A THESIS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Systematic study on Oecophoridae (Lepidoptera: Gelechioidea) in Korea with emphasis on molecular phylogeny

원뿔나방과(나비목: 뿔나방상과)의 계통분류학적 연구

By

Sora Kim

Program in Entomology

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UNDER THE DIRECTION OF ADVISER SEUNGHWAN LEE

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL OF

SEOUL NATIONAL UNIVERSIITY

By

Sora Kim

Program in Entomology

Department of Agricultural Biotechnology

Seoul National University

August, 2015

APRROVED AS A QUALIFIED DISSERTATION OF SORA KIM

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY THE COMMITTEE MEMBERS

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I. Taxonomic review of Oecophoridae (Lepidoptera: Gelechioidea) in Korea

1.1 Abstract

The family Oecophoridae is revised in the Korean Peninsula. One new genus, *Exiguacma* **gen. nov.**, nine new species, *Batia clavata* **sp. nov.**, *B. flavatus* **sp. nov.**, *Cryptolechia albulus* **sp. nov.**., *C. obtusa* **sp. nov.**, *Exiguacma forcipis* **sp. nov.**, *Promalactis candidifascia* **sp. nov.**, *Pseudodoxia gahakensis* **sp. nov.**, *Ripeacma adamantis* **sp. nov.**, and *R. longior* **sp. nov.**, and three unrecorded species, *Epicallima conchylidella* (Snellen), *Promalactis xianfengensis* Wang et Li and *Ripeacma acuminiptera* Wang et Li, are investigated, therefore in total thirty-three species of twelve genera belonging to two subfamilies, Cryptolechiinae **stat. nov.** and Oecophorinae, are recognized.

A full bibliography, diagnosis and descriptions for all known species including new species are provided with distribution and information. Dissection of wings and genitalia is examined delicately for illustration. Keys to subfamilies, genera and species are also given.

Keywords: Oecophoridae, new species, new records, revision, the Korean Peninsula

1.2 Introduction

The family Oecophoridae is one of the largest and least known families of microlepidopteran groups, expecting more than 4,000 species, primarily in the Australasian Region with over 3,000 endemic species (Common 1990). The adults are usually very small to medium-sized with wingspan 7-74 mm., and they are characterized by following characters: head with smoothly covered frons and erect scaled vertex; labial palpi up-curved; forewing with vein R_4 and R_5 stalked, R_5 reaching to costa, apex or termen; hindwing with Rs and M_1 separate and sub-parallel, rounded to nearly straight outer margin; male genitalia with uncus articulated to tegumen; female genitalia with apophysis anterioris shorter than the apophysis posterioris.

1.2.1 Historical review

The traditional conception of family Oecophoridae was very imperfect. Early European researchers regarded the family Oecophoridae as a subfamiliy of the other families, Gelechiidae (Spuler, 1910; Romaniszyn and Schille, 1929-1930; Hering, 1932; Weber, 1948) or Depressariidae (Busck, 1908; Pierce and Metcalfe, 1935;

Clarke, 1941) based on selective morphological characters, such as wing venation, the structure of the labial palpi and antenna. Since the 1960's, more comprehensive studies on the family Oecophoridae have been conducted, however, disagreement classifications were presented by many authors (Table 1).

Early on, the family Oecophoridae was considered to be a large family including four to seven independent subfamilies. Seven subfamilies by Toll, four subfamilies by Hodges (1974) and five subfamilies by Common (1990) were caused to work on indigenous species in geographical difference.

More significant fameworks on classifications of Oecophoridae were started by Hodges (1998) in the classification of superfamily Gelechioidea. He attempted to rearrange the Oecophoridae dividing into two subfamilies, Oecophorinae and Stathmopodinae based on 38 morphological characters in the parsimony analysis, and his system was widely accepted by many authors (Karsholt & Nielson, 1998; Elsner et al., 1999; Wang, 2006), but, the following recent works were disagreed. Based on 197 morphological characters, Kaila (2004) implemented the Oecophorid lineage that Oecophoridae s.s. and the other oecophorids clustered with Xyloryctid assemblage, including Xyloryctinae s.s., Deuterogoniinae and Blastobasinae. This system was revised later by Kaila et al., (2011) in molecular phylogeny of Gelechioidea, but it also not concluded the classification of Oecophoridae. On the other hand, Lvovsky (2009) proposed the classification of Oecophoridae s.s., including Oecophorinae, Pleurotinae and Deuterogoniinae, emphasizing on larva feeding mode. In ‘an outline of higher-level classification and survey of taxonomic richness’, Nieukerken et al. (2011) presented that the family Oecophoridae contains the subfamilies, Oecophorinae and Deuterogoniinae, referred to morphological literatures and molecular results (Baldizzone et al., 2006; Bucheli &Wenzel, 2005; Gozmány, 2000; Heikkilä & Kaila, 2010; Hodges, 1998; Kaila, 2004; Lvovsky, 2011; Mutanen et al., 2010; Passerin d’Entreves & Roggero, 2007; Saito, 2005; Sinev, 2002). Recently, Heikkilä et al. (2014) supplemented previous morphological and molecular data by Kaila (2004) and Kaila et al., (2011) and demonstrated a monophyletic Oecophoridae s.s., upgrading the *Pleurota* to Pleurotinae and downgrading the Deuterogoniinae to *Deuterogona* belonging into Oecophorinae with improved statistical support values, ignoring the other oecophorids clustered with other families. Those controversial classification cause to designate the incomplete delimitation and the disagreed constituents of Oecophoridae.

Up to date, twenty-three species of Oecophoridae have been reported in Korea. *Promalactis odaiensis* Park was new to science in 1980, followed by *Promalactis jezonica* (Matsumura), *P. suzukiella* (Matsumura), *P. enopisema* (Butler), *P. autoclina* Meyrick, *Acryptolechia malacobyrsa* Meyrick, *A. torophanes* Meyrick, *Deuterogonia pudorina* (Wocke), *Pseudodoxia achlyphanes* (Meyrick), *Periacma delegata* Meyrick, *Tyrolimnas anthraconesa* Meyrick, *Martyringa xeraula* Meyrick and *Callimodes zelleri* (Christoph) (Park, 1981a; 1981b; 1983). Besides, Lvovsky (1986) and Jarosi et al. (1992) reported each one species, *Promalactis parki* Lvovsky and *Casmara agronoma* Meyrick, from North Korea. In 1998, Park and Park described six new species, *Promalactis albipunctata* Park, *P. auriella* Park, *P. bitaenia* Park, *P. atriplagata* Park, *P. wonjuensis* Park and *P. striola* Park, with two new records, *P. subsuzukiella* Lvovsky and *P. svetlanae* Lvovsky. Recently, Byun et al., (2012) reported *Casmara agronoma* Meyrick from South Korea.

Herein, a total of thirty-three species of Korean Oecophoridae is revised, comprising two subfamilies, Cryptolechiinae **stat. nov.** and Oecophorinae. One new genus, *Exiguacma* **gen. nov.** and four unrecorded genera, *Acryptolechia*, *Batia*, *Epicallima* and *Ripeacma,* are newly added, including nine new species, *Batia clavata* **sp. nov.**, *B. flavatus* **sp. nov.**, *Cryptolechia albulus* **sp. nov.**., *C. obtusa* **sp. nov.**, *Exiguacma forcipis* **sp. nov.**, *Promalactis candidifascia* **sp. nov.**, *Pseudodoxia gahakensis* **sp. nov.**, *Ripeacma adamantis* **sp. nov.**, and *R. longior* **sp. nov.**, and three unrecorded species, *Epicallima conchylidella* (Snellen), *Promalactis xianfengensis* Wang et Li and *Ripeacma acuminiptera* Wang et Li.

Table. 1. Variable classification of the family Oecophoridae by many authors since 1960's.

Toll (1964)	**Hodges (1974)**	**Hodges(1998)**	**Kaila (2004)**	**Lvovsky (2009)**	**Kaila et al., (2011)**	**Nieukerken et al., (2011)**	**Heikkilä et al., (2014)**
OECOPHORIDAE	OECOPHORIDAE	OECOPHORIDAE		OECOPHORIDAE		OECOPHORIDAE	OECOPHORIDAE S.S.
Amphisbatinae	**Depressariinae**	**Stathmopodinae**	Xyl. assemblage	**Oecophorinae**	**Oecophoridae s.l.**	**Oecophorinae**	**Oecophorinae**
Amphisbatis	**Tribe Amphisbatini**	*Hieromantis*	*Hierodoris*	**Deuterogoniinae**	*Hierodoris*	**Deuterogoniina e**	*Bisigna*
Depressariinae	*Eupragia*	*Lactistica*	*Phaeosaces*	**Pleurotinae**	*Gymnobathra*		*Oecohpora*
Agonopteryx	*Machimia*	*Oedematopoda*	*Izatha*		*Izatha*		*Polix*
Anchinia	*Psilocorsis*	*Pseudaegeria*	**Oecophoridae s.s.**		**Oecophorinae**		*Harpella*
Carcina	**Tribe Depressariini**	*Snellenia*	*Bisigna*		*Bisigna*		*Denisia*
Cryptolecyhia	*Agonopterix*	*Stathmopoda*	*Borkhausenia*		*Harpella*		*Philobota*
Depressaria	*Apachea*	*Tortilia*	*Denisia*		*Oecophora*		*Tingena*
Enicostoma	*Bibarrambla*	**Oecophorinae**	*Harpella f*		*Pleurota*		*Hofmannophila*
Epigraphia	*Depressaria*	*Barea*	*Hofmannophila*		*Borkhausenia*		*Borkhausenia*
Exaeretia	*Himmacia*	*Borkhausenia*	*Oecophora*		*Endrosis*		*Endrosis*
Hypercallia	*Martyrhilda*	*Chezala*	*Palimmeces*		*Hofmannophila*		*Garrha*
Levipalpus	*Nites*	*Chrysonoma*	*Philobota*		*Palimmeces*		*Deuterogonia*
Martyrhilda	*Semioscopis*	*Diocosma*	*Phryganeutis*		*Philobota*		**Pleurotinae**
Semioscopis	**Oecophorinae**	*Endrosis*	*Pleurota*		*Tingena*		*Pleurota*
Oecophorinae	**Tribe Oecophorini**	*Eulechria*	*Polix*		*Wingia*		*Wingia*
Alabonia	*Batia*	*Garrha*	*Prionocris*		**Deuterogoniinae**		

Batia	*Borkhausenia*	*Hofmannophila*	*Promalactis*	*Deuterogonia*
Bisigna	*Brymblia*	*Inga*	*Tingena*	
Borkhausenia	*Callima*	*Orophila*		
Borkhausenia	*Carcina*	*Oxystola*		
Dasycera	*Carolana*	*Philobota*		
Decantha	*Chambersia*	*Pleurota*		
Endrosis	*Dafa*	*Tanyzancla*		
Fabiola	*Decantha*	*Wingia*		
Harpella	*Eido*			
Hofmannophila	*Endrosis*			
Lampros	*Esperia*			
Metalampra	*Fabiola*			
Oecophora	*Hormannophila*			
Schiffermuelleria	*Inga*			
Telechrysis	*Martyringa*			
Tichonia	*Mathildana*			
Tubuliferola	*Polix*			
Pleurotinae	**Tribe Pleurotini**			
Aplota	*Pleurota*			
Holoscolia	**Chimabachinae**			
Macrochila	**Tribe Chimabachini**			
Pleurota	*Cheimophoila*			
Toeutis	**Peleopodinae**			

Deuterogoniinae	**Tribe Peleopodini**
Deuterogonia	*Durrantia*
Diurneinae	*Pseuderotis*
Cheimophila	
Diurnea	
Herrichiinae	
Herrichia	

Table. 2. Historical review of the Korean Oecophoridae.

Year	Author	Species
1980	Park	*Promalctis odaiensis* Park
1981a	Park	*Promalactis jezonica* (Matsumura), P. *suzukiella* (Matsumura), *P. enopisema* (Butler), *P. autoclina* Meyrick
1981b	Park	*Acryptolechia malacobyrsa* Meyrick, *A. torophanes* Meyrick, *Deuterogonia pudorina* (Wocke), *Pseudodoxia achlyphanes* (Meyrick), *Periacma delegata* Meyrick, *Tyrolimnas anthraconesa* Meyrick, *Martyringa xeraula* Meyrick
1983	Park	*Callimodes zelleri* (Christoph)
1986	Lvovsky	*Promalactis parki* Lvovsky (North Korea)
1992	Jarosi	*Casmara agronoma* (North Korea)
1998	Park et Park	*Promalactis albipunctata* Park, *P. auriella* Park, *P. bitaenia* Park, *P. atriplagata* Park, *P. wonjuensis* Park and *P. striola* Park and added two species, *P. subsuzukiella* Lvovsky and *P. svetlanae* Lvovsky
2012	Byun et al	*Casmara agronoma* (South Korea)
TOTAL		**23 pecies**

1.3 Material and Methods

Material examined for the present study is based on collections in the following institutions: College of Agriculture and Life Sciences, Seoul National University (CALS SNU), Korea National Arboretum (KNA) and Department of Biology, University of Incheon (UIB), Korea.

The collections were performed mostly by light trap or bucket light trap. In the light trap, mercury vapor lamp (220V/400W) and black light lamp (20W) was used as the light source. Sweeping and naked eye was usually used during daytime and the bucket light trap was utilized for the overnight collections.

Specimen preparation

Moths were taken alive with the vial-tubes with the cork lids, and killed with ethyl acetate or ammonia, and then, for dried specimen, they were pinned and spreaded with the micro-insect pins of No. A1 and B1-pin (Naturalist Watkins & Doncaster) by double-mounted method.

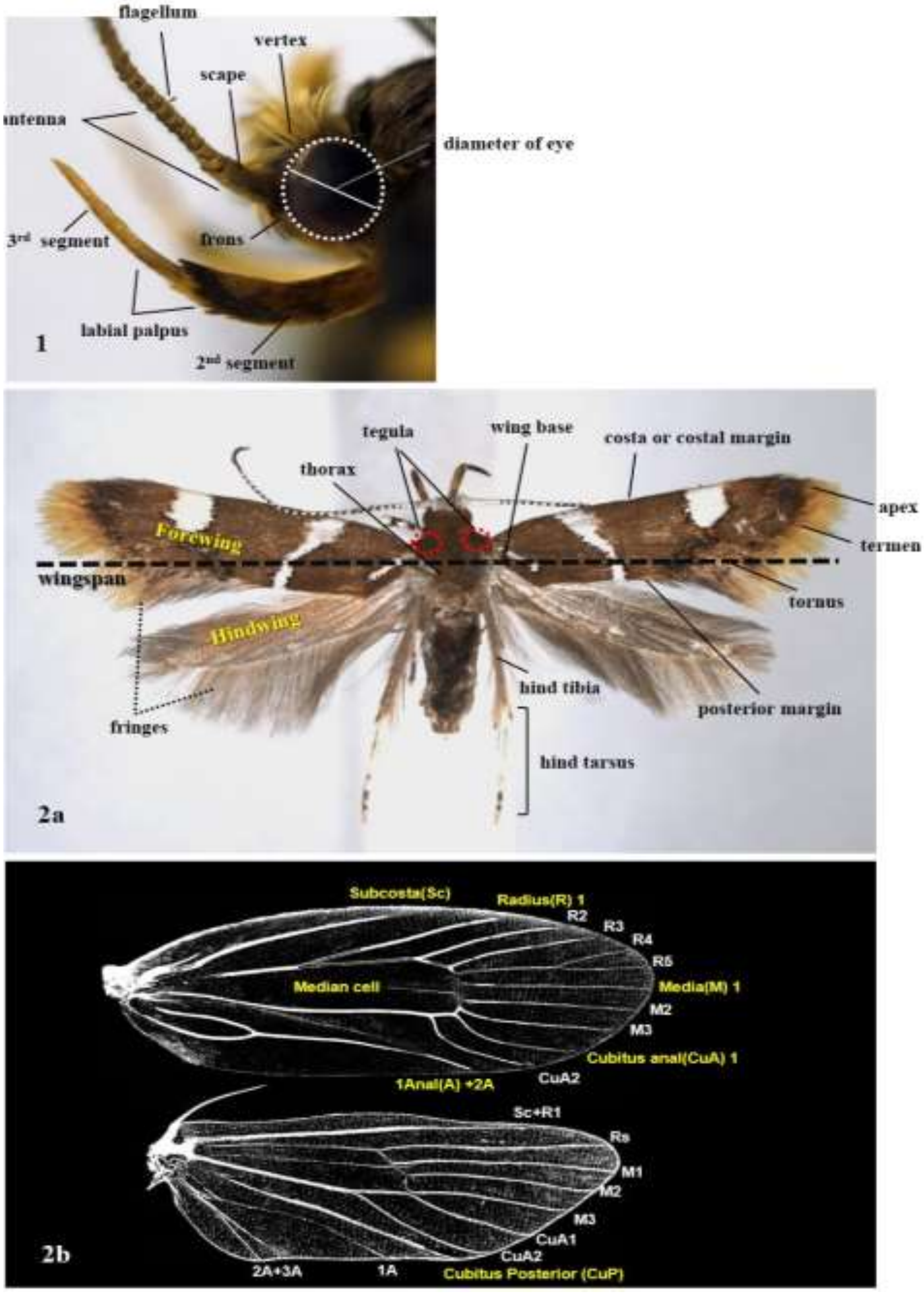
For identification and description, slide vouchers of genitalia and wing venation were made as follows:

i) genitalia dissection: the abdomen is removed from the dried specimen and heated in boiling water with 5 ml of 5% solution of potassium-hydroxide (KOH) for 5-30 minutes, depending on the size. The dissolved abdomen is cleaned in 50%, 70% ethyl alcohol (ETOH) and stained with chlorazol black. The genitalia is soaked in 99% ETOH for dehydration, and into Xylene for fixation, and then, mounted on the slide glass with one or two drops of Canada balsam.

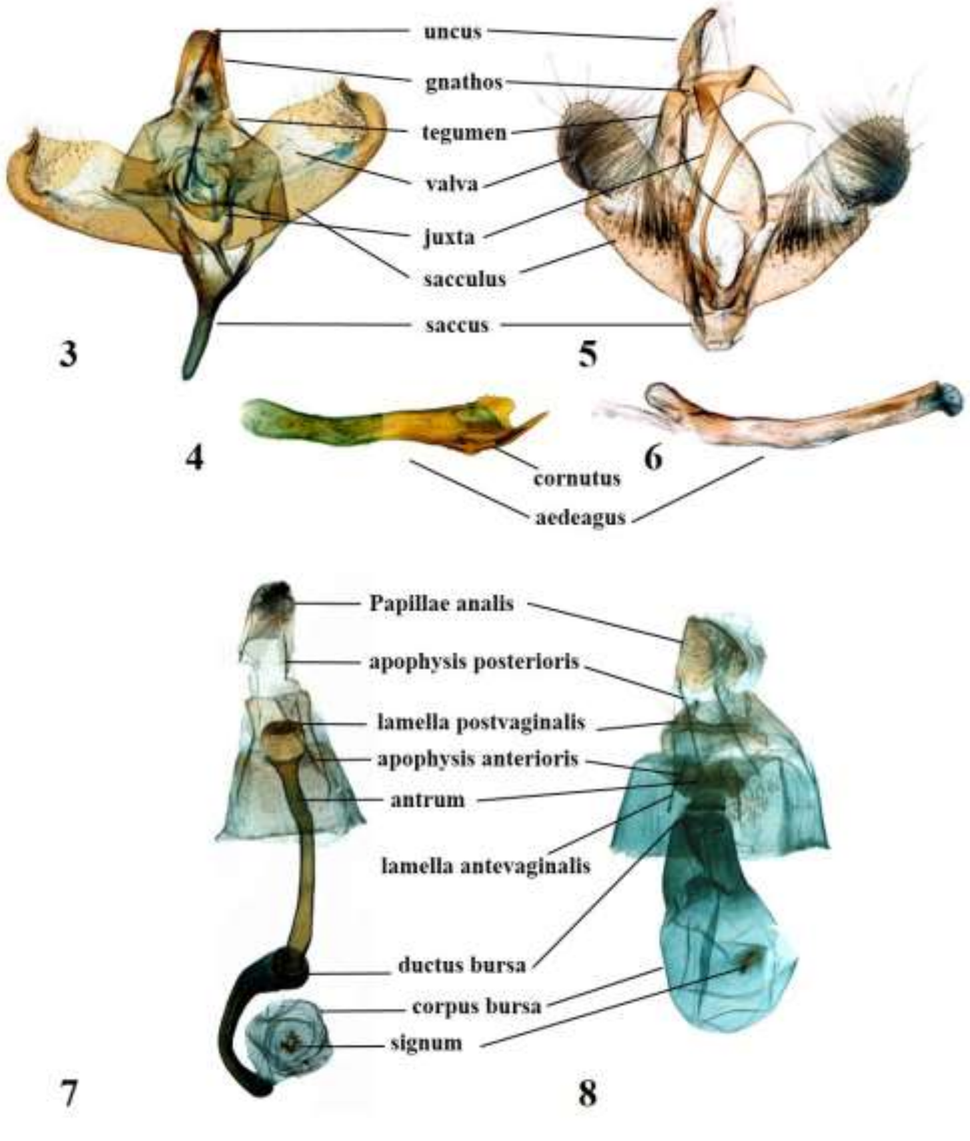
ii) wing venation: fore and hind wings are removed from the thorax with forceps and descaled using a drop of Xylene and 70% Ethyl alcohol. It is fixed in Xylene and mounted with Canada balsam on a slide glass.

Specimens were examined under a microscope, and photographs were taken from digital images using the software, Image Lab version 2.2.4.0 by MCM Design (Hillerød, Denmark). The color standard for the description of adults follows Kornerup and Wanscher (1978). All specimens, including types and slide glass vouchers, are deposited in CALS SNU.

The terminology of the adult and genitalia are explained in figures 1-8., and the abbreviations used here are as follows: GG, Gyeonggi Province; GW, Gangweon Province; CB, Chungcheongbuk Province; CN, Chungcheongnam Province; JB, JeonlabukProvince; JN, Jeonlanam Province; GB, Gyeongsangbuk Province; GN, Gyeongsangnam Province; JJ, Jeju Island.



Figs. 1-2. Terminology of adult.
1, Head: *Acryptolechia torophanes*; **2**, Wings: a, *Promalactis suzukiella*; b, *Periacma delegata*.



Figs. 3-8. Terminology of genitalia.

3, male genitalia of *Promalactis albipunctata*; **4**, aedeagus of *ditto*; **5**, male genitalia of *Callimodes zelleri*; **6**, aedeagus of *ditto*; **7**, female genitalia of *Promalactis odaiensis*; **8**, female genitalia of *Acryptolechia torophanes.*

1.4 Results

Systematic accounts

Order **LEPIDOPTERA** Linnaeus, 1758

Superfamily **GELECHIOIDEA** Stainton, 1854

Family **OECOPHORIDAE** Bruand, 1850

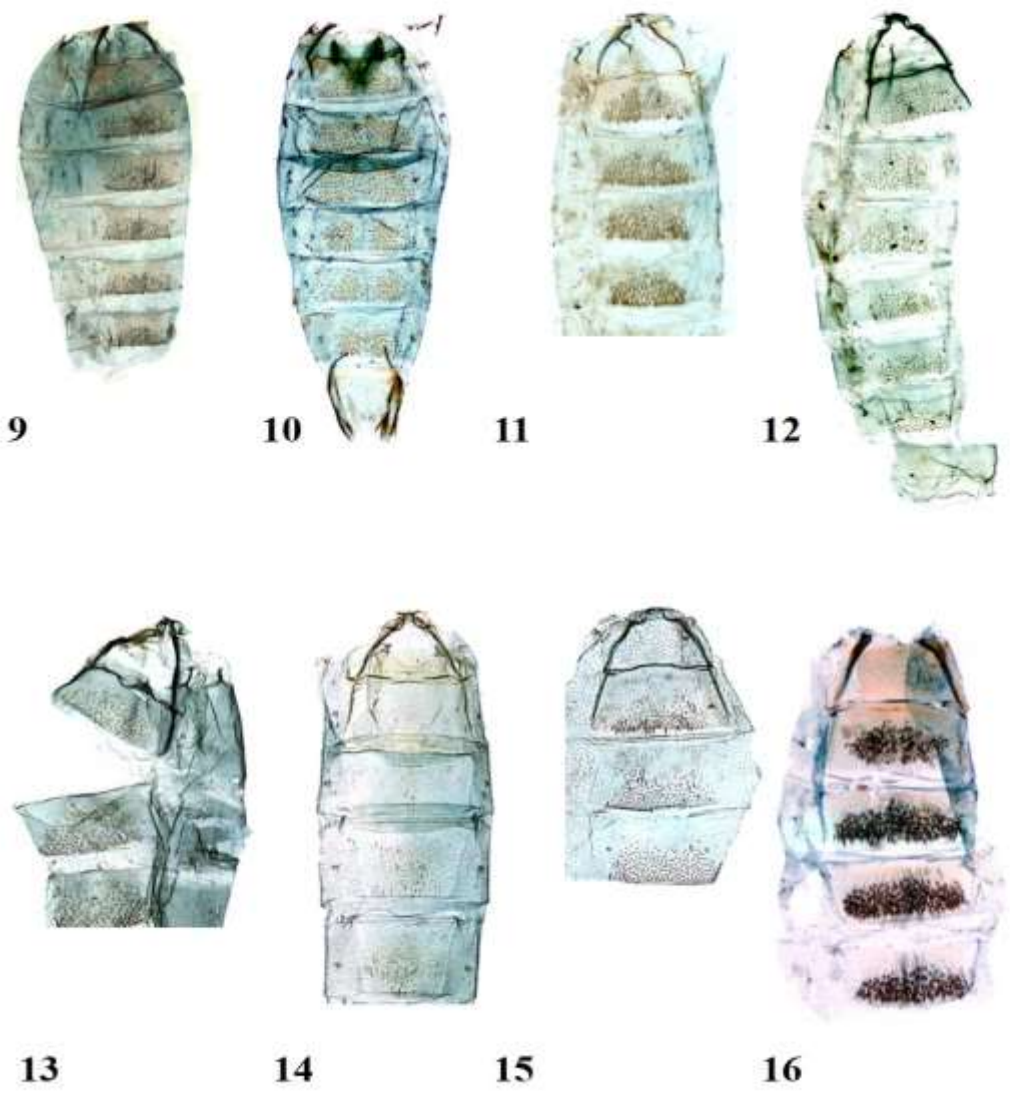
Oecophoridae Bruand, 1850, Mem. Soc. Libre d'Emulation du Doubs, 3: 45.

Type genus: *Oecophora* Latreille, 1802.

Key to the subfamily of the family Oecophoridae

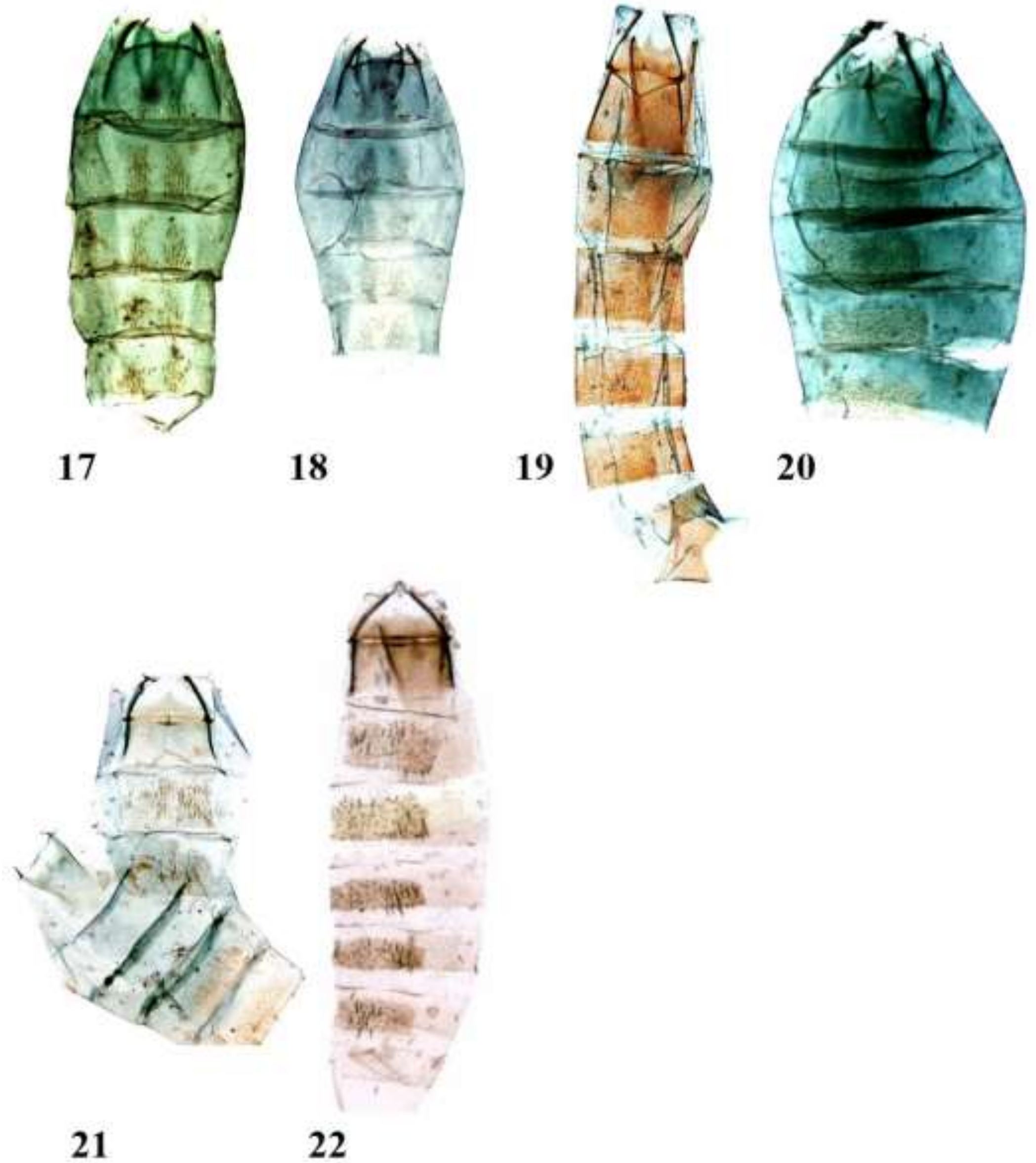
1. Abdominal terga lacking spiniform setae, irregular shaped; Forewing veins, R4 and R5 stalked from just before the half of their length --- **Oecophorinae**

- Abdominal terga with spiniform setae, distinct shaped; Forewing veins, M_3 and CuA_1 from not same point of median cell ------------ **Cryptolechiinae stat. nov.**



Figs. 9-16. Setae of abdominal terga (continued).

