergites always in contact basally; not separated by membrane, each hemitergite bearing processes, 10RP large, generally long, V-shaped, straitly sinuous, at least four times as long as thick, near its base a smaller, medial, flap-like 10RP, the sclerotic portion of which has the same base as 10RP. 10LP generally long with simple or complex. H large, broad basally, elongated and tapered distally in HP directed toward left cercus; LPPT, a sclerotic spine-like appendix terminally, is fused to the left side of HP. LCB free, prominent, ring-like, often produced and specialized mesad. LC_1 subcylindrical to strongly clavate, occasionally lobed on inner side but never echinulate. Apterous female: Body length 12 mm; width 2.0 mm, chestnut brown to blackish. Hind leg with only one basitarsal papilla.

Distribution. Australia, China, East Africa, East Indies, India, Japan, New Guinea, Pacific Ocean, Philippines, Tasmania and Thailand.

Oligotoma humbertiana (Saussure, 1896)
(Figs. 4.48, 4.49, 4.55, 4.56, 4.57)

Embia humbertiana Saussure, 1896: 353.

Oligotoma humbertiana (Saussure) Davis, 1939: 186, fig. 5; Ross, 1940: 674, figs. 48-50; Ross, 2000: 30; Ross, 2006: 341, fig. 40; Yang, 1999: 66, fig. 18-1b.

Oligotoma saundersii (or *saundersi*) (Westwood), Krauss, 1911: 39, fig 7; Ling, 1934b: 261 (misidentifications); Mukerji, 1935: 8; Menon and George, 1936: 90, pl.I, figs. 1a–1b (all misidentifications, *see* Davis, 1939).

Oligotoma califonica (Banks), Navás, 1923: 31 (misidentification, see Davis, 1939).

Holotype. ♂ Muséum d'Histoire Naturelle (MHN), Geneva, Switzerland.
Type locality. Sri Lanka (Ceylon).

Material examined. 5♂♂, 5♀♀, (CUMZ-EMB-Oli.2010.222-231)**, Thailand**, Prachuap Khiri Khan Province, Mueang District, forest park, 11°48.613' N 098°47.329'E, 7 m, 10-24. VIII. 2009. All collected by P. Poolprasert.

Diagnosis. Male of *O. humbertiana* is readily recognized by the minute, outer-apical process on the right tergal process of the tenth abdominal segment. The female differs from congeners by sternite 8 divided with unpigmented spot area at the centre and on both lateral sides with a pattern of two unpigmented narrow convergent lines. Sternite 9 is without a distinct pattern.

Descriptions. Apterous male (n = 5, mean (range) ± SD): Head width x length 1.1 (1.0-1.2) ± 0.25 x 1.2 (1.1-1.3) ±0.53 mm, body length 6.3 (6.1-6.5) ± 0.49 mm, width 1.2 (1.1-1.3) ± 0.13 mm, forewing length 5.5 (5.3-5.6) ± 0.14 mm, hindwing length 4.5 (4.3-4.6) ± 0.13 mm.

Head: Capsule golden, broadest at eye region. Antennae 19 segmented. Mandibles slender.

Thorax: Prothorax brownish, meso- and metathorax paler in color; wings bright brown with MA not forked. All legs, brown color throughout. Hind leg with only one basitasal papilla.

Abdomen: Yellowish brown throughout, slender and flattened. Terminalia darkish brown with 10L narrow, strongly sclerotized along sutural margin; 10LP small, curved slightly leftward with small outer hook; 10RP very long, subparallel sided with distinct subapical tooth on outer side. H broad basally with gradually narrowed caudally. LCB adjoins the dorso-posterio-mesad with a double lobe; basally portion blunt rounded, closely to 10LP. LC_1 tubular and simple.

Apterous female (n = mean (range) ± SD): Head width x length 1.1 (1.0-1.2) ± 0.06 x 1.2 (1.0-1.3) ± 0.14 mm, body length 6.5 (6.3-6.7) ± 1.05 mm, width 1.2 (1.0-1.3) ± 1.22 mm.

Head: Capsule brown, longer than broad. Eyes small and lessr eniform. Antennae 19-20 segmented. Mandibles massive.

Thorax: Brown throughout. Meso and meta-terga smooth undivided. All legs darkish brown throughout. Hind basitarsi with one papilla

Abdomen: Broad and cylindrical. Sternum 10 symmetrically divided longitudinally into two lateral plates. Sternite 8 divided with unpigmented spot area at the centre and on both lateral sides with a pattern of two unpigmented narrow convergent lines. Sternite 9 is without a distinct pattern.

Distribution. China (Canton, Fukien, Hainan, Macau), Hong Kong, India, Indonesia (Java, Sumatra), Laos Madagascar, Mariana Islands (Guam, Saipan, Tinian), Mexico (Sonora, Tres Marias Is., BCS), Philippines, Sri Lanka, Taiwan, Thailand (New record)

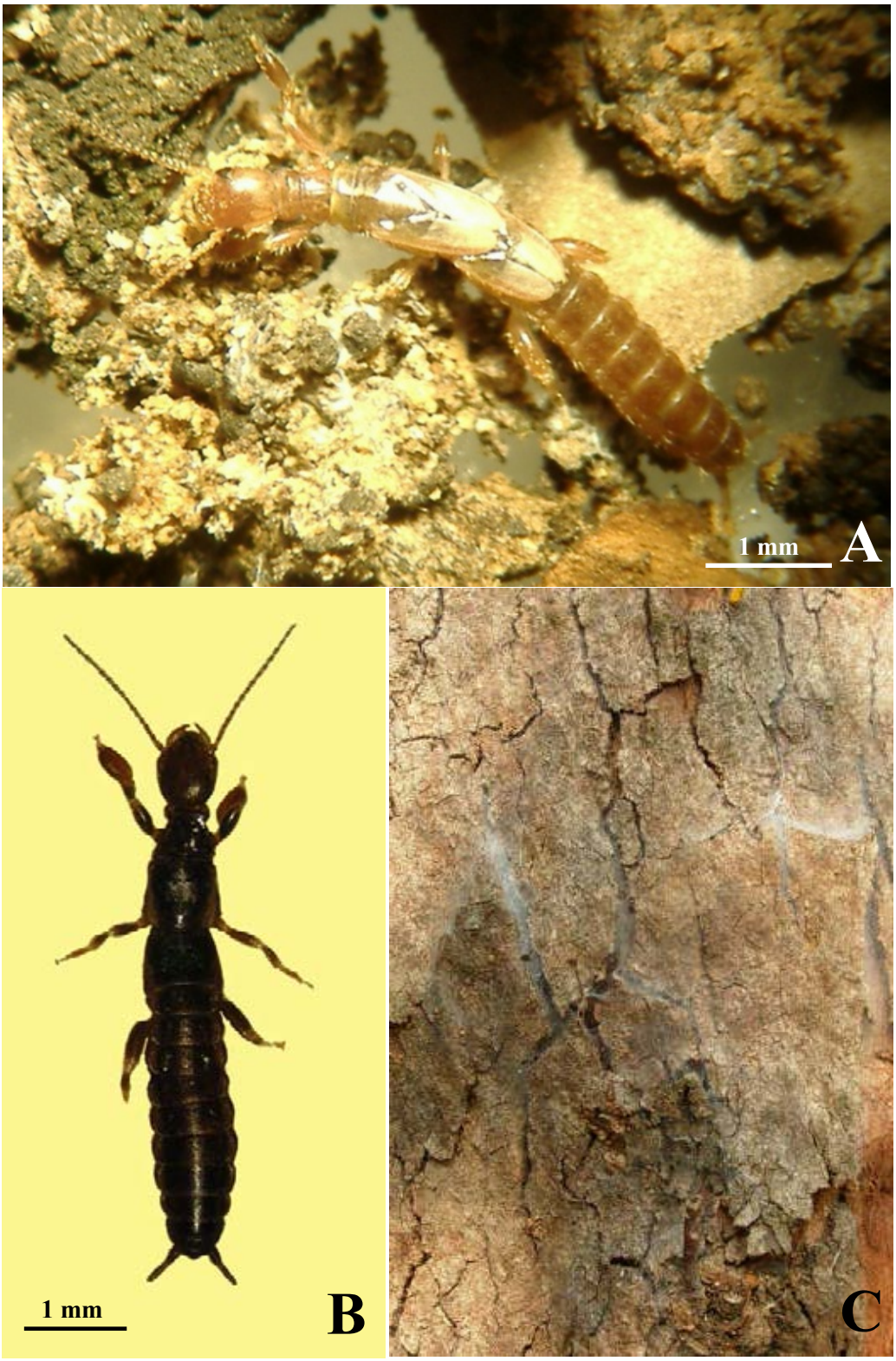


Figure 4.48 *Oligotoma humbertiana* (A) male, (B) female and (C) silk gallery.

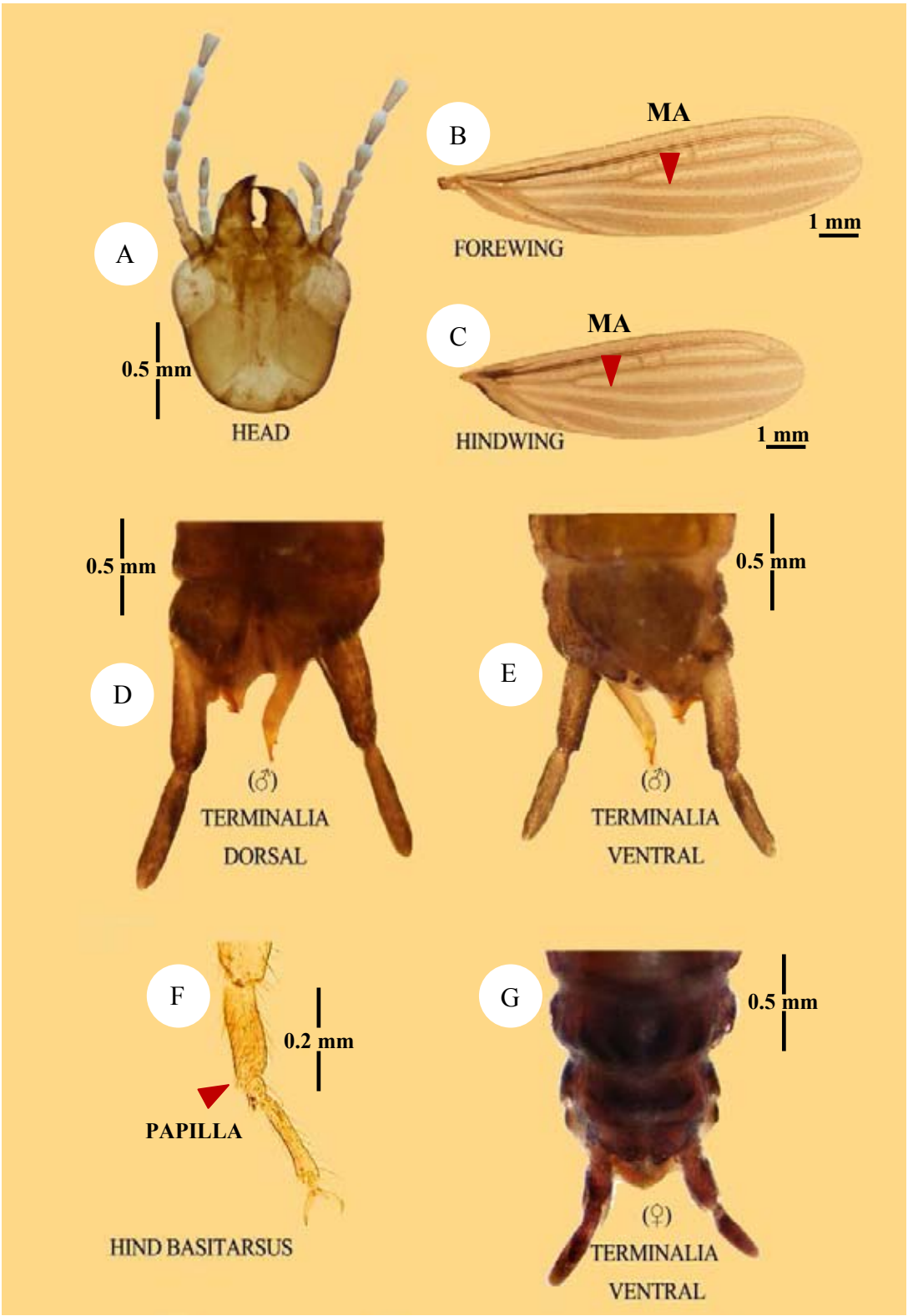


Figure 4 .49 Important ch aracters of m ale (A-F) an d f emale (G) o f *Oligotoma humbertiana*

Oligotoma nigra (Hagen, 1885)
(Figs. 4.50, 4.51, 4.55, 4.56, 4.57)

Embia nigra (*nomen nudum*) Hagen, 1866: 221.

Oligotoma nigra Hagen, 1885: 174; Krauss, 1911: 41; Enderlein, 1912: 86, figs. 59-60; Silvestri, 1923: 261; Friederichs, 1934: 414, fig. 4; Davis, 1939: 188; Davis, 1940: 363, fig. 1; Ross, 1940: 670, figs, 3, 41,45-47; Ross, 1944, 495; Ross, 1981: 207, fig., 5; Ross, 2000: 30; Ross, 2006: 340, fig. 39.

Embia californica Banks, 1906: 1, pl. 1, fig. 1; Krauss, 1911: 70; Enderlein, 1912: 53.

Oligotoma mesopotamica Esben-Petersen, 1929a: 8, fig. 2; Esben-Petersen, 1929b: 258; Morton, 1929: 43; Davis, 1939: 188 (= *O. nigra*); Davia, 1940: 364.

Lectotype. ♂ Museum of Comparative Zoology (MCZ), U.S.A.

Type locality. Island of Rhoda, Cairo, Egypt.

Diagnosis. Male of *O. nigra* can be recognized by hook-like process of left cercus-basipodite (LCB), directed ventrally, rather than horizontal as in *O. saundersii*. Female can be distinguished from congeners by sternite 8 with two indefinably outlined, broad, round, lateral pigmented areas separated medially by almost unpigmented areas. Sternite 9 deeply inset into the segment.

Material examined. 1♂, 2♀♀ (CUMZ-EMB-Oli.2010. 232 -234), **Thailand,** Tak Province, Mae Sod District, plantation, 16°42.475' N 98°34.291'E, 196 m, 04.IV.2008. All collected by P. Poolprasert.

Other specimens examined. 3♂♂, 4♀♀ (CUMZ-EMB-Oli.2010.235-241), **Thailand,** Chiang Mai Province, Mueang District, Huay Kaeo Arboretum, 18°48.348'N 098°57.585'E, 336 m, 01. III. 2008. All collected by P. Poolprasert.

Description: Alate male (n = 4, mean (range) ± SD): Head width x length 1.1 (1.0-1.2) ± 0.05 x 1.2 (1.0-1.3) ± 0.12 mm, body length 6.5 (6.3-6.6) ± 0.24 mm, width 1.2 (0.9-1.3) ± 0.23 mm, forewing length 6.3 (6.0-6.5) ± 0.26 mm, hindwing length 5.4 (5.3-5.5) ± 0.22 mm.

Head: Blackish, quadrated-oval. Antennae 20 segmented. Eye dark, moderately large, inflated.

Thorax: Prothorax darkish, meso and metathorax paler in color. Wings with MA not forked pigmented portions of wing diverse lighter shades of dark brown. All legs dark brown. Hind leg with only one basitarsal papilla.

Abdomen: Darkish brown throughout. Terminalia with 10LP very dark, slender, gradually arched leftward, and tapered to apex. 10 RP much lighter in color, long, broad, gradually narrowed caudally and mostly membranous inner margin. LPPT with ventral hooks lightly curved rightward. Hbroad, transverse basally, abruptly narrowing and produced caudad toward left cercus. LCB produced mesad, bi-lobed; basal lobe narrow, partially overlying spine of HP. LC_1 simple tubular.

Apterous female (n = 6, mean (range) ± SD): Head width x length 1.2 (1.0-1.4) ± 0.04 x 1.2 (1.1-1.3) ± 0.13 mm, body length 6.7 (6.5-6.8) ± 0.17 mm, width 1.3 (1.1-1.5) ± 1.14 mm.

Head: Cranium somewhat lighter particularly in clypeus; rectangular-like small eyes.

Thorax: Dark brown throughout. All legs dark and hind basitarsi with one papilla.

Abdomen: Very dark throughout. Sternite 8 with two indefinably outlined, broad, round, lateral pigmented areas separated medially by almost unpigmented areas. Sternite 9 deeply inset into the segment.

Distribution. Australia, Egypt, India, Iraq, Israel, Mexico, Thailand (New record), USA. (Arizona, California, Texas, Utah)

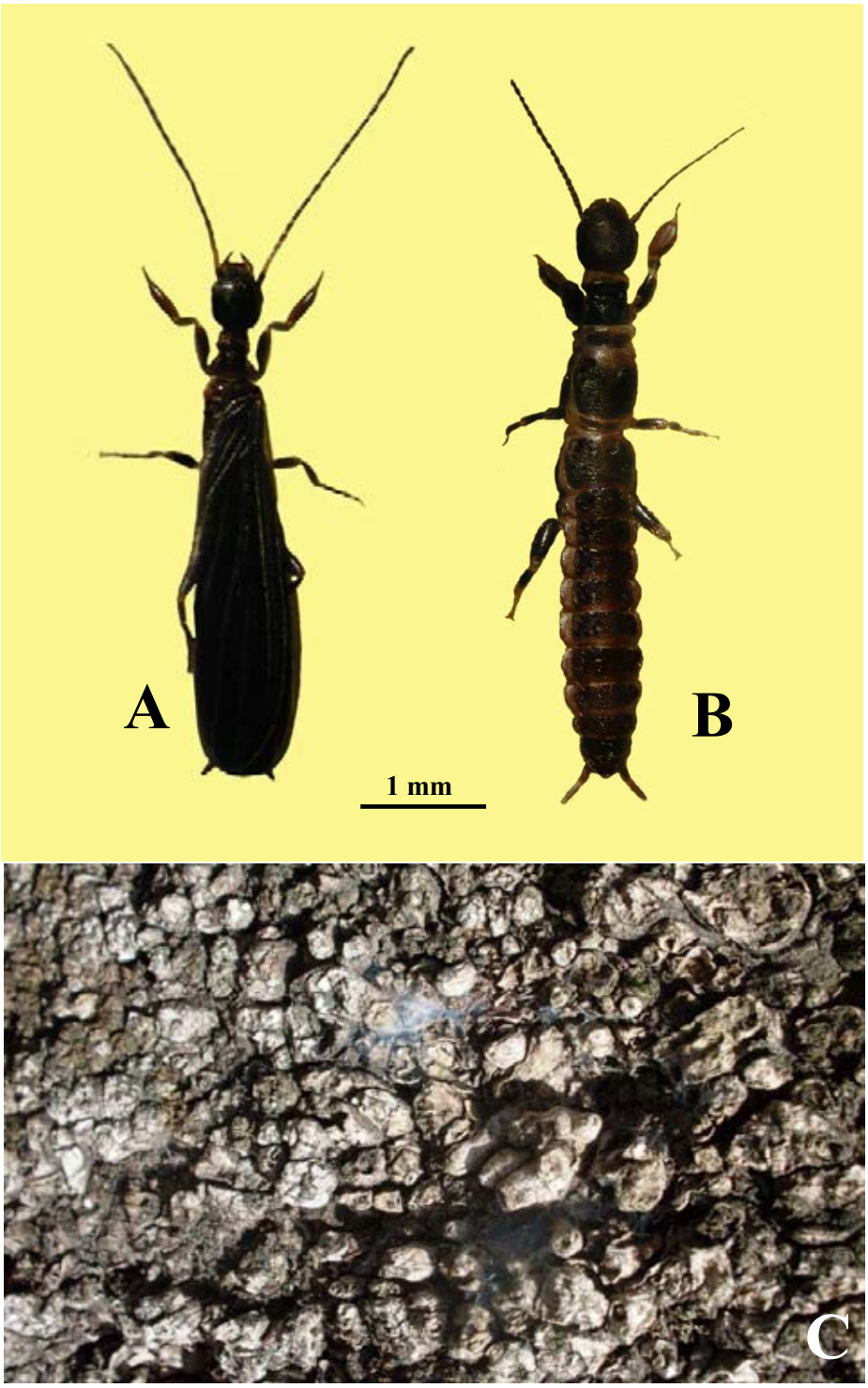


Figure 4.50 *Oligotoma nigra* (A) male, (B) female and (C) silk gallery.