9, *Acryptolechia malacobyrsa*; **10**, *Batia clavata* **sp. nov.**; **11**, *Cryptolechia albulus* **sp. nov.**; **12**, *C. obtusa* **sp. nov.**; **13**, *Exiguacma forcipis* **sp. nov.**; **14**, *Martyringa xeraula*; **15**, *Periacma delegata*; **16**, *Pseudodoxia achlyphanes.*



Figs. 17-22. Setae of abdominal terga.

17, *Ripeacma acuminiptera*; **18**, *R. adamantis* sp. nov.; **19**, *Callimodes zelleri*; **20**, *Deuterogonia pudorina*; **21**, *Epicallima conchylidella*; **22**, *Promalactis svetlanae*.

Subfamily **CRYPTOLECHIINAE** Meyrick, 1883, **stat. n.**

Cryptolechiidae Meyrick, 1883, Trans. Ent. Soc. 2: 119-131.

Type genus: *Cryptolechia* Zeller, 1852.

The subfamily Cryptolechiinae, comprising nearly two hundred species worldwide (Wang, 2006), is characterized by a broadly lanceolate forewing, the male genitalia without gnathos and female genitalia with well-developed lamella antevaginalis. The Cryptolechiinae is distinguished from the other subfamilies of Oecophoridae by semi-circular shaped spiniform setae of abdomen and hind leg without tuft.

From this study, fourteen species belonging to eight genera were investigated with one new genus, *Exiguacma* **gen. nov.**, and eight new species, *Batia clavata* Kim, **sp. nov.**, *B. flavatus* Kim, **sp. nov.**, *Cryptolechia albulus* Kim, **sp. nov.**, *C. obtusa* Kim, **sp. nov.**, *Exiguacma forcipis* Kim, **sp. nov.**, *Pseudodoxia gahakensis* Kim, **sp. nov.**, *Ripeacma adamantis* Kim, **sp. nov.** and *R. longior* Kim, **sp. nov.**. Three un-recorded genera, *Acryptolechia*, *Batia* and *Ripeacma*, including one un-recorded species, *Ripeacma acuminiptera* Wanget Li, 1999, were also added.

Key to genera of the subfamily Cryptolechiinae in Korea based on adult

1. Forewing and hindwing broad --- **2**

 - Forewing and hindwing lanceolate -- **7**

2. Forewing venation with R_1 and R_2 separate -- **3**

 - Forewing venation with R_1 and R_2 connected on median cell -------- ***Martyringa***

3. Forewing venation with R4 and R5 stalked at the half of their length ----------- **4**

 - Forewing venation with R4 and R5 stalked before the half of their length ----- **6**

4. Labial palpus three-segmented in male -- **5**

 - Labial palpus two-segmented in male ------------------------------------- ***Periacma***

5. Forewing with transverse markings ---------------------------------- ***Acryptolechia***

 - Forewing with dot-like markings -------------------------------------- ***Pseudodoxia***

6. Forewing ground color dark brown with whitish yellow markings -----------------
 -- ***Crytolechia***

 - Forewing ground color whitish yellow with fuscous markings ---------------------
 --- ***Exiguacma* gen. nov.**

7. Forewing venation with R4 and R5 stalked before the half of their length -------
 -- ***Ripeacma***

 - Forewing venation with R4 and R5 stalked after the half of their length ----------
 -- ***Batia***

Key to genera of the subfamily Cryptolechiinae in Korea based on male genitalia

1. Transtilla absent -- **2**

 - Transtilla present -- ***Ripeacma***

2. Gnathos absent -- **3**

 - Gnathos present --- **6**

3. Valva with lacking haired; Saccus absent --------------------------------------- ***Batia***

 - Valva with dense haired; Saccus present --- **4**

4. Saccus as same length as tegumen ---------------------------- ***Exiguacma* gen. nov.**

 - Saccus shorter than tegumen --- **5**

5. Uncus wide in width and straight, conical or club-like; saccus triangular --------- -- ***Acryptolechia***

 - Uncus gradually narrow to apex, incised laterally; saccus incised laterally, funnel-like-- ***Cryptolechia***

6. Cucullus with processus -- ***Pseudodoxia***

 - Cucullus without processus -- **7**

7. Uncus and gnathos with wide apexes ------------------------------------- ***Periacma***

 - Uncus and gnathos with pointed apexes --------------------------------- ***Martyinga***

Key to genera of the subfamily Cryptolechiinae in Korea based on female genitalia

1. Lamella postvaginalis incised medially on caudal margin ------------------------ **2**

 - Lamella postvaginalis round on caudal margin ------------------------------------ **5**

2. Lamella antevaginalis absent-- ***Batia***

 - Lamella antevaginalis present --- **3**

3. Antrum small --- **4**

 - Antrum large --- ***Ripeacma***

4. Lamella antevaginalis half length of lamella postvaginalis in width ---------------
--***Acryptolechia***

 - Lamella antevaginalis as long as lamella postvaginalis in width -------------------
--***Cryptolechia***

5. Signum absent -- **6**

 - Signum present -- ***Pseudodoxia***

6. Antrum small and simple --- ***Periacma***

 - Antum large and distinctly developed ---------------------------------- ***Martyringa***

Genus ***ACRYPTOLECHIA*** Lvovsky, 2010

Acryptolechia Lvovsky, 2010, Ent. Rev. 90: 255-258.

Type species: *Cryptolechia malacobyrsa* Meyrick, 1921

Diagnosis. The genus is distinguished from other genera by the comparatively broad and nearly three times as long as wide of wings, male genitalia with uncus conical, gnathos absent and saccus triangular pyramid-like, and female genitalia with antru at the middle part of eighth and seventh sternum and short ductus bursa.

Wing venation (Fig. 23). Forewing broad, long, with radius veins all present: R_4 and R_5 stalked at the half of their length, R_5 reaching to costa; M_1 and M_2 parallel; CuA_1 approximate to M_3; CuP weakly developed. Hindwing broad, wide at width, with ten veins: M_1 and M_2 less parallel; M_3 and CuA_1 from same point from median cell.

Distribution. Oriental, Palaearctic Regions.

Remarks. According to Lvovsky (2009), the genus *Acyrptolechia* includes *Cryptolechia facunda* (Meyrick) reported from India and several species described from China within the genus *Cryptolechia* by Wang (2006).

Key to species of the genus Acryptolechia in Korea based on adult

1. Forewing ground color yellowish brown; three distinct dark brown markings -- ***A. malacobyrsa***

- Forewing ground colour dark brown; two yellow markings ------- ***A. torophanes***

Key to species of the genus Acryptolechia in Korea based on male genitalia

1. Valva with rounded apex -- ***A. malacobyrsa***

- Valva with blunt apex -- ***A. torophanes***

Key to species of the genus Acryptolechia in Korea based on female genitalia

1. Lamella antevaginalis weakly developed; Ductus bursae heavily sclerotized; Corpus bursae very large, rounded with an elongate signum bearing tiny spines -- ***A. malacobyrsa***

- Lamella antevaginalis trapezoidal-like; Ductus bursae short, slighly wider than Antrum; Corpus bursa with a signa, bearing two spines ------------ ***A. torophanes***

Acryptolechia malacobyrsa **(Meyrick), 1921 갈색띠원뿔나방**

Cryptolechia malacobyrsa Meyrick, 1921, Exot. Microl. 2: 394.

Depressaria bicintella Matsumura, 1931, 6000 Ill. Ins. Japan. 1089.

Cryptolechia malacobyrsa Clarke, 1963, Cat. Type Specimens Microl. Brit. Nat. Hist. by E. Meytick. 4: 165.

Acryptolechia malacobyrsa Lvovsky, 2010, Ent. Rev. 90: 255.

Diagnosis. This species is distinguished from others by the yellowish brown ground color with fuscous marking in forewing. The male genitalia is characterized by hairy covered valva, triangular-shaped processus of sacculus and partly densed long hairs in the margin of sacculus.

Description. Adult (Figs. 35, 67, 68). Head: Frons whitish yellow; vertex dark brown tinsed with whitish yellow laterally. Scape of antenna dark brown dorsally, whitish yellow ventrally, as long as diameter of eye; flagellum dark brown alternately. Labial palpus yellowish brown, rarely fuscous scales on the apical part of second segement dorsally; the second segment 1.5 times longer than third segment. Thorax: Thorax and tegula yellowish brown dorsally. Wing expanse 15.0–18.0mm. Forewing ground color yellowish brown; three distinct dark brown markings: one spot-like at 1/3; the oblique one band-like, transverse from the 2/3 costal margin to the 3/4 posterial margin; the other scaterred following by the termen; fringes yellowish brown. Hindwing broad lanceolate, grayish brown ground color; fringes greyish-brown. Legs: hind leg pale whitish yellow dorsally, except two pairs of spur of tibia and apical parts of fifth segment of tarsus.

Male genitalia (Figs. 131, 132). Uncus a conical-shaped, with pointed apex. Gnathos absent. Valva symmetric, covered by hairs; costal margin concave, gradually broader to apex; sacculus with a triangula processus, dense hairs on the caudal margin; saccus triangular-like, as long as the half of the sacculus. Aedeagus cylindrical, slender, a pair of sclerotized spines, bearing saw-teeth.

Female genitalia. According to Wang, 2006: 134-135 (figs. 22, 223), Papilla anales large, sparesely setose. Apophysis posterioris shorter than the half of the apophysis anterioris. Lamella postvaginalis largely developed. Lamella antevaginalis weakly developed. Ductus bursae heavily sclerotized. Corpus bursae very large, rounded with an elongate signum bearing tiny spines.

Material examined. Twenty-one males: one male, Mt. Cheonggye, Gwacheon-si, GG, Korea, 12.viii.1976, K.T. Park, wing slide no. SNU-9053/ S. Kim; one male, same locality, 26.vii.1997, Jeon, Lee, Jang & Gu; one male, Temple-Gwaneum, JJ, Korea, 13.ix.1993, K.T. Park & B.K. Byun; one male, Mt. Jiri, Jungsan-ri, CN, Korea, 20.viii.1996, Bae, Paek, Lee; six males, Wando-arboretum, JN, Korea, 27-28.vii.2005, M.Y. Kim & S. Kim; one male, Mt. Nogudwissan, Samdong-myeon, GN, Korea, 08.viii.2007, B.W. Lee & Y. Park & D.H. Kwon, gen. slide no. SNU-9077/ S. Kim; one male, Mt. Bannon, Yeoryang-myeon, jeongseonl, GW, Korea, 20.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim; two males, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim; one male, Mt. Dondaebong, Is. Hajo, Jodo-myeon, Jindo, JN, Korea, 20.vii.2011, S.Y. Park & J.S. Lim; four males, Mt. Wolyeongbong, Sinsido, Okdo-myeon, Gunsan, JB, Korea, 21.vii.2011, S.Y. Park & J.S. Lim; one male, Bonsan-myeon, Hapcheon-gun, GN, Korea, 26.vii.2011, S. Kim; one male, Mt. Geombong, Samcheok-si, GW, Korea, 24.viii.2011, S. Kim.

Distribution. Korea (South: GG, GW, CN, GN, JB, JN), Japan, China.

Remarks. Comparative to other species of Oecophorids, this species has been often collected, but we have not gotton the female adults.

Acryptolechia torophanes **(Meyrick), 1935 노랑띠원뿔나방**

Cryptolechia torophanes Meyrick, 1935, Materials Microl. Fauna Chinese Prov. Kiangsu. 81.

Acryptolechia torophanes Lvovsky, 2010, Ent. Rev. 90: 255.

Diagnosis. This species is superficially similar to several Chinese *Cryptolechia* species, such as *Cryptolechia falsitorophanes* Wang, *C. furcellata* Wang, *C. latifascia* Wang and *C. stictifascia* Wang, by having dark brown ground color of forewing with distinct yellow marking, but can be distinguished by male genitalia with a blunt apex valva and a thumb-like juxta.

Description. Adult (Figs. 36, 69, 70). Head: Frons and vertex yellow. Scape of antenna pale yellow entirely, shorter than the diameter of eye; flagellum dark brown. Labial palpus yellow, except dark brown the apical part of second segment; third segment slightly shorter than the second segment.

Thorax: Thorax and tegula dark brown dorsally. Wing expanse 16.0–18.0 mm. Forewing ground colour dark brown; two yellow markings: one oblique transverse from costal margin to posterial margin; the other costal spot, triangular-like at 4/5; fringes dark brown, partly yellow below the first yellow marking. Hindwing more or less lanceolate; fringes greyish dark brown. Legs: hind leg whitish yellow, except dark brown at apical parts of fifth, fourth, third and second segments of tarsus.

Male genitalia (Figs. 133, 134). Uncus a club-like, wide at sub-apex, gradually narrowed to base, setose on caudal margin. Gnathos absent. Valva symmetric; costal margin concave, a blunt apex, covered by dense hairs from the apex to saccular margin; a processus of sacculus thumb-like with sclerotized caudal margin; saccus conical-shaped. Aedeagus cylindrical, slender, bearing tiny spines in the middle.

Female genitalia (Figs. 184, 185, 186). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis largely developed, setose, incised on caudal margin. Lamella antevaginalis trapezoidal-like. Antrum short, tetrigonal-shaped. Ductus bursae short, slighly wider than antrum. Corpus bursa with a signa, bearing two spines.

Material examined. Eleven individuals: one female, Mt. Soyo, GG, Korea, 07.vii.1996, Bae, Paek, Lee & Ahn; one male, Mt. Chiak, GW, Korea, 12.vii.1997, Bae & Ahn, gen. slide no. SNU-9084/ S. Kim; one male, same locality and date, wing venation slide no. SNU-9055/ S. Kim; one female, same locality, date and collector; one female, Mt. Taehwa, Gonjiam, GG, Korea, 24.vi.2006, H.J. Han. gen. slide no. SNU-9085/ S. Kim; one male, Mt. Jungmi, Shinbok-ri, Okcheon-myeon, Yangpyeong-gun, GG, Korea, 28.vi.2011, S. Kim, gen. slide no. SNU-9418/ S. Kim; two individuals, same locality, date, collector; one individual, Mt. Joryung-forest lodge, Yeonpung-myeon, Goesan-gun, CB, Korea, 30.vi.2011, S. Kim; two males, Mt. Yeonin, Seungan-ri, Gapyeong, GG, Korea, 09-10.vii.2011, Lee, Park, Kim, Lim, Lim, Kim & Lee.

Distribution. Korea (South: GG, GW, CB), China.

Genus ***BATIA*** Stephens, 1834

Batia Stephens, 1834, Ill. Brit. Ent. 4: 290.

Type species: *Recurvaria lunaris* Haworth, 1828.

Discolata Spuler, 1910, Die Schmett. Europas. 2: 348.

Chirocompa Meyrick, 1914, Exot. Microl. 1: 230.

Diagnosis. The genus *Batia* is characterized from allied genera by forewing with yellow to red orange of ground color and irregular dark brown marking. The female genitalia is differentiated by largely developed of lamella postvaginalis and lamella antevaginalis.

Wing venation (Fig. 24). Forewing elongate, with radius all veins: R_4 and R_5 stalked beyond the half of their length, R_5 reaching to apex. Hindwing elongate, more narrow, with eight veins: M_1 arising at 4/5 length of wing, M_2 approximate to M_3; CuA far from M_3.

Distribution. Afrotropical, Nearctic, Palaearctic Region.

Remarks. *Batia* is small genus, comprising seven species. *Batia lunaris* (Haworth) is widely distributed from Europe to North America. Five species, *B. lambdella* (Donovan), *B. internella* Jäckh, *B. inexpectella* Jäckh, *B. samosella* Sutter and *B. lutosella* Jäckh are reported from Europe and only one species, *B. decurrens* (Meyrick) is recorded from South Africa. The genus is reported for the first time from Korea in this study.

Key to species of the genus Batia in Korea based on adult

1. Forewing dark brown markings with a triangular-shaped ---------------------------
-- ***B. clavata* sp. nov.**

- Forewing dark brown markings without a triangular-shaped ------------------------
---***B. flavatus* sp. nov.**

***Batia clavata* Kim, sp. nov. 손톱무늬원뿔나방 (신칭)**

Diagnosis. This species is externally close to North America species, *Batia lunaris* (Haworth) in having dark brown marking of forewing, but is can be easily differentiated by a triangular-shaped marking of forewing, very long ductus bursa and a nail-like signa of female genitalia.

Description. Adult (Figs. 37, 71, 72). Head: Frons and vertex whitish yellow. Antenna with scape entirely whitish yellow, slightly shorter than the diameter of eye; flagellum yellow and dark brown alternately. Second segment of labial palpus grayish yellow, except dark brown apically; third segment grayish yellow tinged with dark brown, shorter than the second segment. Thorax: Thorax whitish yellow. Tegula whitish yellow, laterally mixted with fuscous scales. Wing expanse 11.0–12.0 mm. Forewing ground color whitish yellow, tinsed with orange to apex; fuscous scales scattered from the wing base to half of the wing followed by the costal margin; dark brown markings: one, triangular-shaped from posterior margin; the other, somewhat triangular-like, from tornus; another, irregular-shaped, near to apex; fringes orange to yellow followed by termen and outer margin, speckled with fuscous scales near to tornus. Hindwing more lanceolate; ground color gray, tinsed with pale yellow at apex; fringes gray, darker to apex. Leg: hind leg pale whitish yellow dorsally.

Male genitalia. Unknown.

Female genitalia (Figs. 187, 188, 189). Apophysis posterioris slightly longer than the apophysis anterioris. Lamella postvaginalis large developed, incised medially on caudal margin with setose. Antrum funnel-shaped. Ductus bursae gradually wider to corpus bursa, nine times length of the diameter of corpus bursa. Corpus bursae rounded, with a nail-like signum.

Holotype. One female, Mt. Ungseokbong, 226m, Danseong-myeon, GN, Korea, 19.vi.2007, B.W. Lee & S.Y. Park, gen. slide no. SNU-9409/ S. Kim, wing venation slide no. SNU-9428/ S. Kim; *Paratype*. One individual, Mt. Gubong, Chuncheon, GW, Korea, 20.vi.1998, S.M. Lee.

Distribution. Korea (South: GW, GN; new record).

Etymology. The specific name is derived from the Latin, *clavi* (= nail) plus a Latin suffix-*atus*, referring to nail-like signum of female genitalia.

Batia flavatus **Kim, sp. nov. 노랑수염원뿔나방 (신칭)**

Diagnosis. This species is superficially similar to *Batia clavata* Kim, **sp. nov.** in having forewing pattern, but is can be distinguished by dark brown markings without a triangular-shaped and yellow labial palpus, rarely scattered with fuscous scales. In comparison with male genitalia of *B. lunaris* (Haworth), this species can easily differentiated by a thumb-like processus of sacculus, no gnathos, a fork-like juxta with blunt point.

Description. Adult (Figs. 38, 73, 74). Head: Frons and vertex shiny whitish yellow. Antenna with scape entirely whitish yellow, as long as diameter of eye; flagellum whitish yellow, tinsed with grayish-yellow from the half of forewing to apex. Labial palpus yellow, rarely fuscous scales speckled on each apical part of segments; third segment shorter than the second segment.

Thorax: Thorax and tegula whitish-yellow; Wing expanse 11.0–12.0 mm. Forewing ground color whitish-yellow, tinsed with pale orange to apex; three irregular fuscous scales presented: one below the discal cell, from posterial margin; the other at tornus; the antoher near to apex; fringes yellow at termen, speckled with fuscous scales near to tornus. Hindwing more lanceolate; ground color pale grayish yellow;

fringes gray, darker to apex. Leg: hind leg pale whitish yellow dorsally.

Male genitalia (Figs, 135, 136). Uncus bell-like, wide at base, gradually narrowed to apex, slightly bent at sub-apex. Gnathos absent. Tegumen large, rounded margined. Valva symmetric, entirely setose; sacculus a half length of valva, basally setose, rarely laterally; processus of sacculus thumb-like, protruding from sub-apical part, shorter than the sacculus margin; juxta fork-like with blunt point. Aedeagus cylindrical, medium-length between the sacculus and valva; cornutus large, almost same length of aedeagus.

Female genitalia. Unknown.

Holotype. Male, Mt. Joryung-forest lodge, Yeonpung-myeon, Goesan-gun, CB, Korea, 30.vi.2011, S. Kim, gen. slide no. SNU-9410/ S. Kim.

Distribution. Korea (South: CB; new record).

Etymology. The specific name is derived from the Latin, *flavus* (= yellow) plus a Latin suffix-atus, referring to mainly yellow color of the adults.

Genus ***CRYPTOLECHIA*** Zeller, 1852

Cryptolechia Zeller, 1852, Lepid. Microptera quae J. A. Wahlberg in Caffrorum terra collegit. 106.

Type species: *Cryptolechia stramineella* Zeller, 1852.

Psilocorsis Clemens, 1860, Proc. Acad. nat. Sci. Philad. 1860: 212.

Bida Walker, 1864, List. Specimens lepid. Insects Colln Brit. Mus. 29: 842.

Hagno Chambers, 1872, Can. Ent. 4: 129.

Melaneulia Butler, 1883, Trans. ent. Soc. lond. 1883: 70.

Leptosaces Meyrick, 1888, Trans N. zeald. Inst. 20: 7

Inga Busck, 1908, proc. U.S. natn. Mus. 35: 200.

Prosarotra Meyrick, 1909, Ann. Transv. Mus. 2: 23.

Hysipselon Chrétien, 1915, Annls. Soc. ent. Fr. 84: 328.

Diagnosis. This genus is close to the genus *Acryptolechia* in having sacculus processus and triangular-shaped saccus in male genitalia, but can be distinguished by forewing veins, R_4 and R_5 stalked for before the half of their length.

Wing venation (Fig. 25). Forewing broad lanceolate, with all radius veins: R_4 and R_5 stalked before the half their length, R_5 reaching to slightly above the apex; M_1 and M_2 less parallel; M_3 approximate to M_2 from angle of cell. Hindwing with seven veins, the others very weak: M_1 and M_2 less parallel; M_3 approximate to CuA_1; CuA_2 remote to CuA_1 arising from median cell.

Distribution. Oriental, Palaearctic Regions.

Remarks. *Cryptolechia* is mainly distributed from the Oriental and Palaearctic Regions, comprising nearly 200 species. The classification position of the genus *Cryptolechia* has been disagreed among the researchers. Some members of the *Cryptolechia* were transferred to the other Oecophorid genus or upgraded to Cryptolechiinae or Depressariinae of the other Gelechioidea families (Hodges, 1998; Lvovsky, 2009; Nieukerken et al., 2011). Considering the results in the Part II, however, this author treated it as an Oecophorid genus. It also agreed with the Wang's system (2006).

Key to the species of the genus Cryptolechia in Korea based on adult

1. Forewing ground color dark brown with pale yellow markings --- ***C. albulus* sp. nov.**
- Forewing ground color dark brown with yellow markings; four dots at median cell --- ***C. obtusa* sp. nov.**

Key to the species of the genus Cryptolechia in Korea based on male genitalia

1. Valva with rounded apex; uncus conical-like, shorter than saccus; aedeagus slender, cylindrical, bearing saw-toothed spine at 1/2; cornutus about 1/3 length of aedeagus ---***C. albulus* sp. nov.**
- Valva with blunt apex; uncus very long, as long as saccus; cornutus with two-fork shaped apex, about 2/3 length of aedeagus -----------------***C. obtusa* sp. nov.**

Cryptolechia albulus Kim, sp. nov. 옅은원뿔나방（신칭）

Diagnosis. This species is similar to Chinese species, *C. rectimarginalis* Wang in wing pattern, but can be easily differentiated by grayish dark brown of hindwing ground color. The male genitalia is characterized by developed processus of sacculus and juxta.

Description. Adult (Figs. 39, 75, 76). Head: Frons grayish yellow; vertex whitish yellow. Scape of antenna yellow tinsed with dark brown basally, shorter than the diameter of eye; flagellum grayish yellow and dark brown alternately. Second segment of labial palpus dark brown entirely, except yellow basally; third segment yellow, except dark brown at sub-apex; second segment 1.5 times longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 17.0–18.0 mm. Forewing ground color dark brown; one pale yellow marking: oblique, transverse from costal margin to posterior margin; fringes grayish dark brown, rarely tinged with pale yellow. Hindwing less lanceolate, grayish dark brown ground color; fringes greyish dark brwon. Legs: hind leg pale grayish yellow slightly mixed with pale dark brown each apical parts of segment of tarsus.

Male genitalia (Figs. 137, 138). Uncus conical-like, somewhat wide at base, incised laterally, gradually rounded of apex. Gnathos absent. Valva symmetric, triangual-shaped with dense hairs on outer maring; a triangular horn-shaped processus, wide at base, just before the 1/2 of costa; two pairs of processus of sacculus: one elongate apically; the other a tooth-like at 1/2 of caudal margin; juxta with a pair of long slender lateral lobes; saccus a long funnel-shaped. Aedeagus slender, cylindrical, bearing saw-toothed spine at 1/2; cornutus about 1/3 length of aedeagus.

Female genitalia. Unknown.

Holotype. One male, Mt. Jugeum, Pocheon, GG, Korea, 25.vi.2004, H.S. Choi, gen. slide no. SNU-9139; Paratypes. Four individuals: one male, Gwangneung, GG, Korea, 25.vi.1999, T.S. Kwon & B.K. Byun; one male, Mt. Jugeum, Pocheon, GG, Korea, 25.vi.2004, H.S. Choi, gen. slide no. SNU-9137/ S. Kim, wing venation slide no. SNU-9138/ S. Kim; two males, same locality, date and collector.

Distribution. Korea (South: GG; new record).

Etymology. The specific name is derived from the Latin, *albulus* (= whitish), referring to ground color of wings.

Cryptolechia obtusa **Kim, sp. nov. 뭉뚝원뿔나방 (신칭)**

Diagnosis. This species is superficially similar to *Cryptolechia luniformis*

Wang, *C. varifascirupta* Wang and *C. wenxianica* Wang, in having wing parttern, but can be easily distinguished by male genitalia with very long and pointed apex of uncus, a blunt apex of valva and processus of sacculus. The female genitalia is charactierized by heavily developed lamella postvaginalis.

Description. Adult (Figs. 40, 77, 78). Head: frons and verthex pale grayish yellow. Scape of antenna whitish yellow partly mixted dark brown, shorter than the diameter of eye; flagellum yellow and dark brown alternate basally, gragually dark brown to the tip. Labial palpus yellow, except dark brown at sub-apical and apical parts of second segment and middle of third segment; second segment wider in width, and 1.5 times longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 11.0–12.0 mm. Forewing ground color dark brown; three irregular yellow markings: one, oblique at 1/3 of costal margin, above two dots at median cell; the other near to angle of medial cell with dots up and down; another one at 3/4 of costal margin; the second and the third marking somewhat connected; fringes dark brown. Hindwing lanceolate, grayish dark brown ground color; fringes greyish-dark brown. Legs: hind leg dark brown, except yellow apical parts of fifth, fourth, third and second segments of tarsus.

Male genitalia (Figs. 139, 140). Uncus very long, gradually narrowed to pointed apex, as same length as the saccus. Gnathos absent. Valva symmetric, entirely setose followed by costal and outer margins, blunt apically; a spine-like processus apically on costal margin; two pairs of sacculus processus small tooth-like, concave medially; saccus a large funnel-shaped. Aedeagus cylindrical; cornutus with two-fork shaped apex, about 2/3 length of aedeagus.

Female genitalia (Figs. 190, 191, 192). Papilla anales large, setose. Apophysis posterioris about two times longer than apophysis anterioris. Lamella postvaginalis large developed, setose on caudal margin. Lamella antevaginalis slightly incised on caudal margin, as same width as lamella postvaginalis. Seventh sternum folded, a net-shaped sclerotized. Antrum short. Ductus bursae broad, straight to corpus bursa. Corpus bursae a pear-like with a signum bearing tiny three spines.

Holotype. Male, Mt. Jung, Sicheon-myeon, Sancheong-gun, GN, Korea, 29.vi.2011, S. Kim, gen. slide no. SNU-9412/ S. Kim; *Paratypes*: one female, Wando-arboretum, JN, Korea, 27-28.vii.2005, M.Y. Kim & S. Kim, gen. slide no. SNU-9413/ S. Kim, wing slide no. SNU-9431/ S. Kim; one male, Mt. Dondaebong, Is. Hajo, Jodo-myeon, Jindo, JN, Korea, 20.vii.2011, S.Y. Park & J.S. Lim; one individual, Songnisan-myeon, Boeun-gun, CB, Korea, 25.vii.2011, S. Kim.

Distribution. Korea (South: CB, GN, JN; new record).

Etymology. The specific name is derived from the Latin, *obtusa* (= blunt), referring to a blunt apex of valva of male genitlia

Genus ***EXIGUACMA*** Kim **gen. nov.**

Type species: *Exiguacma forcipis* Kim, **sp. nov.**

Diagnosis. This genus is allied to genera *Periacma* Meyrick, *Irepacma* Moriuti, Saito et Lewvanich and *Ripeacma* Moriuti, Saito et Lewvanich in superficial similarity and wing venation. However, the *Exiguacma* is distinguished from *Periacma* and *Irepacma* by small-sized body and differentiated from *Ripeacma* by male genitalia without transtilla. Of above all, *Exiguacma* is immediately distinguished by three segmented labial palpus of male.

Wing venation (Fig. 26). Forewing with all radius veins: R_4 and R_5 stalked before the half of their length, the latter reaching to costa; M_1 and M_2 less parallel; M_3 approximate to M2 and CuA_1 from angle of cell. Hindwing with eight veins: M_1 and M_2 less parallel; CuA_1 appoximate to M_3, far from CuA_2.

Distribution. Palaearctic Regions.

Remarks. *Exiguacma*'s allied genera, *Periacma*, *Irepacma* and *Ripeacma* have sexual dimorphism in the structure of labial palpus. Male has abnormally two segmented, while female has ordinally three segmented. *Exiguama* is differentiated from allied genera by three segmented labial palpus of male, although the *Exiguacma* and those three genera have common in external and genitalic characters.

Etymology. The genus name is derived from the Latin, *exigua* (= small) plus –'*cma'*, referring to small sized moth and allied to the genera *Periacma*, *Irepacma* and *Ripeacma*.

Exiguacma forcipis **Kim, sp. nov. 한라원뿔나방 (신칭)**

Diagnosis. This species is externally similar to Chinese *Irepacma magnignatha* Wang et Li, in having ground color of forewing, but distingushied by fuscous costal patch of forewing and three segmented labial palpus of male. The male genitalia is allied to Thai species, *Irepacma pakiensis* Mrt., Sai et Lew, *I. meksongseei* Mrt., Sai et Lew and *I. lannathaiensis* Mrt., Sai et Lew., but it can be differentiated by the absence of gnathos and two forked-like juxta.

Description. Adult (Figs. 41, 79, 80). Head: Frons whitish yellow; vertex pale grayish yellow. Scape of antenna whitish yellow rarely mixed with dark brown scales entirely, as long as diameter of eye; flagellum whitish yellow and dark brown alternately. Labial palpus whitish yellow, mixed with dark brown: first segment darker than the others; second segment rarely mixed with dark brown scales except on inner margin; third segment entirely mixed but rarely; second segment more than two times longer than third segment. Thorax: Thorax whitish yellow; tegula whitish yellow tinsed with dark brown dorsally. Wing expanse 9.0–10.0 mm. Forewing ground color whitish yellow; dark brown markings: one near to wing base, followed by fuscous scales; one costal patch, semicircle-shaped, just beyond the half of costa; two spots, one at median cell, the other under the cubitus vein; the others, irregularly scattered near to tornus and apex; fringes whitish yellow, partly mixed with dark brown near to tornu and terman. Hindwing more lanceolate, pale grayish yellow ground color; fringes grayish yellow. Legs: hind tibia pale yellowish brown dorsally, except dark brown on spur ventrally; tarsus grayish yellow dorsally, fuscous scales partly scattered laterally.

Male genitalia (Figs. 141, 142). Uncus small, a digitate-like, gradually narrowed to apex. Gnathos absent. Tegument roundly margined. Valva symmetric, costal margin slightly concave at 1/3, gradually to apex and roudedly margined, densed hairs on saccular margin; three pairs of processus of sacculus: one near to juxta, a thumb-like, medium-length; the others, a pincers-shaped, concave between them; juxta, short and two forked-like with blunt apex. Saccus large, triangular-shaped, as long as the half of the valva. Aedeagus cylindrical, gradually narrow to apex, shorter than the valva; cornutus short, at apex.

Female genitalia. Unknown.

Holotype. Male, Mt. Halla, Is. JeJu, Korea, 05.vii.1986, K.T. Park, gen. slide no. SNU-9401/ S. Kim; Paratype. One male, Mt. Samak, Chuncheon-si, GW, Korea, 19.vii.1989, K.T. Park, gen. slide no. SNU-9402/ S. Kim, wing slide no.

9429/ S. Kim.

Distributon. Korea (South: GW, JJ; new record).

Etymology. The specific name is derived from the Latin, *forcipis* (= pincers), referring to the shape of processus of sacculus in male genitlia.

Genus ***MARTYRINGA*** Meyrick, 1902

Martyringa Busck, 1902, Jour. New York Ent. Soc. 10: 96.

Type species: *Oegoconia latipennis* Walsingham, 1882.

Anchonoma Meyrick, 1910, Journ. Bombay Nat. Hist. Soc. 20: 143.

Santuzza Heinrich, 1920, Proc. Ent. Soc. Wash. 22: 43.

Diagnosis. This genus is differentiated from other genera by wing venation with stalked radius veins, III, IV and V.

Wing venation (Fig. 27). Forewing with all radius veins: R_1 and R_2 connate on the median cell; R_3, R_4 and R_5 stalked at each 1/3, 2/3 of their length; R_5 reaching to apex; M_1 and M_2 parallel; M3 lost; CuA1 and CuA2 stalked; Cubitus vein curved posteriorly at 1/4 of its length. Hindwing with ten veins: M_1 and M_2 less parallel; M_3 and CuA_1 separate, from same point of anal angle; CuA_2 far from CuA_1; CuP weak.

Distribution. Neartic, Oriental, Palaearctic Regions.

Remarks. *Martyringa* is a small genus of Oecophoridae, comprising only three species. *Martyringa latipennis* (Walsingham) is recorded from the North America and *M. ussuriella* Lvovsky is reported from Russia and Japan. *M. xeraula* is the broadest species, ranging from India, Thailand, China, Korea, Japan, Russia amd North America. *M. ravicapitis* reported from North America is treated as a synonym of *M. xeraula* by Saito (1987), because of variation in venation of M_3 and CuA_1 in the hindwing.

***Martyringa xeraula* (Meyrick), 1910 도둑원뿔나방**

Anchonoma xeraula (Meyrick), 1910, Journ. Bombay Nat. Hist. Soc. 20: 144.

Anchonoma kuwanii Heinrich, 1920, Pro. Ent. Soc. Wash. 22(3): 43.

Martyringa xeraula Moriuti, 1982, Moth of Jap. 1: 249, 2: 205, pl. 11: 47.

Diagnosis. This species is externally close to North American, *M. latipennis* (Walsingham), but can be distinguished by dark gray ground color of forewing, sclerotized sacculus margin of male genitalia and an arrow-shaped antrum of female genitalia.

Description. Adult (Figs. 42, 81, 82). Head: Frons and vertex pale graysich yellow with yellowish brown laterally. Antenna with dark brown scape entirely, except yellow distally, shorter than a diameter of eye; flagellum dark brown. Labial palpus dark brown, mixed with yellow apically on the second and third segments; second segment almost same length as third segment.

Thorax: Thorax dark brown dorsally; tegula dark brown tinsed with yellow posteriorly. Wing expanse 23.0–24.0 mm. Forewing ground color dark brown; pale yellow scales: some from median cell to sub-apex; the others at apex, followed by termen; two dark brown spots: one at 1/3; the other, bigger than the former, at the half of forewing; fringes grayish dark brown. Hindwing less lanceolate; hindwing ground color grayish brown, margined with pale yellow; fringes grayish brown. Legs: hind leg pale yellowish brown dorsally.

Male genitalia (Figs. 143, 144). Uncus beak-like, setose, wide at base. Gnathos tongue-like, as long as uncus. Valva symmetric, convex at 1/3 of costal margin, roundly margined with setose; sacculus sclerotized, setose entirely, the half length of the valva. Vinculum sclerotized. Aedeagus slender, as long as the valva, lateral lobes with pointed apex.

Female genitalia (Figs. 193, 194). Apophysis posterioris two times length of apophysis anterioris. Lamella postvaginalis largely developed, setose on caudal margin. Antrum arrow-shaped, slightly shorter than the seventh sternum. Ductus bursa straight, gradually wider to corpus bursa. Corpus bursa a pear-like without signum.

Material examined. Nine individuals: one male, Muju-gun, JB, Korea, 12.vii.1975, K.T. Park, gen. slide no. SNU-9108/ S. Kim; one male, Seogwipo-si, JJ, Korea, 06.vii.1975, H.S. Kim, wing slide no. SNU-9056/ S. Kim; one individual, Mt. Myeongji, Gapyeong-gun, GG, Korea, 25.vi.1983, K.T. Park; one male, Mt. Soyo, GG, Korea, 07.vii.1996, Bae, Paek, Lee & Ahn; one female, Is. Deokjeok, Buk-ri, GG, Korea, 24.vi.1997, Y.S. Bae, N.H. Ahn; one male, Bongmyeong-ri, GW, Korea, 17.vi.1999, S.T. Kim & S.M Lee; one male, Mt. Seorak, Sokcho-si, GW, Korea, 05.vii.2002, Kim, Oh, Lee & Choi; one male, Mt. Jugeum, Pocheon, GG, Korea, 25.vi.2004, H.S. Choi, gen. slide no. SNU-9137/ S. Kim; one male, Temple-Pyochung, 308m, Danjangmyeon, GN, Korea, 12.vii.2007, B.W. Lee & S.Y. Park & D.H. Kwon.

Distribution. Korea (South: GG, GW, GN, JB, JJ), Japan, China, Russia, Thailand, India, North America.

Genus ***PERIACMA*** Meyrick, 1894

Periacma Meyrick, 1894, Trans. Ent. Soc. Lond. 1894: 21.

Type species: *Periacma ferialis* Meyrick, 1894.

Diagnosis. *Periacma* Meyrick is allied to two genera, *Irepacma* Moriuti, Saito et Lewvanich and *Ripeacma* Moriuti, Saito et Lewvanich, in having sexual dimorphism in structure of labial palpus, but it can be differentiated from *Ripeacma* by broad hindwing, and distinguished from *Irepacma* by hindwing with cubitus vein p (CuP) and female genitlia with apophysis anteriores.

Wing venation (Fig. 28). Forewing with all veins: R_4 and R_5 stalked at the half of their length, the latter reaching to apex; M_1 and M_2 parallel; CuA_1 approximate to M_3; CuA2 arising from sub-anal angle of median cell. Hindwing with ten veins: M_1, and M_2 less parallel; M_3 and CuA_1 from same point from median cell; CuA2 far from CuA1, arising 4/5 of posterior margin of cell; CuP developed.

Distribution. Oriental, Palaearctic Regions.

Remarks. The *Periacma* is mainly distributed from Oriental and Palaearctic Asia Regions, comprising eighty-two species (Wang, 2006), especially from Thailand and China. In Korea, only one species has been reported.

Periacma delegata **Meyrick, 1914 노랑날개원뿔나방**

Periacma delegata Meyrick, 1914, Supp. Ent. 3: 52.

Diagnosis. This species is superficially similar to *Periacma equivalvata* Wang, Li et Liu, *P. orthiodes* Meyrick, *P. vietnamica* Lvovsky, *P. zhouzhiensis* Wang et Zheng and *P. ziuangensis* Wang et Zheng, in having yellow ground color with dark brown marking of forewing, but can be distinguished by male genitalia with broad sagittiform uncus and fan-shaped gnathos.

Description. Adult (Figs. 43, 83, 84). Head: Frons and vertex whitish yellow. Scape of antenna whitish yellow except dark brown innerally, shorter than diameter of eye; flagellum whitish yellow and dark brown alternately. Labial palpus whitish yellow except a few dark brown scales on apical margin of second segment; third segment shorter than second segment. Thorax: Thorax and tegula yellow dorsally. Wing expanse 14.0–17.0 mm. Forewing ground color yellow; dark brown markings: one from posterior margin, oblique, semi-ovate-like; two spots centrally at 1/3 of forewing; one, band-like, transverse from costa to posterior margin at 2/3 of forewing; one at apex; fringes yellow, partly mixed with grayish brown. Hindwing lanceolate, ground color grayish brown; fringes greyish brown. Legs: hind leg yellow, except each apical parts of tarsus.

Male genitalia (Figs. 145, 146). Uncus broad-sagittiform, slightly incised laterally, rounded apically. Gnathos spatulate shaped, as long as the uncus. Valva symmetric; costa straight to apex, roundly margined with dense hairs; sacculus with two pairs of processus: basal one, small and triangular-like; discal one, long and clavate-like. Aedeagus simple and slender without cornutus.

Female genitalia (Fig. 195). Papilla analis setose. Apophysis posterioris and apophysis anterioris somewhat thick, the former more than 1.5 times length of the latter. Lamella postvaginalis largely developed, setose caudally. Antrum short, incised caudally. Ductus bursa membranous, straight to corpus bursa. Corpus bursa without signum.

Material examined. Fifteen individuals: one female, Mt. Seorak, Sokcho-si, GW, Korea, 25.vii.1977, K.T. Park; one female, River-Sogum, CN, Korea, 07.vii.1988, K.T. Park, gen. slide no. SNU-9081/ S. Kim, wing slide no. SNU-9222/ S. Kim; one female, Hwaseong-si, GG, Korea, 16.vii.1993, M.J. Han; one male, Swamp. Upo, Changnyeong-gun, GN, Korea, 28.viii.1997, M.K. Paek, gen. slide no. SNU-9082/ S. Kim, wing slide no. SNU-9057/ S. Kim; one female, Mt. Gunja, Yeoncheon-gun, GG, Korea, 10-12.vii.2000, Paek, Kim, Kim& Ko; two females, Mt. Gaji, Baenaegol Ulsan, GN, Korea, 11-12.vii.2000, J.Y. Choi; one female, Mt. Daewoo, Yangu-gun, GW, Korea, 17.vii.2000, Paek, Kim & Yu; one female, Mt. Ungseokbong, 226m, Danseong-myeon, GN, Korea, 19.vi.2007, B.W. Lee & S.Y. Park; one female, Mt. Maebong, Nam-myeon, Inje-gun, GW, Korea, 22.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim; one female, Mt. Jung, Sicheon-myeon, Sancheong-gun, GN, Korea, 29.vi.2011, S. Kim.

Distribution. Korea (South: GG, GW, GN), Japan, China.

Genus ***PSEUDODOXIA*** Durrant, 1895

Pseudodoxia Durrant, 1895, Ent. Mon. Mag. 31: 107.

Type species: *Fumea limulus* Rogenhofer, 1889.

Diagnosis. This genus is distinguished from other genera by forewing with simple marking, male genitalia with spine-like processus of cucullus and female genitalia with distinct caudal margin of ductus bursa.

Wing venation (Figs. 29). Forewing with all radius veins: R_4 and R_5 stalked at half of their length, the latter reaching to apex; M_1 and M_2 parallel; CuA_1 approximate to M_3, remote from CuA_2. Hindwing with nine veins: M_1 and M_2 less parallel; M_3 and CuA_1 from same point of anal angle; CuA_2 far from CuA_1 arising from 4/5 of median cell; Cup weakly developed.

Distribution. Oriental, Palaearctic Regions.

Remarks. This genus is originated from Oriental Regions, mainly Sri Lanka and South Inia, comprising approximately fourty species. In this study, two descriptions including one new species, *Pseudodoxia gahakensis* Kim, **sp. nov.**, are revised from Korea.

Key to species of the genus Pseudodoxia in Korea based on adult

1. Labial palpus dark brown, except yellow apical second segment and entire third segment; Forewing with yellowish brown marking transverse from costa to posteriror margin sub-apically--***P. achlyphanes***

- Labial palpus brown, except yellow apical second segment and entire third segment; Forewing without transverse marking-------------***P. gahakensis*** **sp. nov.**

Key to species of the genus Pseudodoxia in Korea based on male genitalia

1. Valva as long as cucullus -- ***P. achylyphanes***

- Valva very short, 1/4 length of cucullus ------------------ ***P. gahakensis*** **sp. nov.**

Pseudodoxia achlyphanes **(Meyrick), 1934 통말이원뿔나방**

Cryptolechia achlyphanes (Meyrick), 1934, Exot. Microl. 4(15): 478.

Pseudodoxia achlyphanes Satio, 1976, Trans. Lep. Soc. Jap. 26: 91.

Diagnosis. This species is externally close to *Pseudodoxia pradema* Meyrick, *P. pachnocoma* Meyrick in having forewing marking, but can be distinguished by male genitalia with elongated processus of cucullus.

Description. Adult (Figs. 44, 85, 86). Head: Fron and vertex pale grayish brown mixed with yellow. Scape of antenna grayish brown tinsed with yellow anteriorly, shorter than diameter of eye; flagellum grayish yellow. Labial palpus dark brown, except yellow apical second segment and entire third segment; second segment slightly lonter than third segment. Thorax: Thorax and tegula pale grayish brown dorsally. Wing expanse 13.5–14.0 mm. Forewing ground color yellowish brown scattered by fuscous scales; two black dots: large one at 1/2 of median cell, small one at 2/3 of forewing; fuscous scales more densed from wing base to apex followed by costal margin and from 4/5 of forewing to apex, after yellowish brown transverse from costa to posteriror margin; fringes grayish dark brown, slightly mixed with yellow. Hindwing less lanceolate, ground color grayish brown; fringes grayish brown, tinsed with yellow. Legs: hind leg pale yellow, except pale grayish brown at apical parts of fifth, fourth, third and second segments of tarsus.

Male genitalia (Figs. 147, 148). Uncus thumb-like, wide at base, with rounded apex. Gnathos reversed bell-like, with pointed apex, as same as uncus. Valva symmetric, setose distally, with rounded apex; processus of cucullus enlongate, long spine-shaped, longer than valva; processus of sacculus tridentate distally. Saccus funnel-like. Juxta developed. Aedeagus cylindrical, as long as valva, with cornuti apically.

Female genitalia (Figs. 196, 197, 198). Papilla anales setose. Apophysis posterioris slightly longer than apophysis anterioris. Lamella postvaginalis developed, setose caudally. Antrum cylindrical with a thumb shaped caudal margin, gradually narrow to ductus bursa. Ductus bursa gradually wider to corpus bursa, shorter than antrum. Corpus bursa large, ovate-like. Signum bearing large dentate spine.

Material examined. Twenty-four individuals: one individual, Mt. Jiri, Jungsan-ri, CN, Korea, 19.viii.1981, K.T. Park; one male, same locality, date and collector, gen. slide no. SNU-9110/ S. Kim, wing slide no. SNU-9115/ S. Kim; one female, Gwangneung, GG, Korea, 13.vii.1998, B.K. Byun; one female, same locality and date, gen. slide no. SNU-9109/ S. Kim; one male, Wando-arboretum, JN, Korea, 27-28.vii.2005, M.Y. Kim & S. Kim, gen. slide no. SNU-9437/ S. Kim; one female, same locality, date and collector, gen. slide no. SNU-9438/ S. Kim; three males and fifteen females, same locality, date and collector.

Distribution. Korea (South: GG, CN, JN), Japan, China.

***Pseudodoxia gahakensis* Kim, sp. nov. 가학원뿔나방 (신칭)**

Diagnosis. This species is externally close to *Pseudodoxia achlyphanes* (Meyrick) in having wing pattern, but can be distinguished by male genitalia with very short valva.

Description. Adult (Figs. 45, 87, 88). Head: Frons and vertex pale grayish yellow. Scape of antenna pale dark brownish yellow dorsally, shorter than diameter of eye; flagellum pale dark brownish yellow and pale yellow alternately. Labial palpus brown, except yellow apical second segment and entire third segment; second segment longer than third segment. Thorax: Thorax and tegula pale grayish yellow dorsally, the latter darker than former. Wing expanse 13.5–14.0 mm. Forewing ground colour pale yellow, rarely scattered by fuscous scales; two dots: large one at 1/2 of median cell, small one 2/3 of forewing; grayish dark brown scales near to tegula; fringes pale yellow. Hindwing less lanceolate, ground color pale grayish yellow; fringes grayish yellow. Legs: hind leg pale grayish yellow.

Male genitalia (Figs. 149, 150). Uncus thumb-like, wide at base, with rounded apex. Gnathos beak-like, gradually narrow to rounded apex, shoter than uncus. Valva symmetric, very short; processus of cucullus enlongate, long spine-shaped, more than five times longer than valva; processus of sacculus tridentate distally. Saccus funnel-like. Juxta with thumb-like lobe. Aedeagus cylindrical, slightly bent centrally, as long as tegumen plus saccus. Cornutus absent.

Female genitalia. Unknown.

Holotype. Male, Mt. Gahak, Haenam, JN, Korea, 26.vii.2005, M.Y. Kim & S. Kim, gen. slide no. SNU-9439/ S. Kim.

Distribution. Korea (South: JN; new record).

Etymology. The specific name refers to collection locality, '*gahak*'.

Genus ***RIPEACMA*** Moriuti, Saito et Lewvanich, 1985

Ripeacma Moriuti, Saito et Lewvanish, 1985, Bull. Univ. Osaka Pref. (B) 37: 32.

Type species: *Ripeacma nangae* Moriuti, Saito et Lewvanish, 1985.

Diagnosis. This genus is closely allied to *Periacma* Meyrick and *Irepacma* Moriuti, Saito et Lewvanich, in having two-segmented labial palpus of male and three-segmented labial palpus of female, but can be distinguished by male genitalia with transillia.

Wing venation (Fig. 30). Forewing long and narrow, with all radius veins: R_4 and R_5 stalked at 1/3 of their lenth, the latter reaching to above the apex; M_1 and M_2 less parallel; M2 and M3 connect from same point of anal angle; CuA_1 remote to M3; CuA_2 remote to CuA_1 at 3/4 of median cell. Hindwing with seven veins: M_1 and M_2 less parallel; M_3 connect to CuA_1 from same point of anal angle; CuA_2 remote to CuA_1 at 1/2 of median cell.

Distribution. Oriental, Palaearctic Region.

Remarks. Twenty-two species of *Ripeacma* have been reported from mainly China and Thailand. In this study, one unrecorded species, *Ripeacma acuminiptera* Wang et Li is added and two new species, *R. adamantis* Kim, **sp. nov.** and *R. longior* Kim, **sp. nov.**, are newly reported from Korea.

Key to species of the genus Ripeacma in Korea based on adult

1. Forewing ground color pale yellow, rarely scattered by dark brown scales -----**2**

- Forewing ground color dark brown ------------------------------*R. longior* **sp.nov.**

2. Costal margin of forewing with five spots; hindwing ground color grayish brown -- ***R. acuminiptera***

- Costal margin of forewing with five spots and two dots; hindwing ground color grayish dark brown -- ***R. adamantis*** **sp. nov.**

Key to species of the genus Ripeacma in Korea based on female genitalia

1. Lamella antevaginalis triangular-like, without sclerotized area, bifurcate anteriorly --- ***R. acuminiptera***

- Lamella antevaginalis triangular-like, with sclerotized diamond-like plate, bifurcate anteriorly -- ***R. adamantis*** **sp. nov.**

Ripeacma acuminiptera **Wanget Li, 1999 좁은노랑원뿔나방 (신칭)**

Ripeacma acumniptera Wang et Li, 1999, The Fau. and Tax. of Ins. in Henan. 4: 58.

Diagnosis. This species is superficially similar to *Ripeacma adamantis* Kim, **sp. nov.** in having wing pattern, but can differentiated by female genitalia with weakly developed lamella antevaginalis.

Description. Adult (Figs. 46, 89, 90). Head: Frons pale yellow; vertex pale yellow mixed with black. Scape of antenna pale yellow mixed with black, shorter than diameter of eye; flagellum pale yellow tinsed with dark brown irregularly. Labial palpus pale yellow, except black laterally at basal, middle parts of first segment; basal, 3/5, apical parts of second segment; 1/3, 3/4 parts of third segment; second segment 1.5 times longer than third segment. Thorax: Thorax pale yellow dorsally; tegula pale yellow tinsed with black dorsally. Wing expanse 11.5–12.5 mm. Forewing ground color pale yellow, rarely scattered by dark brown scales; five costal spots: one near to wing base, others at 1/4, 1/2, 2/3 and 3/4; four dots on median cell: one at anterior margin, large one at posterior margin, two others at anal angle; four dots on posterior margin of forewing: one befor tornus, the other at tornus, another at sub-apical, the last one just below apex; fringes grayish dark brown. Hindwing more lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg pale yellow, except dark brown at basal parts of all segment of tarsus.

Male genitalia. According to figure 357 of Wang (2006). Uncus short, incised caudally with setose. Gnothos tongue-like with concave diatally, as same length as uncus. Valva symmetrical with rounded apex, entirely setose, denser hairs at 1/3 basally; transtilla developed; sacculus elongated hook-like, 2/3 length of valva. Aedeagus with spine-like cornutus.

Female genitalia (Figs. 199, 200, 201). Papilla anales setose. Apophysis posterioris more than two times longer than apophysis anterioris. Lamella postvaginalis incised caudally with setose. Lamella antevaginalis large triangular-like, bifurcate anteriorly. Antrum large, somewhat circular-like with uneven margined caudally. Ductus bursa narrow from antrum to 1/3 anteriorly, wider to corpus bursa. Corpus bursa long and narrow, somewhat pear-like, swelling apical-laterally with signum.

Material examined. Five individuals: one individual, Mt. Cheonggye, Gwacheon-si, GG, Korea, 19.viii.1976, K.T. Park; one female, Seo-myeon, Yanyang-gun, GW, Korea, 25.vii.1987, K.T. Park, gen. slide no. SNU-9300/ S. Kim; one female, Mt. Bannon, Yeoryang-myeon, jeongseonl, GW, Korea, 20.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim, gen. slide no. SNU-9298/ S. Kim; one individual, same locality, date and collector; one female, Mt. Maebong, Nam-myeon, Inje-gun, GW, Korea, 22.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim, gen. slide no. SNU-9299/ S. Kim.

Distribution. Korea (South: GG, GW), Japan, China.

Remark. This species is recorded for the first time from Korea, however, Korean species of *R. acuminiptera* is rather differentiated from Chineses of *that* by length and shape of ductus bursa in female genitalia. Considering the varation of species, we determined that both are same species.

***Ripeacma adamantis* Kim, sp. nov. 다이아원뿔나방（신칭）**

Diagnosis. This species is superficially similar to *Ripeacma acumimiptera* (Meyrick) in having wing pattern, but can differentiated by female genitalia with pentagonal papilla analis and diamond-like lamella antevaginalis of female genitalia.

Description. Adult (Figs. 47, 91, 92). Head: Frons pale yellow; vertex pale yellow, tinswd with gray. Scape of antenna pale yellow mixed with black, shorter than diameter of eye; flagellum pale yellow to 1/3, alternately mixed with black from 1/3 to apex. Labial palpus pale yellow, except black laterally at basal part of first segment; middle, apical parts of second segment; 1/3, 4/5 parts of third segment; second segment 1.5 times longer than third segment. Thorax: Thorax pale yellow dorsally; tegula pale yellow mixed with black dorsally. Wing expanse 10.5–11.0 mm. Forewing ground color pale yellow, rarely scattered by dark brown scales; five costal spots: one near to wing base, others at 1/4, 1/2, 2/3 and 3/4; two costal dots between the last costal spots and apical spot; four dots on median cell: one at anterior margin, large one at posterior margin, two others at anal angle; three dots on posterior margin of forewing: one befor tornus, the other at tornus, another just above tornus, the last just below apical spot; fringes pale yellow followed by termen to just above apex, tinsed with gray from apex to just before tornus. Hindwing more lanceolate, ground color grayish dark brown; fringes grayish dark brown. Legs: hind leg pale yellow, tinsed with pale gray from fourth to first segments of tarsus.

Male genitalia. Unknown.

Female genitalia (Figs. 202, 203, 204). Papilla anales large, pentagon-shaped with setose caudally. Apophysis posterioris more than three times length of apophysis anterioris. Lamella postvaginalis incised, setose caudally. Lamella antevaginalis triangular-like bearing sclerotized diamond-like plate, bifurcate anteriorly. Antrum weakly developed, large circular-like, unevenly margined. Ductus bursa membranous, 1.5 times longer than vertical seventh sternum. Corpus bursa enlongated ovate-like with signum.

Holotype. Female, Songnisan-myeon, Boeun-gun, CB, Korea, 25.vii.2011, S. Kim, gen. slide no. SNU-9297/ S. Kim. *Paratype*. One individual, Mt. Jiri, Jungsan-ri, CN, Korea, 14.vii.1976, Y.Y. Ha.

Distribution. Korea (South: CB, CN; new record).

Remark. This species is newly reported in this study, however, the male of this species has not been examined due to the lack of specimen.

Etymology. The specific name is derived from the Latin, *adamas* (= diamond) plus a Latin suffix-*antis*, referring to diamond-like lamella antevaginalis of female genitalia.

***Ripeacma longior* Kim, sp.nov. 긴돌기원뿔나방（신칭）**

Diagnosis. This species is externally similar to *Cryptolechia zhengi* Wang in having wing pattern, but can be easily distinguished by male genitalia with elongated uncus and sacculus.

Description. Adult (Figs. 48, 93, 94). Head: Frons white and vertex pale yellow. Scape of antenna dark brown tinsed with pale yellow apically, as long as diameter of eye; flagellum dark brown entirely. Labial palpus pale yellow, except dark brown apical second segment; first segment 1.5 times longer than second segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 13.0–13.5 mm. Forewing ground color dark brown; one pale yellow costal patch at 3/4 of forewing; one short, oblique, band-like marking just before tornus; fringes dark brown, partly tinsed with pale yellow at termen and before tornus. Hindwing more lanceolate, ground color grayish dark brown; fringes grayish dark brown. Legs: hind leg pale yellow, except dark brown at middle of fifth segment of tarsus.

Male genitalia (Figs. 151, 152). Uncus elongated with swelling apex, long-spatula-like, about two times longer than vertical length of tegumen. Gnothos with triangular lateral lobes. Tegumen extended, dense hairs caudally. Valva symmetric, slightly longer than uncus; Sacculus free, enlongated with pointed apex, long spine-like, more than two times longer than valva. Transtilla developed. Aedeagus long with somewhat blunt apex, gradually wider to beyond the half, straight to base. Cornutus absent.

Female genitalia. Unknown.

Holotype. Male: Mt. Taehwa, Gonjiam, GG, Korea, 25.viii.2006, Park, Kim, Chae, gen. slide no. SNU-9414/ S.Kim, wing slide no. 9432/ S. Kim.

Distribution. Korea (South: GG; new record).

Etymology. The specific name is derived from the Latin, *longior* (= longer), referring to very long uncus and sacculus of male genitalia.

Subfamily **OECOPHORINAE** Bruand, 1850 **원뿔나방아과**

Aecophoridae Bruand, 1849(1850), Mem. Soc. Libre d'Emulation du Doubs. 3: 45.

Type genus: *Oecophora* Latreille, 1802.

The Oecophorinae is the largest subfamily of Oecophoridae, comprising more than 3,300 species (Nieukerken et al., 2011), characterized by various forms, small to medium-sized adult, forewing with a white or fuscous dot or band-like or irregular marking, male genitalia symmetric or asymmetric, with/without gnathos and the female genitalia with distinct spines in ductus bursa. In the Korea fauna, the

Oecophorinae is differentiated from other subfamily, Cryptlechiinae stat. nov. by abdominal terga lacking spiniform setae and R4 and R5 stalked from before the half of their length in forewing venation. In this study, nineteen species of four genera of Korean Oecophorinae were reviewed, with new descriptions of one species, *Promalactis candidifascia* Kim, **sp. nov.** and two un-recorded species, *Epicallima conchylidella* (Snellen, 1884) and *Promalactis xianfengensis* Wang et Li, 2004. One un-recorded genus, *Epicallima*, was also investigated.