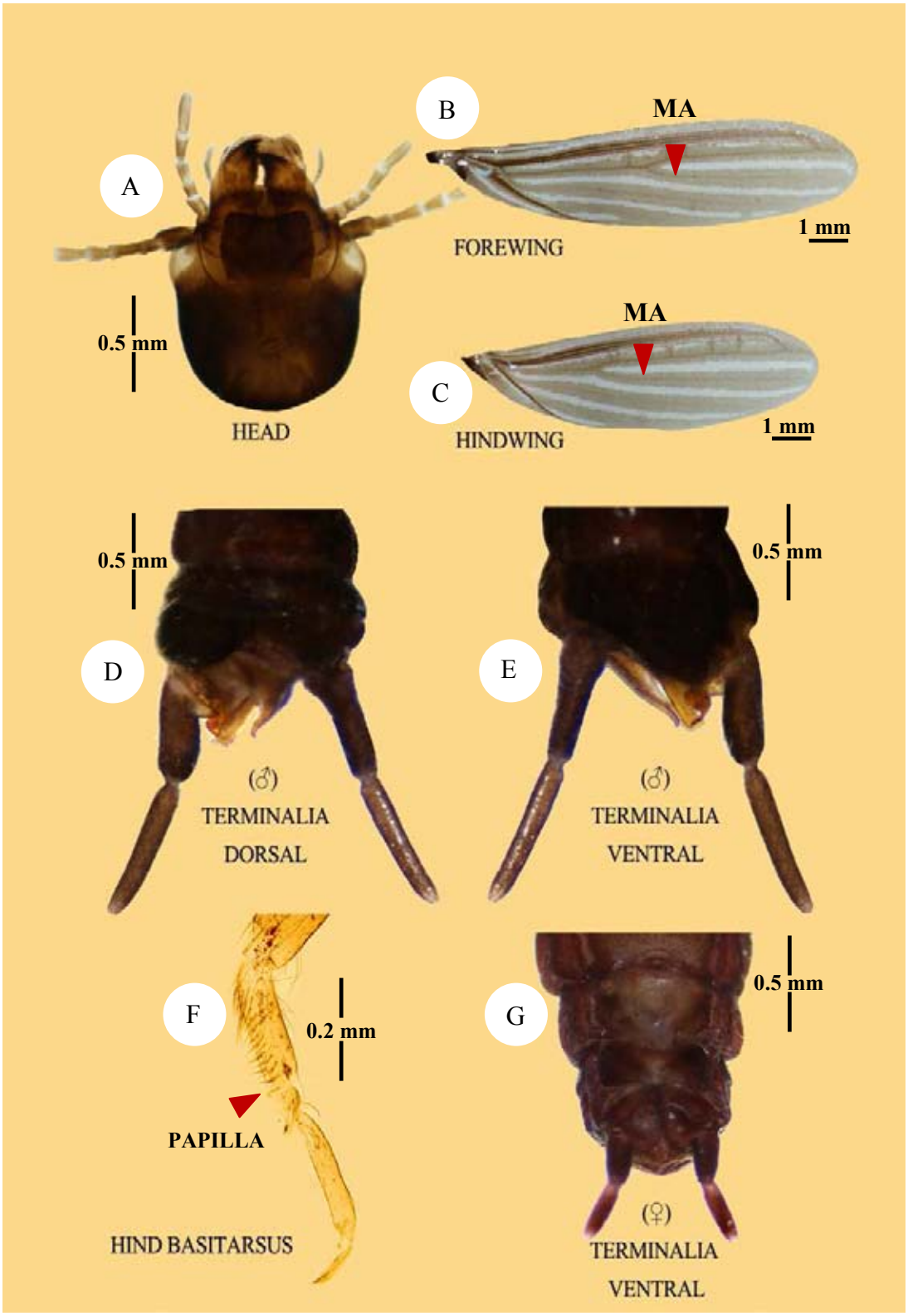


Figure 4.51 Important characters of male (A-F) and female (G) of *Oligotoma nigra*.

Oligotoma saundersii (Westwood, 1837)
(Figs. 4.52, 4.53, 4.55, 4.56, 4.57)

Embia (*Oligotoma*) *saundersii* Westwood, 1837: 373, pl. 2, fig. 2.

Oligotoma saundersii (Westwood) Burmeister, 1839: 770; Wood-Mason, 1883: 628, pl. lvi., figs. 1-5; Hagen, 1885: 144; Davis, 1939: 181, figs. 1-4 (establishes identity); Ross, 1940: 668, figs. 40, 42-44; Ross, 2000: 30; Ross, 2006: 340, fig. 38; Lu, 1990: 324, figs. 1-2; Lee, 2002: 123, fig. 1.

Embia latreillii Rambur, 1842: 312.

Oligotoma latreillei (rambur) Enderlien, 1910: 56; Menon and George, 1936: 95, pl. I, figs. 2a–2b (misidentifications); Davis, 1939: 183 (spelled *latrellii*).

Olyntha cubana Hagen (*nomen nudum*), 1866: 221,222.

Oligotoma cubana Hagen, 1885: 141; Davis, 1939: 183 (establishes synonymy).

Oligotoma insularis McLachlan, 1883: 227.

Embia bramina Saussure, 1896: 35.

Oligotoma bramina (Saussure) Krauss, 1911: 38.

Oligotoma rochai Navás, 1917: 281; Krauss, 1917: 316 (establishes synonymy).

Oligotoma inaequalis Bank, 1924: 421; Davis, 1939: 184. (establishes synonymy).

Holotype. ♂ Hope Department of Entomology (HDE), Oxford University. UK.
Type locality. "East Ind." (India) (W.S. Saunders).

Diagnosis. Male of *O. saundersii* is easily recognized by the horizontal sickle shaped process beneath the hypandrium lobe. Female differs from the congeners as the sternite 8 is divided into a medial with two narrow, caudally convergent membranous lines. Sternite 9 is arrow headed in shape within the body**.**

Material examined. 5♂♂, 7♀♀ (CUMZ-EMB-Oli.2010.242-253), **Thailand,** Ratchaburi Province, Saun Phueng District, Forest park, 13°32.805'N 099°20.126'E, 134 m, 22. VIII-18.IX. 2009. 2♀♀ (CUMZ-EMB-Oli.2010.254-255), Petchaburi Province, Ban Lad Distict, orchard, 13°02.428'N 099°53.043'E, 8 m, 12.VII.2009. 3♀♀ (CUMZ-EMB-Oli.2010.256-258), Prachuap Khiri Khan, Bang Saphan District,

forest p ark, 11°19.124 ’N 099°24.422 ’E, 80 m , 03. V III. 2009. 1 ♂, 2 ♀♀ (CUMZ-EMB-Oli.2010.256-258); Mueang District, plantation, 11°148.613’N 099°47.329’E, 7 m, 01. VIII. 2009.

Other s pecimens ex amined. 2♂♂, 1♀♀ (CUMZ-EMB-Oli.2010.259-261)**, Thailand,** Bangkok P rovivince, Pathumwan D istrict, Lumpini P ark, 13°45.575’N 100°32.304’E, 7 m , 06. V .-05. X . 2008; 2♂♂, 4♀♀ (CUMZ-EMB-Oli.2010.262-267), Chulalongkorn University, rain tree, 13°44.288’N 100°31.824’E, 8 m, 10. V II.-08. I X 2009; 4♂♂, 6♀♀, (CUMZ-EMB-Oli.2010.268-277), Bangkhean D istrict, Kasetsart U niversity, Eucalyptus t ree, 13°50'929"N 100°34'239"E, 6 m , 31. V I.-14. XII. 2008 . 1♂, (CUMZ-EMB-Oli.2010.278) Chiang M ai Province, Mueang District, Huay K aeo A rboretum, 18°48.348’ N 098°57.585’E, 336 m , 21. V. 2008 . 1♂, 2♀♀ (CUMZ-EMB-Oli.2010.279-281), Chiang R ai P rovince, Mueang District, Forest park, 19°58.363’N 099°53.212’ E, 383 m , 24. IX. 2009. 1♀ (CUMZ-EMB-Oli.2010.282), Kalasin P rovince, Khao W ong D istrict, Dry dipterocrap f orest, 16°45.415’N 104°07.526’ E, 280 m , 21. V. 2008 . 1♂, 1♀ (CUMZ-EMB-Oli.2010.283-284), Nong Kai P rovince, Mueang District, Forest p ark, 14°58.160’ N, 102°05.591’E, 182 m , 28. XI. 2009. 4♂♂, 7♀♀ (CUMZ-EMB-Oli.2010.285-295), Nong B ua Lam P hu Province, N aklang District, deciduous di pterocarp forest, 17°12.839’N, 102°08.176’ E, 293 m, 16. VII. 2010.; 2♂, 3♀ (CUMZ-EMB-Oli.2010.296-300), Forest p ark, 17°18.557’N, 102°11.198’ E, 256 m , 17. VII. 2010. 1♂♂, 3♀♀ (CUMZ-EMB-Oli.2010.301-304), Sa Kaeo P rovince, Aranyaprathet District, forest park, 13°48.531’N, 102°04.193’E, 102 m, 15. V II. 2011. 2♀ (CUMZ-EMB-Oli.2010.305-306), Satun Province, Mueang District, forest park, 06°37.242’N, 100°04.021’E, 25 m, 22. X. 2008. 1♀ (CUMZ-EMB-Oli.2010.307), Trang P rovince, Mueang District, forest park, 07°33.255’N, 099°36.831’E, 22 m, 02.XII.2010.

Description. Alate male (n = 24, mean (range) ± SD): H ead width x length 1.1 (0.9-1.2) ± 0.33 x 1.3 (1.0-1.3) ± 0.21 mm, body length 6.7 (6.5-6.9) ± 0.45 mm, width 1.2 (1.1-1.3) ± 0.06 m m, forewing l ength 5.5 (5.2-5.7) ± 0.43 m m, hindwing l ength 4.4 (4.2-4.6) ± 0.49 mm.

Head: Capsule darkish, longer than broad. Antennae 23-25 segmented

Thorax: Prothorax darkish brown, meso- and metathorax paler in color. Wings light brown with MA not forked. All legs brownish. Hind leg with only one basitarsal papilla.

Abdomen: Light brown with terminalia darker. Terminalia with 10LP broad, thin, slightly constricted basally but broads ubapically; 10RP long, gradually distended with a smaller sharp projection at the extremity; H broad, transverse basally with left apical angle like a narrow sickle spine. LCB free, ring-like, broadest ventrally; produced mesad as a narrow, simple, rounded lobe. LC_1, cylindrical.

Apterous female (n = 48, mean (range) ± SD): Head width x length 1.1 (1.0-1.2) ± 1.43 x 1.3 (1.1-1.4) ± 0.09 mm, body length 6.8 (6.5-7.1) ± 0.47 mm, width 1.3 (1.1-1.4) ± 1.17 mm.

Head: Darkish brown, longer than width. Eyes small. Antennae 20 segmented.

Thorax: Darkish brown throughout. All legs dark. Hind leg with only one basitarsal papilla.

Abdomen: Broad and cylindrical, chocolate-brown throughout. Sternite 8 is divided into a medial with two narrow, caudally convergent membranous lines. Sternite 9 is arrow headed in shape within the body.

Distribution. Australia, Brazil, Cuba, India, Indonesia, Korea, Madagascar, Marcus Island, Mexico (Guanajuato), New Caledonia, Taiwan, Thailand (New record), U.S.A. (Florida, Hawaii, Texas), Venezuela, Virgin Islands (St. Croix).

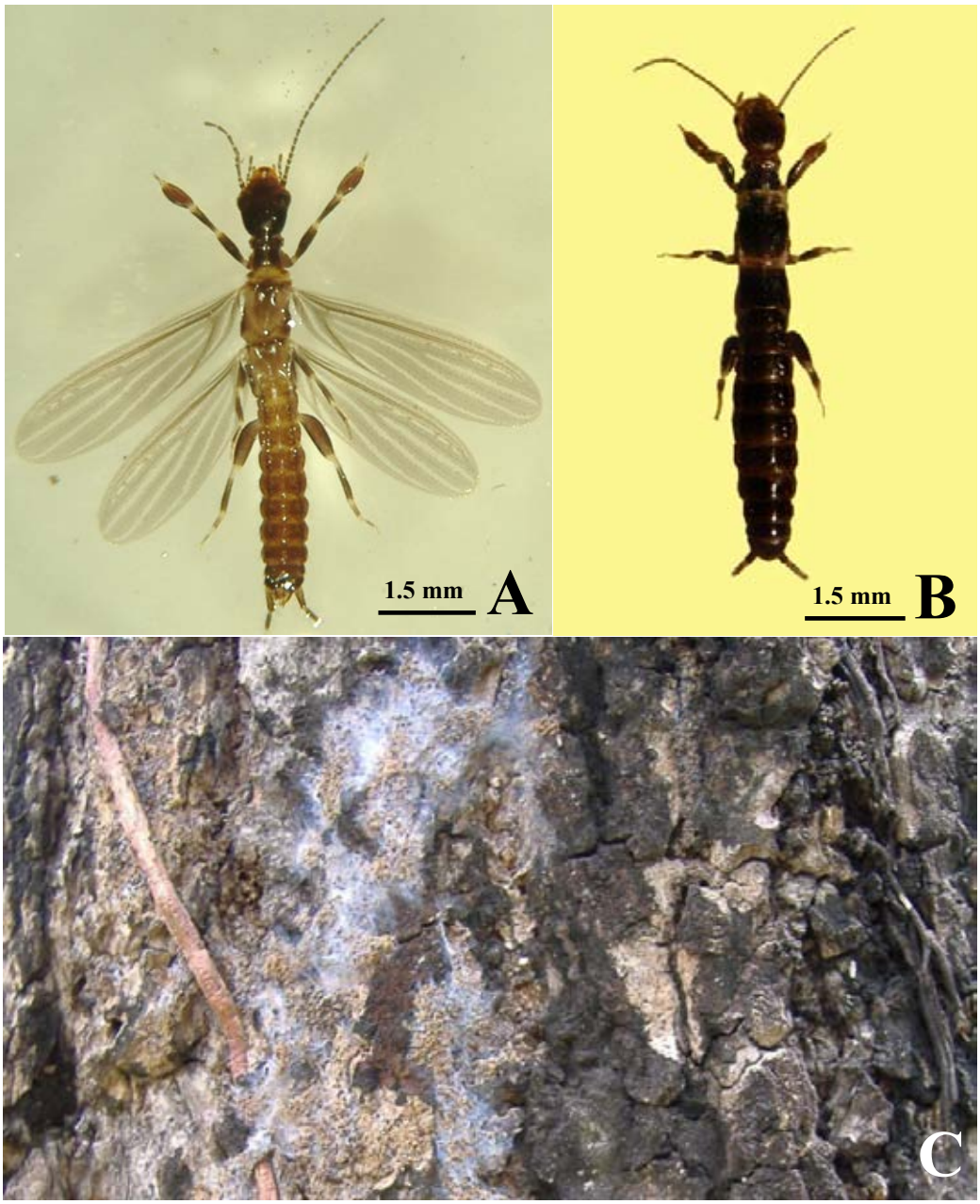


Figure 4.52 *Oligotoma saundersii* (A) male, (B) female and (C) silk gallery.

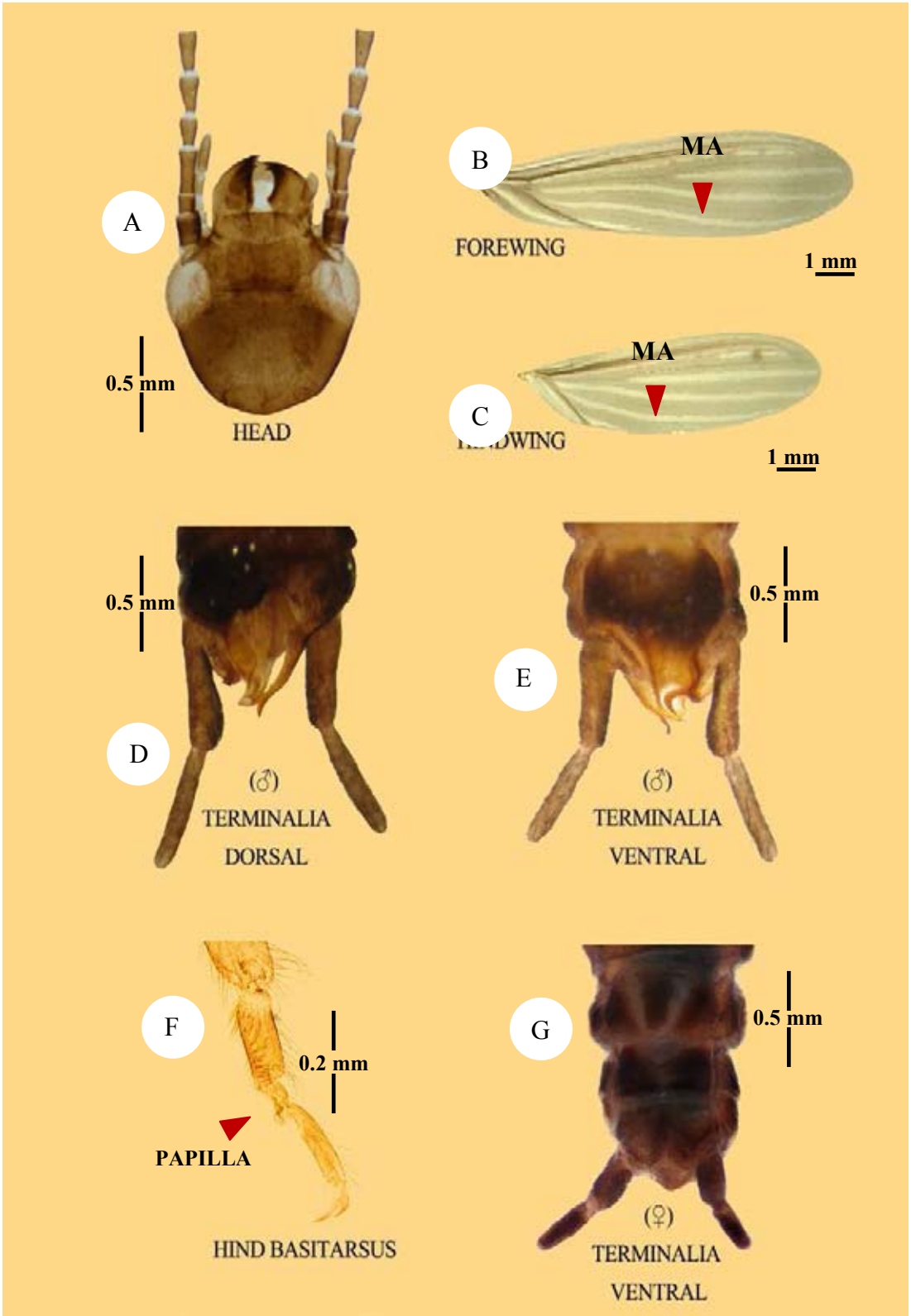


Figure 4 .5 Important ch aracters o f male (A-F) a nd fe male (G) o f *Oligotoma saundersii*.