Key to genera of the subfamily Oecophorinae in Korea based on adult

1. Termen of wings concave --- ***Deuterogonia***

  - Termen of wings round --- **2**

2. Forewing venation with Cup developed -- **3**

  - Forewing venation with Cup absent or weakly developed ----------- ***Promalactis***

3. Labial palpus with 2^{nd} longest segment --------------------------------- ***Epicallima***

  - Labial palpus with 3^{rd} longest segment --------------------------------- ***Callimodes***

Key to genera of the subfamily Oecophorinae in Korea based on male genitalia

1. Uncus weakly developed--- ***Deuterogonia***

- Uncus sclerotized-- **2**

2. Valva with terminal margin dentate -------------------------------------- ***Callimodes***

- Valva with terminal margin round or pointed --------------------------------------- **3**

3. Aedeagus with bulbed apex --- ***Epicallima***

- Aedeagus with pointed or simple apex --------------------------------- ***Promalactis***

Key to genera of the subfamily Oecophorinae in Korea based on female genitalia

1. Lamella postvaginalis absent or weakly developed -------------------------------- **2**

- Lamella postvaginalis distinctly developed ---------------------------- ***Promalactis***

2. Ductus bursa narrow with numerous spines ----------------------------- ***Epicallima***

- Ductus bursa wide in width without spine ------------------------------ ***Callimodes***

Genus ***CALLIMODES*** Leraut, 1989

Callimodes Leraut, 1989. Alexanor, Rev. des Lép. Fra. Par. 16(2): 112.

Type species: *Oecophora heringii* Lederer, 1864. Wien. Ent. Monotschr. 8: 172.

Diagnosis. This genus is externally characterized from allied genera by large sized body and distinct marking of forewing.

Wing venation (Fig. 31). Forewing long and narrow, with all radius veins: R_4 and R_5 stalked at 1/3 of their length, the latter reaching to slightly above the apex; M_1 and M_2 less parallel; M_3 and CuA_1 fro m same point of median cell; CuA_2 remote to CuA_1; Cup developed; 1A connect to 2A. Hindwing with ten veins: M_1 and M_2 less parallel; M_3 and CuA_1 from same point of anal angle; CuA_2 remote to CuA_1 arising from central-posterior margin of median cell; CuP weakly developed; 1A separate to 2A.

Distribution. Palaearctic Regions.

Remark. Callimodes is a small genus, mainly distributed from Palaearctic Regions. Only three species, *Callimodes heringii* (Lederer), *C. mannii* (Lederer) and *C. zelleri* (Christoph) are described.

Callimodes zelleri (Christoph), 1882 젤러리원뿔나방

Oecophora zelleri (Christoph), 1882. Bull. Soc. Nat. Mosc. 57(1): 35.

Schiffermuelleria zelleri Inoue, 1954, Check List Lep. Jap. 1: 62.

Diagnosis. This species is distinguishied from other genera by large sized and distinct forewing marking. The male genitalia is also characterized by longer gnathos and juxta.

Description. Adult (Figs. 49, 95, 96). Head: Frons and vertex black. Antenna with black scape entirely, shorter than diameter of eye; flagellum black from base to 2/3 of its length, white from 2/3 of that to apex dorsally. Labial palpus brownish black, except pale yellow at basal second segment; third segment slightly longer than second segment. Thorax: Thorax blalck tinsed with shiny dark brown dorsally; tegula black. Wing expanse 16.5–22.0 mm. Forewing ground colour brownish yellow surrounded by black followed by costa, termen and posterior margin of forewing; two white bands from costa, oblique, surrounded by fuscous scales: one at 1/4, the other at 1/3, not reaching to posteriror margin; two spots: small one at 1/2, surrounded by fuscous scales, the other large one, ovate-like, at 2/3 after black transverse scales from costa to before tornus; fringes black. Hindwing less lanceolate, ground color grayish dark brown; fringes grayish brown. Legs: hind leg black, except white at basal and apical parts of fifth and at basal part of fourth, third, second segments of tarsus.

Male genitalia (Figs. 153, 154). Uncus bell-like, wide at base, gradually narrowed to apex, setose entirely. Gnathos tongue-like with pointed apex, bent medially, longer than uncus. Valva symmetric, with dentate apex, dense hairs distally; saccular margin sclerotized with dense hairs anteriorly, about half length of valva. Juxta with long lateral lobes, longer than tegumen; left lobe longer than right lobe. Saccus somewhat triangular-like, shorter than uncus. Aedeagus long, slightly bent medially without cornutus.

Female genitalia. Unknown.

Material examined. Four males: one male, Chuncheon-si, GW, Korea, 21.v. 1983, K.T. Park; one male, Mt. Tonggo, Uljin-gun, GB, Korea, 26-31.vi.2000, Bae et al., gen. slide no. SNU-9099/ S. Kim; one male, Samgok, Seolcheon, Muju-gun, JB, Korea, 03.ix.2004, M.O. Yeom, gen. slide no. SNU-9417/ S. Kim, wing venation slide no. SNU-9446/ S. Kim; one male, Mt. Jobong, Seo-myeon, Yangyang-gun, GW, Korea, 22.v.2009, S.Y. Park, J.S. Lim & K.M. Kim

Distribution. Korea (South: GW, GB, JB), Japan, Russia.

Remark. We do not examine the female due to lack of specimen.

Genus ***Deuterogonia*** Rebel, 1901

Deuterogonia Rebel, 1901, Cat. Leid. Palaearct. Faunengebietes 2: 158.

Type species: *Gelechia pudorina* Wocke, 1857

Diagnosis. This genus is distinguished from other genera by broad forewing with stripe-like marking. The male genitailia is characterized by weak or absent uncus and short valva.

Wing venation (Fig. 32). Forewing broad and wide, with all radius veins: R_4 and R_5 stalked at half of their length, the latter reaching to termen, under apex;

M_1 and M_2 parallel; CuA_2 remote to CuA_1 from 2/3 of posterior margin of median cell. Hindwing broad and wide, with ten veins: M_1 and M_2 less parallel; M_3 and CuA_1 from same point of anal angle; CuA_2 remote to CuA_1 from 2/3 of posterior margin of median cell; Cup weakly developed; 1A and 2A separate.

Distribution. Oriental, Palaearctic Regions.

***Deuterogonia pudorina* (Wocke), 1857 북방원뿔나방**

Gonia pudorina Wocke, 1857, Z. Ent., 10: 5.

Deuterogonia pudorina Staudinger et Rebel, 1901, Cat. Lepid. Papaeackt. Faunengbietes. 2: 158.

Parocystola pudorina Meyrick, 1922, Gen. Ins. 180: 98.

Deuterogonia pudorina Eckstein, 1933, Kleinschm. Deutschl. 1933: 126.

Diagnosis. This species is superficially similar to *Deuterogonia henanensis* Wang et Li in the wing pattern, but can be distinguished by male genitalia with uncus and longish processus of cucullus. The female genitalia is characterized by crescent-shapec signum.

Description. Adult (Figs. 50, 97, 98). Head: Frons and vertex white. Scape of antenna white tinsed with brownish yellow, as long as diameter of eye; flagellum white and brownish yellow alternately. Labial palpus with pale brownish yellow second segment and white third segment; the former slightly longer than the latter. Thorax: Thorax and tegula white rarely nsed with pale brownish yellow dorsally. Wing expanse 16.0–16.5 mm. Forewing broad, two ground color: white from wing base, followed by costal margin, above radius vein I, scattered by brownish yellow scales, pink from sub-basal to apex, mixed with fuscous scales; two brown broad band-like markings transverse from costa to posterior margin, surrounded by fuscous scales: one at 1/3, the other at 2/3; brown scales partly tinsed: one after white near to wing base, the other above apex; fringes brown followed by termen, mixed with dark brown scales, partly pinkish fringes near to tornus. Hindwing broad, ground color pale grayish brown; fringes grayish brown. Legs: hind leg with dark brown tibia; white tarsus except brownish yellow at middle part of fifth and fourth segments, basal part of third segment, apical part of second segment; fifth segment with tuft in middle.

Male genitalia (Figs. 155, 156). Uncus weakly developed, incised caudally, setoes. Gnothos absent. Tegumen weakly developed, with setose caudally. Valva symmetric, setose distally; two pair processus of cucullus: one near base, thin, weakly developed and setose distally, the other heavily curved U-like, thicker than the former; saccular margin 2/3 length of valva. Juxta with thumb-like lateral lobes bearing setose distally. Saccus short, triangular-like, as long as uncus. Aedeagus simple, slightly bent at 2/3. Cornutus absent.

Female genitalia (Figs 205, 206). Papilla anales setose. Apophysis posterioris 1.5 times length of apophysis anterioris. Lamella postvaginalis weakly developed, setose caudally. Antrum short. Ductus bursa membranous, gradually wider from antrum; ductus seminalis arising anteriorly. Corpus bursa somewhat longish ovate-shaped. Signum crescent-like.

Material examined. Eleven individuals: one female, Mt. Bangtae, Inje-gun, GW, Korea, 14.viii.1995, S.S. Kim; one female, Gwangneung, GG, Korea, 10.vi. 1998, B.K. Byun, gen. slide no. SNU-9238/ S. Kim; one female, same locality, date and collector, wing slide no. SNU-9123/ S. Kim; one female, Mt. Sobaek, Youngpung-myeon, GB, Korea, 17.vii.1998, S. Kim, gen. slide no. SNU-9239/ S. Kim; one individual, Baeklim Exp. For., Hongcheon, GW, Korea, 18.vii.2000, B.K. Byun & W.L. Bae; one female, Seonad-ri, Jindong valley, Inje-gun, GW, Korea, 13.viii.2000, B.K. Byun & W.L. Bae; one female, Electric power plant 760m, Korea, site 17, 18.vii.2001, Park, Sohn, Han; one individual, KNU Camp., Chuncheon, GW, Korea, 30.vi.2005, T.M. Kang; one female, Mt. Baegun, Gwangyang-si, JN, Korea, 15-18.vi.2011, S. Kim, gen. slide no. SNU-9416/ S. Kim; one male, Mt. Jungmi, Shinbok-ri, Okcheon-myeon, Yangpyeong-gun, GG, Korea, 28.vi.2011, Sora Kim, gen. slide no. SNU-9415/ S. Kim; one female, Songnisan-myeon, Boeun-gun, CB, Korea, 25.vii.2011, S. Kim.

Distribution. Korea (South: GG, GW, CB, GB, JN), Japan, China, Russia, Europe.

Genus ***EPICALLIMA*** Dyar, [1903]

Epicallima Dyar, [1903], U.S. Natl. Mus. Bull. 52: 525.

Type species: *Callima argenticinctella* Clemens, 1960.

Callima Clemens, 1860, Proc. Acad. nat. Sci. Philad. 1860: 166.

Dafa Hodges, 1974, in Dominick et al., Moths of Amer. nor. of Mex. 6(2): 111.

Diagnosis. This genus is externally close to the genus *Promalactis* Meyrick, in having brownish yellow ground color of forewing, but can be easily distinguished by a distinct trapezoidal-shaped brown marking of forewing.

Wing venation (Fig. 33). Forewing with all radius veins: R_4 and R_5 stalked before the half of their length, the latter reaching to costa; M_1 and M_2 less parallel; M_3 approximate to CuA_1 and CuA_2 from angle of cell. Hindwing with eight veins: M_1 and M_2 less parallel; M_2 and M_3 parallel; M_3 and CuA_1 from same point of cell.

Distribution. Palaearctic Regions.

Remarks. *Epicallima* is small genus, describing only seven species. Among them, *Epicallima formosella* (Denis & Schiffermüller) is widely distributed from Europe to Asia. Three species, *Epicallima bruandella* (Ragonot), *E. icterinella*

(Mann) and *E. gerasimovi* (Lvovsky) are reported from European area. Other three species, *E. conchylidella* (Snellen), *E. nadezhdae* (Lvovsky) and *E. subsuzukiella* (Lvovsky) are distributed from Asia area. The genus is reported from Korea for the first time.

Epicallima conchylidella **(Snellen, 1884) 사각무늬원뿔나방 (신칭)**

Lampros conchylidella Snellen, 1884, tijdschr. Ent. 27: 176

Borkhausenia conchylidella Staudinger et Rebel, 1901, Cat. Lep. Pal. Fauna. 2: 178.

Schiffermüelleria conchylidella Meyrick, 1922, Gen. Ins. 180: 27.

Diagnosis. This species is externally similar to North American species, *E. argenticinctella* Clemens, in having distinct marking of forewing, but is can be differentiated by male genitalia with long cornutus. The female genitalia is characterized by very long and slender ductus bursa, bearing numerous tiny spines of female genitalia.

Description. Adult (Figs. 51, 99, 100). Head: Frons dark brown mixed with white; vertex dark brown. Scape of antenna dark brown and white striped entirely, as long as diameter of eye; flagellum dark brown and white alternately. Labial palpus dark brown, except white inner margin of second segment and basal and apical parts of third segment; second segment almost two times longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 12.0–13.0 mm. Forewing ground color dark brownish yellow, tinsed with brown followed by costal margin and near to apex; two dark brown markings surrounded by fuscose scales: one, trapezoidal-shaped, after and followed by white vegrayrtical scales at 1/3 of posterior margin; the other just below a white spot, oblique, darker than the former at tornus; fringes brownish yellow, partly darker near to tornus. Hindwing less lanceolate, ground color brownish gray; fringes gray. Legs: hind leg pale grayish brown, except tarsus; tarsus dark brown, except white each basal parts of segments.

Male genitalia (Figs. 157, 158). Uncus bell-like, wide at base, gradually narrowed to sub-apex. Gnathos a tongue-shaped, outer margin rounded, as long as the uncus. Valva symmetric, setose apically; sacculus extended, gradually narrow to apex, longer than the valva; juxta with lateral lobes, triangular pyramid-shped. Saccus a funnel-like, lateral margin incised. Aedeagus slender, dilated basally, longer than the valva; cornutus long, 5/6 length of aedeagus.

Female genitalia (Figs. 207, 208, 209). Papilla anales setose. Apophysis anterioris 4/5 length of apophysis posterioris. Antrum short, cylindrical. Ductus bursae very long, alomost four times length of seventh sternum, bearing numerous spines medially. Corpus bursa a circular-like. Signum irregular shaped bearing with tiny spines.

Material examined. Eleven individuals: one female, Cheongnyangni, Seoul, Korea, 20.vi.1996, B.K. Byun; one female, Hongreung-arboretum, Seoul, Korea, 26.vi.1996, B.K. Byun; one female, same locality, 1.vii.1998, B.K. Byun; one female, KNU Camp., Chuncheon, GW, Korea, 27.vi.1996, B.K. Byun; one male and one female, same locality, 19.vi.2001, H.L. Han; one female, same locality, 29.iv.2005, M.Y. Kim; one female, same locality, 30.vi.2005, T.M. Kang; one male, Changdeok-Palace, Seoul, Korea, 30.vi.1999, Bae et al., gen. slide no. SNU-9064/ S. Kim, wing slide no. SNU-9066/ S. Kim; one female, same locality, date and collector, gen. slide no. SNU-9063/ S. Kim; one male, same locality, date and collector.

Distribution. Korea (South: Seoul, GW; new record), China, Russia.

Remarks. This speceis is newly recorded from Korea.

Genus ***PROMALACTIS*** Meyrick, 1908

Promalactis Meyrick, 1908a, J. Bombay Nat. His. Soc. 18: 806.

Type species: *Promalactis holozona* Meyrick, 1908.

Diagnosis. This genus is superficially characterized by the brownish-yellow to yellowish-brown forewing ground color with variable markings, such as costal patch, band-like marking or sometimes irregular complex marking of forewing.

Wing venation (Fig. 34). Forewing long and narrow, with all radius veins: R_4 and R_5 stalked at 1/3 of their length, the latter reaching to costa; M_1 and M_2 parallel; M_3 approximate to CuA_1 from angle of cell. Hindwing with seven veins: M_1 and M_2 less parallel; M_3 and CuA_1 from same point of anal angle; CuA_2 far from CuA_1 arising from median cell.

Distribution. Afrotopical, Neartic, Oriental, Palaearctic Regions.

Remarks. The genus *Promalactis* Meyrick is one of the most diverse genera of the family, comprising more than 160 species (Du et al., 2009, 2011; Fujisawa, 2002; Kim et al. 2010, 2012, 2014; Lvovsky, 1976, 1985, 1988, 1997, 2000a, 2000b, 2007a; Meyrick, 1908a, 1908b; Wang, 2006; Wang et al., 2009). *Promalactis* is originated from Oriental Regions, including India, Indonesia, Malaysia, Myanmar, Philippines and Vietnam (Kim et al. 2010, 2012, 2014; Lvovsky, 1988, 1997, 2000a, 2000b, 2007a; Meyrick, 1908a, 1908b). So far, fourteen species of *Promalactis* have been recorded (Park, 1980; 1981a; 1998) in Korea. One new species, *Promalactis candidifascia* Kim, **sp. nov.** and one unrecorded species, *P. xianfengensis* Wang et Li are newly added in this study.

Key to species of the genus Promalactis in Korea based on adult character

1. One forewing ground color, brownish yellow or reddish brown or dark brown or brown ---**2**

 - Two forewing ground colors, brown or brownish yellow from wing base, tinsed with brownish yellow or brown to apex ---**14**

2. Forewing marking with white band-like ---**3**

 - Forewing marking without white band-like ------------------------------***P. bitaenia***

3. Forwing marking with white semi-circular costal patch ---------------------------**4**

 - Forewing marking without white semi-circular costal patch ----------------------**8**

4. Forewing marking with white band-like oblique or curved toward to apex --**5**

 - Forwing marking without white band-like oblique or curved toward to apex -- **7**

5. One white apical spot of forewing, surrounded by fuscous scales --***P. odaiensis***

 - Four white apical spots of forewing, surrounded by fouscous scales -------------**6**

6. White band-like marking at 1/3 of forwing oblique and slightly bent at sub-apically --***P. jezonica***

 - White band-like marking at 1/3 of forwing oblique, not bent ------***P. wonjuensis***

7. Forewing ground color reddish brown without fuscous scales before tornus -----
---***P. albipunctata***

- Forewing ground color brown with fuscous scales before tornus -------------------
--- ***P. suzukiella***

8. Forewing with fuscous costal patch ---**9**

- Forwing without fuscous costal patch --**11**

9. White apical spot present -- ***P. xianfengensis***

- White apical spot absent --- **10**

10. Fuscous costal patch at 2/3 -- ***P. atriplagata***

- Fuscous costal patch at 2/3 with followed by white irregular marking -----------
---***P. striola***

11. Two white oblique band-like marking from posterior margin in forewing ------
--- ***P. candidifascia* sp. nov.**

- Three white oblique band-like marking from posterior margin in forewing -----
--- **12**

12. White oblique band-like marking from 1/2 of posterior margin in forewing reaching to costa ---**13**

- White oblique band-like marking from posterior maring of forewing reaching to costa -- ***P. auriella***

13. Fringes of forewing grayish brown before tornus; hindwing ground color grayish dark brown; --***P. enopisema***

- Fringes of forewing brown before tornus; hindwing ground color brown -------
---***P. parki***

14. Two forewing ground colors, brown from wing base, tinsed with brownish yellow to apex --15

- Two forewing ground colors, brownish yellow from wing base, tinsed with brown to apex, the latter color followed by termen --------------------***P. svetlanae***

15. Forewing with white large semi-circular patch; fuscous patch near tornus ------
---***P. subsuzukiella***

- Forewing without white large semi-circular patch; fuscous patch near tornus --
---***P. autoclina***

Key to species of the genus Promalactis in Korea based on male genitalia

1. Valva of male genitalia symmetric --**2**

- Valva of male genitlia asymmetric ---**12**

2. Male genitalia with gnathos ---**3**

- Male genitalia without gnathos ---------------------------- ***P. candidifascia* sp. nov.**

3. Gnathos as long as uncus --- **4**

- Gnathos shorter than uncus -- **8**

4. Saccus as long as uncus, somewhat triangular-like -------------------------------- **5**

- Saccus more than 2 times longer than uncus, funnel-like ------------------------- **7**

5. Uncus with two pointed apexes -- ***P. bitaenia***

- Uncus with one pointed apex -- **6**

6. Juxta present ---***P. xianfengensis***

- Juxta absent ---***P. atriplagata***

7. Sacculus margin with sclerotized processus ----------------------------- ***P. svetlanae***

- Sacculus margin without sclerotized processus ------------------------- ***P. odaiensis***

8. Apex of uncus pointed --- **9**

- Apex of uncus incised or bifurcate -- **11**

9. Aedeagus with cornutus -- ***P. albipunctata***

- Aedeagus without cornutus --- **10**

10. Vava narrow, elongated, setose entirely without processus of cucullus; juxta with blunt apex --- ***P. autoclina***

- Valva broad, elongate with processus of cucullus, thumb-like; juxta incised caudally -- ***P. suzukiella***

11. Cucullus with processus -- ***P. enopisema***

- Cucullus without processsus ------------------------------------- ***P. subsuzukiella***

12. Gnathos with lateral lobes -- **13**

- Gnathos without lateral lobes -- **14**

13. Juxta as long as veritical length of tegumen ---------------------------- ***P. jezonica***

- Juxta longer than vertical length of tegumen ------------------------ ***P. wonjuensis***

14. Processus of cucullus present, club-like, setose caudally ------------- ***P. auriella***

- Processus of cucullus absent, valva with blunt apex ---------------------- ***P. parki***

Key to species of the genus Promalactis in Korea based on female genitalia

1. Lamella postvaginalis slightly or deeply incised in middle, setose caudally-------
--- **2**

- Lamella postvaginalis variable shaped ---**6**

2. Ductus bursa membranous bearing spines --**3**

- Ductus bursa membranous without spine --- **4**

3. Ductus bursa swelling and wrinkled vertically; corpus bursa small, circular-like
-- ***P. xianfengensis***

- Ductus bursa narrow, elongated, coiled twice; corpus bursa pear-like -------------
--***P. atriplagata***

4. Seventh sternum without sclerotized area --- **5**

- Seventh sternum with sclerotized aresa laterally ----------------------***P. suzukiella***

5. Antrum heavily sclerotized, short funnel-like ----------------------***P. albipunctata***

- Antrum membranous, narrow funnel-like -------------------------***P. subsuzukiella***

6. Apophysis posterioris 1.5 times longer than apophysis anterioris----------------- **7**

- Apophysis posterioris more than 2 times longer than apophysis anterioris----- **11**

7. Lamella postvaginalis short than vertical seventh sternum ------------------------**8**

- Lamella postvaginalis longer than vertical seventh sternum--------------***P. striola***

8. Signum absent -- **9**

- Signum present -- **10**

9. Caudal margin of lamella postvaginalis with dense hairs ------------------- ***P. parki***

- Caudal margin of lamella postvaginalis setose, dense hairs laterally on eighth sternum --- ***P. enopisema***

10. Caudal margin of lamella postvaginalis round with setose -----------***P. odaiensis***

- Caudal margin of lamella postvaginalis somewhat blunt, setose laterally-------- --- ***P. autoclina***

11. Ductus bursa bearing spines in middle ---------------------------------- ***P. bitaenia***

- Ductus bursa without spine --- **12**

12. Apophysis posterioris 2.5 times longer than apophysis anterioris; lamella postvaginalis a large crown-shaped ------------------------------------ ***P. jezonica***

- Apophysis posterioris 3 times longer than apophysis anterioris; lamella postvaginalis large clown-like, heavily sclerotized, with widely extended medial apex, semi-star-like --- ***P. wonjuensis***

***Promalactis albipunctata* Park et Park, 1998 구슬무늬큰원뿔나방**

Promalactis albipunctata Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is similar to *Promalactis suzukiella* (Matsumura), in having white costal marking of forewing, but can be distinguished by male genitalia with convex costal margin of valva, a conical-like uncus and a tongue-shaped gnathos. The female genitalia is similar to *P. gigaspinata* Kim and Park, in having distinct lamella antevaginalis, but can be characterized by sclerotized lamella postvaginalis with setose, antrum with wide caudal margin and ductus bursa without spines.

Description. Adult (Figs. 52, 101, 102). Head: Frons brown pale whitish dark brown; vertex white tinsed with dark brown. Scape of antenna white entirely, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus reddish dark brown; second segment 1.5 times longer than third segment.
Thorax: Thorax and tegula reddish dark brown dorsally. Wing expanse 9.0–14.0 mm. Forewing ground color brown, tinsed with reddish brown apically; two white bands oblique surrounded by dark brown scales: one near to wing base, the other slightly bent at 1/3 at 1/3 of posterior margin, not reaching to costa; one white costal patch at 2/3, somewhat semi-ovate-shaped, surrounded by dark brown scales;

fringes yellowish brown, partly mixed with reddish brown at apex and tornus. Hindwing lanceolate, ground color grayish dark brown; fringes greyish dark brown. Legs: hind leg dark brown, except white at basal parts of fifth, four and first segments of tarsus.

Male genitalia (Figs. 159, 160). Uncus conical-like, wide at base, gradually narrowed to apex. Gnathos tongue-like, wide at base, roundly margined, slightly shorter than uncus. Valva symmetric; slightly convex at 1/2 of costal margin, straight to apex with setose; sacculus sclerotized, curved innerly at sub-apex, dense hairs apically. Saccus large funnel-like, as long as uncus plus tegument. Aedeagus cylindrical, slender, longer than valva; cornutus about 1/3 length of aedeagus.

Female genitalia (Figs. 210, 211). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis sclerotized developed, incised medially, setose on caudal margin. Lamella antevaginalis wide caudally. Antrum a funnel-shaped, sclerotized. Ductus bursa membranous, as long as vertical length of eighth sternum. Corpus bursae with a signa bearing dentate processus.

Material examined. Eleven individuals: one female, Suwon-si, GG, Korea, 14.i.1986, S.W. Lee, gen. slide no. SNU-9104/ S. Kim; two males and two females, Gwangneung, GG, Korea, 27.vii.1998, B.K. Byun; two females, same locality, 03.viii.2000, B.K. Byun; one male, same locality, 13.viii.2005, B.K. Byun; one male, Mt. Duryun, CN, Korea, 15.vii.1999, J.C. Sohn, gen. slide no. SNU-9101/ S. Kim; one male, Bongmyeong-ri, GW, Korea, 24.vii.1999, J.C. Sohn, gen. slide no. SNU-9100/ S. Kim; one female, Changdeok-Palace, Seoul, Korea, 29.vii.1999, Peak, Lee & Kim, gen. slide no. SNU- 9102/ S. Kim; one male, KNU Camp., Chuncheon, GW, Korea, 30.vi.2005, B.Y. Chae & T.M. Kang, gen. slide no. SNU-9129/ S. Kim; one male, same locality, date and collector, wing slide no. SNU-9130/ S. Kim.

Distribution. Korea (South: Seoul, GG, GW, CN).

Remarks. Description of male of *P. albipunctata* is newly added in this study.

Promalactis atriplagata **Park et Park, 1998 설악원뿔나방**

Promalactis atriplagata Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is similar to *Promalactis bitaenia* Park et Park, in superficial apperance, but can be differentiated by distinct fuscous apical marking of forewing, tongue-like gnothos and long cornutus of male genitalia and long and coiled ductus bursa of female genitlia.

Description. Adult (Figs. 53, 103, 104). Head: Frons and vertex grayish dark brown. Antenna with dark brown scape entirely, shorter than diameter of eye;

flagellum white and dark brown alternately. Labial palpus bronwish yellow, except dark brown central ventral margin of third segment; second segment 1.5 times longer than third segment. Thorax: Thorax dark brown, mixted with brownish yellow dorsally; tegula dark brown dorsally. Wing expanse 12.0–13.0 mm. Forewing ground color brownish yellow; three grayish dark brown bands oblique surrounded by fuscous scales: one near to wing base, the others at 1/3 and 1/2 of forewing, not reaching to costa; one white costal patch at 2/3, somewhat semi-ovate-shaped, surrounded by fuscous scales; the other near to tornus; another apical patch surrounded and conneted to tournus patch; fringes brownish yellow, partly dark brown at tornus. Hindwing lanceolate, ground color dark brown; fringes dark brown. Legs: hind leg dark brown, except white basal and medial parts of fifth and each basal parts of fourth and first segments of tarsus.

Male genitalia. According to figures 38, 39, 40 by Park et Park (1998), Uncus slender, bent ventrally. Gnathos tongue-shaped with rounded apex, as same length as uncus. Valva symmetric; processua of sacculus sclerotized, bent apically bearing numerous hairs. Aedeagus long and straight; cornutus about 2/3 length of aedeagus.

Female genitalia (Figs. 212, 213, 214). Papilla anales setose. Apophysis posterioris about 1.5 times length of apophysis anterioris. Apophysis anterioires thicker than apophysis posterioiris, gradually narrow to anteriorly. Lamella postvaginalis largely developed, incised medially. Antrum wide caudally, gradually narrow to ductus bursa. Ductus bursa long, coiled anteriorly, bearing several spines: one large, somewhat triangular-like; the others small. Corpus bursa ovate-like with two signa, leaf-like, bearing numerous spines.

Material examined. six individuals: one female, Mt. Jang, 1006m, Sangdong-eup, Yeongwol-gun, GW, Korea, 21.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim, gen. slide no. SNU-9227/ S. Kim; one female, same locality, date and collector; one female, Mt. Gariwang, Najeon-ri, Bukpyeong-myeon, Jeonseon, GW, Korea, 29.vi.2011, B.W. Lee, J.O. Lim; one female, Mt. Jeombong, 735m, Girin-myeon, Inje-gun, GW, Korea, 04.vii.2011, J.O. Lim, K.M. Kim; two females, Mt. Taehwa, Docheck-myeon, Gwangju, GG, Korea, S. Kim.

Distribution. Korea (South: GG, GW).

Remarks. I cound not collected the male of *P. atriplagata*.

Promalactis auriella Park et Park, 1998 **칼무늬원뿔나방**

Promalactis auriella Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is superficially close to *Promalaceis striola* Park et Park and *P. parki* Lvovsky, in having forewing pattern, but can easily distinguished by male genitalia with asymmetrical valva.

Description. Adult (Figs. 54, 105, 106). Head: Frons whitish brownish yellow; vertex white tinsed with dark brown. Scape of antenna white dorsally, tinsed with dark brown anteriorly, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, darker third segment with white apex; second segment 1.5 times longer than third segment. Thorax: Thorax and tegula brownish yellow dorsally. Wing expanse 13.5–14.0 mm. Forewing ground color brownish yellow; four white bands oblique surrounded by fuscous scales: one from posterior margin to wing base, the second one slightly bent from 1/3 of posterior margin, not reaching to costa, the other from the half of posterior margin toward to another short one after fuscous scale; fringes brownish yellow, tinged with dark brown above apex and before tornus. Hindwing lanceolate, ground color dark brown; fringes dark brown. Legs: hind leg dark brown, except white basal parts of fifth, fourth and first segments of tarsus.

Male genitalia (Figs. 161, 162). Uncus hook-like, dense hairs on apex. Gnathos reversed hook-like, as long as uncus. Valva asymmetric; cucullus club-shaped, setose caudally; sacculus asymmetric, left sacculus larger than the right one, extended margin of sacculus dense hairs distally. Saccus small, as long as uncus. Aedeagus cylindrical, slender, bent at 1/3, longer than sacculus; two cornuti: one more than four times longer than the other one, longer one 3/4 length of aedeagus.

Female genitalia. Unknown.

Material examined. Two individuals: one male, Gwangneung, GG, Korea, 22.v.1998, B.K. Byun, gen. slide no. SNU-9441/ S. Kim; one male, same locality, 4.vi.1999, J.W. Jung & S.H. Won, gen. slide no. SNU-9421/ S. Kim.

Distribution. Korea (South: GG).

Promalactis autoclina **Meyrick, 1935 꼬마원뿔나방**

Promalactis autoclina Meyrick, 1935, Exot. Microlepid. 4: 592.

Diagnosis. This species is characterized from allied species by forwing ground color, brown from wing base, tinsed with brownish yellow from 1/3 to apex.

Description. Adult (Figs. 55, 107, 108). Head: Frons white; vertex white tinsed with brown. Scape of antenna white with dark brown spot dorsally, shorter than diameter of eye; flagellum white and brown alternately. Labial palpus with brownish yellow second segment, dark brown third segment with white basally; the former 1.5 times longer than latter. Thorax: Thorax and tegula brown dorsally. Wing expanse 7.0–8.5 mm. Forewing ground color, brown from wing base, tinsed with brownish yellow to apex; three white bands oblique followed after fuscous scales: one near to wing base, the other at 1/3, transverse from costa to posterior margin, another short, from 2/3 of costal margin; one grayish dark brown irregular marking near tornus, connect to costal and apical fuscous scales; one white costal patch at two-thirds, somewhat triangular-shaped, surrounded by fuscous scales; fringes yellow, partly with grayish brown near tornus. Hindwing lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white basal parts of each segments of tarsus.

Male genitalia (Figs. 163, 164). Uncus forefinger-like, wide at base, slightly bent sub-apically. Gnathos with blunt apex, shorter than uncus. Valva symmetric, narrow, elongated; costal margin with setose. Juxta short, with blunt apex. Saccus semi-ovate shaped, as same length as uncus. Aedeagus cylindrical, slender without cornutus.

Female genitalia (Figs. 215, 216, 217). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Antrum funnel-like, setose, gradually narrow to ductus bursa with setose apex. Ductus bursa membranous, more than three times longer than antrum. Corpus bursa pear-like. Signum with two spines: one nail-like, the other more than three times longer than the former, the latter with emerginate side.

Material examined. Twenty-one individuals: one individual, Suwon-si, GG, Korea, 23.viii.1974, K.T. Park, wing slide no. SNU-9069/ S. Kim; one individual, same loclaity, 23.vii.1975, K.T. Park; one male, same loclaity, 24.vii.1975 K.T. Park; one male, Changdeok-Palace, Seoul, Korea, 30.vi.1999, Bae et al., gen. slide no.

SNU-9225/ S. Kim; one male, Mt. Waryong, Jungnim-dong, Sacheon, GN, Korea, 05.vii.1999, H.K. Lee; one male, Mt. Wolyeongbong, Sinsido, Okdo-myeon, Gunsan, JB, Korea, 21.vii.2011, S.Y. Park & J.S. Lim; one male, Is. Yeonpyeong, Ongjin-gun, Incheon, Korea, 31.viii.2010, S.Y. Park & J.S. Lim; one female, Mt. Baegun, Gwangyang-si, JN, Korea, 15-18.vi.2011, S. Kim, gen. slide no. SNU-9223/ S. Kim; one individual, same locality, date and collector; one male, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim; one male, Mt. Dondaebong, Is. Hajo, Jodo-myeon, Jindo, JN, Korea, 20.vii.2011, S.Y. Park & J.S. Lim, gen. slide no. SNU-9411/ S. Kim; one male, same locality, date and collector; one female, Temple-Geumsan, Aphae-do, Sinan, JN, Korea, 29.viii.2011, S.Y. Park & J.S. Lim; two males, four females and one individual, Mt. Seongchi, Bigeum-do, Sinan, JN, Korea, 31.viii.2011, S.Y. Park & J.S. Lim; one female, Chusa-ri, Okryong-myeon, Gwangyang-si, JN, Korea, 28.xii.2013, Y. Lee; one female, Byungdae-ri, Pyeongchang-gun, GW, Korea, 14.viii.2013, Y. Lee.

Distribution. Korea (South: Seoul, GG, Incheon, GW, GN, JB, JN), Japan, China.

Promalactis bitaenia Park et Park, 1998 **두줄띠원뿔나방**

Promalactis bitaenia Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is characterized from congeneric speceis by forewing without white marking, male genitalia with distinct uncus and gnothos and female genitalia with a spade-like lamella postvaginalis and ductus bursa bearing comb-like spine.

Description. Adult (Figs. 56, 109, 110). Head: Frons whitish yellow; vertex brownish yellow. Antenna with dark brown scape entirely, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus yellow, tinsed with brownish yellow laterally; second segment 1.5 times longer than third segment.
Thorax: Thorax and tegula brownish yellow dorsally. Wing expanse 10.0–11.0 mm. Forewing ground color brownish yellow; three band-like dark brown markings: one from 1/3 posterior margin, slightly bent medially, not reaching to costa, the other just before tornus, bent and connect to another one, the latter transerse from posterior margin to costa; fringes brownish yellow. Hindwing lanceolate, ground color grayish dark brown; fringes grayish dark brown. Legs: hind leg dark brown, except white basal parts of each segments of tarsus.

Male genitalia (Figs. 165, 166). Uncus roundly margined with two tiny processus. Gnathos trigonal pyramid-like, as same length as uncus. Valva symmetric; extended margin of sacculus incurved with dense hairs. Juxta with lateral lobes, about 1.5 times longer than uncus. Saccus triangular-like, longer than uncus. Aedeagus long with cornutus; cornutus 4/5 length of aedeagus.

Female genitalia (Figs. 218, 219). Papilla anales setose. Apophysis posterioris more than two times length of apophysis anterioris. Lamella postvaginalis large, heavily sclerotized, somewhat spade-shaped. Lamella antevaginalis with blunt apex, wide caudally, 1/3 length of lamella postvaginalis. Antrum narrow, cylindrical, longer than lamella postvaginalis. Ductus bursa same width as antrum anteriorly, wider from the half of its length, bearing one large comb-like spine medially. Corpus circular without signum.

Material examined. Thirty-three individuals: one individual, Chuncheon-si, GW, Korea, 01.v.1989, K.T. Park; one female and one individual, Mt. Soyo, GG, Korea, 07.vii.1996, Bae, Paek, Lee & Ahn; one male, Mt. Jung, Sicheon-myeon, Sancheong-gun, GN, Korea, 5-6.vi.1997, S.B. Ahn; one female, same locality, 29.vi.2011, S. Kim; one female, Mt. Mireuk, Tongyeong-si, GN, Korea, 14.vi.1997, Y.S. Bae, gen. slide no. SNU-9090/ S. Kim; one female, same locality and date, gen. slide no. SNU-9088/ S. Kim; two females, same locality, date and collector; one individual, Mt. Jeombong, 735m, Girin-myeon, Inje-gun, GW, Korea, 11.vii.1997, Paek, Lee, Jang, Choi & Kim; one female, same locality, 04.vii.2011, J.O. Lim, K.M. Kim; one male, Jiam-ri, Chuncheon-si, GW, Korea, 28.iv.1998, S.M. Lee, gen. slide no. SNU-9229/ S. Kim, wing slide no. SNU-9241/ S. Kim; one male, Gwangneung, GG, Korea, 29.vi.1998, B.K. Byun & Y.S. Park; one female, Yupyeong-ri, Samjang, Sancheong, GN, Korea, 7.vii.1999, G.M. Kwon; one male, Hwacheon-gun, Haesanroung, GW, Korea, 16.v.2003, H.L. Han; one female, Mt. Worak, Jecheon-si, CB, Korea, 17-20.vi.2005, J.C Sohn; one female, Temple-Pyochung, 308m, Danjangmyeon, GN, Korea, 21.iv.2007, B.W. Lee; one female, same locality, 12.vii.2007, B.W. Lee & Y. Park & D.H. Kwon; one individual, Jugye-ri, Waryong-myeon, Andong, GB, Korea, 13.vi.2008, B.W. Lee & B.H. Kim; four males and four females, Lake Yuklim, GW, Korea, 01.vii.2010, S.Y. Park, K.H. Ko & K.A. Yii; two females, Mt. Baegun, Gwangyang-si, JN, Korea, 15-18.vi.2011, S. Kim; one individual, Mt. Jungmi, Shinbok-ri, Okcheon-myeon, Yangpyeong-gun, GG, Korea, 28.vi.2011, S. Kim; one female, same locality, date and collector; one male, Mt. Horyonggok, Muuido, Incheon, Korea, 30.vi.2011, S.Y. Park & J.S. Lim; one female, Osan-ri, Gosan-myeon, Wanju-gun, JB, Korea, 07.vi.2012, S. Kim.

Distribution. Korea (South: Incheon, GG, GW, GB, GN, JB, JN).

Promalactis candidifascia **Kim, sp. nov. 흰두줄원뿔나방 (신칭)**

Diagnosis. This species is superficially similar to *Promalactis auriella* Park et Park and *P. enopisema* Butler, in wing pattern, but can be easily distinguished by no band-like marking near to wing base of forewing and gnothos absent in male genitalia.

Description. Adult (Fig. 57, 111, 112). Head: Frons dark brown; vertex white, tinsed with dark brown. Antenna with white scape dorsally, dark brown ventrally, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, darker third segment mixed with white dorsally, dark brown ventrally; second segment longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 13.5–14.0 mm. Forewing ground color brownish yellow; three white bands oblique surrounded by fuscous scales: one at 1/3 of forewing, the other at 1/2 of forewing, both from posterior margin, not reaching to costa, another one from costal margin, straight to second band, not connected; fringes brownish yellow. Hindwing less lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white basal parts of fifth, fourth and first segments of tarsus.

Male genitalia (Figs. 167, 168). Uncus thumb-like, with blunt apex, concave laterally, wide at base, basal-lateral margin entirely setose. Gnathos absent. Valva symmetric; costal margin convex at half of valva; sacculus with sclerotized hooked-shaped apex. Aedeagus slender, gradually narrow to apex; cornutus about half length of aedeagus.

Female genitalia. Unknown.

Holotype. One male, Reservoir-Jichang, Hwasong-ri, JN, Korea, 15.v.1996, S.K. Lee, gen. slide no. SNU-9136/ S. Kim.

Distribution. Korea (South: JN; new record).

Etymology. The specific name is derived from the Latin, *candidus* (= white) plus a Latin *fascia* (= band), referring to white two band-like marking of forewing.

Promalactis enopisema (Butler), 1879 매끈이원뿔나방

Oecophora enopisema (Butler), 1879, Ill. Het. Brit. Mus. 3: 82.

Promalactis enopisema Inoue, 1954, Check List Lep. Jap.1: 63.

Diagnosis. This species is externally similar to *Promalactis auriella* Park et Park and *P. striola* Park et Park in the wing pattern, but can be distinguished by processus of cucullus of male genitala and dense hairs of lateral margin of lamella antevaginalis and ductus bursa bearing distinct spines of female genitalia.

Description. Adult (Figs. 58, 113, 114). Head: Frons white; vertex whited, tinsed with brownish yellow. Antenna with white scape entirely, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, third segment darker than second segment; second segment almost 1.5 times longer than third segment. Thorax: Thorax and tegula brownish yellow dorsally. Wing expanse 9.5–14.0 mm. Forewing ground colour brownish yellow; three white bands oblique surrounded by fuscous scales: one from posterior margin reaching to wing base, the other from 1/3 of posterior margin, not reaching to costa, another 1/2 of posterior margin, reaching to 2/3 of costa; fringes yellowish brown, tinged with grayish brown near to tornus. Hindwing more lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white basal parts of each segments of tarsus.

Male genitalia (Figs. 169, 170). Uncus trapezoid-like, wide at base, gradually narrowed to apex, incised caudally. Gnathos small, tongue-like, setose, shorter than uncus. Valva symmetric; processus of cucullus at sub-apex, entirely dense setose; sacculus longer than cucullus, roundly margined with setose. Saccus long, more than two times longer than uncus. Aedeagus cylindrical with cornutus; cornutus about 1/4 length of aedeagus.

Female genitalia (Figs. 220, 221, 222). Papilla anales setose. Apophysis posterioris about than 1.5 times length of apophysis anterioris. Lamella postvaginalis small, setose caudally. Lateral margin of lamella antevaginalis in eighth sternum dense hairs. Antrum cylindrical. Ductus bursa coiled, bearing two large spines, finger-like. Courpus bursa small without signum.

Material examined. Forty-two individuals: one male, Pohang-ri, GN, Korea, 12.iii.1991, K.S. Lee; one individual, Gwangneung, GG, Korea, 26.v.1992, Gab Jae Weon; one female, Cheongnyangni, Seoul, Korea, 27.v.1996, B.K. Byun; one female, Mt. Soyo, GG, Korea, 09.vi.1996, Y.S. Bae; one female, Hongreung-arboretum, Seoul, Korea, 12.v.1997, B.K. Byun; one female, same locality, 13.v.

1998, B.K. Byun; one male, same locality, 3.vi.1998, B.K. Byun; one female, Mt. Cheonggye, Gwacheon-si, GG, Korea, 15.v.1997, Y.M. Park & J.S. Lee, gen. slide no. SNU-9231/ S. Kim; one male, Sucheong-dong, Osan-si, GG, Korea, 30.v.1997, Y.M. Park; one male, Geoje, Dongbu, GB, Korea, 04-05.vi.1997, S.B. Ahn, gen. slide no. SNU-9114/ S. Kim; one male, same locality and date, gen. slide no. SNU-9142/ S. Kim; three males, one female and one individual, same locality, date and collector; one female, Mt. Suri, Gunpo-si, GG, Korea, 12.vi.1997, Y.M. Park; one female, Changgyeong-palace, Seoul, Korea, 30.vi.1999, Bae et al.; one male, Mt. Duta, Donghae-si, GW, Korea, 16.v.2001, J.Y. Choi, G.M. Kwon, H.W. Byun, gen. slide no. SNU-9230/ S. Kim; one male and one individual, same locality, date and collector; one male, Sinam, Chuncheon-si, GW, Korea, 4.vi.2003, H.R. Han, M.N. Jung; one female, Mt. Taehwa, Gonjiam, GG, Korea, 24.vi.2006, Park, Kim, Chae, gen. slide no. SNU-9085/ S. Kim; one female and one individual, Jugye-ri, Waryong-myeon, Andong, GB, Korea, 13.vi.2008, B.W. Lee & B.H. Kim; one female, Is. Jeju, Korea, 7-11.v.2009, S. Kim; one individual, Temple-Geonbong, GW, Korea, 09.vi.2010, B.K. Byun, S.Y. Park & J.S. Lim; one male, Mt. Noin, Hyeonnae-myeon, Goseong, GW, Korea, 11.vi.2010, B.K. Byun, S.Y. Park & J.S. Lim; two females, Mt. Baegun, Gwangyang-si, JN, Korea, 15-18.vi.2011, S. Kim; two males and and one individual, Mt. Jungmi, Shinbok-ri, Okcheon-myeon, Yangpyeong-gun, GG, Korea, 28.vi.2011, S. Kim; two females, Mt. Joryung-forest lodge, Yeonpung-myeon, Goesan-gun, CB, Korea, 30.vi.2011, S. Kim; four males and three females, Osan-ri, Gosan-myeon, Wanju-gun, JB, Korea, 07.vi.2012, S. Kim.

Distribution. Korea (South: GG, GW, CB, GB, GN, JB, JN), Japan, China.

***Promalactis jezonica* (Matsumura), 1931 네방원뿔나방**

Borkhausenia jezonica (Matsumura), 1931, 6000 Ill. Ins. Japan. 1088.

Promalactis symbolopa Meyrick, 1935, Exot. Microlepid. 4: 593.

Promalactis jezonica Kuroko, 1959, Trans. Lep. Soc. Jap. 10: 34-35.

Diagnosis. This species is externally similar to *Promalactis wonjuensis* Park et Park and *P. meyricki* Wang in wing pattern, but can be distinguished by crown-shaped and large lamella postvaginalis in the female genitalia.

Description. Adult (Figs. 59, 115, 116). Head: Frons dark brown; vertex white, tinsed with dark brown. Antenna with white scape entirely, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus with brownish yellow second segment, dark brown third segment; second segment as long as third segment. Thorax: Thorax and tegula dark brownish yellow dorsally. Wing expanse 8.5–10.0 mm. Forewing ground color brownish yellow; three white bands oblique surrounded by fuscous scales: one from basal posterior margin to wing base, the other, slightly bent, at 1/4 of posterior margin, not reaching to costa, another from 1/3 of posterior margin, reaching to irregular gray marking surrounded by fuscous scales before tornus; one white costal patch, semi-ovate shaped, at 2/3 of costa; four white spots at apex surrounded by fuscous scales; fringes brownish yellow, partly grayish brown just below gray marking near tornus. Hindwing more lanceolate, ground color, grayish brown; fringes grayish brown. Legs: hind leg pale grayish yellwo, except dark brown at apical parts of fourth and third segments of tarsus.

Male genitalia (Figs. 171, 172). Uncus conical-like, wide at base, gradually narrow to apex, roundly margined. Gnathos gourd bottle-shaped with small lateral lobes, as same length as uncus. Valva asymmetric; cucullus with dense hairs distally: right one as same length as sacculus, left one shorter than sacculus; sacculus distally incurved with setose; Juxta long spine-like, almost same length of tegumen. Saccus triangular-like, roundly margined, almost same length as uncus. Aedeagus narrow-cylindrical, longer than valva without cornutus.

Female genitalia (Figs. 223, 224). Papilla anales setose. Apophysis posterioris more than 2.5 times longer than apophysis anterioris. Lamella postvaginalis large clown-like, heavily sclerotized. Antrum cylindrical, straight to ductus bursa. Ductus bursa membranous, wider than antrum. Corpus bursa circular-like; Signum with two spines, canine teeth-like.

Material examined. Thirty-seven individuals: one female, Hongcheon-gun, GW, Korea, 05.viii.1989, S.B. Ahn; one female, KNU Camp., Chuncheon, GW, Korea, 15.vi.1992, K.T. Park & B.K. Byun; one female, same locality, 05.viii.1992, K.T. Park & B.K. Byun, gen. slide no. SNU-9086/ S. Kim; one female, same locality, date and collector, gen. slide no. SNU-9083/ S. Kim, wing slide no. SNU-9244/ S. Kim; one male, Mt. Soyo, GG, Korea, 07.vii.1996, Bae, Paek, Lee & Ahn; one male, Mt. Gaji, Baenaegol Ulsan GN, Korea, 11-12.vii.2000, June Yeol Choi, gen. slide No. SNU-9233/ S. Kim; two females, Mt. Gahak, Haenam, JN, Korea, 26.vii.2005, M.Y. Kim & S. Kim; four males and nineteen females, Wando-arboretum, JN, Korea, 27-28.vii.2005, M.Y. Kim& S. Kim; one male and two females, Mt. Tongmyeong, Gokseong-gun, JN, Korea, 29.vii.2005, M.Y. Kim & S. Kim; one individual, Seungeon-ri, Is. Anmyeon, CN, Korea, 18.v.2006, H.J. Han; one female, Mt. Maebong, Nam-myeon, Inje-gun, GW, Korea, 22.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim; one individual, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim.

Distribution. Korea (South: GG, GW, CN, GN, JN), Japan, China, India.

***Promalactis odaiensis* Park, 1980 솔피원뿔나방**

Promalactis odaiensis Park, 1980, Korean J. Plant Prot. 193: 145-147.

Diagnosis. This species is similar to *Promalactis jezonica* (Matsumura) and *P. wonjuensis* Park et Park in the wing pattern, but can be distinguished by the heavily curved white band-like marking of forewing, long saccus of male genitalia and very long antrum and wrinkled ductus bursa of female genitalia.

Description. Adult (Figs. 60, 117, 118). Head: Frons white; vertex grayish dark brown. Scape of antenna white dorsally, dark brown ventrally, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, tinsed with dark brown apically on third segment; second segment 1.5 times longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 9.5–11.0 mm. Forewing ground color brownish yellow; three white bands surrounded by fuscous scales: one from basal posterior margin reaching to wing base, the other from 1/4 of posteor margin, bent toward to wing base, another from 1/3 of posterior margin, curved to fuscous scales near to tornus; one white costal patch semi-ovate-like, after and followed by fuscous patch at 2/3 of costa; one apical spot after fuscous scales; fringes brownish yellow, mixed with fuscous scales before tornus. Hindwing more lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white at basal parts of each segments of tarsus.

Male genitalia (Figs. 173, 174). Uncus bell-like, wide at base, gradually narrowed to apex. Gnathos tongue-like, wide at base, as long as uncus. Valva symmetric; cucullus somewhat convex sub-apically, setose apically; sacculus margin extended, longer than cucullus, with setose after half of it length to apex. Saccus very long, longer than uncus plus tegument. Aedeagus slender, narrow-cylindrical, somewhat bent sub-basally with wide, shorter than sacculus; two cornuti: shorter one at apex, longer one 1/4 length of aedeagus centrally positioned.

Female genitalia (Figs. 225, 226, 227). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis roundly developed with setose caudally. Antrum very long, funnel-like, incised caudally. Ductus bursa wider than antrum, wrinkled vertically, several spines anteriorly positioned, 2/3 length of antrum. Corpus bursa small, circular-like; Signum with teeth-like several spines.

Material examined. Forty-five individuals: one individual, Is. Ganghwa, GG, Korea, 16.vii.1995, Y.S. Bae; one male, Mt. Cheonma GG, Korea, 05.ix.1995, Y.S. Bae, gen. slide no. SNU-9087/ S. Kim; one individual, Gwangneung, GG, Korea, 27.vii.1998, B.K. Byun; one individual same locality, 20.vi.2000, B.K. Byun & W.L. Bae; one individual same locality, 28.vii.2000, B.K. Byun & W.L. Bae; one individual, Mt. Myeongji, Buk-myeon, Gapyeong-gun, GG, Korea, 06.viii.1999, S.H. Lee, wing slide no. SNU-9245/ S. Kim; one individual, Mt. Yumyeong, GG, Korea, 27.vii.2000, B.K. Byun; one individual, KNU Camp., Chuncheon, GW, Korea, 30.vi.2005, T.M. Kang; one female, Wando-arboretum, JN, Korea, 27-

28.vii.2005 M.Y. Kim & S.R. Kim, gen. slide no. SNU-9232/ S. Kim; one male, same locality, date and collector, gen. slide no. SNU-9443/ S. Kim; ten individuals, same locality, date and collector; one individual, Is. Daecheong, Ongjin-gun, Incheon, Korea, 06-09.vii.2008, H.S. Song; two individuals, JJ, Korea, 7-11.v.2009, S. Kim; one individual, Mt. Bannon, Yeoryang-myeon, jeongseonl, GW, Korea, 20.vii.2010, S.Y. Park, J.S. Lim, K.M. Kim; one individual, Mt. Horyonggok, Muuido, Incheon, Korea, 30.vi.2011, S.Y. Park & J.S. Lim; eight individuals, Mt. Joryung-forest lodge, Yeonpung-myeon, Goesan-gun, CB, Korea, 30.vi.2011, S. Kim; one individual, Mt. Yeonin, Seungan-ri, Gapyeong, GG, Korea, 04-05.vii. 2011, B.W. Lee & S.Y. Park; one individual, Mt. Yangrobong, Is. Yeongheung, Ongjin, GG, Korea, 19.vii.2011, J.O. Lim, K.M. Kim; seven individuals, Songnisan-myeon, Boeun-gun, CB, Korea, 25.vii.2011, S. Kim; one individual, Mt. Geombong, Samcheok-si, GW, Korea, 24.viii.2011, S. Kim; one individual, Mt. Jungmi, Shinbok-ri, Okcheon-myeon, Yangpyeong-gun, GG, Korea, 01.ix.2011, S. Kim; one individual, Osan-ri, Gosan-myeon, Wanju-gun, JB, Korea, 07.vi.2012, S. Kim.

Distribution. Korea (South: Incheon, GG, GW, CB, JB, JN, JJ).

Promalactis parki **Lvovsky, 1986 애각시원뿔나방**

Promalactis parki Lvovsky, 1986. In Sys. and ecol. lep. Far East USSR. 37-41.

Diagnosis. According to Park et Park, 1998: 56-56 (Figs. 4, 22-24, 45), this species is superficially similar to *Promalactis enopisema* Butler in having wing pattern, but can be distinguished by valva with blunt apex in male gentitalia and dense hairs on caudal margin of lamella postvaginalis in female genitalia.

Distribution. Korea (North, South), Russia

Remarks. This species was recorded from Russia by Lvovsky (1986) based on North Korea specimen collected from Mt. Myohang. After that, Park and Park (1998) were reported South Korea specimens. However, I could not examine this species due to the lack of specimen.

***Promalactis striola* Park et Park, 1998 금빛날개원뿔나방**

Promalactis striola Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is superficially similar to *Promalactis auriella* Partk et Park in the wing pattern, but can be distinguished by second white band-like marking more bent and female genitalia with large hook-shaped lamella postvaginalis and ductus bursa bearing spines.

Description. Adult (Figs. 61, 119, 120). Head: Frons white mixed with brownish yellow; vertex grayish dark brown. Antenna with white scape dorsally, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus with brownish yellow second segment, brown third segment, the former 1.5 times longer than the latter.

Thorax: Thorax and tegula brownish yellow dorsally. Wing expanse 14.0–14.5 mm. Forewing ground color brownish yellow; three white bands oblique surrounded by fuscous scales: one near to wing base, the other at 1/3 of posterior margin not reaching to costa, slightly bent in middle, another before tornus reaching to other white irregular marking after fuscous triangular costal patch; fuscous scales partly mixed above apex; fringes brownish yellow, partly tinsed with dark brown before tornus. Hindwing more lanceolate, ground color grayish dark brown; fringes grayish dark brown. Legs: hind leg with pale gray tibia, dark brown tarsus, except white at basal part of fifth, fourth and first segments.

Male genitalia. Unknown.

Female genitalia (Figs. 228, 229, 230). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis largely developed with dense hairs entirely, a hook-like, wrinkled lateral margin, gradually narrow to apex, incurved distally, as long as the vertical lenth of eighth plus seventh sternums. Ductus bursa very long, narrow to 1/3 of its length and coiled, swelling and gradually narrow to corpus bursa. Corpus bursa very small without sigum.

Material examined. Ten individuals: three females, Gwangneung, GG, Korea, 10.vi.1998, B.K. Byun; one male and five females, same locality, 04.vi.1999, J.W. Jung & S.H. Won, gen. slide no. SNU-9442/ S. Kim; one female, Mt. Joryung-forest lodge, Yeonpung-myeon, Goesan-gun, CB, Korea, 30.vi.2011, S. Kim.

Distribution. Korea (South: GG, CB).

Remark. We do not examined the male of this species due to the lack of specimen.

***Promalactis subsuzukiella Lvovsky,* 1985 흰점꼬마원뿔나방**

Promalactis subsuzukiella Lvovsky, 1985, Trudy zool. Inst. Leningr. 134: 98-99.

Diagnosis. This species is externally similar to *Promalactis suzukiella* (Matsumura) in wing pattern, but can be easily distinguished by male genitalia with two-fork shaped uncus, distinct gnathos and split valva.

Description. Adult (Figs. 62, 121, 122). Head: Frons grayish dark brown; vertex dark brown. Antenna with white scape dorsally, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, tinsed with dark brown apically on second and third segment; second segment slightly longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 8.5–9.5 mm. Forewing ground color brown near to wing base, followed by brownish yellow to apex; two white band oblique: one from posterior margin to wing base, other from 1/3 of posterior margin to costa, wider than former; one white semi-circular costal patch above fuscous scales at 2/3 of posterior margin; fuscous scales at apex; fringes brownish yellow, mixted with grayish dark brown before tornus of posterior margin. Hindwing lanceolate, ground color grayish dark brown; fringes grayish brown. Legs: hind leg pale grayish yellow, except dark brown each apical parts of fifth, fourth, third and second segments of tarsus.

Male genitalia (Fig. 175). Uncus bifurcate, two-fork-like, each lobes gradually narrowed to apex, setose sub-basally. Gnathos tongue-like. Valva symmetric; sacculus separated from valva, slightly incurved with dense hairs, slightly longer than cucullus. Juxta Y-shaped. Aedeagus missing.

Female genitalia (Figs. 231, 232, 233). Papilla anales setose. Apophysis posterioris as same length as apophysis anterioris. Lamella postvaginalis weakly developed, setose caudally. Antrum funnel-like, gradually narrow to ductus bursa. Ductu bursa wider and longer than antrum, wrinkled vertically, coiled at 1/3. Corpus bursa small, circular-shaped with teeth-like signa.

Material examined. Four individuals: one individual, Gwangneung, GG, Korea, 29.vi.1998, B.K. Byun & Y.S. Park, wing slide no. SNU-9246/ S. Kim; one male, same locality, date and collector, gen. slide no. SNU-9234/ S. Kim; one female, same locality, date and collector, gen. slide no. SNU-9235/ S. Kim; one individual, same locality, date and collector.

Distribution. Korea (South: GG), Japan, China, Russia.

***Promalactis suzukiella* (Matsumura), 1931 구슬무늬원뿔나방**

Borkausenia suzukiella (Matsumura), 1931, 6000 Ill. Ins. Japan. 1089.

Promalacits semantris Issikii, 1957 in Esaki et al., Incon. Het. Jap. Color. Nat. 1: 52.

Diagnosis. This species is similar to *Promalactis albipunctata* Park et Park in wing pattern, but can be distinguished by male genitalia with bell-like uncus and thumb-like processus of cucullus of valva, and female genitalia with sclerotized lateral margin of seventh sternum and distinct signum.

Description. Adult (Figs. 63, 123, 124). Head: Frons dark brown; vertex white tinsed with dark brown. Antenna with white scape entirely, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus with second segment brownish yellow tinsed with dark brown dorsally; third segment dark brown except white basal and apical parts; second segment 1.5 times longer than third segment. Thorax: Thorax and tegula dark brown dorsally. Wing expanse 12.0–12.5 mm. Forewing ground color brown; two white bands oblique surrounded by fuscous scales: one near to wing base, the other from 1/3 of posterior margin reaching to costa, gradually wider to costa; one white semi-ovate costal patch at 2/3 of forewing above fuscous scales before tornus; fuscos scales followed by termen at apex; fringes brownish yellow, mixed with grayish dark brown near tornus. Hindwing more lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg pale grayish brown, except white each basal parts of fifth, fourth and third segments of tarsus.