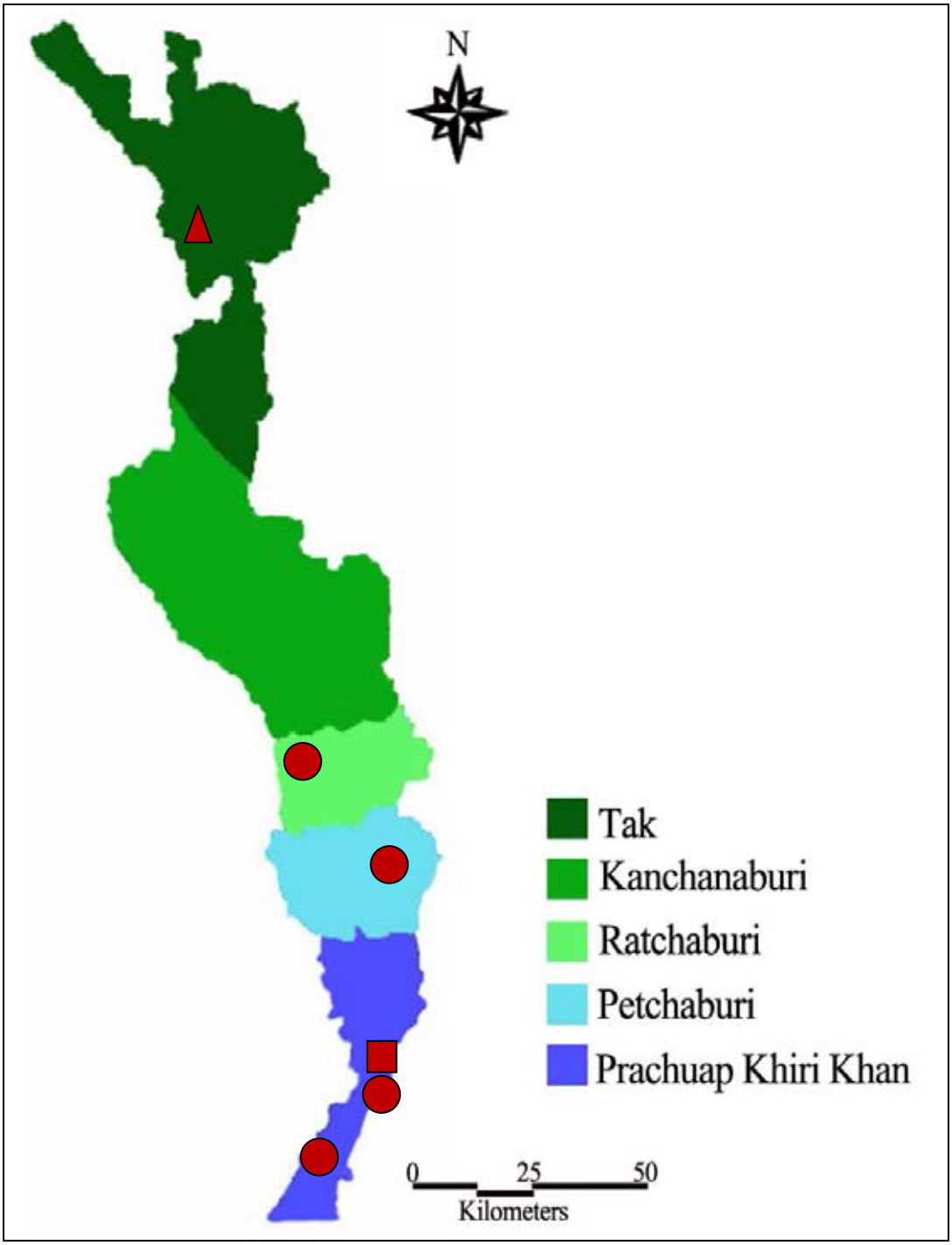


Figure 4.54 Distribution of the genus *Oligotoma* (F. Oligotomidae) found in western Thailand.

Oligotoma humbertiana *O. nigra* *O. saundersii*

Key to species of the genus *Oligotoma* Westwood, 1837 (Adult males)

1. 10LP broad, slightly constricted basally but swollen subapically, narrowly; 10RP long, gradually, evenly acuminated istally, extreme apex hooked to right, subtended by smaller sharp projection; H broad, transverse basally with left apical angle like narrow sickle spine..... *O. saundersii*
- 10 LP narrow 2
2. 10LP small, curved and slightly leftward with small outer hook; 10RP very long subparallel sided with distinct sub-apical tooth on outer side; H broad basally gradually narrowed caudally..... *O. humbertiana*
- 10LP slender, gradually arced leftward, evenly tapered to apex; 10RP long, broad gradually narrowed caudally and mostly membranous inner margin; LPPT with ventrally hook, slightly curved rightward; H broad, transverse basally, abruptly narrowed and produced caudally toward left cercus..... *O. nigra*

Key to species of the genus *Oligotoma* Westwood, 1837 (Adult females)

1. Head quadrated-oval, blackish; sternite 8 with two indefinitely-outlines, broad, round, lateral pigmented areas separated medially by an almost unpigmented area; sternite 9 with a median, narrowly-transverse membranous area in basal haft; devided to apex by a very narrow pigmented line ..... *O. nigra*
- Head, longer than broad.....2
2. Head chocolate brown; sternite 8 divided into a medial and two lateral pigmented areas by two narrow, caudually convergent membranous lines; sternite 9 incised medially by a V-shaped pale area almost to posterior margin..... ..... *O. saundersii*
- Head golden-yellow; sternite 8 divided into a medial with oval unpigmented area inside and two lateral pigmented areas by two narrow, caudually convergent membranous line; sternite 9 without distinctly pattern..... *O. humbertiana*

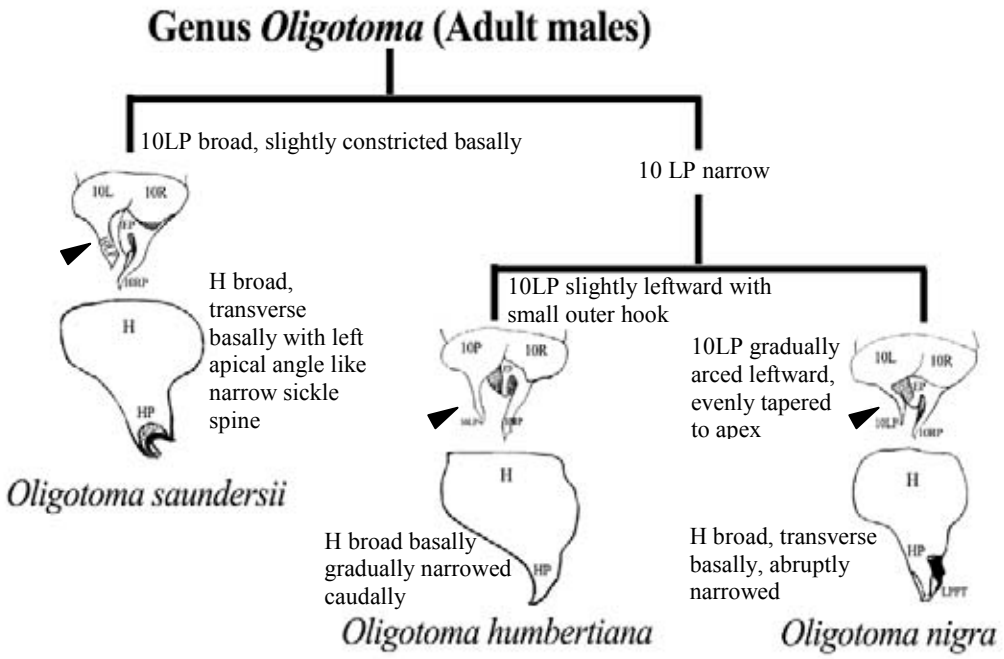


Figure 4.55 Pictorial key to species for adult males of genus *Oligotoma* of western Thailand.

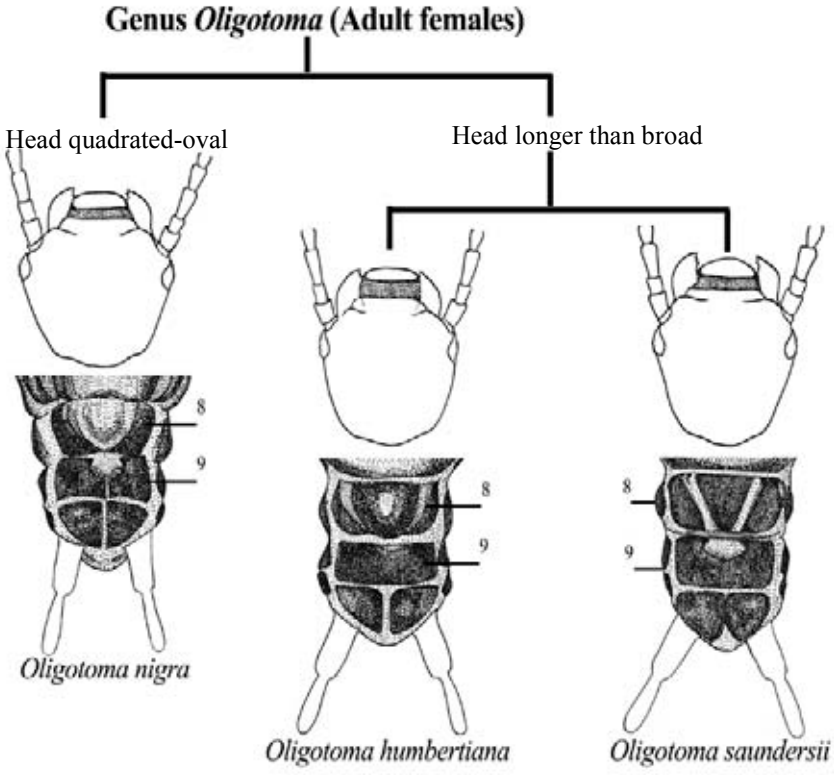


Figure 4.56 Pictorial key to species for adult females of genus *Oligotoma* of western Thailand, showing the pattern of abdominal segment 8th and 9th, ventrally.

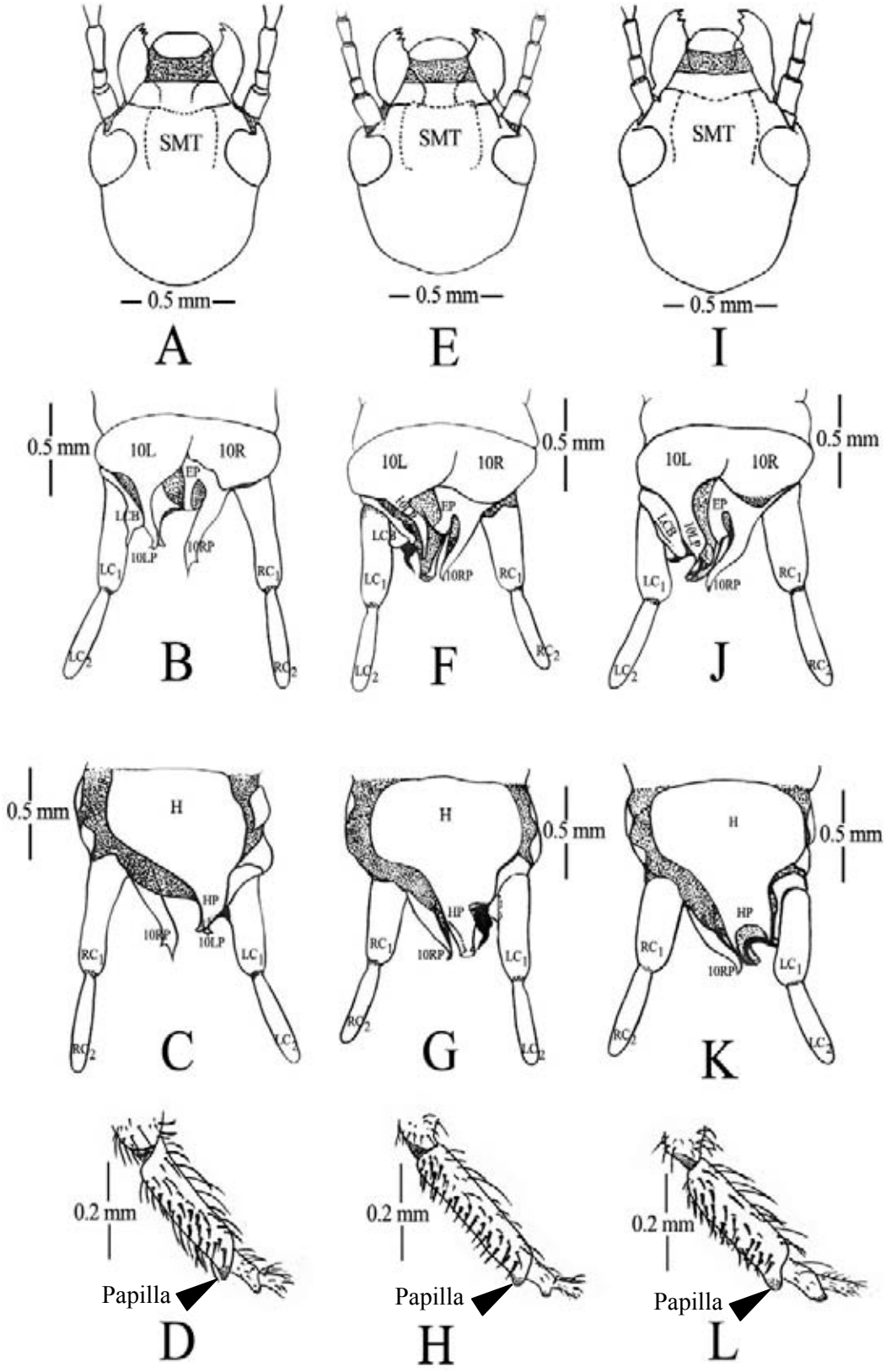


Figure 4.57 Important characters of male *Oligotoma humbertiana* (A-D), *O. nigra* (E-H) and *O. saundersii* (I-L). A, E, I) Head. B, F, J) Dorsal views of terminalia. C, G, K) Ventral views of terminalia. D, H, L) Hind basitarsus.

Teratembiidae Krauss, 1911

Diagnosis. Alate male: Body length 6 mm; forewing length 5 mm, width 1 mm, light brown, head and terminalia darker, wings light brown. Head longer than broad. Wings with MA forked. Mandibles always apically dentate, submentum sclerotic with all margins inflexed. Hind basitarsus with only one ventral papilla. 10L and 10R fused to an exceptionally large MS. EP and 10RP completely separated from the right 10R. LPPT large, fused to the side of HP, and often extended caudal. LCB completely fused to the base of the left cercus and bears one or more small mesal lobes. LC_1 never echinulated on its inner surface. Base of the right cercus ventrally extended basad and apically lobed. Apterous female: Body length 6.5 mm; width 1 mm. Body broader and cylindrical, similar coloration to male. Head longer than broad. Eyes small. No distinct family characters.

Distribution: South Mississippi to Florida and the coastal plains of Georgia, Mexico, Argentina, Brazil, Peru, Paraguay, Panama, Southwest Africa (Congo region with extensions into Uganda, Tanganyika and soutern Rhodesia) and Thailand.

Genus ***Oligembia*** Davis, 1939

Oligembia Davis, 1939: 217; 1942: 117; Ross, 1940b: 636; Ross, 1944: 459; Ross, 1952: 226; Ross, 1992: 133; Mill, 2009: 16.

Type species. - *Oligotoma hubbardi* Hagen, 1885: 142, by original designation.

Diagnosis. Males of *Oligembia* are distinguished from congeners by the following characters of the abdominal terminalia: Lines of fusion of 10L, 10R, and MS still evident as shallow, indistinct grooves, 10R with outer side short, tapered laterad. The apex of 10LP does not have an extensive, talon-like, inner process well separated from a flange-like outer portion. LCB has only a single inner process terminated by minute bifurcation. The inner side of RC_1 is relatively simple. Females without significant characters.

***Oligembia* sp.1**

(Figs. 4.58, 4.59, 4.60)

Material ex amined. 1♂, 2 ♀♀ (CUMZ-EMB-Ter.2010.308-310), **Thailand,** Tak Province, Mae Sod District, hill evergreen forest, 16°45.838'N 098°54.543'E, 943 m, 26. VI. 2009. All collected by P.Poolprasert.

Other s pecimens ex amined. 1♂ (CUMZ-EMB-Ter.2010.311), **Thailand,** Chaiyaphum Provivince, Thep S athit D istrict, deciduous di pterocarp f orest, 15°37.683'N 101°23 .323'E, 681 m, 07. IX. 2008; 1♂, 1♀ (CUMZ-EMB-Ter.2010.312-313), Chiang M ai, Sanpatong D istrict, H ill ev ergreen f orest, 18°32.217'N 098°31.377'E, 1258 m, 03. III. 2008; 1♂ (CUMZ-EMB-Ter.2010.314), Lampang P rovince, N gao D isrtict, m ixed de ciduous f orest, 18°46.361' N 99°58.123'E, 412 m , 12.X II.2008. 1♂ (CUMZ-EMB-Ter.2010.315) Loei P rovince, Phu R uea District, Hill evegreen forest, 17°29.907' N 101°20.483' E, 1196 m, 21. I I. 2008. 1♂ (CUMZ-EMB-Ter.2010.316), Petchabun Province, Nam N ao District, Mixed deciduous forest, 16°44.963'N 101°27.833'E, 711 m, 12. II. 2008; 1♂, 2♀♀ (CUMZ-EMB-Ter.2010.317-319), Khao Kh o District, Hill ev ergreen forest, 17°00.276'N 100°59.672'E, 1153 m, 05. IX. 2009. 1♂ (CUMZ-EMB-Ter.2010.320), Phitsanulok Province, Nakhon T hai D istrict, Mixed de ciduous f orest, 16°52.464' N, 100°49.665'E, 501 m, 28. X. 2009. 1♂ (CUMZ-EMB-Ter.2010.321), Ubon Ratchathani Province, Khong C hiam District, de ciduous di pterocarp forest, 17°12.839'N, 102°08.176'E, 230 m, 24. II. 2008. All collected by P. Poolprasert.

Description. Alate male (n = 9 , mean (range) ± SD): Head width x length 0.7 (0.6-0.8) ± 1.13 x 0.9 (0.8-1.0) ± 0.45 mm, body length 6.2 (6.0-6.4) ± 1.05 mm, width 0.7 (0.6-0.8) ± 0.53 mm, forewing length 3.8 (3.7-5.9) ± 0.41 mm, hindwing length 3.3 (3.2-3.4) ± 0.19 mm.

Head: Capsule elongate-oval, da rkish. Eyes d ark l avender. Submentum trapezoidal with shallow medial concave anterior magin. Mandible dark and slender. Antennae short, brownish throughout, 16 segmented

Thorax: Brownish throughout. Wings light brown with MA not forked. All legs entirely brownish. Hind leg with only one basitarsal papilla.

Abdomen: Light brown with terminalia paler. Terminalia with forward projection of MS extending one third length of ninth tergite (9), apex rounded. 10LP with apex dorsally furrowed. The inner lobe of LCB is finger-like, tapered distally leftward. LPPT sclerotized without outer hook. 10 LP broad basally then tapered terminally with small outer hook at apex. 10RP long, broad, gradually narrowing caudally, mostly membranous inner margin. LC_1, very broad basally then slightly constricted through distal tip.

Apterous female (n = 5 , mean (range) ± SD): Head width x length 0.7 (0.6-0.8) ± 0.27 x 1.0 (0.9-1.1) ± 0.35 mm, body length 6.4 (6.3-6.5) ± 0.17 mm, width 0.7 (0.6-0.8) ± 0.29 mm

Head: Capsule darkish, longer than width. Eyes smaller and less reiniform than in male. Antennae brown throughout, 14 segmented.

Thorax: Brownish throughout. All legs concolorous with thorax. Hind leg with only one basitarsal papilla.

Abdomen: Cylindrical, brown throughout. Tenth sternite symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.

Distribution. Northern, northeastern and western Thailand

Remark. This unknown species is very hard to see in the nature because its gallery is very small, completely concealed beneath pulverized bark particles and feces. Moreover, in this observation showed that most of the nests under the particular foliose lichen were pefererd to make. (Fig. 4.58C).

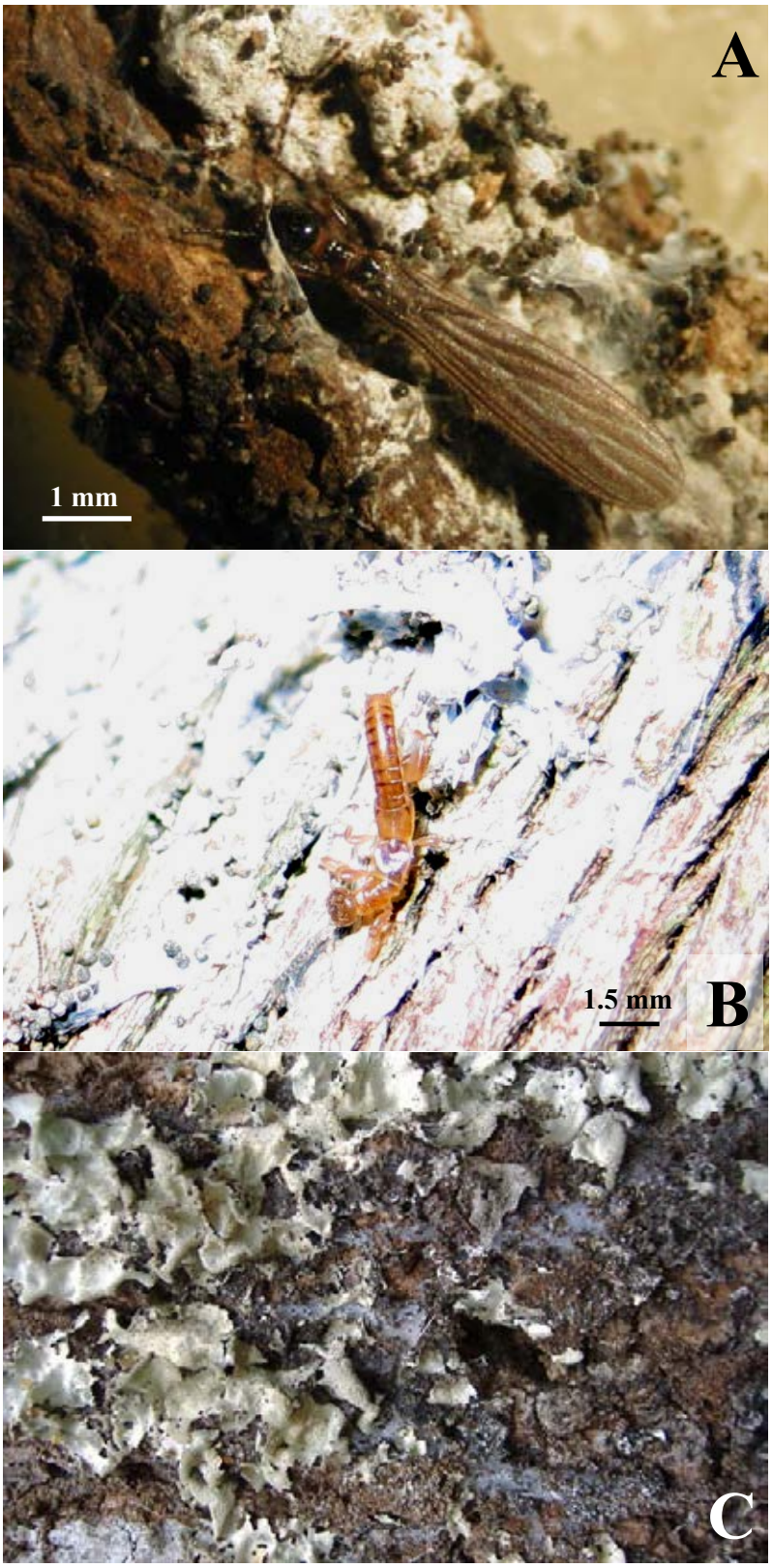


Figure 4.58 *Oligembia* sp.1 (A) male, (B) female and (C) silk gallery.