Male genitalia (Figs. 176, 177). Uncus bell-like, wide at base, gradually narrowed to apex. Gnathos tongue-like, incurved lateral margin, wide at base, shorter than uncus. Valva symmetric; processus of cucullus thumb-like with setose; sacculus extended, hook-like apex with dense setose. Saccus funnel-like, more than two times longer than uncus. Aedeagus long, simple without cornutus.

Female genitalia (Figs. 234, 235, 236). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis developed, incised caudally with setose. Antrum short, cup-like. Seventh sternum with sclerotized lateral margin, ovate-shaped. Ductus bursa long, narrow to half, gradually wider to corpus bursa. Corpus bursa pear-like. Signum large, two triangular connected-shaped.

Material examined. Thirty-two individuals: one female, Suwon-si, GG, Korea, 27.viii.1980, C.G. Yoo; one female, same locality, 05.vi.1983, D.J. Lim; one male, same locality, 20.viii.1986, S.B. Ahn; one female, Cheongnyangni, Seoul, Korea, 15.vii.1989, G.J. Weon, gen. slide no. SNU-9105/ S. Kim; one female, Goseong, GW, Korea, 24.vi.1997, B.K. Byun, gen. slide no. SNU-9089/ S. Kim; two females, Is. Jebu, GG, Korea, 28.vi.1997, Bae & Ahn; one female, Hongreung-arboretum, Seoul, Korea, 21.vii.1997, B.K. Byun, gen. slide no. SNU-9113/ S. Kim, wing slide no. SNU-9128/ S. Kim; one female, same locality, date and collector; one female, Changgyeong-palace, Seoul, Korea, 30.vi.1999, Bae et al.; four females, Wando-arboretum, JN, Korea, 27-28.vii.2005, M.Y. Kim & S. Kim; one female, same locality, JN, Korea, 9-10.viii.2006, K.T. Park & M.Y. Kim; one female, Mt. Tongmyeong, Gokseong-gun, JN, Korea, 29.vii.2005, M.Y. Kim & S. Kim; one male, Gwangneung, GG, Korea, 16.viii.2006, H. L. Han; one individual, Jugye-ri, Waryong-myeon, Andong, GB, Korea, 13.vi.2008, B.W. Lee & B.H. Kim; one female, IS. Yeonpyeong, Ongjin-gun, GG, Korea, 07.vii.2010, S.Y. Park, J.S. Lim, G.H. Ko; one female, same locality, 31.viii.2010, S.Y. Park, J.S. Lim; one female, Mt. Keun, Is. Docho, Sinan, JN, Korea, 01.vi.2011, S.Y. Park & J.S. Lim; one female, Mt. Baegun, Gwangyang-si, JN, Korea, 15-18.vi.2011, S. Kim; one female, Mt. Horyonggok, Muuido, Incheon, GG, Korea, 30.vi.2011, S.Y. Park & J.S. Lim; one individual, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim; one male, two females and one individual, Mt. Yangrobong, Is. Yeongheung, Ongjin, Incheon, Korea, 19.vii.2011, J.O. Lim & K.M. Kim; one male, Mt. Wolyeongbong, Sinsido, Okdo-myeon, Gunsan, JB, Korea, 25.vii.2011, S.Y. Park & J.S. Lim; four females, Bonsan-myeon, Hapcheon-gun, GN, Korea, 26.vii.2011, S. Kim; two males and one female, Temple-Geumsan, Aphae-do, Sinan, JN, Korea, 29.viii.2011, S.Y. Park & J.S. Lim.

Distribution. Korea (South: Seoul, Incheon, GG, GW, CN, GB, JB, JN), Japan, China, Russia, Vietnam, USA.

Remarks. According to Park (1981) and Adamski (2009), larvae of *Promalactis suzukiella* were found under bark of rotting logs of chokecherry, *Prunus virginiana* L. (Rosaceae), oak, Quercus sp. (Fagaceae), peach, *Prunus persica* (L.), especially parts damaged by *Synathedon hector* Butler.

***Promalactis svetlanae* Lvovsky, 1985 갈색원뿔나방**

Promalactis svetlanae Lvovsky, 1985, Trydy Zool. Inst. Leningr. 134: 100-101, fig. 9.

Diagnosis. This species is distinguished from congeneric species by brownish yellow forewing tinsed with brown scales followed by termen.

Description. Adult (Figs. 64, 125, 126). Head: Frons dark brown; vertex brownish yellow. Antenna with white dorsally and ventrally, dark brown anteriorly and posteriorly, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus brownish yellow, third segment darker; second segment

1.5 times longer than third segment. Thorax: Thorax and tegula brownish yellow dorsally. Wing expanse 10.5–13.0 mm. Forewing ground color brownish yellow, tinsed with brown from 3/4 of costal margin, followed by termen, beyond tornus to 1/2 of posterior margin; three white bands oblique surrounded by fuscous scales: one from 1/6 of posterior margin to wing base, other 1/3 of posterior margin, not reaching to costa, bent sub-apically; another from 1/2 of posterior margin, connecting to brown scales; fuscous scales at 2/3 of costa; fringes brownish yellow, mixed with brown near tornus. Hindwing lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white at basal parts of all segment of tarsus.

Male genitalia (Figs. 178, 179). Uncus beak-like, wide at base, gradually narrowed to apex. Gnathos tongue-like, as same length as uncus. Valva symmetric, short; processus of cucullus thumb-like, setose; sacculus extended, distally incurved with setose; processus of sacculus: one thumb-like, other longer than former, sclerotized clavate-shaped. Saccus funnel-like, almost same length as uncus plus tegumen. Aedeagus long, slightly bent, with long cornutus.

Female genitalia (See that Park et Park, 1998: 57, Fig. 47). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis slightly incised with setose caudally. Antrum cylindrical connect to ductus bursa, Ductus bursa very long, more than two times longer than seventh sternum, bearing three spines. Corpus bursa ovate with three short signa.

Material examined. Nine individuals: one male, Andong, GB, Korea, 10.v.2009, S. Kim, gen. slide no. SNU-9058/ S. Kim, wing slide no. SNU-9126/ S. Kim; one individual, Chuncheon-si, GW, Korea, 16.v.1986, K.T. Park; one individual same locality, 07.v.1989, K.T. Park; one male, Tonggichon, GG. Korea, 17.v.1995, M.K. Paek, gen. slide no. 9221/ S. Kim; one male, Jiam-ri, 12m, Chuncheon-si, GW, Korea, 28.iv.1998, S.M. Lee; one male, Suanbo, CB, Korea, 07.v.1999, S.M. Lee; one male, Paju-si, Bugok-ri, GG, Korea, 21.v.2000, Y.S. Bae; two males, Mt. Hyinbau, Cheorwon-gun, GW, Korea, 23.v.2000, Paek & Kim.

Distribution. Korea (South: GG, GW, CB, GB).

Remark. We do not examined the female of this species due to the lack of specimen.

Promalactis wonjuensis Park et Park, 1998 **흰머리원뿔나방**

Promalactis wonjuensis Park et Park, 1998, J. Asia-Pacific Entomol. 1(1): 51-70.

Diagnosis. This species is externally similar to *Promalactis jezonica* (Matsumura) in wing pattern and male genitalia, but can be distinguished by white band-like marking straight of forewing, distinct developed lamella postvaginalis and signa of the female genitalia.

Description. Adult (Figs. 65, 127, 128). Head: Frons dark brownish yellow; vertex white, tinsed with dark brownish yellow. Antenna with white scape entirely, as long as diameter of eye; flagellum white and dark brown alternately. Labial palpus dark brown, third segment darker than second segment; second segment as long as third segment. Thorax: Thorax and tegula dark brownish yellow dorsally. Wing expanse 8.0–9.5 mm. Forewing ground color brownish yellow, three white bands oblique, straight, surrounded by fuscous scales: one from basal posterior margin to wing base, the other at 1/4 of posterior margin, not reaching to costa, another from 1/3 of posterior margin, reaching to irregular gray marking surrounded by fuscous scales, above white scales before tornus; one white costal patch, semi-ovate shaped, at 2/3 of costa; four white spots at apex surrounded by fuscous scales; fringes brownish yellow, partly mixed with white below white marking near tornus. Hindwing more lanceolate, ground color, grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white at basal parts of fifth, fourth and third segments of tarsus.

Male genitalia (Figs. 180, 181). Uncus conical-like, wide at base, gradually narrow to apex, roundly margined. Gnathos gourd bottle-shaped with small lateral lobes, as same length as uncus. Valva asymmetric; cucullus with dense hairs distally: right one longer than sacculus, left one shorter than sacculus; sacculus setose distally; Juxta long spine-like, longer than tegumen. Saccus triangular-like, roundly margined, almost same length as uncus. Aedeagus cylindrical, gradually narrow to 1/3 of its length, longer than valva without cornutus.

Female genitalia (Figs. 237, 238, 239). Papilla anales setose. Apophysis posterioris more than three times longer than apophysis anterioris. Lamella postvaginalis large clown-like, heavily sclerotized, with widely extended medial apex, semi-star-like. Antrum cylindrical. Ductus bursa membranous, gradually wider to corpus bursa. Corpus bursa small pear-like; Signum with one large and tiny several canine teeth-like spines.

Material examined. Eleven individuals: one female, Mt. Samak, Chuncheon-si, GW, Korea, 19.vii.1989, K.T. Park, gen. slide No. SNU-9141/ S. Kim; one female, Mt. Palbong, GW, Korea, 05.vii.1990, K.T. Park; one male, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim, gen. slide no. SNU-9444/ S.Kim; two males and three females, same locality, date and collector; one male, Songnisan-myeon, Boeun-gun, CB, Korea, 25.vii.2011, S. Kim, gen. slide no. SNU-9445/ S. Kim; one female and one individual, Bongsan-myeon, Hapcheon-gun, GN, Korea, 26.vii.2011, S. Kim.

Distribution. Korea (South: GW, CB, GN, JB), China.

***Promalactis xianfengensis* Wang et Li, 2004 대륙원뿔나방(신칭)**

Promalactis xianfengensis Wang et Li, 2004, Ori. Ins. 38: 7.

Diagnosis. This species is superficially similar to Vietnamese *Promalactis polyspina* Kim and Park in wing pattern, but can be distinguished by forewing with white diamond-like marking from 1/3 of posterior margin and female genitalia with ductus bursa swelling medially, bearing numerous spines.

Description. Adult (Figs. 66, 129, 130). Head: Frons dark brown; vertex dark brown, tinsed with white. Scape of antenna white mixed with dark brown apically, shorter than diameter of eye; flagellum white and dark brown alternately. Labial palpus dark brown, except white on sub-apical of second segment and basal and apical of third segment; the former 1.5 times longer than the latter.

Thorax: Thorax and tegula dark brown dorsally. Wing expanse 8.5.–9.0 mm. Forewing ground color brownish yellow; dark brown marking followed by white scales at basal, central and sub-apical costal margin, near to wing base and tornus on posterior margin; two reddish brown mixed with fuscous scales: one under basal dark brown marking on costa, other at central-posterior margin of median cell, surrounded by white scales, diamond-like; one fuscous spot at anal angle of median cell, before white scales; fringes brownish yellow, mixed with dark brown at sub-apical dark brown marking and near tornus. Hindwing more lanceolate, ground color grayish brown; fringes grayish brown. Legs: hind leg dark brown, except white at basal parts of fifth, fourth and second segments and entire first segment of tarsus.

Male genitalia (Figs. 182, 183). Uncus bell-like, wide at base, gradually narrowed to apex. Gnathos tongue-shped with pointed apex, as same length as uncus. Valva symmetric; costal margin rarely setose, slightly convex sub-apically; sacculus margin gradually narrow to apex, incurved distally with dense hairs. Juxta with lateral long lobes with pointed apex. Aedeagus cylindrical, slightly bent; cornutus about 2/3 length of aedeagus.

Female genitalia (Figs. 240, 241). Papilla anales setose. Apophysis posterioris more than 1.5 times length of apophysis anterioris. Lamella postvaginalis large, incised medially with setose on caudal margin. Antrum narrow-cylindrical, straight to ductus bursa. Ductus bursa swelling medially, gradually narrow to corpus bursa, wrinkled vertically; numerous spines of ductus bursa vertically positioned. Corpus bursa small, without signum.

Material examined. Fifteen individuals: one individual, Mt. Soyo, GG, Korea, 05.viii.1996, Bae, Paek, Lee & Ahn; one male, Mt. Suri, Gunpo-si, GG, Korea, 26.vii.1997, Y.M. Park, gen. slide no. SNU-9061/ S. Kim; one male, Temple-Yaksu, Sinlim 9 dong, Seoul, Korea, 28.vii.1997, Y.M. Park, wing slide no. SNU-9243/ S. Kim; one female, same locality, date and collector, gen. slide no. SNU-9062/ S. Kim; five females, same locality, date and collector; one female, Gwangneung, GG, Korea, 29.vii.2000, B.K. Byun & W.L. Bae; one female, KNU

Camp., Chuncheon, GW, Korea, 20.vii.2005, S. Kim, gen. slide no. SNU-9407/ S. Kim; one female, Mt. Bongrae, Oenarudo, Bongnae-myeon, Goheung, JN, Korea, 19.vii.2011, S.Y. Park & J.S. Lim, gen. slide no. SNU-9408/ S. Kim; one female, Mt. Wolyeongbong, Sinsido, Okdo-myeon, Gunsan, JB, Korea, 21.vii.2011, S.Y. Park & J.S. Lim; one male and one female, Chusan-ri, Okryong-myeon, Gwangju-si, GG, Korea, 28.vii.2013, Y. Lee.

Distribution. Korea (South: Seoul, GG, GW, JB, JN), China.

1.6 Checklist of Oecophoridae in the Korean Peninsula

Family **Oecophoridae** Bruand, 1850

Subfmaily **Cryptolechiinae** Meyrick, 1883, **stat. n.**

Genus ***Acryptolechia*** Lvovsky, 2010

Acryptolechia malacobyrsa (Meyrick), 1921 **갈색띠원뿔나방**

Acryptolechia torophanes (Meyrick), 1935 **노랑띠원뿔나방**

Genus ***Batia*** Stephens, 1834

Batia clavata Kim, **sp. nov.** **손톱무늬원뿔나방**(**신칭**)

Batia flavatus Kim, **sp. nov.** **노랑수염원뿔나방**(**신칭**)

Genus ***Cryptolechia*** Zeller, 1852

Cryptolechia albulus Kim, **sp. nov.** **옅은원뿔나방**(**신칭**)

Cryptolechia obtusa Kim, **sp. nov.** **뭉뚝원뿔나방**(**신칭**)

Genus ***Exiguacma*** Kim, **gen. nov.**

Exiguacma forcipis Kim, **sp. nov.** **한라원뿔나방**(**신칭**)

Genus ***Martyringa*** Meyrick, 1902

Martyringa xeraula (Meyrick), 1910 **도둑원뿔나방**

Genus ***Periacma*** Meyrick, 1894

Periacma delegata Meyrick, 1914 **노랑날개원뿔나방**

Genus ***Pseudodoxia*** Durrant, 1895

Pseudodoxia achlyphanes (Meyrick), 1934 **통말이원뿔나방**

Pseudodoxia gahakensis Kim, **sp. nov. 가학원뿔나방(신칭)**

Genus ***Ripeacma*** Moriuti, Saito et Lewvanich, 1985

Ripeacma acuminiptera Wanget Li, 1999 **좁은노랑원뿔나방(신칭)**

Ripeacma adamantis Kim, **sp. nov. 다이아원뿔나방(신칭)**

Ripeacma longior Kim, **sp. nov. 긴돌기원뿔나방(신칭)**

Subfamily **Oecophorinae** Bruand, 1850 **원뿔나방아과**

Genus ***Callimodes*** Leraut, 1989

Callimodes zelleri (Christoph), 1882 **젤러리원뿔나방**

Genus ***Deuterogonia*** Rebel, 1901

Deuterogonia pudorina (Wocke), 1857 **북방원뿔나방**

Genus ***Epicallima*** Dyar, [1903]

Epicallima conchylidella (Snellen, 1884) **사다리원뿔나방(신칭)**

Genus ***Promalactis*** Meyrick, 1908

Promalactis albipunctata Park et Park, 1998 **구슬무늬큰원뿔나방**

Promalactis atriplagata Park et Park, 1998 **설악원뿔나방**

Promalactis auriella Park et Park, 1998 **칼무늬원뿔나방**

Promalactis autoclina Meyrick, 1935 **꼬마원뿔나방**

Promalactis bitaenia Park et Park, 1998 **두줄띠원뿔나방**

Promalactis candidifascia Kim, **sp. nov.** **흰두줄원뿔나방(신칭)**

Promalactis enopisema (Butler), 1879 **매끈이원뿔나방**

Promalactis jezonica (Matsumura), 1931 **네방원뿔나방**

Promalactis odaiensis Park, 1980 **솔피원뿔나방**

Promalactis parki Lvovsky, 1986 **애각시원뿔나방**

Promalactis striola Park et Park, 1998 **금빛날개원뿔나방**

Promalactis subsuzukiella Lvovsky, 1985 **흰점꼬마원뿔나방**

Promalactis suzukiella (Matsumura), 1931 **구슬무늬원뿔나방**

Promalactis svetlanae Lvovsky, 1985 **갈색원뿔나방**

Promalactis wonjuensis Park et Park, 1998 **흰머리원뿔나방**

Promalactis xianfengensis Wang et Li, 2004 **대륙원뿔나방(신칭)**

II. Molecular phylogeny and evolutionary history of Oecophoridae (Lepidoptera: Gelechioidea) inferred from microhabitat and sheltering strategy of larvae

2.1 Abstract

Phylogenetic relationships within family Oecophoridae have been poorly understood and consequently the subfamily or genus level classifications problematic. A comprehensive phylogenetic analysis of Oecophoridae, the concealer moths, is performed based on analysis of 4,444 base pairs of mitochondrial COI, nuclear ribosomal RNA genes (18S and 28S) and nuclear protein coding genes (IDH, MDH, Rps5, EF1a and wingless) for 82 taxa. Data were analysed using maximum likelihood (ML), parsimony (MP) and Bayesian (BP) phylogenetic frameworks.

The phylogenetic analyses indicates that i) genera *Casmara*, *Tyrolimnas* and *Phaeosaces* are separated from the oecophorid lineage suggesting that Oecophoridae is not monophyletic; ii) Cryptolechiinae, Pleurotinae and Oecophorinae are nested within the same clade as the main oecophoridae clade; iii) Xyloryctidae is clustered within oecophorid lineage, as sister to the other clades.

BayesTraits were implemented to explore the ancestral character states inferring historical microhabitat patterns and sheltering strategy of larvae. Reconstruction of the ancestral microhabitat of oecophorids indicates that oecophorids may have evolved from dried plant feeders and convergently further specialized. The ancestral larva sheltering strategy of oecophorids might have made a silk tube, shifting from leaf miner or open habit (not make a shelter). Biogeographical approach is also discussed based on molecular dating. The oecophorid lineage diverged in the Late Eocene at 43.4 Mya and underwent rapid radiation from the Late Eocene to Miocene and dispersal from mixed area, Afrotropical and Oriental Regions.

Key words: Oecophoridae, concealer moths, molecular phylogeny, evolution, estimation of divergence time

2.2 Introduction

Oecophoridae (Lepidoptera: Gelechioidea), one of the most speciose microlepidopteran Ditrysia, is worldwide in distribution and comprises more than 4,000 described and undescribed species, particularly in Australia with over 3,000 endemic species (Common 1990; 1994; 1997; 2000). Approximately, 450 species of the Palaearctic Regions, mainly from Europe and China areas, 207 species of the

Neotropical Regions, 194 species of the Oriental Regions, 143 species of the Nearctic Regions and 139 species of the Afrotropical Regions are distributed (Becker, 1984; Hodges, 1974; Kim et al. 2010, 2012, 2014; Lvovsky, 1996; Moriuti, 1982; Moriuti et al., 1985, 1987 and 1989; Park, 1980, 1981a, 1981b, 1983, 1998; Saito et al., 1992; Saito, 1987 and 1989; Vári & Kroon, 1986; Wang, 2006). The diversity and increase of each regional oecophorids are probably related to their environmental conditions. The species endemic to Australia adapt themselves to dry condition accompanied with eucalypt forests or woodlands, whereas the species of genus *Promalactis* with highest diversity in South and East Asia adapt to relatively damp habitats for feeding fungi.

Oecophorids comprise tiny to large sized moths, wingspan ranging from 7 to 74 mm. The majority of oecophorid larvae are concealed feeders, sheltering themselves, often within their feeding substrate or with dense siken shelters.

2.2.1 Phylogenetic relationships

Historically, Oecophoridae have been considered to comprise two to seven subfamilies by different authors (Table 1). Lack of a well resolved phylogeny for the Oecophoridae, together with taxonomic uncertainties within the constituent groups, has contributed to confusion over the classification of the family. So far, relationships of family or subfamily levels of the Oecophoridae have only been dealt in analytical phylogenetic works of the whole Gelechioidea. Although several recent attempts on the phylogeny of Gelechioidea using characters from morphology as well as molecular data (Minet, 1990; Hodges, 1998; Kaila, 2004; Kaila et al., 2011; Heikkilä et al., 2014) have been made to obtain a global framework for a comprehensive gelechioid phylogeny, the classification of the internally heterogeneous Oecophoridae has not been explored in detail and remains obscure.

In the first phylogenetic analysis of Gelechioidea using parsimony with 38 morphological characters, Hodges (1988) restricted the family Oecophoridae to include two subfamilies, Oecophorinae and Stathmopodinae (Fig. 242, a) on the basis of the lack of an articulation between the gnathos and tegumen in male genitalia. He excluded the (sub) families, Deuterogoniinae (Oecophoridae in Toll, 1964; Hodges, 1978), Depressariinae (Oecophoridae in Toll, 1964; Hodges, 1974, 1978; Common, 1990), Stenomatinae (Oecophoridae in Hodges, 1978; Common 1990) and Ethmiinae (Oecophoridae in Hodges, 1978) to Elachistidae, and the Amphisbatini/ Amphisbatinae (Oecophoridae in Toll, 1964; Hodges, 1974), Chimabachinae (Oecophoridae in Hodges, 1974, 1978), Peleopodinae (Oecophoridae in Hodges, 1974, 1978; Common, 1990), and Autostichinae (Oecophoridae in Hodges, 1978; Common, 1990) to each independent family.

Despite limited numger of morphological characters and problematic methodology, his work was accepted as a major rearrangement of family and subfamily concepts. In an anlaysis using 143 taxa with 193 characters and species as terminals, Kaila (2004) presented the Gelechioidea to be divided into two main lineages, 'gelechioid lineage' and 'oecophorid lineage' (Fig. 242, b). The *Stathmopoda* species (Oecophoridae: Stathmophodinae in Hodges, 1998) clustered with "batrachedrid taxa' with Coleophoridae in the 'gelechiid lineage', and Oecophorinae species (Oecophoridae: Oecophorinae in Hodges, 1998) were divided into two groups: i) three New Zealand oecophorid genera, i.e. *Hierodoris*, *Izatha* and *Phaeosaces*, belonging to 'xyloryctid assemblage', supported by two larva characters (an absence of a submental pit and a presence of a pinacular ring in abdominal SD1), with Xyloryctinae s.s. (Xyloryctidae: Xyloryctinae in Hodges 1998), Deuterogoniinae (Elachistidae: Deuterogoniinae in Hodges, 1998) and Blastobasinae (Coleophoridae: Blastobasinae in Hodges, 1998); ii) the New Zealand genus *Tingena* and a number of other genera, i.e. *Palimmeces*, *Pleurota*, *Philobota*, *Prionocris*, *Phryganeutis*, *Borkhausenia*, *Hofmannophila*, *Oecophora*, *Harpella*, *Denisia*, *Bisigna*, *Promalactis* and *Polix*, formed the 'Oecophoridae s.s.', supporting their sister-group relationship with Amphisbatidae s.s., Carcinidae, Stenomati[n/d]ae, Chimabachidae and Elachistidae. However, he was doubtful about accepting *Martyringa* (Oecophoridae: Oecophorinae in Hodges, 1998). He excluded it from the final analaysis, due to the taxon with incomplete data removing all basal resolution between the groups Oecophorinae and the xyloryctid assemblage in consensus tree. On the other hand, Lvovsky (2009) presented a non-analytical cladogram (Fig. 242, c) of Oecophoridae s.s., including Oecophorinae, Pleurotinae and Deuterogoniinae by characters on adult and larva feeding mode and separating them from other "broad winged" gelechioids, i.e. Chimabachidae, Amphisbatidae and Depressariidae, that had previously been regarded as belonging to Oecophoridae by, e.g., Toll (1964) and Hodges (1974). Kaila et al. (2011) performed a large-scale molecular phylogeny of Gelechioidea. The results (Fig. 242, d) supports that the clade with the core Xyloryctidae and the New Zealandian Oecophorid genera *Hierodoris*, *Gymnobathra* and *Izatha* is monophyletic as in Kaila (2004). A significant difference between Kaila (2004) and Kaila et al. (2011) was the placement of *Phaeosaces* that in Kaila (2004) was grouped in Xyloryctidae s.l., but in Kaila et al. (2011) was associated with the 'Elachistid s. l. clade. Hoare (2005), with reservations, tentatively accepted the position of *Phaeosaces* in the *Hierodoris* group, following Kaila (2004), but had doubts in its placement because of sharing the typical characters of Oecophoridae s. s. (Common 1994, 1997, 2000). Oecophoridae s. s. (Kaila et al., 2011) was delineated as Oecophorinae *sensu* Hodges (1998) and Deuterogoniinae (Elachistidae in Hodges, 1998; 'xyloryctid assemblage' in Kaila, 2004) like in by Tokár et al. (2005), Saito (2005) and Wang

(2006), but was separated from the Stathmopodinae and Coleophoridae as in Kaila (2004). The Stathmopodinae was grouped as the sister-group of Blastobasidae. Due to several conflicting results, the classification of Oecophoridae remined unclear, as mentioned by Kaila et al. (2011). Recently, Heikkilä et al., (2014) implemented the most comprehensive phylogeny of Gelechioidea so far, based on combined morphological and molecular data. Their results closely corroborate the molecular-based work by Kaila et al., (2011). Heikkilä et al. suggested the monophyly of Oecophoridae s.s., with the exclusion of *Martyringa* (Oecophoridae: Oecophorinae in Hodges, 1974, 1998; Lvovsky, 2008; Wang, 2006) and *Hierodoris* (Oecophoridae: Oecophorinae in Dugdale, 1988; Xyloryctidae s.l. in Kaila, 2004; Xyloryctidae s.l./ Oecophoridae s.l., Kaila et al, 2011). The aim of this study is to perform a molecular phylogeny of Oecophoridae with global sampling comprehensively encompassing the diversity of the family. I focus on testing the monophyly of Oecophoridae and clarifying the relationships of its constituent subfamilies or genera.

Trophic associations of the lepidopteran larvae were formed during a long period of evolution (Powell, 1980; Powell et al., 1998; Lvovsky, 2009). It appears to be tightly related to biological characters such as larval feeding substrate, habitat and behavior (Powell et al., 1998; Kaila et al., 2011).

For Oecophoridae, the vernacular name, 'concealer moths' has often been used. The larva of Oecophoridae keep concealed with several strategies. They may be sheltered within a web or hidden under bark or dead wood, or inside leaves rolled by them, sometimes they bore stem or trunk, or burrow under bark or in soil. As indicated by so diverse range of sheltering strategies, oecophorids are also found in very diverse, often specialized microhabitats. As examples, *Bisigna procerella* and *Callimodes heringii* feed on lichens, *Oecophora bractella* and *Harpella forficella* consume fungi growing on the tree trunks (Schütze, 1931; Toll, 1964; Harper et al., 2002; Lvovsky, 2006). Larvae of *Borkhausenia fuscescens*, *Endrosis sarcitrella* and *Hofmannophila pseudospretella* have been found even in bird's nests (Waters, 1929; Ford, 1949; Klimesch, 1961; Lvovsky, 2009). *Deuterogonia pudorina* has been bred from oak galls evoked by Cynipidae (Hymenoptera) (Toll, 1964) and often feed bast and mouldering wood under bark of trees or lichens (Schütze, 1931; Toll, 1964; Harper et al., 2002; Lvovsky, 2006). This study aims also to assess the ancestral character state of microhabitat and larva sheltering strategy within the phylogenetic relationship of Oecophoridae, for understanding the evolutionary transition and adaptation of larva microhabitat and sheltering strategy.

Lepidopteran families have been identified in fossil resins, mostly in the Baltic amber dated at the Late Eocene and Early Oligocene (Skalski, 1977). Among them, about 30 % of the Baltic amber Lepidoptera had been regard as the Oecophorids due to the ambiguous delimitation of the family and numerous Oecophoridae-like related taxa. Consequentially, a few fossil records of Oecophoridae have been recognized. The extinct species, *Epiborkhausenites obscurotrimaculatus* closely related to fossil genus *Paraborkhausenites* described from the Baltic amber (Kuznetsov, 1941) was also recognized from Baltic amber (Skalski, 1973). The species is externally similar to some recent Oecophorid species, in particular, *Hofmannophila pseudospretella* and *Inga sparsiciliella* and related other species previously regard as Oecophorids, *Pseudatemelia josephinae* (Lypusidae) and *Psilocorsis quercicella* (Elachistidae: Depressariinae). The other species, *Schiffermuelleria jantharica*, described from the Baltic amber (Skalski, 1977), had similar shape of valva of male genitalia with recent genera, *Schiffermuelleria*, *Batia* and *Borkhausenia*. Oecophorid-like moths are also found in Dominican amber from 40 to 15 Mya (Poinar, 1992). Among them, only one species referred to the recent genus *Schiffermuelleria* (Kristensen and Skalski, 1999).

With Oecophoridae, majority of the recorded families from Baltic amber belong to the Microlepidoptera (Skalski, 1990). Now, it seems that the Microlepidoptera from the Baltic amber display variously developed relationship to the lepidoptero-faunas of various zoogeographical regions (Skalski, 1977). The fossil closely related to the genus *Depressaria* distributed in Holarctic was found in this amber and the *Micropterxyx* is connected with Palearctic. In case of *Heliodines*-like forms from the amber related to species from North America, India, Australia and Europe respectively (Turner, 1941). The aim of this study is also to investigate the historical biogeography and evolution of the family Oecophoridae and related higher taxa for understanding their global radiation and distribution. To reconstruct the historical biogeography, I conducted a molecular clock analysis in order to date the phylogenetic tree of the Oecophoridae. This enables an assignment of radiation events to certain geological time frames.

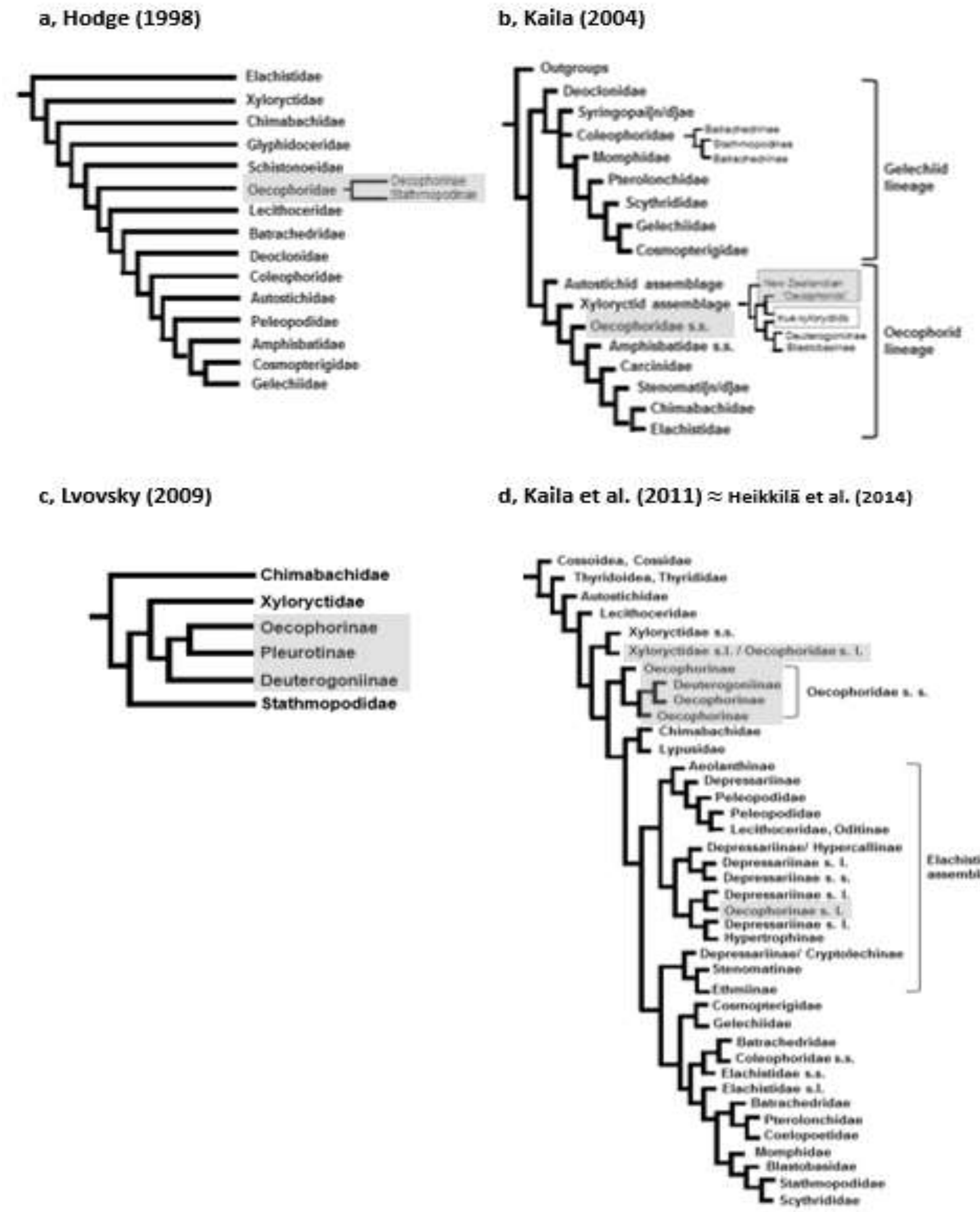


Fig. 242. Current hypotheses of family relationships within the superfamily Gelechioidea.

(a) cladogram after Hodges (1998), and the classification system; (b) cladogram after Kaila (2004), and the classification system; (c) cladogram after Lvovsky (2009); (d) cladogram after Kaila et al. (2011) and the classification system.'

2.3 Material and methods

2.3.1 Taxon sampling

A total of 82 taxa, comprising 80 ingroup terminals and two outgroup taxa of Cossoidea and Thyridoidea (Mutanen et al., 2010; Kaila et al., 2011), were included in this study (Table 3). To clarify the delimitation of family Oecophoridae with its constituents, 43 putative 'core' species were selected considering the biogeographical vast radiation of Oecophoridae. Other 37 species, either formerly considered to belong to Oecophoridae or closely clustered with them in the comprehensive phylogeny works of Gelechioidea by Hodges (1998), Kaila (2004), Lvovsky (2009) and Kaila et al. (2011), were added to: Oecophorids (Oecophorinae, Oecophoridae s. s./ s. l., Deuterogoniinae, Pleurotinae), Xyloryctid assemblage (Xyloryctidae, so-called New Zealandian oecophorids, Deuterogoniinae and Blastobasinae), elachistid assemblage (Aeolanthinae, Cryptolechiinae, Depressariinae, Ethmiinae, Hypertrophinae and Stenomatinae), Chimabachidae, Lypusidae as being closest sister groups of Oecophoridae in Lvovsky (2009) and Kaila et al. (2011), and Stathmopodinae, separated from Oecophoridae in Kaila (2004) and Kaila et al., (2011) but still supported by Lvovsky (2009) and other authors (Hodges 1998; Harper et al., 2002; Wang, 2006). Among them, sequenced data for 46 samples were downloaded from NCBI (Kaila et al., 2011), (Table 2-2).

Moreover, we included previously untested and problematic species: i) *Martyringa ussuriella* or *Martyringa* sp. collapsing all basal resolution between the Oecophorinae and the xyloryctid assemblage, and subsequently excluded from the Kaila's result (2004). Those species were not dealt in the Kaila et al., (2011) and excluded from the Oecophoridae in Heikkilä et al., (2014). In this study, we could test congeneric species, *Martyringa xeraula*; ii) the composition and placement of members of Cryptolechiinae is still unstable. *Orophia ferrugella* of Cryptolechinae closely associated with Depressariinae in Kaila et al, (2011) and Hodges (1998), where it was considered a synonym of Depressariinae. The representatives, *Cryptolechia* and *Acryptolechia*, have been treated as genera of Oecophoridae in the Asia area i.e. Oriental and Palaeartic regions (Saito et al., 1992; Wang 2006), or a subfamily Cryptolechiinae of an independent family Cryptolechiidae (Lvovsky, 2009). The identity and composition of Cyptolechiinae, even the nominate genus *Cryptolechia* is, however, unclear. Therefore the taxa included as representatives of Cryptolechiinae should be taken with caution. Two representatives of so-called Cryptolechiinae or Cryptolechiidae were included, viz., *Acryptolechia malacobyrsa* and *A. torophanes,* recently transferred from *Cryptolechia* by Lvovsky (2009).

2.3.2 Specimen vouchering, DNA extraction, PCR amplification, and sequencing

Before the extraction, all specimens were examined for identification under the microscope (DM 4000B, Leica Microsystems, Wetzlar, Germany), taken photos (18.3 Three Shot Color, Diagnostic Instruments, Sterling Heights, MI, USA), and the mounted slides of genitalia were made.

Total genomic DNA was extracted by grinding up usually legs of alcohol vouchers or whole body except abdomen of dried specimens using DNeasy® Blood and Tissue kit (QIAGEN, Inc), according to the manufacturer's protocol. The remaining parts of specimens were also preserved as vouchers. Genes were chosen by utility in Lepidoptera systematics. One mitochondrial protein coding gene, the cytochrome oxidase subunit I gene (COI) (Folmer et al., 1994, Simon et al., 1994; Aubert et al., 1999; Martin et al., 2002; Zakharov et al., 2004; Hundsdoerfer et al., 2005; Bucheli and Wenzel, 2005; Katoh et al., 2005, Kaila et al., 2011), two nuclear ribosomal RNA genes, 18S rRNA (18S) (Wiegmann et al., 2000) and 28S rRNA (28S) (Abraham et al., 2001; Brady et al., 2006; Niehuis et al., 2006; Yamamoto et al., 2007) and five nuclear protein coding genes, Ribosomal protein S5 (Rps5), Isocitrate dehydrogenase (IDH), the Cytosolic malate dehydrogenase (MDH), elongation factor-1α (EF1α) and wingless were selected (Wahlberg and Wheat, 2008; Kaila et al., 2011). We also tried to amplify the mitochondrial 16S rRNA (16S) and two nuclear protein coding genes, Carbamoylphosphate synthase domain protein (CAD) and Glyceral-dehyde-3-phosphate dehydrogenase (GAPDH), but got too low success rate to analysis, we decided to omit this genes. Each gene region used for PCR amplification is given in Table 4. PCRs were performed using Advantage PCR II Taq polymerase (BD Advantage™) and the reactions were performed in 20 μL volumes containing 0.4 μm of each primer, 200 μm dNTPs, 2.5 μm $MgCl_2$, and 0.05 μg genomic DNA template. The thermal cycling program consisted of 95℃/ 5 min, 38-40 cycles of 95℃/ 30 sec and 72°/ 60 sec followed by a final extension at 72℃/ 10 min, but the annealing temperatures were adjusted accordingly genes (Table 4). The PCR products were cleaned using a QIAquick® PCR purification kit (QIAGEN, Inc.) and directly sequenced at Macrogen, Inc (Geumcheon–Gu, Seoul, Republic of Korea).

Table. 3-1. Taxa used in this study with GenBank accession numbers, employing Nieukerken et al., (2011)'s classification.

Family	Subfamily	Species	Collecting country	Genbank assession number							
				18S rDNA	**28S rDNA**	**COI**	**IDH**	**MDH**	**RPS5**	**EF1A**	**WINGLESS**
Peleopodidae		*Acria sp.*	S. Korea	KF377325	KF311806	KF311836	KF311907		KF377379	KF311873	KF311772
Elachistidae	Aeolanthinae	*Aeolanthes semiostrina*	S. Korea	KF377326		KF311837				KF311874	KF311773
Elachistidae	Depressariinae	*Agonopterix lnigrum*	S. Korea	KF377327	KF311807	KF311838	KF311908		KF377380	KF311875	KF311774
Statomopodidae		*Atrijuglans hetaohei*	S. Korea	KF377328	KF311808	KF311868	KF311909		KF377381	KF311876	KF311775
Blastobasidae	Blastobasinae	*Blastobasis sprotundalis*	S. Korea	KF377329	KF311809	KF311839	KF311910	KF377354		KF311877	KF311776
Oecophoridae		*Casmara agronoma*	S. Korea	KF377330	KF311810	KF311840	KF311911	KF377355	KF377382	KF311878	KF311777
Oecophoridae	Cryptolechiinae	*Acryptolechia malacobyrsa*	S. Korea	KF377331	KF311811	KF311841			KF377383	KF311879	KF311778
Oecophoridae	Cryptolechiinae	*Acryptolechia torophanes*	S. Korea	KF377332	KF311812	KF311842	KF311912	KF377356	KF377384	KF311880	KF311779
Oecophoridae	Deuterogoniinae	*Deuterogonia pudorina*	S. Korea	KF377333	KF311813	KF311843	KF311913	KF377357	KF377385	KF311881	KF311780
Statomopodidae		*Hieromantis kurokoi*	S. Korea	KF377334	KF311814	KF311844	KF311914		KF377386	KF311882	KF311781
Oecophoridae	Oecophorinae	*Marlyringa xeraula*	S. Korea	KF377335	KF311815	KF311845	KF311915		KF377387	KF311883	KF311782
Oecophoridae	Oecophorinae	*Periacma delegata*	S. Korea	KF377336	KF311816	KF311846	KF311916	KF377358	KF377388	KF311884	
Oecophoridae	Oecophorinae	*Promalactis albisquama*	Cambodia		KF311817	KF311847	KF311917	KF377359		KF311885	

Oecophoridae	Oecophorinae	*Promalactis atriplagatta*	S. Korea			KF311848	KF311918	KF377360	KF377389		KF311783
Oecophoridae	Oecophorinae	*Promalactis autoclina*	S. Korea	KF377337	KF311818	KF311849	KF311919	KF377361	KF377390	KF311886	KF311784
Oecophoridae	Oecophorinae	*Promalactis bidenscula*	Cambodia	KF377338		KF311850	KF311920	KF377362		KF311887	KF311785
Oecophoridae	Oecophorinae	*Promalactis enopisema*	S. Korea	KF377339	KF311819	KF311851	KF311930	KF377363	KF377391	KF311888	KF311786
Oecophoridae	Oecophorinae	*Promalactis jezonica*	S. Korea		KF311820	KF311852	KF311921	KF377364	KF377392	KF311889	KF311787
Oecophoridae	Oecophorinae	*Promalactis kuznetzovi*	Vietnam			KF311853	KF311922	KF377365	KF377393	KF311890	KF311788
Oecophoridae	Oecophorinae	*Promalactis odaiensis*	S. Korea	KF377340	KF311821	KF311854	KF311923	KF377366	KF377394	KF311891	KF311789
Oecophoridae	Oecophorinae	*Promalactis polyspina*	Vietnam	KF377341	KF311822	KF311855	KF311924		KF377395	KF311892	
Oecophoridae	Oecophorinae	*Promalactis prolixolobi*	Cambodia		KF311823	KF311856	KF311925	KF377367	KF377396	KF311893	KF311790
Oecophoridae	Oecophorinae	*Promalactis serratusola*	Cambodia	KF377342		KF311857	KF311926	KF377368	KF377397	KF311894	KF311791
Oecophoridae	Oecophorinae	*Promalactis striola*	S. Korea	KF377343	KF311824	KF311858		KF377369	KF377398		KF311792
Oecophoridae	Oecophorinae	*Promalactis suzukiella*	S. Korea	KF377344	KF311825	KF311859	KF311927		KF377399	KF311895	KF311793
Oecophoridae	Oecophorinae	*Promalactis tamdaoella*	Vietnam			KF311860	KF311928		KF377400	KF311896	KF311794
Oecophoridae	Oecophorinae	*Promalactis wonjuensis*	S. Korea	KF377345	KF311826	KF311861	KF311929	KF377370	KF377401	KF311897	KF311795
Oecophoridae	Oecophorinae	*Promalctis bitaenia*	S. Korea			KF311862	KF311931	KF377371	KF377402	KF311898	KF311796
Oecophoridae	Oecophorinae	*Pseudodoxia achlyphanes*	S. Korea	KF377346	KF311827	KF311863	KF311932	KF377372	KF377403		KF311797

Oecophoridae	Oecophorinae	*Ripeacma acuminipiptera*	S. Korea	KF377347	KF311828	KF311864	KF311933	KF377373	KF377404	KF311899	KF311798
Oecophoridae	Oecophorinae	*Callimodes zelleri*	S. Korea	KF377348	KF311829	KF311865	KF311934	KF377374	KF377405	KF311900	KF311799
Statomopodidae		*Stathmopoda auriferella*	S. Korea		KF311830	KF311866	KF311935		KF377406	KF311901	KF311800
Statomopodidae		*Stathmopoda masinissa*	S. Korea	KF377349	KF311831	KF311867	KF311936		KF377407	KF311902	KF311801
Statomopodidae		*Stathmopoda opticaspis*	S. Korea	KF377350	KF311832	KF311869	KF311937	KF377375	KF377408	KF311903	KF311802
Statomopodidae		*Stathmopoda sp1*	S. Korea	KF377351	KF311833	KF311870	KF311938	KF377376	KF377409	KF311904	KF311803
Statomopodidae		*Stathmopoda sp2*	S. Korea	KF377352	KF311834	KF311871	KF311939	KF377377	KF377410	KF311905	KF311804
Oecophoridae	Oecophorinae	*Tyrolimnas anthraconesa*	S. Korea	KF377353	KF311835	KF311872	KF311940	KF377378	KF377411	KF311906	KF311805

Table. 3-2. Taxa used in this study with GenBank accession numbers, employing Nieukerken et al., (2011)'s classification.

Family	Subfamily	Species	Collecting country	Genbank assession number					
				COI	IDH	MDH	RPS5	EF1A	WINGLESS
Chimabachidae		*Diurnea fagella*	Finland	GU828735/ GU929710	GU830119	GU830437		GU829051/ GU829336	GU829602
Cossidae	Cossinae	*Cossus cossus*	Finland	GU828604/ GU828403	GU829992	GU830315	GU830615	GU828938/ GU829232	GU829499
Elachistidae	Aeolanthinae	*Aeolanthes sp*	Vietnam	JF818803	JF818994	JF819062	JF819128	JF818886	JF818641
Elachistidae	Depressariinae	*Agonopterix heracliana*	Finland	JF818718	JF818931	JF818996	JF819064	JF818805	JF818574
Elachistidae	Depressariinae	*Cacochroa corfuella*	Greece	JF818729	JF818937	JF819004	JF819071	JF818815	
Elachistidae	Depressariinae	*Cephalispheira/Orophia ferrugella*	Finland	JF818773	JF818969	JF819039	JF819104	JF818857	JF818617
Elachistidae	Depressariinae	*Eutorna sp*	New Zealand	JF818749		JF819021	JF819084	JF818833	JF818596
Elachistidae	Depressariinae	*Exaeretia ciniflonella*	Finland	JF818750	JF818950		JF819085	JF818834	JF818597
Elachistidae	Depressariinae	*Machimia tentoriferella*	USA	JF818766		JF819035		JF818850	JF818611
Elachistidae	Depressariinae	*Nymphostola galactina*	New Zealand	JF818771	JF818967		JF819102	JF818855	JF818616
Elachistidae	Depressariinae	*Proteodes carnifex*	New Zealand	JF818782	JF818977		JF819112	JF818866	JF818626
Elachistidae	Depressariinae	*Psilocorsis reflexella*		JF818783			JF819113	JF818867	JF818627
Elachistidae	Depressariinae	*Semioscopis steinkellneriana*	Finland	JF818789	JF818982	JF819053	JF819118	JF818872	JF818631
Elachistidae	Depressariinae	*Telechrysis tripuncta*	Finland	JF818794	JF818986	JF819055	JF819122	JF818877	JF818635
Elachistidae	Ethmiinae	*Ethmia clytodoxa*	Australia	JF818745	JF818947	JF819018	JF819081	JF818829	JF818594
Elachistidae	Ethmiinae	*Ethmia pusiella*	Finland	GU828588/ GU828387	GU829977	GU830300	GU830603	GU828924/ GU829220	GU829486
Elachistidae	Hypertrophinae	*Anchinia daphnella*	Finland	JF818720	JF818933	JF818998	JF819065	JF818807	JF818575
Elachistidae	Hypertrophinae	*Hypercallia citrinalis*	Finland	GU828596/ GU828395	GU829985	GU830308	GU830608	GU828930/ GU829227	GU829492
Elachistidae	Hypertrophinae	*Pedois lewinella*	Australia	JF818777	JF818972	JF819043	JF819107	JF818861	JF818621
Elachistidae	Hypertrophinae	*Peridroma oligodrachma*	Australia	JF818760	JF818959	JF819030	JF819094	JF818844	JF818605
Elachistidae	Hypertrophinae	*Thudaca mimodora*	Australia	JF818796	JF818988	JF819057	JF819124	JF818879	
Elachistidae	Stenomatinae	*Agriophara axesta*	Australia	JF818719	JF818932	JF818997		JF818806	

Elachistidae	Stenomatinae	*Antaeotricha leucillana*	Canada	JF818722	JF818935	JF819000	JF819067	JF818809	JF818577
Lypusidae		*Pseudatemelia josephinae*	Finland	GU828593/ GU828392	GU829982	GU830305	GU830606	GU828928/ GU829224	GU829490
Oecophoridae	Oecophorinae	*Borkhausenia fuscescens*	Finland	JF818728	JF818936	JF819003			JF818581
Oecophoridae	Oecophorinae	*Endrosis sarcitrella*	Finland	JF818743	JF818945	JF819016	JF819079	JF818827	JF818593
Oecophoridae	Oecophorinae	*Harpella forficella*	Finland	JF818753	JF818953	JF819024	JF819087	JF818837	JF818600
Oecophoridae	Oecophorinae	*Hofmannophila pseudospretella*	Finland	JF818756	JF818955	JF819026	JF819090	JF818840	JF818603
Oecophoridae	Oecophorinae	*Oecophora bractella*	Finland	GU828695/ GU828491	GU830082	GU830400	GU830685	GU829018/ GU829307	
Oecophoridae	Oecophorinae	*Palimmeces sp*	Australia	JF818774	JF818970	JF819040		JF818858	JF818618
Oecophoridae	Oecophorinae	*Philobota sp*	Australia	JF818780	JF818975	JF819046	JF819110	JF818864	JF818624
Oecophoridae	Oecophorinae	*Pleurota bicostella*	Finland	JF818781	JF818976	JF819047	JF819111	JF818865	JF818625
Oecophoridae	Oecophorinae	*Tingena armigerella*	New Zealand	JF818797	JF818989		JF819125	JF818880	JF818636
Oecophoridae	Oecophorinae	*Wingia aurata*	Australia	JF818801	JF818992	JF819060	JF819127	JF818884	JF818640
Oecophoridae		*Gymnobathra flavidella*	New Zealand	JF818751	JF818951	JF819022		JF818835	JF818598
Oecophoridae		*Gymnobathra omphalota*	New Zealand	JF818752	JF818952	JF819023	JF819086	JF818836	JF818599
Oecophoridae		*Hierodoris atychioides*	New Zealand	JF818755			JF819089	JF818839	JF818602
Oecophoridae		*Izatha austera*	New Zealand	JF818762	JF818961	JF819032	JF819096	JF818846	JF818607
Oecophoridae		*Izatha peroneanella*	New Zealand	JF818761	JF818960	JF819031	JF819095	JF818845	JF818606
Oecophoridae		*Phaeosaces coarctatella*	New Zealand	JF818779	JF818974	JF819045	JF819109	JF818863	JF818623
Oecophoridae		*Phaeosaces compsotypa*	New Zealand	JF818778	JF818973	JF819044	JF819108	JF818862	JF818622
Peleopodidae		*Carcina quercana*	Bulgaria	GU828758/ GU929731	GU830142	GU830458	GU830726	GU829071/ GU829353	GU829620
Thyrididae	Thyridinae	*Thyris fenestrella*	Bulgaria	GU828761/ GU929735	GU830146	GU830462	GU830728	GU829074/ GU829357	GU829623
Xyloryctidae	Xyloryctinae	*Cryptophasa sarcoxantha*	Australia	JF818739	GU830159	GU830478	GU830739	GU829367	GU829638
Xyloryctidae	Xyloryctinae	*Tymbophora peltastis*	Australia	JF818800	JF818991	JF819059		JF818883	JF818639

Table. 4. Primers used in the present study.

Gene region	Direction	Primer name	Primer	Annealing temperature	Product length bp	Reference
16SrRNA	Forward	16SgaF	5' GTA TCT TGT GTA TCA GAG TT 3'	50	1011	Yamamoto and Sota, 2007
16SrRNA	Reverse	16SgaR	5' CCT GGC TTA CAC CGG TTT GAA 3'	50		Yamamoto and Sota, 2007
18SrRNA	Forward	18H'	5' GCCCTTCCGTCAATTCCTTTAAGTTTCAGC 3'	55	550	Wiegmann et al., 2000
18SrRNA	Reverse	18L	5' CACCTACGGAAACCTTGTTACGACTT 3'	55		Wiegmann et al., 2000
28SrRNA	Forward	28SD1F	5' GGG GAG GAA AAG AAA CTA AC 3'	61	300	Larsen, 1992
28SrRNA	Reverse	28SD1R	5' CAA CTT TCC CTT ACG GTA CT 3'	61		Larsen, 1992
COI	Forward	LCO	5' GGT CAA CAA ATC ATA AAG ATA TTG G 3'	50	658	Folmer et al., 1994
COI	Reverse	HCO	5' TAA ACT TCA GGG TGA CCA AAA AAT CA 3'	50		Folmer et al., 1994
COI	Forward	Jerry	5' CAA CAY TTA TTT TGA TTT TTT GG 3'	50	829	Simon et al., 1994
COI	Reverse	Pat	5' ATC CAT TAC ATA TAA TCT GCC ATA 3'	50		Simon et al., 1994
EF-1a	Forward	Starsky	5' CAC ATY AAC ATT GTC GTS ATY GG 3'	57	541	Cho et al., 1995
EF-1a	Reverse	Luke	5' CAT RTT GTC KCC GTG CCA KCC 3'	57		Cho et al., 1995
EF-1a	Forward	Cho	5' GTC ACC ATC ATY GAC GC 3'	50	517	Reed and Sperling, 1999
EF-1a	Reverse	Verdi	5' GAT ACC AGT CTC AAC TCT TCC 3'	50		Nazari et al., 2007
EF-1a	Forward	EF51.9	5' CAR GAC GTA TAC AAA ATC GG 3'	50	511	Cho et al., 1995
EF-1a	Reverse	EFrcM4	5' ACA GCV ACK GTY TGY CTC ATR TC 3'	50		Cho et al., 1995
wingless	Forward	LepWg1	5' GAR TGY AAR TGY CAY GGY ATG TCT GG 3'	50	400	Brower and DeSalle, 1998
wingless	Reverse	LepWg2	5' ACT ICG CAR CAC CAR TGG AAT GTR CA 3'	50		Brower and DeSalle, 1998
GAPDH	Forward	Frigga	5' AAR GCT GGR GCT GAA TAT GT 3'	55	691	Wahlberg and Wheat, 2008

GAPDH	Reverse	Burre	5' GWT TGA ATG TAC TTG ATR AGR TC 3'	55		Wahlberg and Wheat, 2008
RpS5	Forward	RpS5f	5' ATG GCN GAR GAR AAY TGG AAY GA 3'	55	617	Wahlberg and Wheat, 2008
RpS5	Reverse	RpS5r	5' CGG TTR GAY TTR GCA ACA CG 3'	55		Wahlberg and Wheat, 2008
MDH	Forward	MDHf	5' GAY ATN GCN CCN ATG ATG GGN GT 3'	55	733	Wahlberg and Wheat, 2008
MDH	Reverse	MDHr	5' AGN CCY TCN ACD ATY TTC CAY TT 3'	55		Wahlberg and Wheat, 2008
CAD	Forward	CAD743f	5' GGN GTN ACN ACN GCN TGY TTY GAR CC 3'	55	850	Wahlberg and Wheat, 2008
CAD	Reverse	CAD1028r	5' TTR TTN GGN ARY TGN CCN CCC AT 3'	55		Wahlberg and Wheat, 2008
IDH	Forward	IDHdeg27F	5' GGW GAY GAR ATG ACN AGR ATH ATH TGG 3'	55	710	Wahlberg and Wheat, 2008
IDH	Reverse	IDHdegR	5' TTY TTR CAI GCC CAN ACR AAN CCN CC 3'	55		Wahlberg and Wheat, 2008

2.3.3 Alignment and characterization of gene fragments

The character set used for the analysis contained 1,355 bp of COI, 579 bp of 18S rRNA, 272 bp of 28S rRNA, 369 bp of EF1α, 657 bp of IDH, 313 bp of MDH, 553 bp of Rps5 and 346 bp of wingless, for a total of 4,444 bp of sequence.

For the alignments, we retrieved GenBank reference sequences for the six genes, COI, RpS5, MDH, IDH, EF1α and wingless (Kaila et al., 2011), with which to compare our sequences. Raw sequences were assembled and edited using SeqMan™II (version 5.01, 2001; DNA-star™). Sequence alignments were conducted by using MAFFT (Katoh et al., 2002; Katoh et al., 2005) of the online server, (http://mafft.cbrc.jp/alignment/server/, version 7). The FFT-NS-i (approximate group-to-group alignment algorithm) for mitochondrial COI, and Q-INS-i (CONTRAfold algorithm) for rRNA genes, 18S and 28S, and nuclear EF1α, RpS5, MDH, IDH, and wingless were setting for strategy (Katoh and Toh, 2008). During the alignment, severely contaminated or very short sequences were excluded for minimizing the risk of any kind of confusion and errors. Some ambiguous sites in each gene fragments were removed using GBLOCK 0.91b (Castresana, 2002; default settings were used except for choosing the gap option 'with half'). Each sequence data was combined using SequenceMatrix windows ver. 1.7.8. (Vaidya et al., 2010).

For phylogenetic resolution, we used maximum parsimony, Bayesian and maximum likelihood analyses for the combined data sets.

2.3.4 Phylogenetic analyses

Maximum parsimony (MP) analysis was implemented in PAUP*4.0b10 (Swofford, 1998) using a heuristic search procedure, tree bisection reconnection (TBR) branch swapping, and 1000 random sequence additions with 10 trees held at each pseudoreplicate. All characters were treated as unordered and equally weighted for MP analysis. One thousand MP bootstrap replicates were performed using a heuristic search procedure, with a maximum tree setting of 200 trees. Decay index values (Bremer, 1988) were calculated to determine branch support using TreeRot v3 (Sorenson and Farnzosa, 2007). The partition-homogeneity test (Farris et al., 1994) was also performed to test for significant phylogenetic conflict between the three gene fragments in the PAUP*.

For maximum likelihood (ML) analysis, MODELTEST version 3.06 (Posada and Crandall, 1998) was used to select the best-fitting nucleotide substitution model, and then PAUP* settings were optimized using data of the selected model before searching. ML analyses were performed using RAxML 7.2.6. (Stamatakis, 2006) at the CIPRES Web portal (Miller et al., 2009) and supports for nodes were evaluated with 1000 bootstrap replicates.

Bayesian phylogenetic (BP) analysis was implemented in MrBayes (version 3.1.2; Ronquist and Huelsenbeck, 2003) for combined datasets. We analyzed the combined dataset using partitioned Bayesian analysis, in which the data were partitioned into 18S, 28S, COI, EF1a, RpS5, MDH, IDH and wingless segments, with BP performed using a partition scheme that maximized the likelihood based on the GTR + I + G model with specific model scores estimated by the MODELTEST for each gene region. For the BP analyses, four chains (three heated and one cold) were run, starting from a random tree and proceeding for 10 million Markov chain Monte Carlo (MCMC) generations, sampling the chains every 100th cycle. To ensure that the distribution had stabilized, Tracer version 1.4.1. (Rambaut and Drummond, 2008) was used to view the graphical representation of MCMC chain mixing. Burn-in was set at 15% of the sampled number of trees. Convergence was confirmed by monitoring likelihood values graphically. A 50% majority-rule consensus tree was constructed from the remaining trees to estimate posterior probabilities (PP).