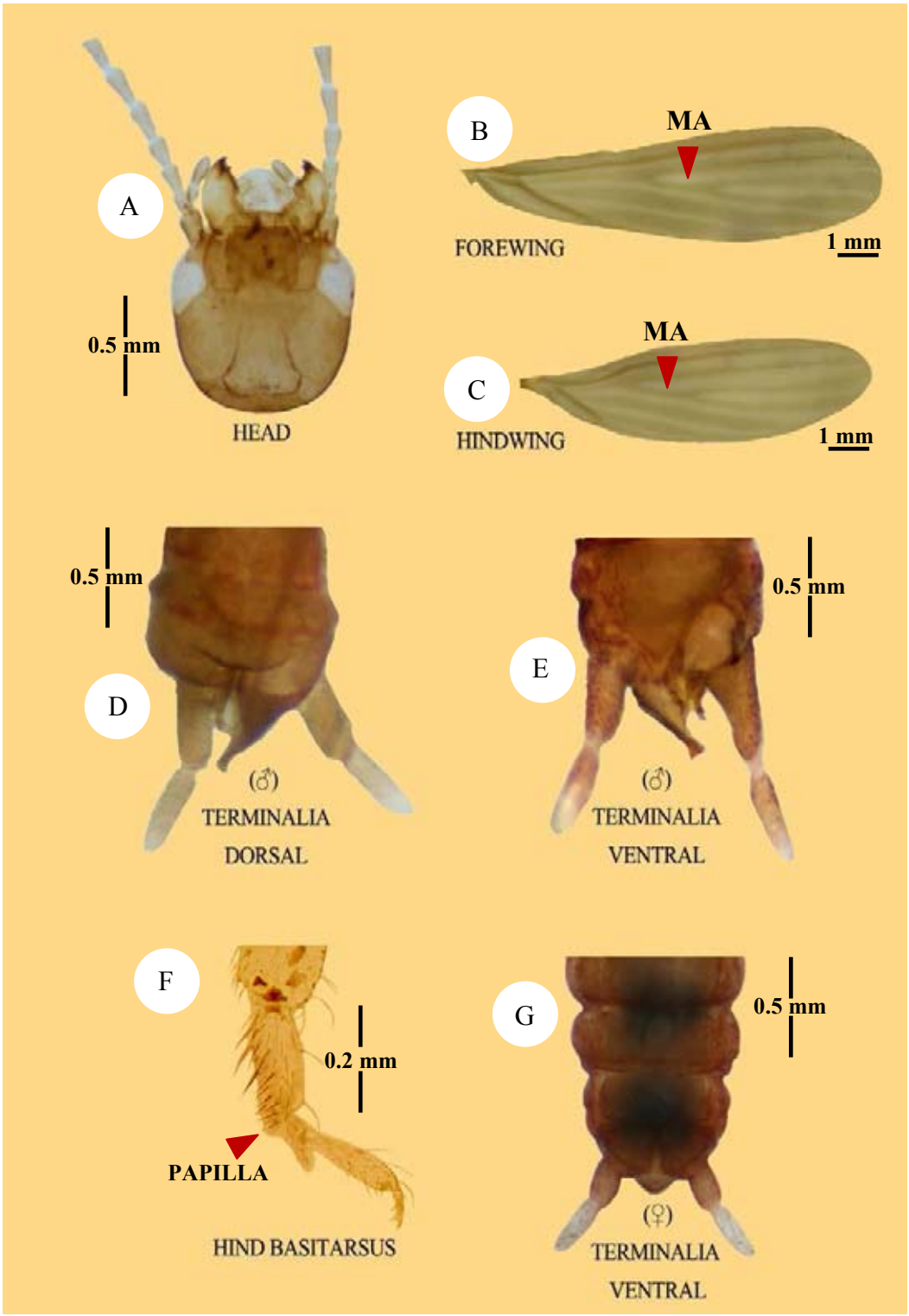


Figure 4.59 Important characters of male (A-F) and female (G) of *Oligembia* sp.1.

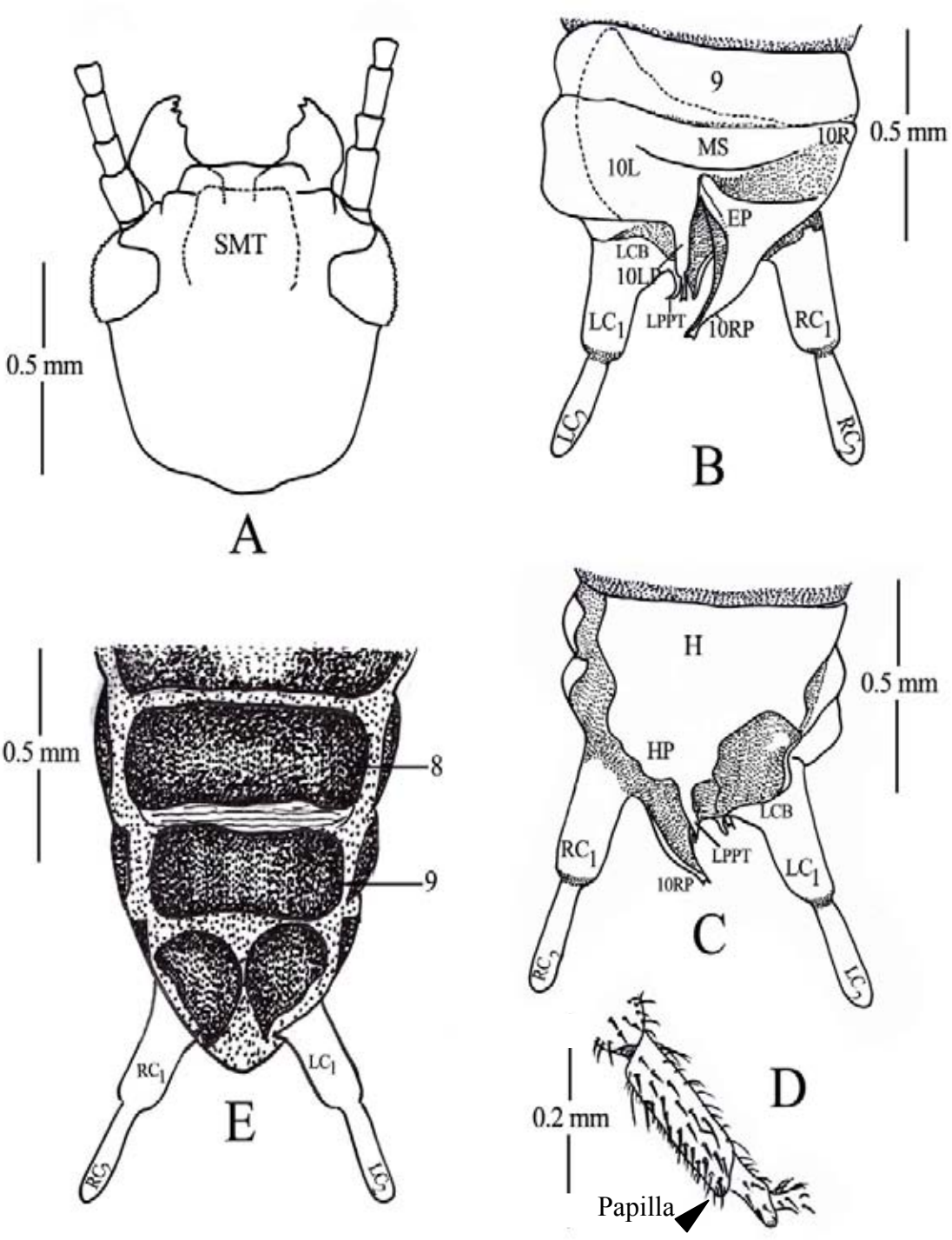


Figure 4 .60 Illustrations of *Oligembia* sp.1. (A) Head of male, (B) Terminalia (dorsal) of male, (C) Terminalia (ventral) of male, (D) Hind basitarsus of male and (E) Sternites of female.

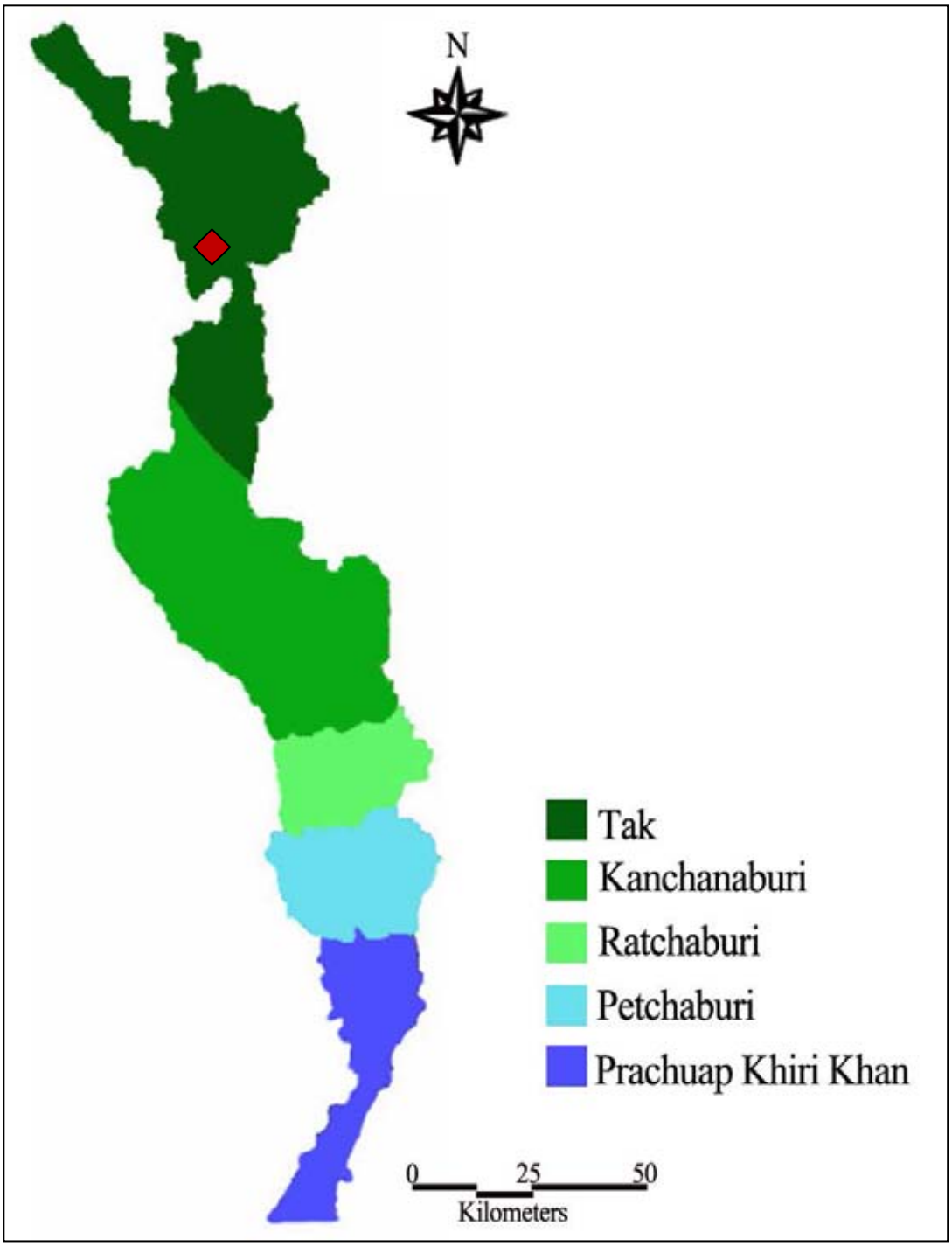


Figure 4.61 Distribution of the genus *Oligembia* (F. Teratembiidae) found in western Thailand.

◆ *Oligembia* sp.1

4.2 Diversity and distribution of webspinners

The species richness and distribution of the webspinners were conducted in both natural forests and human exploited areas: dry dipterocarp forest (DDF), dry evergreen forest (DEF), hill evergreen forest (HEF), mixed deciduous forest (MDF), beach forest (BF), tropical rain forest (TRF), coniferous plantation (CP), forest park (FP), rubber plantation (RP) and mango plantation (MP) including eight microhabitats: lichens, mosses, outer bark, on/ under rocks, termite mounds, bark crevices and soil in western Thailand by hand collecting from 2008 to 2010. From the studies, ten species and seven morphospecies, seven genera and four families were reported.

4.2.1 Diversity in different habitat characteristic types

As a result of this study, a total of four familiies of webspinners, inculding Embiidae, Oligotomidae, Notoligotomidae and Teratembiidae, were recorded in all localities. Taxonomic diversities (in term of S/G ratio) of webspinners for all localities were relatively high, with values ranging between 1 and 4 (Table 4.1). It was found that the major part of the Embiidina fauna of the western region is formed by the family Oligotomidae (10 species; 58.82 %), followed by Noligotomidae (4 species; 23.53%), Embiidae (2 species; 11.76 %) and Teratembiidae (1 species; 5.88%), respectively, in species richness (Figures 4.62 and 4.63). The genus *Ptilocerembia* was the richest genus with 4 species (23.53%) from the western region (Figures 4.64 and 4.65) followed by *Aposthonia, Eosembia* and *Oligotoma* (3 species each; 17.65% each), *Oedembia* (2 species; 11.67%), *Lobosembia* and *Oligembia* (1 species each; 5.88% each) (Table 4.2).

Table 4.1 Summary data on number of taxa and taxonomic diversities of webspinners in western Thailand.

Family	Genus	Species	S/G*
Embiidae	1	2	2
Notoligotomidae	1	4	4
Oligotomidae	4	10	2.5
Teratembiidae	1	1	1

*A low value for S/G implies a higher overall taxonomic diversity than a high value.

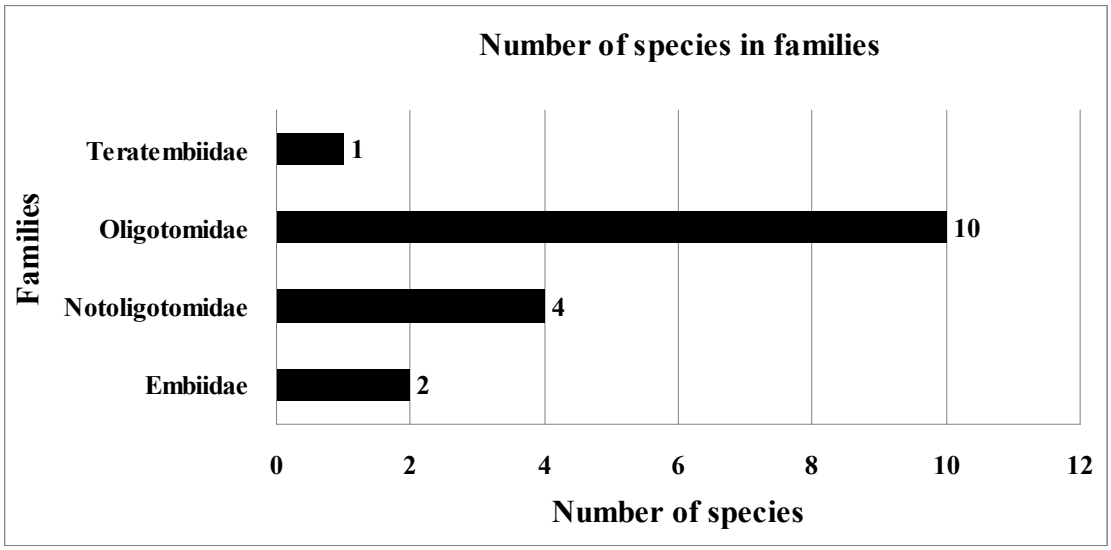


Figure 4.62 Number of species in the families.

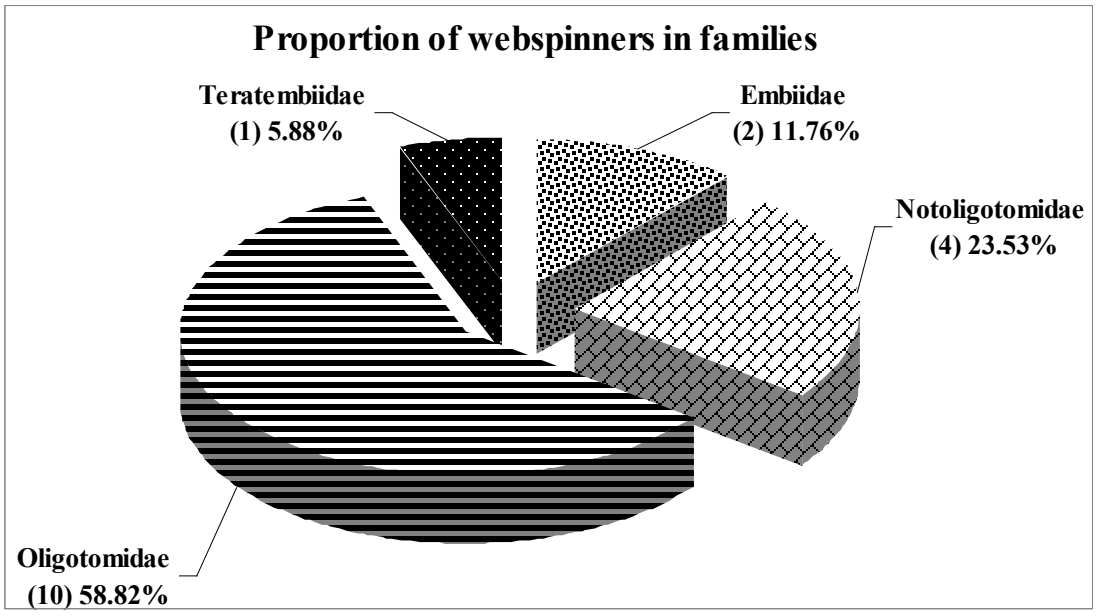


Figure 4.63 Proportion of webspinners in the families.

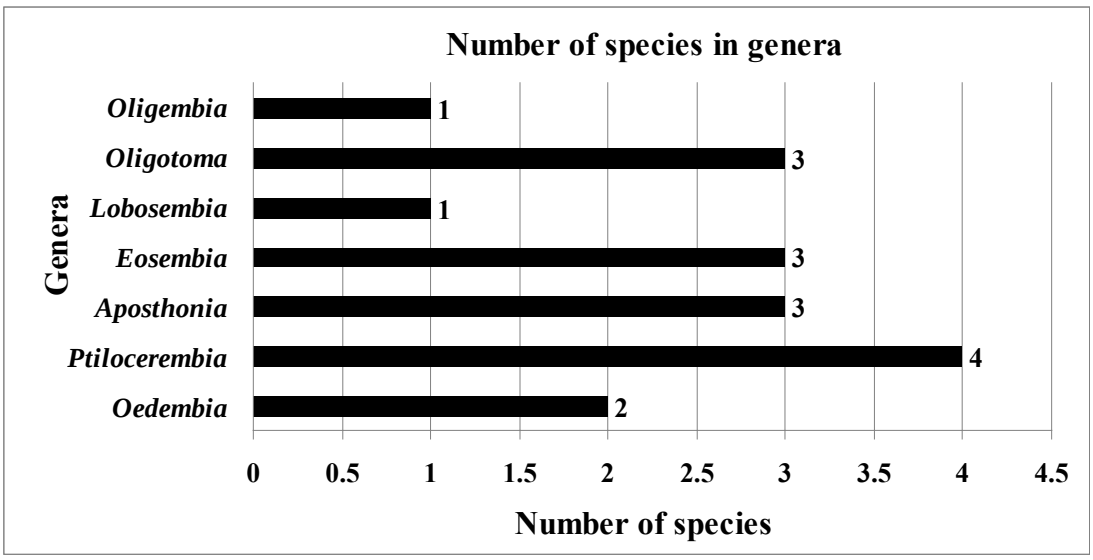


Figure 4.64 Number of species in genera.

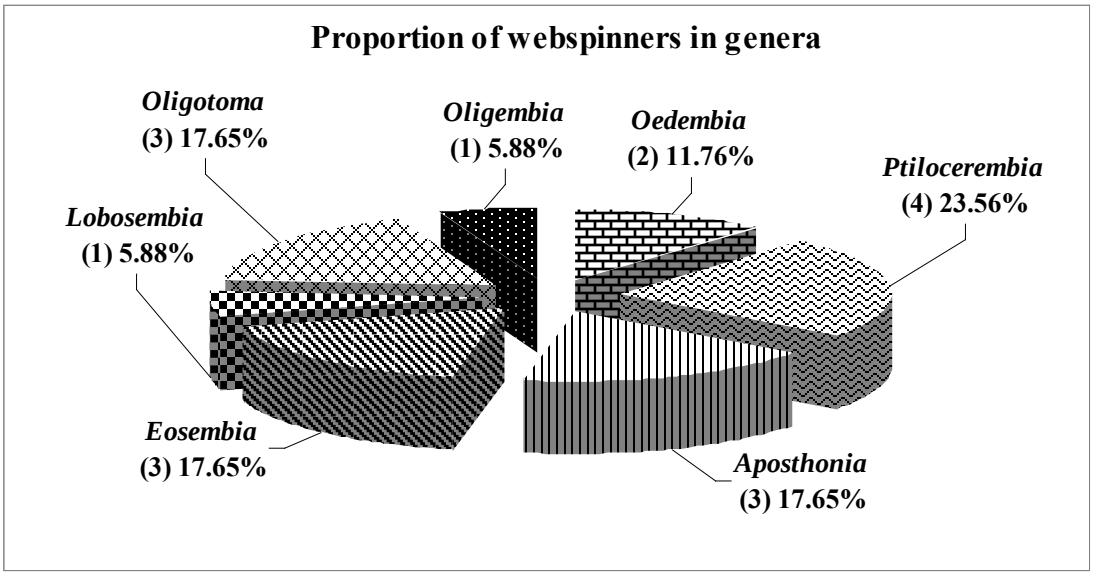


Figure 4.65 Proportion of webspinners in genera.

Table 4.2 Summary data on number of species in each genus of webspinners in western Thailand.

Families	Genera	Species
Embiidae	*Oedembia*	2
Notoligotomidae	*Ptilocerembia*	4
Oligotomidae	*Aposthonia*	3
	Eosembia	3
	Lobosembia	1
	Oligotoma	3
Teratembiidae	*Oligembia*	1
Total species		**17**

When the seven habitat types in natural forest and three habitat types in human areas of western Thailand were considered, the assemblages of webspinners were different for these of those land utilization. The total number of species of webspinners in each habitat type from the highest (6 species) to the lowest (1 species) was shown in Table 4.3 and 4.4. Taxonomic diversities (in term of S/G ratio) of webspinners for all habitat types were relatively high, with value ranging between 1.0 and 2.0 (Table 4.3).

Table 4.3 Summary data on number of taxa and diversity values for the various habitat types.

	Habitat characteristic types									
	Natural forests							Human exploited areas		
	DDF	DEF	HEF	MDF	CP	BF	TRF	RP	MP	FP
Total number of species	2	6	5	6	1	1	2	4	5	6
Total number of genera	2	3	4	5	1	1	2	3	3	3
Taxonomic diversity (S/G)*	1.0	2.0	1.3	1.2	1.0	1.0	1.0	1.3	1.7	2.0

Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.
*A low value for S/G implies a higher overall taxonomic diversity than a high value.

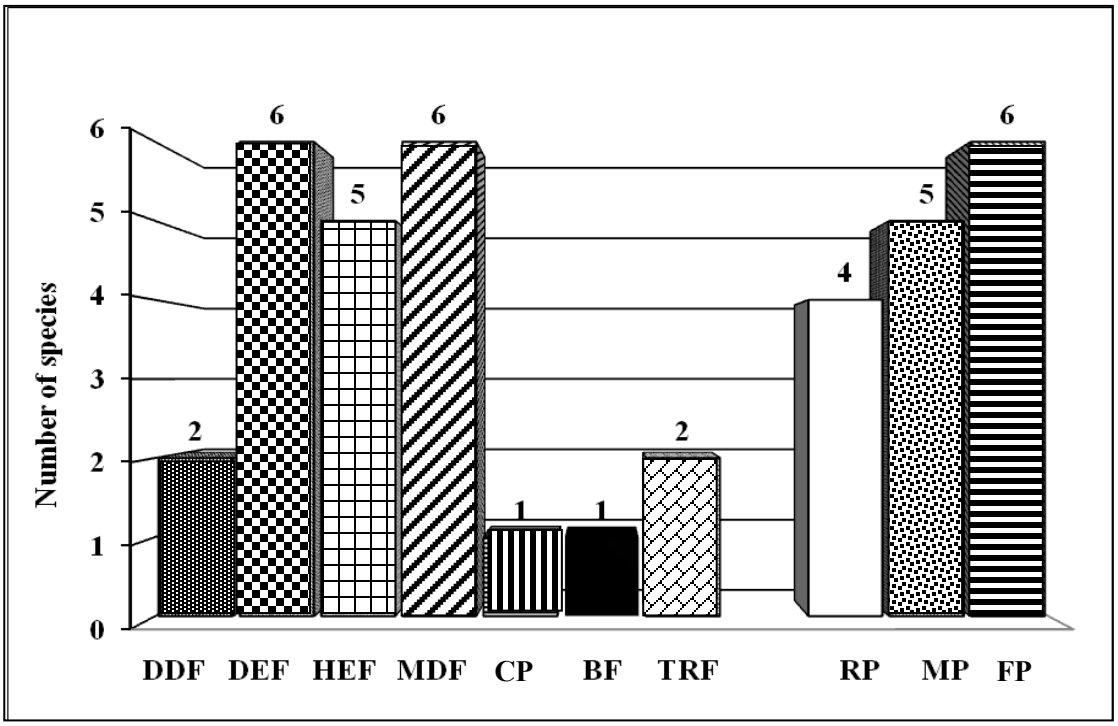
A total species of webspinners observed in natural habitats (23) was higher than the total species of webspinners in human habitats (15). The embiid species associated with habitat characteristic types were shown in Table 4.4.

Dry evergreen forest, mixed deciduous forest and forest park sheltered six species each (35.29% of total). Five species each (29.41%) were found in hill evergreen forest and mango plantation. Four species (23.53%) were found only in rubber plantation. Two species (11.76%) were found in dry dipterocarp forest and mixed deciduous forest and only one species (5.88%) were found in beach forest and coniferous plantation, respectively (Table 4.4 and Figure 4.66).

Table 4.4 List of embiid species found in different habitat types.

Species composition	Habitat types									
	Natural forests							Human exploited areas		
	DDF	DEF	HEF	MDF	CP	BF	TRF	RP	MP	FP
Family Embiidae										
Oedembia sp.1	-	X	X	-	-	-	-	-	-	-
Oedembia sp.2	-	-	-	X	-	-	-	-	-	-
Family Notoligotomidae										
Ptilocerembia sp.1	X	X	X	X	-	-	-	-	-	-
Ptilocerembia sp.2	-	-	-	X	-	-	-	-	-	-
Ptilocerembia sp.3	-	X	X	-	X	-	-	-	-	-
Ptilocerembia sp.4	-	-	-	-	-	-	X	X	-	-
Family Oligotomidae										
Aposthonia borneensis	-	-	-	-	-	-	-	-	X	X
Aposthonia ceylonica	-	-	-	X	-	X	-	X	X	X
Aposthonia problita	-	-	-	-	-	-	X	X	-	-
Eosembia auripecta	X	X	X	X	-	-	-	X	X	X
Eosembia lamunae	-	X	-	-	-	-	-	-	-	-
Eosembia paradorni	-	X	-	-	-	-	-	-	X	-
Lobosembia mandibulata	-	-	-	X	-	-	-	-	-	-
Oligotoma humbertiana	-	-	-	-	-	-	-	-	-	X
Oligotoma nigra	-	-	-	-	-	-	-	-	-	X
Oligotoma saundersii	-	-	-	-	-	-	-	-	X	X
Family Teratembiidae										
Oligembia sp.1	-	-	X	-	-	-	-	-	-	-
Species richness	**2**	**6**	**5**	**6**	**1**	**1**	**2**	**4**	**5**	**6**
Total species	**23**							**15**		

Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.



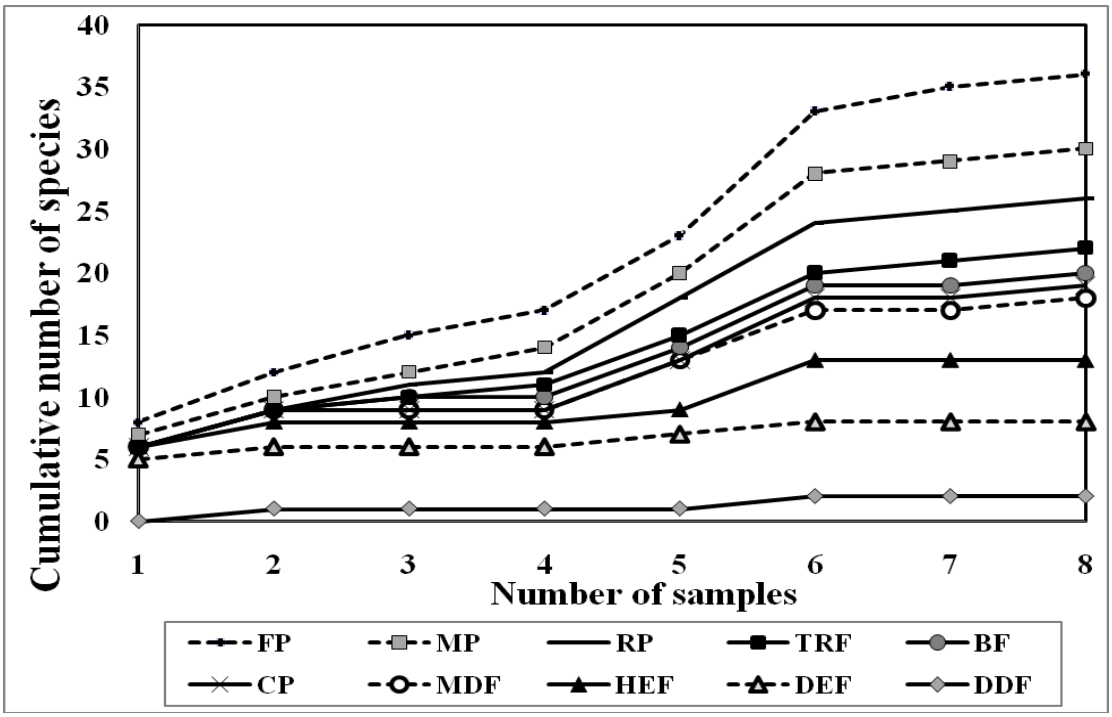
Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed de ciduous forest, BF = beach f orest, T RF = tropical r ain forest, C P = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.

Figure 4.66 Number of embiid species per habitat characteristic types.

In na tural f orests, dry ev ergreen forest h arbored six s pecies, a number ve ry similar to t hat of m ixed deciduous f orest, b ut t he composition of s pecies w as different. S pecies i n dr y evergreen f orest c omprising *Oedembia* sp.1, *Ptilocerembia* sp.1, *Plilocerembia* sp.3, *Eosembia auripecta, E. lamunae* and *E. paradonni* while *Oedembi*a sp.2, *Ptilocerembia* sp.1, *Ptilocerembia* sp.2, *Aposthonia ceylonica, Eoesmbia auripecta* and *Lobosembia mandibulata* were f ound i n mixed de ciduous forest. Five species including *Oedembia* sp.1, *Ptilocerembia* sp.1, *Ptilocerembia* sp.3, *Eosembia auripecta* and *Oligembia* sp.1 were appeared in hill evegreen forest. There were t wo species w ithin different each habitat found i n dry di pterocarp f orest (*Ptilocerembia* sp.1 and *Eosembia auripecta*) and tropical rain forest (*Ptilocerembia* sp.4 and *Aposthonia problita*). Only one species each were also found in coniferous plantation (*Ptilocerembia* sp.3) and be ach forest (*Aposthonia ceylonica*) (Table 4.4 and Figure 4.66).

In the human exploited areas, the highest number of species (6 species) occurred in forest park; *Aposthonia borneensis, A. ceylonica, Eosembia auripecta, Oligotoma humbertiana, O. nigra* and *O. saundersii* followed by five species, which occurred in mango plantattion; *Aposthonia borneensis, A. ceylonica, Eosembia auripecta, Eosembia paradoni* and *Oligotoma saundersii* whereas, the lowest number of species (6 species) occurred in rubber plantation; *Ptilocerembia* sp. 4, *Aposthonia ceylonica*, *A. problita* and *A. Eosembia auripecta*.

For the species accumulation curves (observed and expected) for all habitats, the curves of dry dipterocarp, dry evergreen and hill evergreen forests were consistent when survey stopped whereas the curves of mixed deciduous, beach, tropical rain forests and also coniferous plantations, forest park, rubber and plantations were still increasing slightly. Sampling of webspinners produces accumulation curves as shown in Figure 4.67



Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.

Figure 4.67 Species accumulation curve for webspinners survey in ten habitat characteristic types.

4.2.2 Community similarity in different habitat characteristic types

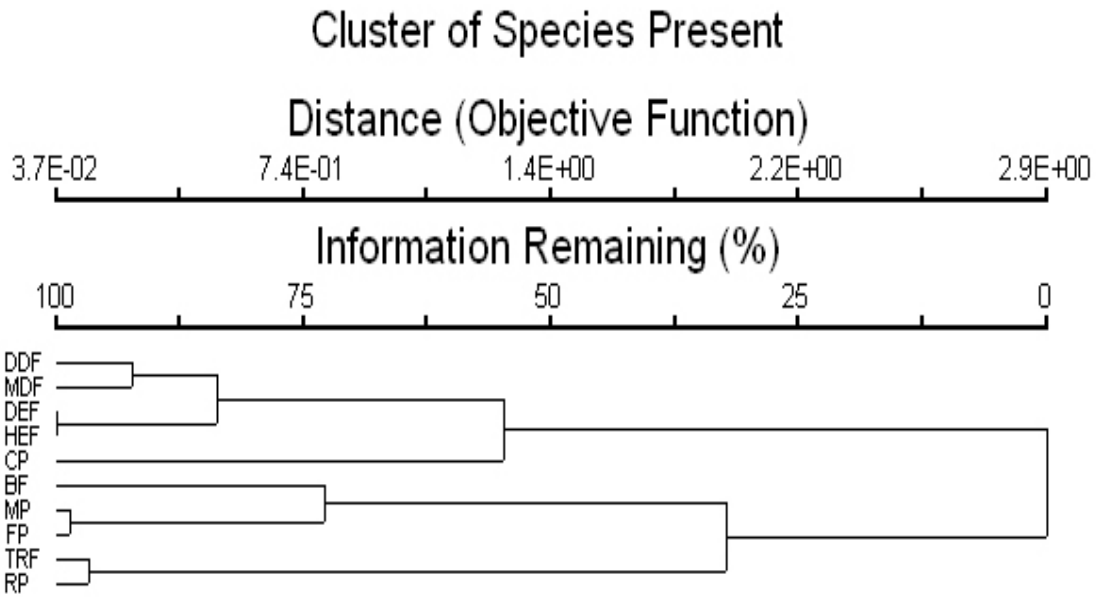
On the basis of the coefficient of community indices calculated for all possible combinations of the ten habitat characteristic types, no habitat had an index value higher than 0.5 (Table 4.5). Among the combinations of pair-wise comparison, the most similar habitats of natural forests were dry evergreen forest (DEF) and hill evergreen forest (HEF) (0.42). In the same manner, forest park and mango plantation shared the highest similarity (0.42).

The dendrogram produced from the cluster analysis (Figure 4.68) indicated that the communities of webspinners from the ten habitat types were somewhat different. The two habitat types of natural forests between dry evergreen forest (DEF) and hill evergreen forest (HEF) habitats were more similar to each other than those found at the various other habitats. In the same way, the cladogram showing the results of cluster analysis indicated that webspinner communities in mango plantation and forest park were more similar to each other than to the other types of human exploited areas.

Table 4.5 Pair-wise combinations of the assemblage of species recorded in natural forests and human habitats. Values are coeffcient of community indices (upper right) and number of species shared in common (lower left).

	DDF	**DEF**	**HEF**	**MDF**	**CP**	**BF**	**TRF**	**RP**	**MP**	**FP**
DDF	---	0.33	0.36	0.33	0.00	0.00	0.00	0.25	0.22	0.20
DEF	2	---	0.42	0.25	0.22	0.00	0.20	0.17	0.15	0.14
HEF	2	4	---	0.27	0.25	0.00	0.00	0.18	0.17	0.15
MDF	2	2	2	---	0.00	0.22	0.00	0.29	0.27	0.25
CP	0	1	1	0	---	0.00	0.00	0.00	0.00	0.00
BF	0	0	0	1	0	---	0.40	0.29	0.25	0.22
TRF	0	1	0	0	0	1	---	0.40	0.00	0.00
RP	1	1	1	2	0	1	2	---	0.31	0.29
MP	1	1	1	2	0	1	0	2	---	0.42
FP	1	1	1	2	0	1	0	2	4	---

Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.



Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.

Figure 4.68 Dendrogram of the communities of webspinners in the various habitat types, obtained by the cluster analysis.

4.2.3 Distribution

The comparison of the embiid species found in western region and other parts of Thailand were shown in Table 4.6. The total of number of species in the central, east, north, northeast and south of Thailand were 4, 5 10, 6 and 6 species, respectively. *Aposthonia ceylonica* and *Oligotoma saundersii* were fairly common thoughtout Thailand whereas *Oedembia* sp.2, *Ptilocerembia* sp.2 *Eosembia laumunae, E. paradorni* and *Oligotoma humbertiana* were recorded only in the western part of Thailand. Additionally, the map distributions of each species collected from these regions were given in Appendix Figures 1-7.

Table 4.6 List of webspinner species in western region compared with other regions of Thailand.

Species composition	Distribution in Thialad					
	West	**Central**	**East**	**North**	**Northeast**	**South**
Family Embiidae						
Oedembia sp.1	/	-	-	/	-	-
Oedembia sp.2	/	-	-	-	-	-
Family Notoligotomidae						
Ptilocerembia sp.1	/	/	-	/	/	-
Ptilocerembia sp.2	/	-	-	-	-	-
Ptilocerembia sp.3	/	-	-	/	-	-
Ptilocerembia sp.4	/	-	/	-	-	/
Family Oligotomidae						
Aposthonia borneensis	/	/	-	/	/	/
Aposthonia ceylonica	/	/	/	/	/	/
Aposthonia problita	/	-	/	-	-	/
Eosembia auripecta	/	-	/	/	/	/
Eosembia lamunae	/	-	-	-	-	-
Eosembia paradorni	/	-	-	-	-	-
Lobosembia mandibulata	/	-	-	/	-	-
Oligotoma humbertiana	/	-	-	-	-	-
Oligotoma nigra	/	-	-	/	-	-
Oligotoma saundersii	/	/	/	/	/	/
Family Teratembiidae						
Oligembia sp.1	/	-	-	/	/	-
Species richness	**17**	**4**	**5**	**10**	**6**	**6**

4.2.4 Altitudinal zonation

Specimens of webspinners collected from different altitudes and vertical distribtution of species exhibited different. Evaluations of vertical distribution of species were made in term of vertical intervals, which are appointed as 100 meters (A: 0-100 m, B: 101-200 m, C: 201-300 m, D: 301-400 m, E: 401-500 m, F: 501-600 m, G: 601-700 m, H: 701-800 m, I: 800-900 m and J: > 900 m). Evaluation of the results showed that there were differences in vertical distributions of species (negative relationship). Subconsequently, most of the species were collected from interval A: 0-100 m (14 species). This interval was followed by interval B: 101-200 m (9 species), interval C: 201-300 m (8 species), intervals D: 301-400 m and E: 401-500 m (4 species each), interval I: 801-900 (3 species), interval J: > 900 m (2 species) and intervals F: 501-600 m and H: 701-800 m (1 species each) whereas in interval G: 601-700 no webspinner were observed (Figure 4.69a and Table 4.7). Vertical distributions of species were given in Table 4.8. *Eosembia auripecta* were the most diverse species vertically.

Table 4.7 List of embiid spepecies at different altitudes.

Species composition	Altitude (m)															
	0-100						101-200					201-300				
	FP	BF	DEF	MP	TRF	RP	FP	DEF	MDF	MP	RP	DDF	DEF	MDF	MP	RP
Family Embiidae																
Oedembia sp.1	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Oedembia sp.2	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Family Notoligotomidae																
Ptilocerembia sp.1	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-
Ptilocerembia sp.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ptilocerembia sp.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ptilocerembia sp.4	-	-	-	-	X	X	-	-	-	-	X	-	-	-	-	-
Family Oligotomidae																
Aposthonia borneensis	X	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-
Aposthonia ceylonica	X	X	-	X	-	-	X	-	-	-	-	-	-	-	-	X
Aposthonia problita	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-
Eosembia auripecta	-	-	X	X	-	-	X	X	X	-	-	-	-	X	-	-
Eosembia lamunae	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Eosembia paradorni	-	-	-	-	-	-	-	-	-	-	-	-	X	-	*X*	-
Lobosembia mandibulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligotoma humbertiana	*X*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligotoma nigra	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Oligotoma saundersii	-	-	-	X	-	-	X	-	-	X	-	-	-	-	-	-
Family Teratembiidae																-
Oligembia sp.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Species richness	**3**	**1**	**2**	**4**	**2**	**2**	**4**	**1**	**1**	**2**	**1**	**1**	**2**	**3**	**1**	**1**
Total species	**14**						**9**						**8**			

Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.

Table 47. (Cont.)

Species composition	Altitude (m)									
	301-400			401-500		501-501	601-700	701-800	801-900	> 900
	DEF	MDF	CP	MDF	RP	CP		MDF	HEF	HEF
Family Embiidae										
Oedembia sp.1	-	-	-	-	-	-	-	-	-	X
Oedembia sp.2	-	-	-	-	-	-	-	-	-	-
Family Notoligotomidae										
Ptilocerembia sp.1	X	-	-	-	-	-	-	-	X	-
Ptilocerembia sp.2	-	-	-	X	-	X	-	-	-	-
Ptilocerembia sp.3	X	-	X	-	-	-	-	-	X	-
Ptilocerembia sp.4	-	-	-	-	-	-	-	-	-	-
Family Oligotomidae										
Aposthonia borneensis	-	-	-	-	-	-	-	-	-	-
Aposthonia ceylonica	-	X	-	-	-	-	-	-	-	-
Aposthonia problita	-	-	-	-	-	-	-	-	-	-
Eosembia auripecta	X	-	-	X	X	-	-	-	X	-
Eosembia lamunae	-	-	-	-	-	-	-	-	-	-
Eosembia paradorni	-	-	-	-	-	-	-	-	-	-
Lobosembia mandibulata	-	-	-	-	-	-	-	X	-	-
Oligotoma humbertiana	-	-	-	-	-	-	-	-	-	-
Oligotoma nigra	-	-	-	-	-	-	-	-	-	-
Oligotoma saundersii	-	-	-	-	-	-	-	-	-	-
Family Teratembiidae										
Oligembia sp.1	-	-	-	-	-	-	-	-	-	X
Species richness	**3**	**1**	**1**	**2**	**1**	**1**	**0**	**1**	**3**	**2**
Total species	**4**			**4**		**1**	**0**	**1**	**3**	**2**

Note: DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation.

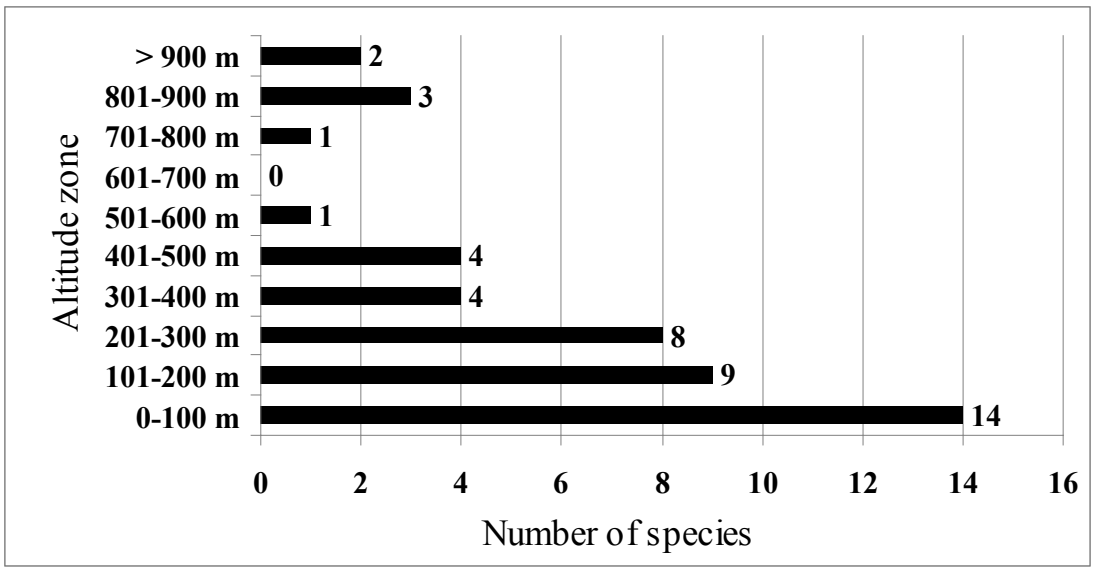


Figure 4.69 Number of collected species according to altitude zone.

Table 4.8 Number of species at different habitats and vertical distribution.

Species composition	Habitats	Vertical distribution
Family Embiidae		
Oedembia sp.1	DEF, HEF	C, J
Oedembia sp.2	MDF	C
Family Notoligotomidae		
Ptilocerembia sp.1	DDF, DEF, HEF, MDF	C, D, I
Ptilocerembia sp.2	MDF	E
Ptilocerembia sp.3	DEF, HEF, CP	D, E, F
Ptilocerembia sp.4	TRF, RP	A, B
Family Oligotomidae		
Aposthonia borneensis	MP, FP	A, B
Aposthonia ceylonica	MDF, BF, RP, MP, FP	A, B, C, D
Aposthonia problita	TRF, RP	A
Eosembia auripecta	DDF, DEF, HEF, MDF, RP, MP, FP	A, B, C, D, E,I
Eosembia lamunae	DEF	A
Eosembia paradorni	DEF, MP	C
Lobosembia mandibulata	MDF	H
Oligotoma humbertiana	FP	A
Oligotoma nigra	FP	B
Oligotoma saundersii	MP, FP	A, B
Family Teratembiidae		
Oligembia sp.1	HEF	J

Note: Habitats; DDF = dry dipterocarp forest, DEF = dry evergreen forest, HEF = hill evergreen forest, MDF = mixed deciduous forest, BF = beach forest, TRF = tropical rain forest, CP = coniferous plantation, FP = forest park, RP = rubber plantation, MP = mango plantation. Vertical distribution; A: 0-100 m, B: 101-200 m, C: 201-300 m, D: 301-400 m, E: 401-500 m, F: 501-600 m, G: 601-700 m, H: 701-800 m, I: 800-900 m and J: > 900 m.

4.2.5 Community similarity at different altitudes

Coefficient of community indices of webspinner communities among the different elevations (10 levels) were shown in Table 4.9. There were no elevation with an index value higher than 0.5. However, the assemblage recorded of embiid species between 0-100 meters had the highest similalities (0.42)

The dendrogram produced from the cluster analysis (Figure 4.70) indicated that the communities of webspinner from the ten elevations were quite different. The cladogram appearing the results of cluster analysis indicated those embiid communities at elevations between 0-100 meters and 101-200 meters were more similar to each other than those found at the various other elevations.

Table 4.9 Pair-wise combinations of the assemblage of species recorded from at different elevations. Values are coefficient of community indices (upper right) and number of species shared in common (lower left).

	0-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	> 900
0-100	---	0.42	0.22	0.27	0.15	0.00	0.00	0.00	0.15	0.00
101-200	5	---	0.25	0.31	0.18	0.00	0.00	0.00	0.18	0.00
201-300	2	2	---	0.40	0.18	0.00	0.00	0.00	0.31	0.20
301-400	2	2	3	---	0.25	0.00	0.00	0.00	0.40	0.00
401-500	1	1	1	1	---	0.33	0.00	0.00	0.40	0.00
501-600	0	0	0	0	1	---	0.00	0.00	0.33	0.00
601-700	0	0	0	0	0	0	---	0.00	0.00	0.00
701-800	0	0	0	0	0	0	0	---	0.00	0.00
801-900	1	1	2	2	2	1	0	0	---	0.00
> 900	0	0	1	0	0	0	0	0	0	---

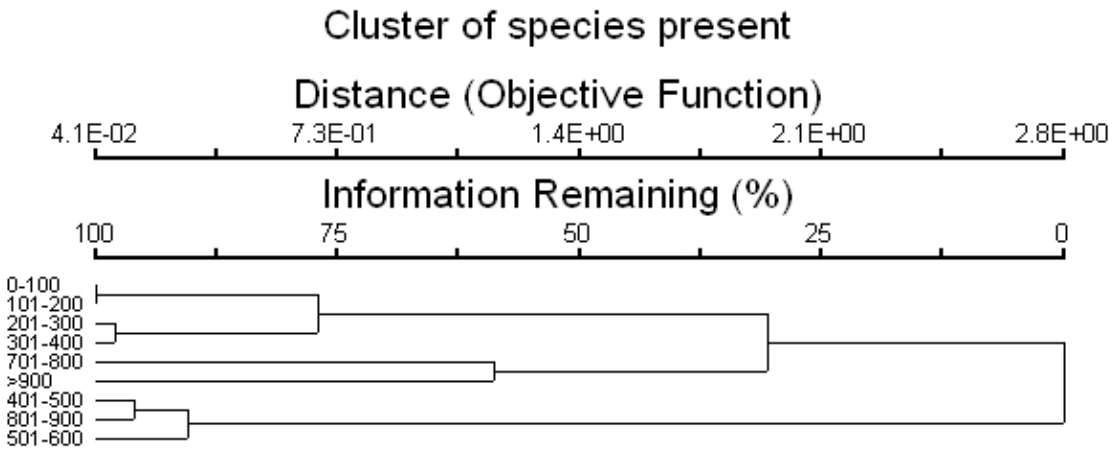


Figure 4.70 Dendrogram of the communities of webspinners in the different altitudes, obtained by the cluster analysis.

CHAPTER V

DISCUSSION

5.1 Taxonomic study of webspinners

From the study, 10 species, 7 morphospecies, 7 genera, and 4 families of webspinners were recorded from 5 provinces in western Thailand. These embiid species were found belonging to the families Embiidae Burmeister (2 morphospecies), Noligotomidae Davis (4 morphospecies), Oligotomidae Westwood (10 species), and Teratembiidae Krauss (1 morphospecies), respectively. In addition, 3 new record species and 3 new species, belonging to Oligotomidae, were discovered from this study (Table 5.1). In each species of 4 families was discussed as follows.

Family Embiidae Burmeister, 1836

Genus *Oedembia* Ross, 2007

In 2007, only two species in genus *Oedembia,* which distributed in India, Nepal, Pakistan and Myanmar, have been found by Ross. This genus is most closely related to *Parembia* Davis, 1939, treated in error by Ross (1950) as a subgenus of *Embia.* Ross (2007) considered *Oedembia* a distinct genus because of its swollen submentum, more elongate left tergal process. A transverse dorsal fold on the basal segment of the left cercus lobe is also absent in *Parembia*. There are also other distinctions.

For this study, two undescribed species were added (*Oedembia* sp.1 and *Oedembia* sp.2) in this genus. However, these two species are still unclear about their important characters, which are not related to this genus. Some additional character is related to genus *Ptilocerembia* in the family Notoligotomidae but it can be distinguished from *Ptilocerembia* by medial sclerite (MS) is narrower and longer than in *Ptilocerembia* except for hypandrium (H) and its process (HP) are similar to *Ptilocerembia*. It should be treated into the new genus and family (Ross, pers comm.).

Therefore, *Oedembia* from this study should be revised in Part II of Southeast Asia Embiidina of Dr. Edward Ross' Asia work in the near future.

Family Notoligotomidae Davis, 1940
Genus *Ptilocerembia* Friederichs, 1923

Davis (1940) established the new family Noligotomidae based on the Australian genera *Notoligotoma* Davis 1936. Several unrelated southeastern Asian genera were added in this family. *Ptilocerembia* Friederichs, 1923, which based on a single species, *P. roepkei* Friederichs, known only from Java and Sumatra was also added in this family. However, present collected materials shows that this genus is a complex of many species occurring in this study. It probably takes place also throughout Thailand and on all larger Indonesian islands, as well as in eastern Myanmar (Ross, 1963).

Only the genus *Ptilocerembia* remains under the present interpretation. Among many distinguishing features males of Ptilocerembiidae (*Ptilocerembia*) have a profusion of long, wavy setae on most antennal segments. Antennae of Notoligotomidae (*Notoligotoma*) have short setae on their slender antennal segments. The Notoligotomidae is strictly Australian, whereas Ptilocerembiidae occur in Indonesia and extensively in southeastern Asia. In Ptilocerembiidae the wings's posterior media vein (RP) is forked. This vein is unbranched in Notoligotomidae. In Ptilocerembiidae, the left tergal process (10LP) is short, rugose. In Notoligotomidae, 10LP is long, slender, and tapered to a sharp point. In the latter genera, its medial flap (MF) is conspicuous, elevated, arcuate and finely echinulated. In Ptilocerembiidae MF is not a flap but apparently with a variable hook which is subtended by a small echinulated nodule in some species. In Ptilocerembiidae, the hind basitarsus is densely clothed ventrally with large setae and dl ack apapilla whereas, in Notoligotomidae, the plantar surface has smaller well space and a terminal papilla.

The species compose groups, perhaps subgenera, which are most easily distinguished by female coloration. Males also have combination of good anatomical characters, especially in the head and terminalia.

Herein, four morphospecies from a survey of webspinners in the mountainous forest regions of western part of Thailand were discovered and described. As discussed above, genus *Ptilocerembia,* found from this study together with discovering by Ross from Malaysia, northern Thailand, Myanmar, Laos and Vietnam (Ross, pers comm.), is very distinct from the genus *Notoligotoma* of Notoligotomidae, which is now treated exclusively as an Australia family. Hence, *Ptilocerembia* would be treated as components of the new family and is expected to publish in the Embiidina of Southeast Asia Part II by Dr. Edward Ross.

Family Oligotomidae Enderlein, 1909

Genus *Aposthonia* Krass, 1911

The genus *Aposthonia* was established by Krauss (1911) and later synonymized with *Oligotoma* Westwood, 1837 by Davis (1940). Ross (1951) treated *Aposthonia* as a subgenus of *Oligotoma*, but later revised it as a genus in its own right (Ross 1963). Szumik (1996) suggested that *Aposthonia* might be paraphyletic because some characters of *Aposthonia* seem closer to *Oligotoma*; for instance, the anterior medial branch (MA) in the wings is itself unbranched. They also share the shape of the left paraprocts (LPPT), but this character is actually missing in some *Aposthonia*. According to Ross (2007), *Aposthonia* differs from *Oligotoma* by the absence of mesal lobing of the left cercus-basipodite (LCB) and the simplicity of the left paraproct process.

Based on the literature, (Bradoo 1967; Davis 1940; Enderlein 1912; Kapur & Kripalani 1957; Menon & George 1936; Mukerji 1935; Ross 1943, 1978, 2000b) and the results of our studies in Western Thailand, *Aposthonia borneensis* and *A. ceylonica* were recorded before and *A. problita* was described to be one new species for Thailand (Poolprasert *et al*., 2011a) (Table 5.1). Ross (1943, 1978) provided a thorough description of *Aposthonia borneensis* (Hagen, 1885). However, we have added more detail regarding some important morphological characteristics of Thai specimens, including the head, pappillae and genitalia of the male. Thai female specimens differ from previously described specimens in color pattern. Examples of *Aposthonia ceylonica* (Enderlein, 1912) have been reported by various authors under

the name *Oligotoma ceylonica* (Bradoo 1967; Davis 1940; Enderlein 1912; Kapur & Kripalani 1957; Menon & George 1936; Mukerji 1935). Ross (2000b) transferred this species from *Oligotoma* to *Aposthonia* without description, so the details of the male characters as well as providing female characters have been added. In addition, *Aposthonia problita* discovered in this study is the 3rd species described in this genus of Thailand and it is the 25th species of the world (Poolprasert *et al,* 2011a).

Genus *Eosembia* Ross, 2007

The genus *Eosembia* is closely related to the genera *Aposthonia* Krauss, 1911 and *Oligotoma* Westwood, 1837. Ross (2007) erected *Eosembia* as a new genus on the basis of the following characters: the antennae are usually distally white, the setae are usually longer than the bearing segment and there are two ventral papillae on the hind basitarsi. Consequently, some species of the *Aposthonia* and the *Oligotoma* were then moved to *Eosembia*.

This work represents an additional contribution to the knowledge of the embiid fauna of Thailand, specifically from the mountains of the western region. Previous notes about Thai embiids in the genus *Eosembia* are included (*E. aequicercata* Ross, 2007, *E. apterosa* Poolprasert and Edgerly, 2011 and *E. auripecta* Ross, 2007) with emphasis on their ecological preferences. Because embiids can be found in several forest types (Ross, 2000b), it is possible that a rich fauna remain in the patchy remnants of the diverse flora of Thailand, particularly in the biodiversity hotspot of western forested zones (Poolprasert and Edgerly, 2011). From survey in the mountainous forested zones of western Thailand, *Eosembia lamunae* and *E. paradorni* were discovered (Poolprasert *et al*, 2011b). These species bring the total number of species known from eastern, south eastern and southern Asia to 15 species. However, there are more than 25 species in this genus which are waiting for description (Ross, 2007).

Genus *Lobosembia* Ross, 2007

In 2007, Ross erected the genus *Lobosembia*, which based on a single species, *Lobosembia mandibulata* as a new genus on the basis of the following distinguish characters: the lobe mandible and that of the submentum and the composite left paraproct (HP+LPPT). The hypandrium (H) lobe and gallery formation distinguish this genus from all others in the family but it is probably most closely related to the genus *Aposthonia* Krauss, 1911. In addition, he also collected a possible new species in northwest Thailand.

Genus *Oligotoma* Westwood, 1837

Three species of *Oligotma* (Oligotomidae): *O. humbertiana*, *O. nigra* and *O. saundersii*, respectively, are the first recorded from Thailand (Table 5.2). *Oligotoma* is potentially one of the largest genera of Embiidina and it is relatively common and cosmopolitan because of the rapid (anthropogenic) colonization and proliferation rates, being spread by humans throughout tropical Asia (Ross, 2000, 2007).

All three species reported here predominately occur in northern India (Ross 2000). However, *Oligotoma humbertiana* is very common in eastern and southern Asia including being recorded in Thailand, albeit thus far only at a single locality in the Prachuap Khiri Khan Province. *O. saundersii* is likely to be found in either tropical or temperate zones, and in this study in Thailand. *O. nigra* is commonly found in the Middle East and the Red Sea region (Ross 2006), and now also extends into the southern United States as an introduced species (Ross, 1957), in addition to other localities where it can also be found. Presently, it was identified in Tak Province.

Family Teratembiidae Krauss, 1911

Genus *Oligembia* Davis, 1939

The genus *Oligembia* is closely allied to the *Diradius* Friederichs, 1934, in which, the process of the left hemitergite (10L) is simply tapered, and the left cercus-basipodite of different form (Davis, 1940). The left cercus is also superficially similar

to those of *Oligotoma* Westwood, 1837. However, *Oligembia* can be distinguished from *Oligotoma* by the wing with anterior media (MA) is forked.

Actually, this morphospecies from this study along with Ross' collection is not very closely related to any other known genus except *Oligembia*. The detail of characters especially terminalia, which are complex within teratembiid group, is still obscure. Both segments of left and right cerci of this morphospecies seem to be equal in both size and shape (Ross, pers comm.). Subsequently, it is not possible to develop an adequate classification at this time. Currently, because most of the many Thai taxa, which were compiled both from this study and Ross' collection, await close study and description. Careful study, based on sufficient series, may prove this to be a distinct species. Therefore, this is possible that Thai teratembiid fauna will move to be new genus and species of Teratembiidae in the further study.

Table 5. 1 The reports of webspinners from Thailand are provided. Presence and absence of each species are indicated by + and – respectively.

Species	Ross, 1978	Ross, 2000a	Ross, 2007	Poolprasert & Edgerly, 2011	Present study
Family Embiidae					
Oedembia sp.1	-	-	-	-	+
Oedembia sp.2	-	-	-	-	+
Family Notoligotomidae					
Ptilocerembia sp.1	-	-	-	-	+
Ptilocerembia sp.2	-	-	-	-	+
Ptilocerembia sp.3	-	-	-	-	+
Ptilocerembia sp.4	-	-	-	-	+
Family Oligotomidae					
Aposthonia borneensis	+	-	-	-	+
Aposthonia ceylonica	-	+	-	-	+
Aposthonia problita	-	-	-	-	+
Bulbosembia thailandica	-	-	+	-	-
Eosembia aequicercata	-	-	+	-	-
Eosembia apterosa	-	-	-	+	-
Eosembia auripeceta	-	-	+	-	+
Eosembia lamunae	-	-	-	-	+
Eosembia paradorni	-	-	-	-	+
Lobosembia mandibulata	-	-	+	-	+
Oligotoma humbertiana	-	-	-	-	+
Oligotoma nigra	-	-	-	-	+
Oligotoma saundersii	-	-	-	-	+
Family Teratembiidae					
Oligembia sp.1	-	-	-	-	+

5.2 Species diversity and distribution of webspinners

In the survey of species richness of webspinners along with an altitudinal gradient of 0 meter to 1000 meters and various habitat types i.e. dry dipterocarp forest (DDF), dry evergreen forest (DEF), hill evergreen forest (HEF), mixed deciduous forest (MDF), beach forest (BF), tropical rain forest (TRF), coniferous plantation (CP), forest park (FP), rubber plantation (RP) and mango plantation (MP) All of ten species and seven morphospecies, seven genera and four families were reported.

The total number of species collected per family per altitude was deferent influenced by the interaction between in sect family and altitudes. It might be indicated that the distribution of webspinner communities in western Thailand varied with altitudes and in which family of particular webspinners was in. Many researchers have used altitude, an indirect environmental variable, as a surrogated variable for temperature (Sanders, 2002 ; Thakur *et al.,* 2008; Wolda, 1987). However, this parameter is complex and may co-vary with other climatic factors such as wind, rainfall and cloud cover and with the isolation degree on the summit of mountains. A negatively respond along the altitudinal gradients with insect species richness has been reported in different ecosystems (i.e., in mountain forests by Idris *et al*., 2002).

Oedembia sp.1 was found from Tak Province at elevations of 201-1,000 meters (Table 5.1) and distributed in dry dipterocarp forest, dry evergreen forest and hill evergreen forest whereas *Oedembia* sp.2 was known from Ratchaburi Province at 201-300 meters that occurred only mixed deciduous forest. These two species seemed to be distributed along near Myanmar (Appendix Figure 1.) where *Oedembia burmana* were discovered in south east of Mandalay at elevation of 100-1,800 meters. According to Ross, genus *Oedembia* has only two species that were found in 2007 and were distributed in India, Nepal, Pakistan and Myanmar. In this study, both species could increase additional records from Thailand. Therefore, it is possible that genus *Oedembia* will be multispecific and profilic in Eastern Asia. These species of *Oedembia* may also have increased as a result of colonial traffic (Ross, 2007).

Ptilocerembia spp. could be found at both low and high elevations from 0-900 meters (Table 5.2) in tropical evergreen forests i.e. dry dipterocarp, dry evergreen, hill

evergreen, mixed deciduous and tropical rain forests and rubber plantation. *Ptilocerembia* sp. 1 and *Ptilocerembia* sp. 3 were fairly common in natural forest whereas *Ptilocerembia* sp. 2 and *Ptilocerembia* sp. 4 were limited in specific areas. *Ptilocerembia* sp. 2 can be encountered in mixed dry evergreen forest where multiplecrops occurred, but *Ptilocerembia* sp.4 can be appeared in tropical rain forest where high moisture occurred in this habitat type. Nonetheless, *Ptilocerembia* sp. 4 can also extended occupying with rubber plantation near the natural forest. It would be suggested that in the more humid areas of both habitat characteristic types where *Ptilocerembia* sp. 4 found are being inhabit restricted habitat. Besides, addition records of these four species in genus *Ptilocerembia* found from Thailand are also reported and presented in map distribution (Appendix figure 7).

In the current survey, the habitat of *Aposthonia borneensis* was always on the bark of shade trees and near residential or developed areas at the elevation between 0-200 meters (Table 5.2), such as orchards, forest park (ornamental plants) and plantations, but it was never found in forest habitats (Poolprasert *et al*., 2011a). This species is an anthropogenic "weed" species with a wide distribution in the commercial areas of many localities in southern Asia, Indonesia, Laos and Malaysia and has previously been recorded from Nan Province in Thailand (Ross, 1978). These records suggest that this species is now relatively common and widespread throughout Thailand (Appendix Figure 3). The habitats of *Aposthonia ceylonica* were found to be on the orchard, forest park, rubber plantations, beach forest and mixed deciduous forests in western region. Moreover, *A. ceylonica* can be found at the low to average level of elevation (0-400 meters) as shown in Table 5.2. For *Aposthonia problita,* which are considered as new species (Poolprasert *et al*., 2011 a), may well be widespread across much of Thailand, as it is commonly found in tropical rain forests and in rubber plantations in southern Thailand (Nakhon Si Thammarat and Ranong Provinces), Sa Kaeo Province in eastern Thailand and Prachuap Khiri Khan Province in western Thailand (Appendix Figure 3). This species also found less than 100 meters (Table 5.2) above sea level. Therefore, it might be expected that this species may thrive in restricted habitats having specific requirements within these habitats.

From surveys in the mountainous forest regions of western Thailand, two previously unknown *Eosembia* species (*E. lamunae* and *E. paradorni*) were

discovered and considered to be new species (Poolprasert *et al*., 2011b), one each from Prachuap Khiri Khan and Kanchanaburi Provinces, respectively. Both *Eosembia lamunae* and *E. paradorni* can be found in dry evergreen forest at low to average elevation (Table 5.2). *Eosembia parodorni* also extended to colonize in mango plantation near dry evergreen forest. On the other hand, *Eosembia auripecta* was fairly common in this study and was able to be encountered in both residential areas and natural forests at the low to high above sea level (Table 5.2). The known map distribution of three species found from western region and other parts of Thailand are also shown in Appendix Figure 4.

Lobosembia mandibulata was distributed in the mixed tropical forest of nothern Thailand i.e. east slope of Doi Sutep, 400-600 meters, Samuang District, 900 meters and northwest of Fang District, Chiang Dao (cave), Chiang Mai Province and probably also ranged into Laos, eastern Myanmar, and southwest China (Ross, 2007). For addtional record in this study, *Lobosembia mandibulata* was found only in mixed deciduous forest at high elevavtion (Table 5.2) from Tak Province. Their colonies were also most often spun on the bark surface of slender trees in open hardwood forest on sunny ridges of the lower slope of montains (Ross, 2007). Distribtution of this species is still limited in Tak and Chiang Mai Provinces (Appendix Figure 5).

These three embiids within the genus *Oligotoma* can be found in various habitat types, being either forests or human habitats. The majority of habitats in this study were found on the tree bark of shaded trees and near to residential areas, such as in forest parks and gardens. However, some were found in dry dipterocarp or dry evergreen forests. The habits of *O. humbertiana* have been rather extensively described (Ling 1934a, 1934b; Ananthasubramanian, 1957; Edgerly 1997), and our observations in this survey have so far mostly concurred with them. *O. humbertiana* was presented under the bark of *Cassia fistula* and inside the hollows of dry twigs in forest park at the low elevation (Tables 5.2). It tends to be a solitary embiid being found alone in galleries. *Oligotoma nigra* was found on the bark of ornamental trees (especially in the family *Palmae*) located around villages and gardens. This species appears to prefer dry areas (Ross, 2006), and was apparently introduced into southern United States in date palm cuttings (Ross, 1957). Herein, it was found in western Thailand (Tak Province) in the plantation at about 200 meters elevation (Tables 5.2).

However, it is not reported to be occupying natural habitats. *Oligotoma saundersii* was never found inhabiting exposed places during the dry season, but rather they were found to disappear into crevices and under the bark of trees and other humid and shady places. This probability shows the moist atmosphere is suitable for them. In addition, *O. saundersii* tends to inhabit the bark crevices of trees, the most common being found were *Acacia auriculaeformis, Cassia javanica, Mangifera indica, Pithecolobiuma* and *Tamarindus indica*. Most *Oligotoma saundersii* from this study was found in human habitats i.e. orchard, plantation and forest park at the low level of elevation (Table 5.2). This species was dominant at this altitudinal sites. The social and maternal care habits of these insects, as observed during this study at the collection sites and in the laboratory rearing (data not shown), were consistent with the well-known habits that have been reported before for this species in other localities (Edgerly *et al*, 2002; Lee *et al.*, 2002). Because they tend to live in groups that adopt shared breeding sites and cooperation in brooding care, they are considered as communal colonies. The maps showing the distribution of three species was exhibited in Appendix Figure 6.

Only *Oligembia* sp.1 of family Teratembiidae was discovered from Tak Province at the high altitude in hill evergreen forest (Table 5.2). It was considered as rare and elusive species because of its camouflage beneath pulverized bark particles and feces. However, to increase more about its distribution of this genus, additional records were conducted from other parts of Thailand. The results showed this species were also found especially in northern and northeastern regions (Appendix Figure 7).

Table 5.2 Altitudinal occurrences of embiid species found from western Thailand.

Species composition	Altitude (m)									
	0-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	> 901
Family Embiidae										
Oedembia sp.1	-	-	X	-	-	-	-	-	-	X
Oedembia sp.2	-	-	X	-	-	-	-	-	-	-
Family Notoligotomidae										
Ptilocerembia sp.1	-	-	X	X	-	-	-	-	X	-
Ptilocerembia sp.2	-	-	-	-	X	-	-	-	-	-
Ptilocerembia sp.3	-	-	-	-	X	X	-	-	X	-
Ptilocerembia sp.4	X	X	-	-	-	-	-	-	-	-
Family Oligotomidae										
Aposthonia borneensis	X	X	-	-	-	-	-	-	-	-
Aposthonia ceylonica	X	X	X	X	-	-	-	-	-	-
Aposthonia problita	X	-	-	-	-	-	-	-	-	-
Eosembia auripecta	X	X	X	X	X	-	-	-	X	-
Eosembia lamunae	X	-	-	-	-	-	-	-	-	-
Eosembia paradorni	-	-	X	-	-	-	-	-	-	-
Lobosembia mandibulata	-	-	-	-	-	-	-	X	-	-
Oligotoma humbertiana	X	-	-	-	-	-	-	-	-	-
Oligotoma nigra	-	X	-	-	-	-	-	-	-	-
Oligotoma saundersii	X	X	-	-	-	-	-	-	-	-
Family Teratembiidae										
Oligembia sp.1	-	-	-	-	-	-	-	-	-	X
Species richness	**8**	**6**	**6**	**3**	**3**	**1**	**0**	**1**	**3**	**2**

CHAPTER VI

CONCLUSIONS AND RECOMMENDATION

A taxonomic study, species richness and distribution of webspinners were carried out in western part of Thailand, which is situated in the biodiversity hotspot, and covered five provinces; Tak, Kanchanaburi, Petchaburi, Ratchaburi and Prachaub Khiri Khan. The study took place from 2008 to 2010 in both wet and dry seasons at each study site. Adult specimens of webspinners were collected by visual searching and hand collecting from the field in both forest and human habitat areas. Some adult specimens were obtained under laboratory rearing. The dichotomous and pictorial keys have been constructed to distinguish among families, genera, and species levels of Embiidina from the study, especially keys to Thai webspinners, based on adult females are provided for rapid observation in the field study and in the laboratory observation.

Over 456 specimens were examined based on morphological characters. Four families, 7 genera, 10 species and 7 morphospecies of webspinners were collected in this study. The family Oligotomidae contained the greatest number of species (10) inventory: *Aposthonia borneensis, A. ceylonica, A. problita, Eosembia auripecta, E. lamunae, E. paradorni, Lobosembia mandibulata, Oligotoma humbertiana, O. nigra* and *O. saundersii*, followed by Notoligotomidae (4): *Ptilocerembia* sp.1, *Ptilocerembia* sp.2, *Ptilocerembia* sp.3 and *Ptilocerembia* sp.4, Embiidae (2); (*Odembia* sp. 1 and *Odembia* sp.2) and Teratembiidae (1): *Oligembia* sp.1. Of the 10 species and 7 morphospecies, three species of genus *Oligotoma; O. humbertiana, O. nigra* and *O. saundersii* were the first records in Thailand and three species; *Aposthonia problita, Eosembia lamunae* and *E. paradorni* found for the first time, were described and recorded to be newly to science.

Most of the webspinners in the study are widely distributed in different habitat types and at a wide range of gradient from 0 to 1,000 meters. The common habitat of webspinners, which is one and under tree bark, some were found on rock covered in moss and lichens, under leaf litter and in soil. *Aposthonia problita* is known from this study and may be endemic, as it was collected only in tropical rain forest and some in

rubber plantations. In the same manner, *Eosembia lamunae* and *E. paradorni* may be endemic in dry ever green forest except for *E. auripecta*, fairly common species, can be found in several habitats of this subregion. Additionally, all species of *Oligotoma, Aposthonia borneensis* and *A. ceylonica*, weed or introduced species, were also found in this study. However, the number of species associated with each habitat type, elevation and season are more limited.

From this study alone, there are still seven morphospecies that are not published which would likely to change poorly known embiids fauna status in Thailand. This present work is only part of Ross' Asia work, which will be included the description of new families in Embiidina of Southeast Asia Part II. It is plausible that a rich fauna exists. In addition, this study did not cover a full geographic range of habitat coverage of the country, therefore, further surveys are still require and are likely to reveal future new records and species for Thailand. However, the results from this study increased the available information on the zoological distribution of order Embiidina within Thailand. It is worthwhile to suggest that a more extensive evaluation of these uncommon and elusive species in the other countries of Southeast Asia (e.g., Myanmar, Laos and Malaysia) occurs in order to build a better understanding of the biodiversity and biogeography of order Embiidina.

Based upon field observations, the quantitative analysis of behaviors in various webspinner species should be initiated. The information from such studies should add significantly to the scant information that currently exists in the literature, especially in the field of biodiversity and evolutionary of webspinners, and may further aid in the understanding of the evolution of eusociality. Moreover, a molecular and morphological phylogenetic trees should be constructed.

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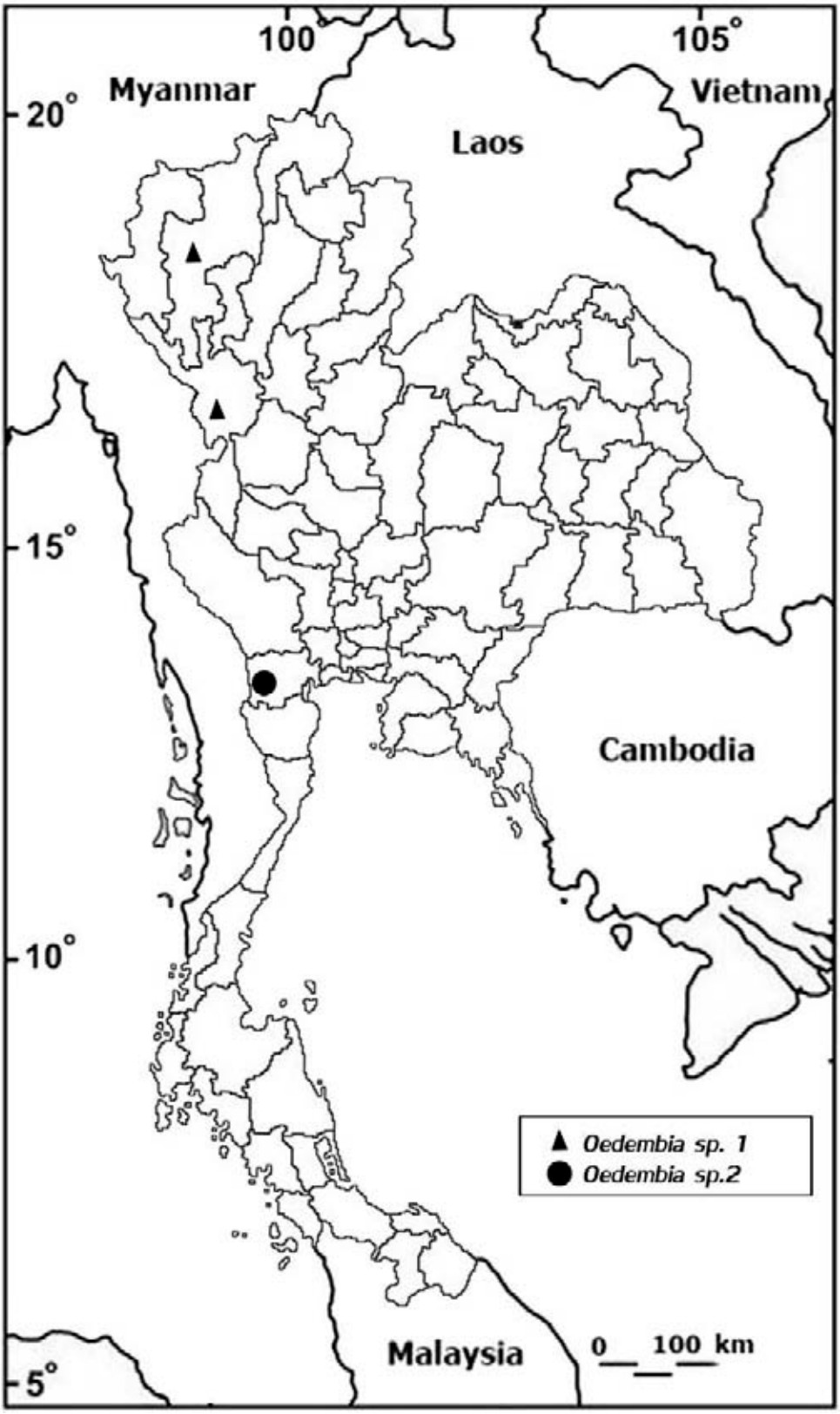
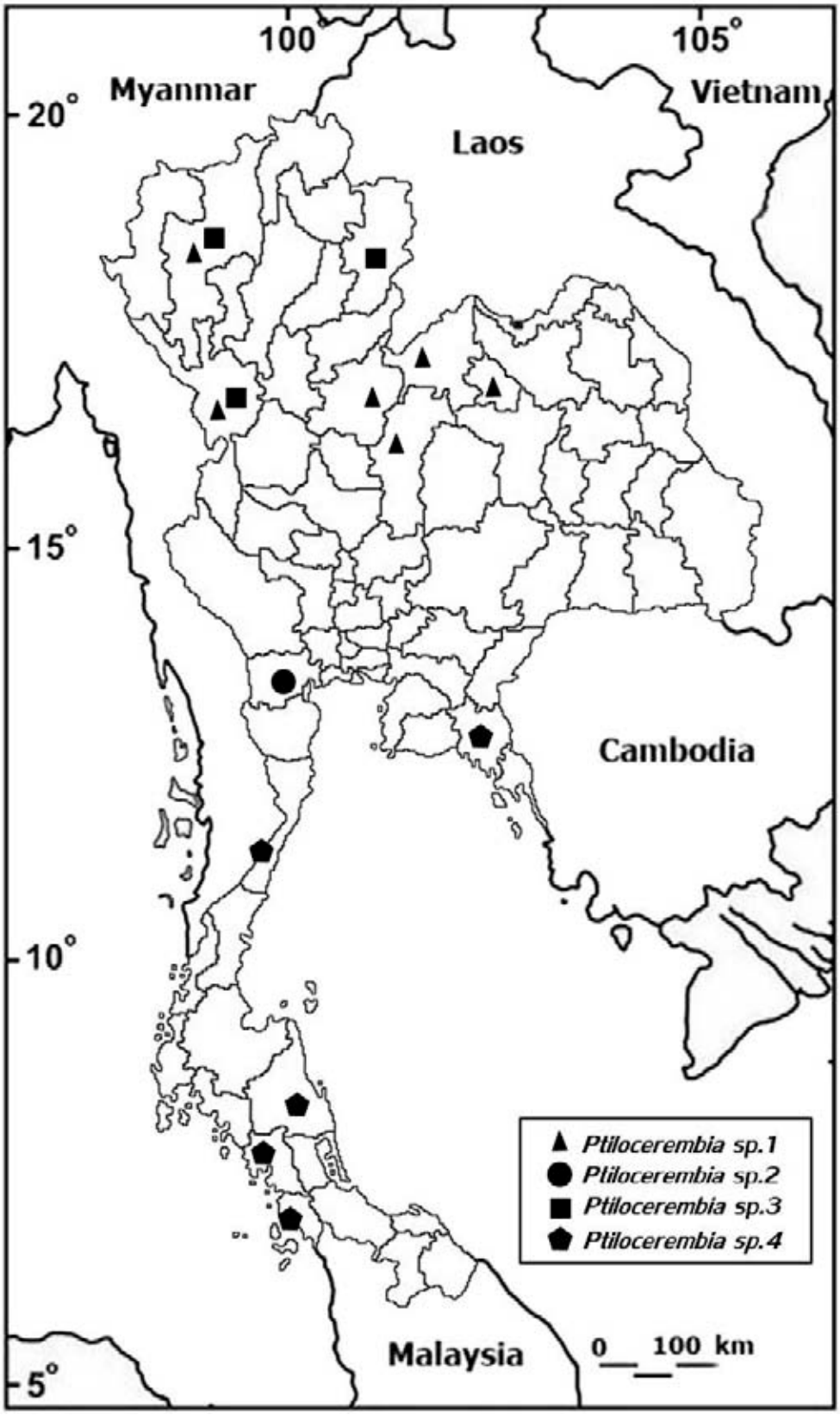
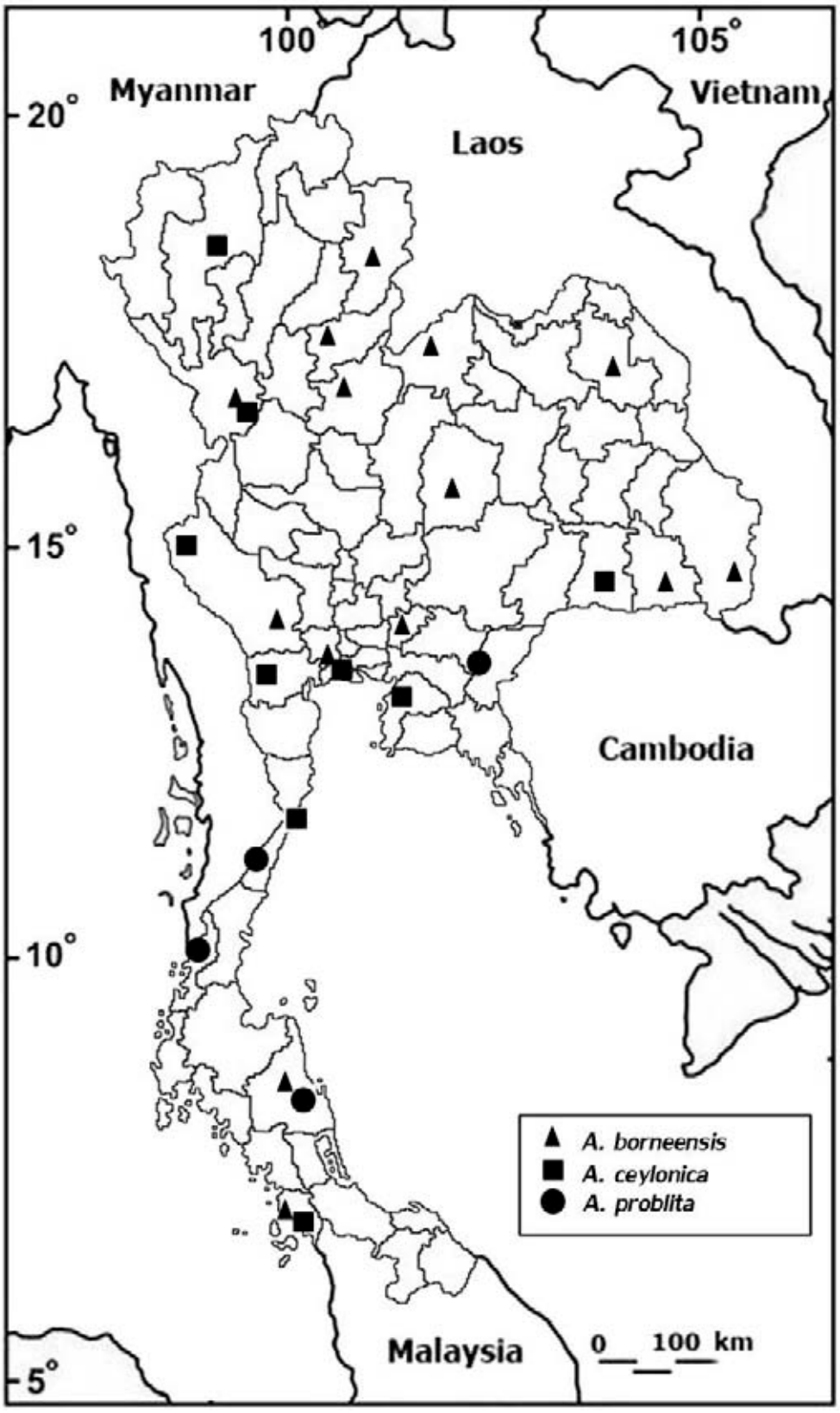
APPENDIX



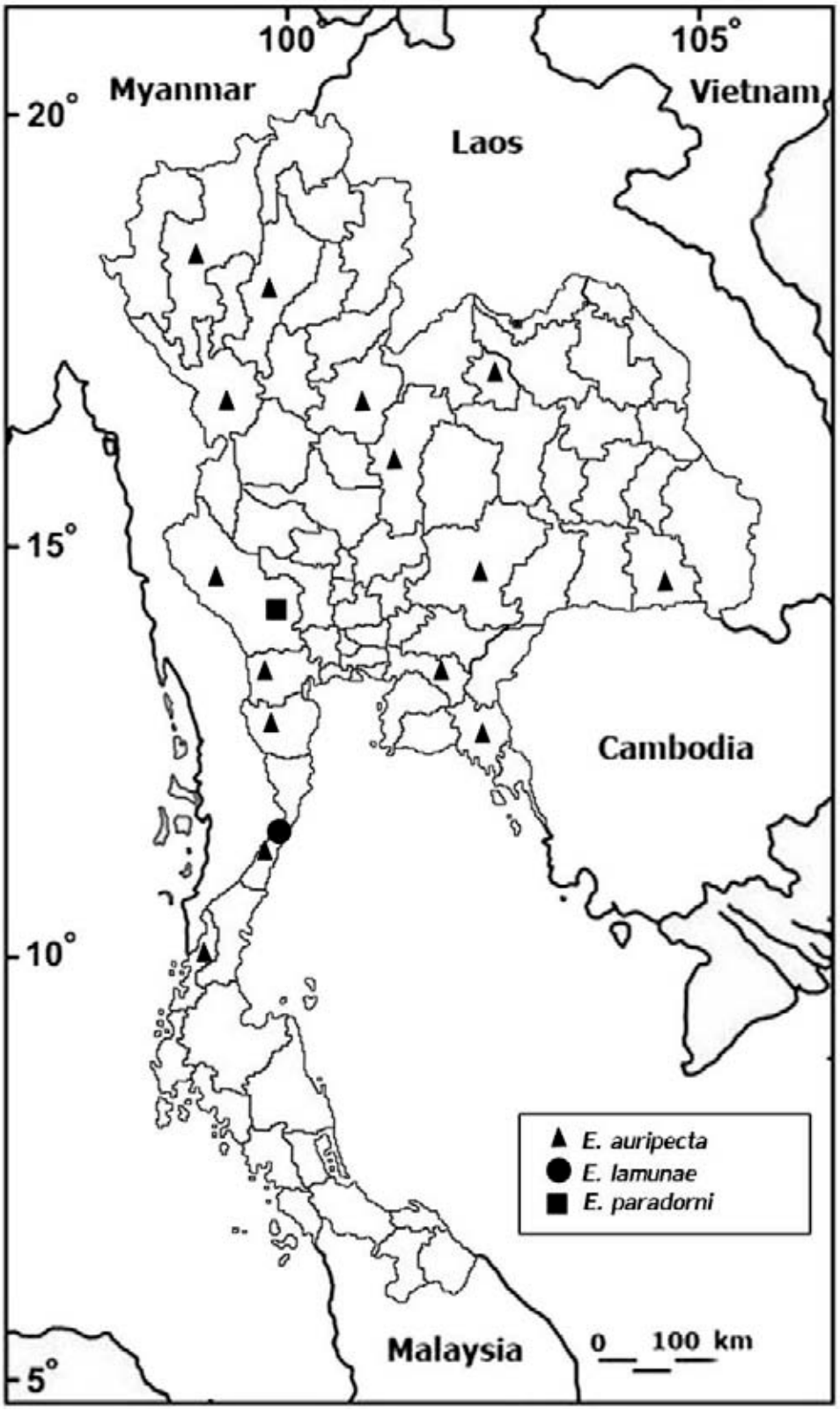
Appendix Figure 1. Distribution of the genus *Oedembia* (F. Embiidae) found in Thailand.



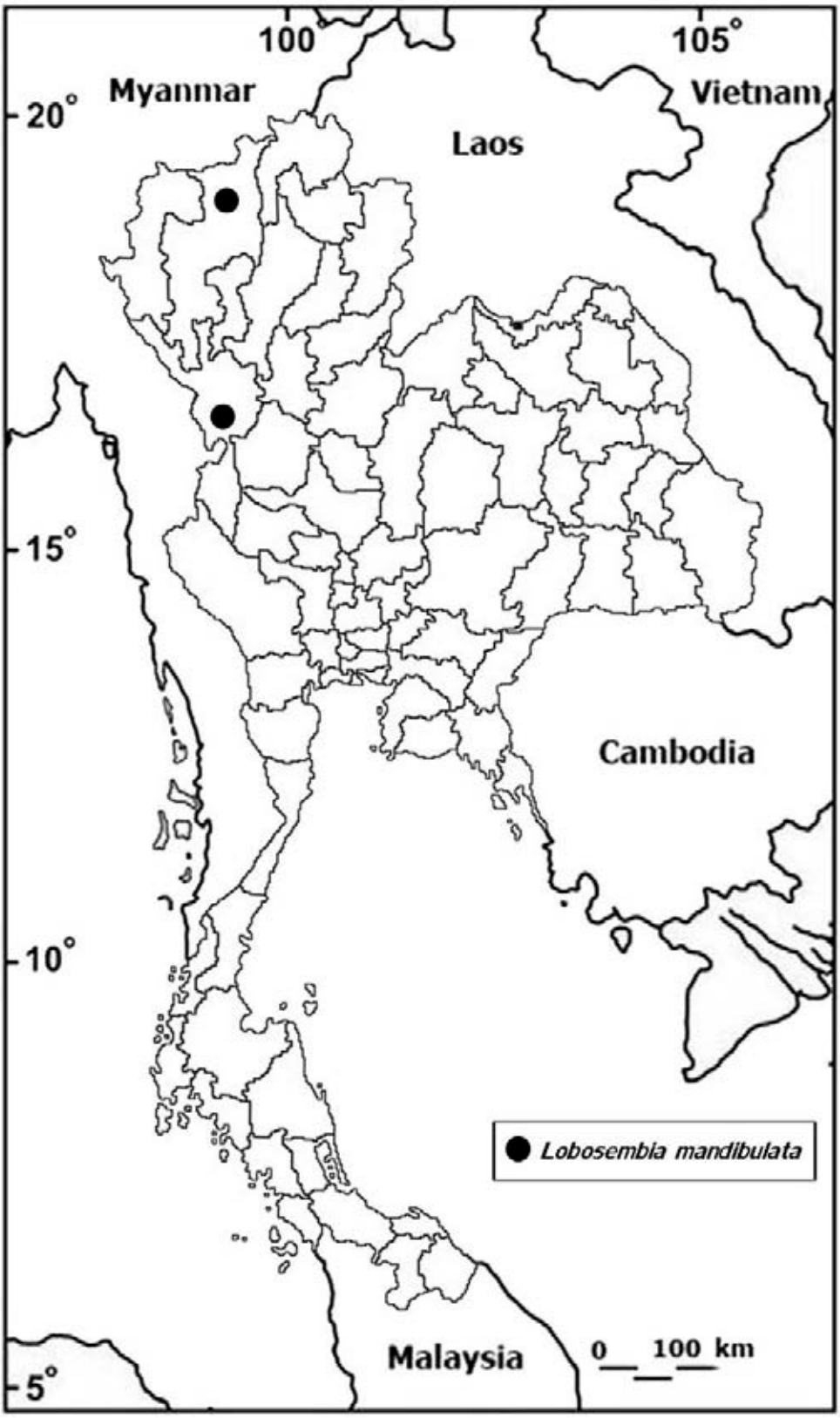
Appendix Figure 2. Distribution of the genus *Ptilocerembia* (F. Notoligotomidae) found in Thailand.



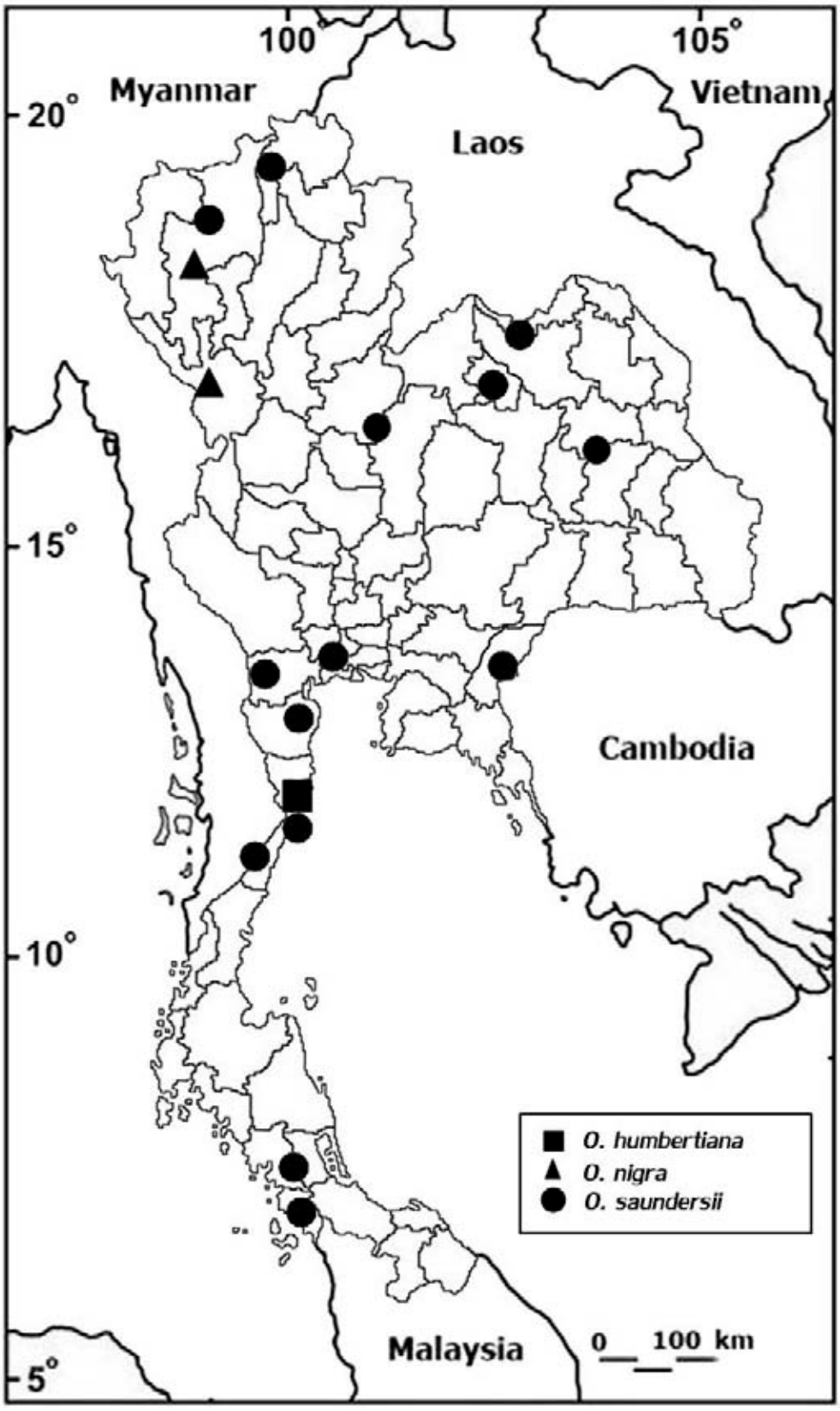
Appendix Figure 3. Distribution of the genus *Aposthonia* (F. Oligotomidae) found in Thailand.



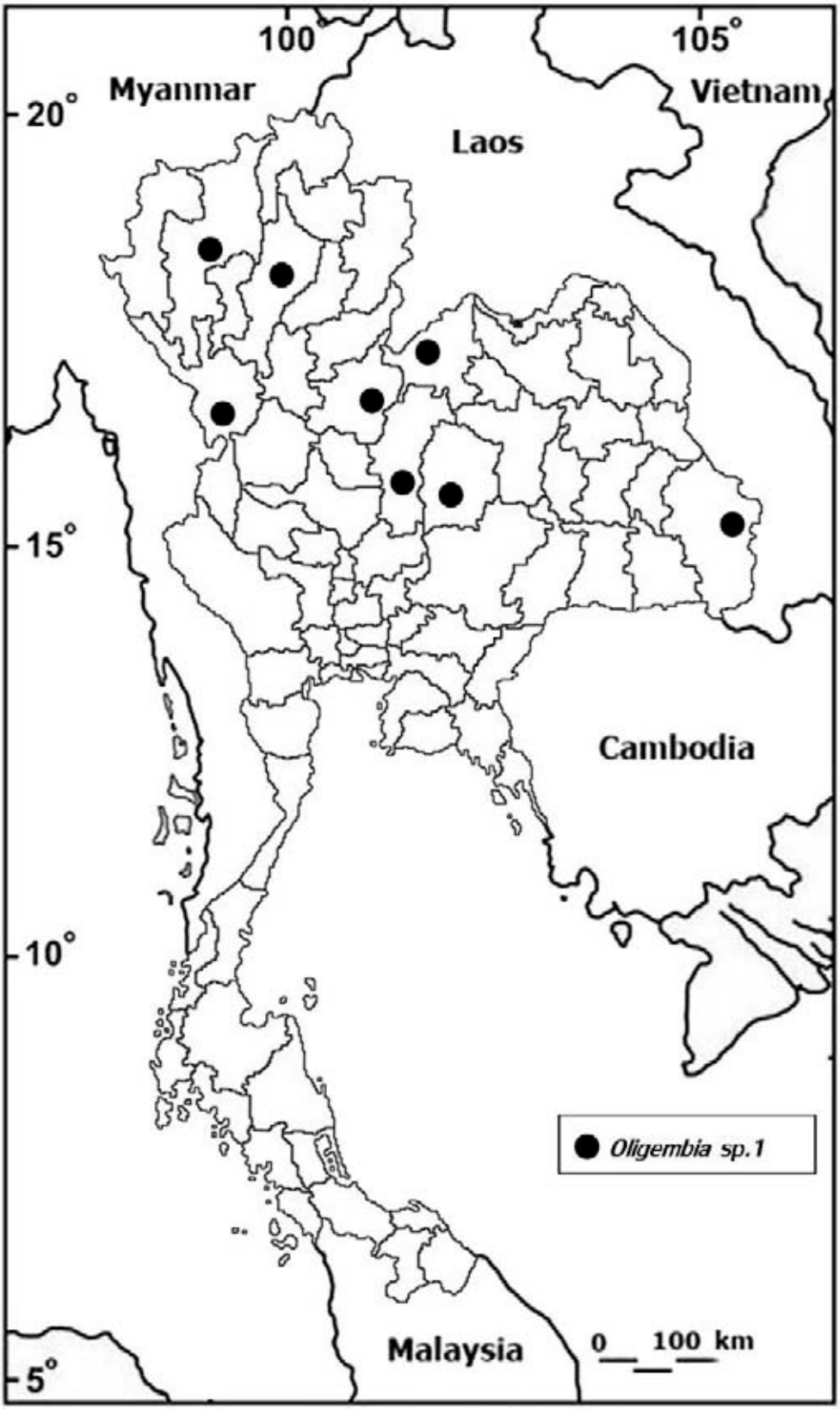
Appendix Figure 4. Distribution of the genus *Eosembia* (F. Oligotomidae) found in Thailand.



Appendix Figure 5. Distribution of the genus *Lobosembia* (F. Oligotomidae) found in Thailand.



Appendix Figure 6. Distribution of the genus *Oligotoma* (F. Oligotomidae) found in Thailand.



Appendix Figure 7. Distribution of the genus *Oligembia* (F. Teratembiidae) found in Thailand.

BIOGRAPHY

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PUBLICATIONS

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