2.3.5 Reconstruction of ancestral character states

The information of microhabitats and larva sheltering types of Oecophoridae was collected from literature (Table 5). Microhabitat types were coded as follows: (A) on foliage; (B) live shrub or tree; (C) flowers or fruit capsule; (D) lichen; (E) leaf litter; (F) decaying wood or dead tree; (G) under bark; (H) on fungi; (I) bird's nests; (J) dried plant (including stored grain). Larval sheltering strategy types were coded as follows: (A) open habit; (B) leaf mine; (C) tied or folded or rolled leaves; (D) boring seeds, fruits or buds; (E) boring other insect's gall or frass or eggs; (F) boring stem or trunk; (G) burrowing under bark or in soil; (H) make a silk web on leaf or flowers or stem; (I) make a silk tube (silk + live or dried materials). In some cases, two or three types were coded for the same taxon, based on reference papers, while some taxa were coded as 'unknown' because of lack of information.

Bayesian ancestral-state reconstruction methods were implemented using BayesTraits v.1.0 (Pagel et al., 2004; Pagel and Meade, 2007) to reconstruct ancestral feeding microhabitat and larva sheltering character states for selected nodes in the molecular phylogeny. BayesTraits uses reversible-jump MCMC methods to derive posterior probabilities and the values of traits at ancestral nodes of the phylogeny (Pagel et al., 2004). BayesMultiState was selected as the model of evolution and MCMC as the method of analysis. Considering that some taxa had mixed microhabitat or larva sheltering strategy, we used the multiple character-state option of BayesMultistate. We first reconstructed the phylogenetic tree obtained by the maximum likelihood analysis and used the topology in the BayesMultistate analysis. The rate deviation was set to 30. A hyperprior approach was employed with an exponential prior seeded from a uniform prior in the interval 0–10. Thus, acceptance rates in the preferred range of 20–40% were achieved (Pagel et al., 2004; Pagel and Meade, 2007). A total of 50 million iterations were run for each analysis with the first 1 million samples discarded as burn-in, with sampling every 1000th generation. Because the posterior probabilities for ancestral patterns of the single runs differed slightly, we calculated the arithmetic mean of all samples for reconstruction of ancestral types.

2.3.6 Molecular dating

A total of 80 species of Oecophoridae and related higher taxa were included in the current investigation and they were listed in the Table 3, except two species, *Cossus cossus* of Cossoidea and *Thyris fenestrella* of Thyridoidea.

To estimate divergence times, a relaxed clock Bayesian analysis was implemented in Beast ver. 1.5.2 (Drummond et al., 2009). The combined dataset was used with unlinked GTR models of nucleotide substitution, gamma rate heterogeneity and proportion of invariant sites for each gene partition. A single relaxed molecular clock using the uncorrelated lognormal model was applied to the combined dataset with the Yule process as the tree prior.

Taxon sets were defined on the stem group of Elachistidae s.l. and Oecophorinae clade including *Borkhausenia fuscescens* with a uniform prior bounded between 55 and 23.6 Mya based on the fossil described during the Late Eocene to Early Oligocene (Skalski, 1977) and the other Oecophorinae clade including *Callimodes zelleri* with a uniform prior bounded between 40 and 15 Mya based on the related fossil of *Schiffermuelleria* described from younger Dominican amber (Poinar, 1992; Kristensen and Skalski, 1999). The MCMC analyses were carried out for 10 million generations, sampling every 1000 generations to ensure effective sample size values above 200 for most parameters. Effective sample size values of each parameter were measured with tracer v1.4.1 (Rambaut & Drummond, 2008), and tree topologies were assessed using treeannotator v.1.5.2 to generate a consensus tree out of all sampled trees, and figtree v.1.2.2 (Rambaut, 2009) was used to view the consensus tree along with node ages and age deviations.

2.3.7 Biogeographic analysis

Recent geographical distributions were used to assess the biogeographical history of the Oecophoridae and the related higher taxa. The type of seven ecozones was coded as follows: Afrotropical (AF); Australasian (AU); Nearctic (NE); Neotropical (NEO); Oriental (O); Palaearctic Asia regions (PA); Palaearctic Europe regions (PE). Each species was assigned to one or more areas based on distribution information. Detailed information about the distribution coding and reference is available in Table 5.

I used BayesMultiState implemented in BayesTraits (Pagel et al., 2004; Pagel and Meade, 2007) to infer ancestral states and likely vicariance and dispersal events that shaped the current distribution of Oecophoridae and related higher taxa. The multiple character-state option of BayesMultistate was used because some taxa had diverse biogeography. Firstly, I reconstructed the phylogenetic tree obtained in Beast analysis and used the topology in the BayesMultistate analysis. The rate deviation was set to 30. A hyperprior approach was employed with an exponential prior seeded from a uniform prior in the interval 0–10. Thus, acceptance rates in the preferred range of 20–40% were achieved (Pagel et al., 2004; Pagel and Meade, 2007). A total of 50 million iterations were run for each analysis with the first 1 million samples discarded as burn-in, with sampling every 1000th generation. Because the posterior probabilities for ancestral patterns of the single runs differed slightly, we calculated the arithmetic mean of all samples for reconstruction of ancestral types.

Table. 5. Microhabitat, larva sheltering and geography type coding based on references for species sequenced in this study.

Microhabitat types were coded as follows: (A) on foliage; (B) live shrub or tree; (C) flowers or fruit capsule; (D) lichen; (E) leaf litter; (F) decaying wood or dead tree; (G) under bark; (H) on fungi; (I) bird's nests; (J) dried plant (including stored grain). Larva sheltering strategy types were coded as follows: (A) open habit; (B) leaf mine; (C) tied or folded or rolled leaves; (D) boring seeds, fruits or buds; (E) boring other insect's gall or frass or egg; (F) boring stem or trunk; (G) burrowing under bark or soil; (H) make a silk web on leaf or flowers or stem; (I) make a silk tube (silk + live or dried materials). Seven geography types were coded as follows: Afrotropical (AF); Australasian (AU); Nearctic (NE); Neotropical (NEO); Oriental (O); Palaearctic Asia regions (PA); Palaearctic Europe regions (PE).

Family	Subfamily	Species	Type coding			Distribution	References
			micro-habitat	larva sheltering	geography		
Blastobasidae	Blastobasinae	*Blastobasis sprotundalis*			PA	Korea, Japan, Russia Far East	Park, 1984; Byun et al., 2009
Chimabachidae		*Diurnea fagella*	A	C	PE	Europe, Western Russia	Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008
Cossidae	Cossinae	*Cossus cossus*	B	A	PE, PA	Europe, Russia	Karsholt & Razowski, 1996; Sinev, 2008
Elachistidae	Aeolanthinae	*Aeolanthes semiostrina*	A	C	PA	Korea, China	Powell, 1973; Park and Shin, 1985; Byun et al., 2009
Elachistidae	Aeolanthinae	*Aeolanthes sp*	A	C	O	Vietnam	Robinson et al., 1994; Kaila et al., 2011
Elachistidae	Depressariinae	*Agonopterix heracliana*	AC	B	PE, PA	Europe, Western and Central Russia	Hering, 1957; Toll, 1964; Karsholt & Razowski, 1996; Sinev, 2008
Elachistidae	Depressariinae	*Agonopterix lnigrum*	AC	B	PA	Korea, Japan, Russia	Hering, 1957; Toll, 1964Park, 1981b; Sinev, 2008; Byun et al., 2009
Elachistidae	Depressariinae	*Cacochroa corfuella*	A	B	PE	Greece	Hering, 1957; Lvovsky, 2008; Kaila et al., 2011
Elachistidae	Depressariinae	*Cephalispheira ferrugella*	AC	B	PE	Europe	Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 1996, 2008

Elachistidae	Depressariinae	*Eutorna sp*	A	A	AU	New Zealand	Kaila et al., 2011
Elachistidae	Depressariinae	*Exaeretia ciniflonella*	A	A	PE	Europe	Karsholt & Razowski, 1996; Kaila et al., 2011
Elachistidae	Depressariinae	*Machimia tentoriferella*	BE	C	NE	USA	Hodges, 1974
Elachistidae	Depressariinae	*Nymphostola galactina*	A	A	AU	New Zealand	Kaila et al., 2011
Elachistidae	Depressariinae	*Proteodes carnifex*	A	A	AU	New Zealand	Kaila et al., 2011
Elachistidae	Depressariinae	*Psilocorsis reflexella*	B	C	NE	USA	Hodges, 1974
Elachistidae	Depressariinae	*Semioscopis steinkellneriana*	A	C	PE, PA	Europe, Central Russia	Toll, 1964; Karsholt & Razowski, 1996; Sinev, 2008
Elachistidae	Depressariinae	*Telechrysis tripuncta*	B		PE, PA	Europe, Russia	Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008
Elachistidae	Ethmiinae	*Ethmia clytodoxa*	A	H	AU	Australia	Kaila et al., 2011
Elachistidae	Ethmiinae	*Ethmia pusiella*	A	H	PE	Europe	Karsholt & Razowski, 1996
Elachistidae	Hypertrophinae	*Anchinia daphnella*	A	C	PE, PA	Europe, Central Russia	Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 2008; Sinev, 2008
Elachistidae	Hypertrophinae	*Hypercallia citrinalis*	A	H	PE	Europe	Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 2008
Elachistidae	Hypertrophinae	*Pedois lewinella*	A	A	AU	Australia	Kaila et al., 2011
Elachistidae	Hypertrophinae	*Periacma delegata*			O, PA	Korea, Japan, China, Taiwan, Eastern Russia	Park, 1981b; Saito et al. 1992, Wang 2006; Sinev, 2008
Elachistidae	Hypertrophinae	*Thudaca mimodora*	A	A	AU	Australia	Kaila et al., 2011
Elachistidae	Stenomatinae	*Agriophara axesta*	A	A	AU	Australia	Kaila et al., 2011
Elachistidae	Stenomatinae	*Antaeotricha leucillana*	A	A	NE	Canada	Kaila et al., 2011
Lypusidae		*Pseudatemelia josephinae*	F	C	PE	Europe	Karsholt & Razowski, 1996
Oecophoridae	Cryptolechiinae	*Acryptolechia malacobyrsa*			PA	Korea, China, Japan	Saito et al. 1992, Wang 2006, Lvovsky 2009

Oecophoridae	Cryptolechiinae	*Acryptolechia torophanes*			PA	Korea, China	Park 1981b; Wang 2006
Oecophoridae	Deuterogoniinae	*Deuterogonia pudorina*	DG	EG	O, PA, PE	Korea, Japan, China, Europe, Russia	Schütze, 1931; Toll, 1964; Park, 1981b; Harper et al., 2002; Lvovsky, 2006; Wang 2006; Sinev, 2008; Byun et al., 2009
Oecophoridae	Oecophorinae	*Borkhausenia fuscescens*	FGHI	H	PE	Europe, Western Russia	Waters, 1929; Ford, 1949; Klimesch, 1961; Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008; Kaila et al., 2011
Oecophoridae	Oecophorinae	*Endrosis sarcitrella*	IJ	E	AU, NE, PE, NEO, AF	Europe, US, New zealand, Chile, Western Russia, South Africa	Waters, 1929; Ford, 1929; Klimesch, 1961; Toll, 1964; Hodges, 1974; Saito et al. 1992; Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008; http://museumpests.net
Oecophoridae	Oecophorinae	*Harpella forficella*	FGH	A	PE	Europe, Western Russia	Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008; Kaila et al., 2011
Oecophoridae	Oecophorinae	*Hofmannophila pseudospretella*	IJ	H	PE, NE, NEO	UK, North America, Western Russia	Waters, 1929; Ford, 1949; Klimesch, 1961; Cole, 1962; Toll, 1964; Hodges, 1974; Saito et al., 1992; Karsholt & Razowski, 1996; Lvovsky, 1996; Sinev, 2008; Lee & Brown, 2009
Oecophoridae	Oecophorinae	*Marlyringa xeraula*	J	E	O, PA, NE	Korea, Japan, China, India, Thailand, Eastern Russia, USA	Hodges, 1960, 1974; Zagulajev, 1965; Saito, 1987, 1992; Park 1981b; Lvovsky, 1994; Wang 2006; Heppner, 2007; Sinev, 2008

Oecophoridae	Oecophorinae	*Oecophora bractella*	FGH	H	PE	Europe, Western Russia	Schütze, 1931; Toll, 1964; Karsholt & Razowski, 1996; Lvovsky, 1996, 2006; Harper et al., 2002; Sinev, 2008; Kaila et al., 2011
Oecophoridae	Oecophorinae	*Palimmeces sp*	FH	G	AU	Australia	Kaila et al., 2011
Oecophoridae	Oecophorinae	*Peridroma oligodrachma*	A	A	AU	Australia	Kaila et al., 2011
Oecophoridae	Oecophorinae	*Philobota sp*	E	G	AU	Australia	Common, 1990; Kaila et al., 2011
Oecophoridae	Oecophorinae	*Pleurota bicostella*	B	H	PE, PA	Europe, Russia	Toll, 1964; Karsholt & Razowski, 1996; Sinev, 2008; Kaila et al., 2011
Oecophoridae	Oecophorinae	*Promalactis albisquama*	FG	G	O	Vietnam	Kim et al., 2010
Oecophoridae	Oecophorinae	*Promalactis atriplagatta*	FG	G	PA	Korea	Park & Park, 1998
Oecophoridae	Oecophorinae	*Promalactis autoclina*	FG	G	O, PA	Korea, Japan, China	Park, 1981b; Wang 2006
Oecophoridae	Oecophorinae	*Promalactis bidenscula*	FG	G	O	Cambodia	Kim et al., unpublished
Oecophoridae	Oecophorinae	*Promalactis enopisema*	FG	G	PA	Korea, Japan, Chian, Russian Far East	Park & Park, 1998
Oecophoridae	Oecophorinae	*Promalactis jezonica*	FG	G	O, PA	Korea, Japan, China, India, Eastern Russia	Park 1981a; Wang, 2006; Sinev, 2008
Oecophoridae	Oecophorinae	*Promalactis kuznetzovi*	FG	G	O	Vietnam	Lvovsky, 1988
Oecophoridae	Oecophorinae	*Promalactis odaiensis*	FG	G	PA	Korea, China	Park & Park, 1998; Wang, 2006
Oecophoridae	Oecophorinae	*Promalactis polyspina*	FG	G	O	Vietnam	Kim et al., 2012
Oecophoridae	Oecophorinae	*Promalactis prolixolobi*	FG	G	O	Cambodia	Kim et al., unpublished
Oecophoridae	Oecophorinae	*Promalactis serratusola*	FG	G	O	Cambodia	Kim et al., unpublished
Oecophoridae	Oecophorinae	*Promalactis striola*	FG	G	PA	Korea	Park & Park, 1998
Oecophoridae	Oecophorinae	*Promalactis suzukiella*	BFGH	G	O, PA, NE	Korea, Japan, China, Taiwan, Vietnam, USA	Park & Park, 1981, 1998; Wang 2006; Adamsky et al., 2009
Oecophoridae	Oecophorinae	*Promalactis tamdaoella*	FG	G	O	Vietnam	Kim et al., 2010

Oecophoridae	Oecophorinae	*Promalactis wonjuensis*	FG	G	PA	Korea	Park & Park, 1998
Oecophoridae	Oecophorinae	*Promalactis bitaenia*	FG	G	PA	Korea	Park & Park, 1998
Oecophoridae	Oecophorinae	*Pseudodoxia achlyphanes*	E	A	PA	Korea, Japan, China	Saito 1976; Wang, 2006
Oecophoridae	Oecophorinae	*Ripeacma acuminipiptera*			O, PA	Korea, China	This study, Wang, 2006
Oecophoridae	Oecophorinae	*Callimodes zelleri*	DFG	G	PA	Korea, Japan, Russia	Byun et al., 2009
Oecophoridae	Oecophorinae	*Tingena armigerella*			AU	New Zealand	Kaila et al., 2011
Oecophoridae	Oecophorinae	*Tyrolimnas anthraconesa*			PA	Korea, Japan, China	Park 1981b
Oecophoridae	Oecophorinae	*Wingia aurata*	A	C	AU	Australia	Common, 1990; Kaila et al., 2011
Oecophoridae		*Casmara agronoma*	B	F	O, PA	Korea, Japan, China, Indonesia	Robinson, 1994; Byun et al., 2012
Oecophoridae		*Gymnobathra flavidella*	EFG	I	AU	New Zealand	Hudson, 1928; Dugdale, 1988; Hoare, 2005
Oecophoridae		*Gymnobathra omphalota*	EFG	I	AU	New Zealand	Hudson, 1928; Dugdale, 1988; Hoare, 2005
Oecophoridae		*Hierodoris atychioides*	BE	CE	AU	New Zealand	Kay, 1980; Dugdale, 1988; Hoare, 2005
Oecophoridae		*Izatha austera*	EFG	F	AU	New Zealand	Dugdale, 1988; Hoare, 2005
Oecophoridae		*Izatha peroneanella*	EFG	F	AU	New Zealand	Dugdale, 1988; Hoare, 2005
Oecophoridae		*Phaeosaces coarctatella*	BD	AF	AU	New Zealand	Dugdale, 1988; (http://en.wikipedia.org/wiki/Phaeosaces_coarctatella)
Oecophoridae		*Phaeosaces compsotypa*	BD	AF	AU	New Zealand	Dugdale, 1988; Davies, 1990
Peleopodidae		*Acria sp.*	B		PA	Korea	This study
Peleopodidae		*Carcina quercana*	B	A	PE	Europe, Western Russia	Toll, 1964; Leraut, 1993; Karsholt & Razowski, 1996; Lvovsky, 1996, 2008; Sinev, 2008
Statomopodidae		*Atrijuglans hetaohei*	B	C	PA	Korea, Japan, China, Russian Far East	Wang, 2006; Sohn, 2007; Byun et al., 2009

Statomopodidae		*Hieromantis kurokoi*		D	PA	Korea, Japan, China	Robinson et al., 1994; Wang, 2006; Sohn, 2007
Statomopodidae		*Stathmopoda auriferella*	C	D	PA	Korea	Wang, 2006; Byun et al. 2009
Statomopodidae		*Stathmopoda masinissa*	BC	D	PA	Korea, Japan, China, Taiwan	Wang, 2006; Byun et al. 2009
Statomopodidae		*Stathmopoda opticaspis*	C	D	PA	Korea, Japan, China	Wang, 2006; Byun et al. 2009
Statomopodidae		*Stathmopoda sp1*	C	D	PA	Korea	Wang, 2006; This study
Statomopodidae		*Stathmopoda sp2*	C	D	PA	Korea	Wang, 2006; This study
Thyrididae	Thyridinae	*Thyris fenestrella*	B	A	PE, PA	Europe, Russia	Karsholt & Razowski, 1996; Sinev, 2008
Xyloryctidae	Xyloryctinae	*Cryptophasa sarcoxantha*	B	F	AU	Australia	Robinson et al., 1994; Kaila et al., 2011
Xyloryctidae	Xyloryctinae	*Tymbophora peltastis*	B	C	AU	Australia	Common, 1990; Kaila et al., 2011

2.4 Results

2.4.1 Characteristics of the eight gene fragments

The alignment results of each gene region used in this study using the eight aligning programs are almost identical to each other.

The mitochondrial COI dataset comprised 1,355 aligned base pairs (bp), 620 bp were variable and 533 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for COI was 12.0 %, and the average proportions of T:C:A:G were 41:15:31:14. The nuclear 18S rRNA dataset comprised 579 bp of aligned sequences, but some ambiguous sites were excluded using GBLOCK 0.91b with the half-option. Among the selected 531 bp, 26 bp were variable and 10 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for 18S rRNA was 1.0 % and the average proportions of T:C:A:G = 21: 29: 25: 26. For the nuclear 28S rRNA data set, 272 aligned bp of sequences were aligned, but a site was excluded using GBLOCK 0.91b with the half-option. Among the final 271 bp, 28 bp were variable and 8 bp were parsimony informative. The average uncorrected sequence divergence of the 28S gene among taxa was 2.0 %, while the average proportions of T:C:A:G were 21:26:19:34. The mitochondrial COI sequences were AT rich as observed in several studies on the insect mitochondrial DNA sequences (Tauz et al., 1988; Crozier and Crozier, 1993; Yamamoto et al., 2007), whereas the nuclear ribosomal RNA genes had more even base compositions. The nuclear protein coding Rps5 dataset comprised 553 aligned base pairs (bp), 220 bp were variable and 202 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for Rps5 was 12.0 %, and the average proportions of T:C:A:G were 25:24:26:26. Of the nuclear protein coding gene IDH dataset comprised 657bp, 355 bp were variable and 295 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for IDH was 15%, and the average proportions of T:C:A:G were 27: 20: 31: 22. Of a total 313 aligned base pairs (bp) of the nuclear protein coding gene MDH dataset, 168 bp were variable and 142 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for MDH was 16.0 %, and the average proportions of T:C:A:G were 24:24:28:24. The nuclear EF1α comprised 369 bp, 135 bp were variable and 122 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for EF1α was 8.0 %, and the average proportions of T:C:A:G were 23:30:25:23. The nuclear wingless comprised 346 aligned base pairs (bp), 200 bp were variable and 151 bp were parsimony informative. The average of the uncorrected sequence divergence among taxa for wingless was 13.0 %, and the average proportions of T:C:A:G were 15:33:21:31.

In the nuclear protein coding gene sequences, the Rps5, IDH and MDH were observed AT richness as like mitochondrial COI sequences, whereas the EF1α and the wingless were CG richness as like the nuclear ribosomal RNA genes, 18S and 28S.

2.4.2 Conclusion on tree topology from combined dataset

The tree resulting from parsimony (MP), Bayesian (BP), and maximum-likelihood (ML) analyses based on the combined data sets, mitochondrial and nuclear genes, were shown in Fig. 243. The MP analysis produced four equally parsimonious trees with a tree length of 17,945. The parsimony bootstrap values and decay index (DI) values for the strict consensus cladogram of the four most parsimonious trees are shown in Fig. 243, a. For BP and ML analyses, the GTR + I + G model selected by MODELTEST analysis as the most suitable for the combined dataset were used. Posterior probabilities of BP and bootstrap values of ML tree ($-\ln L$ = 76245.013186) were presented in Fig. 243, b, c.

The parsimony topology was different from the topologies estimated from the BP (Fig. 243, b) and ML (Fig. 243, c) analyses with regard to the position of Stathmopodinae, Blatobasidae, Chimabachidae and Lypusidae. The clade of Blastobasidae + Stathmopodidae was separated from the elachistid s.l., in the BP and ML, but nested within the elachistid s.l. in the MP. The BP topology is almost identical to ML topologies as to the position of oecophorid lineage, but they differed with position of Aeolanthinae clade.

Although the monophyly of the family Oecophoridae (symbols at the terminals of branches ‘O’, Oecophorinae/ Oecophoridae s.s. in Fig. 243) was not supported in any of the analyses, the clade of oecophorid lineage was supported in all analyses. Xyloryctidae was closely clustered with the New Zealandian oecophorid genera *Gymnobathra*, *Hierodoris* and *Izatha* in all analyses. Paraphyly of Cryptolechiinae had strong support with separation of *Acryptolechia* that nested within Oecophoridae, while *Cacochroa* + *Orophia* + *Eutorna* clustered with elachistid s.l.. Deuterogoniinae was nested within the Oecophorinae. Monophyly of *Promalactis* was well supported in all analyses.

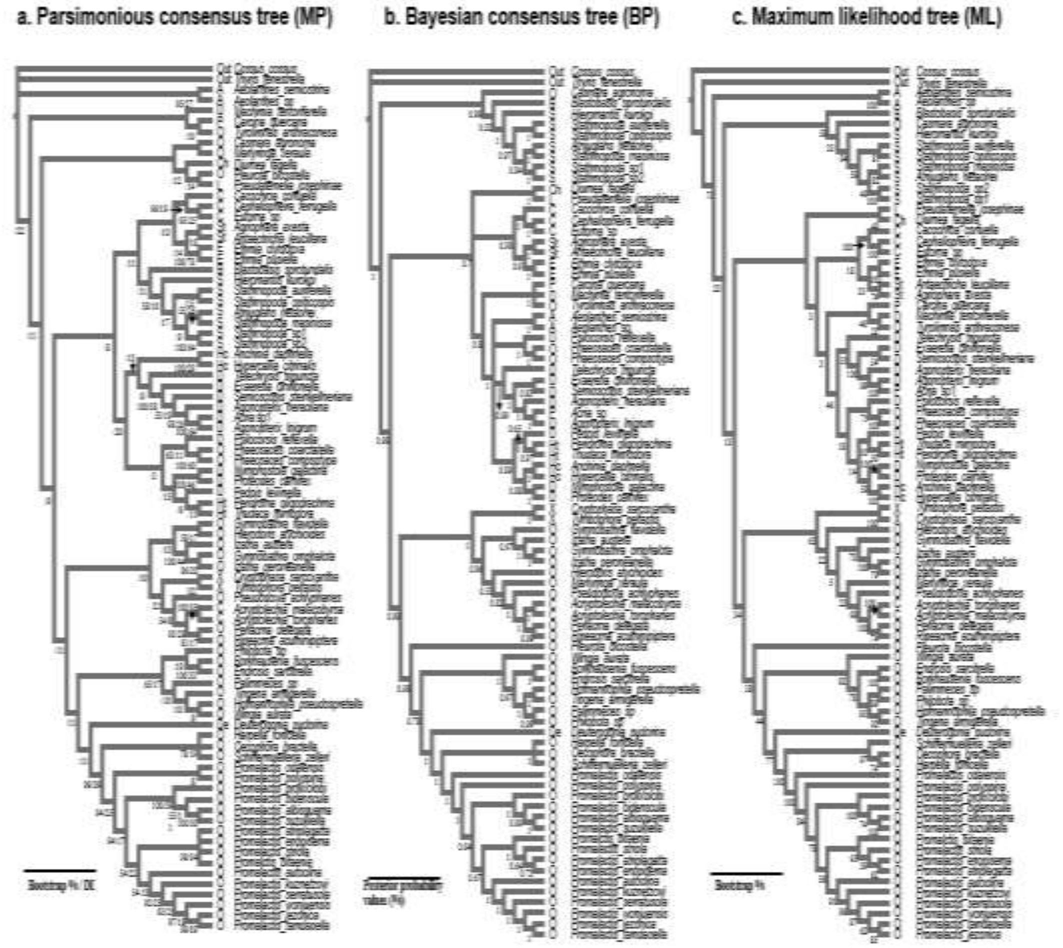


Fig. 243. Phylogenetic trees resulting from the combined data of all mitochondrial and nuclear genes.

(a) Strict consensus tree of 4 shortest trees resulting from parsimony analysis (consistency index [CI] = 0.1700; retention index [RI] = 0.3584). The numbers below the branches are bootstrap percentages/ Decay index [DI]). (b) Fifty percent majority consensus tree resulting from Bayesian analysis. The numbers below the branches are posterior probability values (%). (c) Maximum likelihood tree (-In*L*= 76245.013186). The numbers below the branches are bootstrap percentages. Symbols at the terminals of branches indicate subfamilies/ families): A, Aeolanthinae; B, Blastobasinae; C, Cryptolechiinae; Ch, Chimabachidae; D, Depressariinae; De, Deuterogoniinae; E, Ethimiinae; Hp, Hypertrophinae; Hc, Hypercallinae; L, Lypusidae; O, Oecophorinae/ Oecophoridae s.s.; P, Peleopodidae; S, Stathmopodinae; St, Stenomatinae; X, Xyloryctidae. Each name of family follows Nieukerken et al., (2011).

2.4.3 Ancestral microhabitat analysis

The ancestral microhabitat of Oecophoridae and related higher taxa within Gelechioidea were estimated for the 18 nodes shown in the Maximum likelihood tree (Fig. 244). BayesMultistate analyses allowed for free rates of microhabitat types exchange among the 10 types coded for each species (Table 5).

The analysis suggests that the microhabitat type coded as D (lichen in Fig 244, node A) at the root of Gelechioidea in this study had a reconstructed probability of greater than 99 % compared to alternative microhabitat types. The ancestral microhabitat types are reconstructed as types D + J that code for ‘lichen’ +’ dried plant’ at the root of elachistid lineage and oecophorid lineage (Fig. 244, node C) with the reconstructed probabilities of more than 99 %. The origin of microhabitat type for elachistid lineage (Fig. 244, node K, including Depressariinae/ Cryptolechiinae or Hypercaliinae, Ethmiinae, Stenomatinae, Peleopodidae, Hypertrophinae and Oecophoridae s.l.), reconstructed as ‘on foliage’ + ‘lichen’ with a probability of more than 95% (on foliage 71 % + lichen 27%), whereas the ancestral microhabitat type for oecophorid lineage (Fig. 244, node D, including Xyloryctidae, Oecophoridae s.l., Oecophorinae, Cryptolechiinae and Deuterogoniinae) was reconstructed as ‘dried plant’ with a probability of 95 %.

Within the oecophorid lineage, the ancestral microhabitat types were reconstructed as types G + H, ‘under bark’ + ‘on fungi’ at the nodes representing Deuterogoniinae and Oecophorinae spp. of genera *Callimodes*, *Oecophora*, *Harpella* and *Promalactis* (Fig. 244, node F) with a reconstructed probabilities of more than 90 % (under bark 56 % + on fungi 39 %). The common ancestral microhabitat at the node of clusters, Xyloryctidae, Oecophoridae s.l. (*Hierodoris*, *Gymnobathra* and *Izatha*), Oecophorinae (*Martyringa*, *Pseudodoxia*, *Periacma* and *Ripeacma*) and Cryptolechiinae (*Acryptolechia*), was also reconstructed as ‘dried plant’ with a probability of more than 90 %, although each ancestral microhabitat of three groups reconstructed as ‘live shrub or tree’ with a probability of 86 % at the node of Xyloryctidae (Fig. 244, node N), ‘decaying wood or dead tree’ + ‘on fungi’ with a probability of 91% at the node of genera *Gymnobathra* and *Izatha* (Fig. 244, node P), ‘decaying wood or dead tree’ + ‘on fungi’ + ‘bird’s nests’ with a probability of more than 80 % at the node of genera *Martyringa*, *Pseudodoxia*, *Periacma* and *Ripeacma* of Oecophorinae and *Acryptolechia* of Cryptolechiinae (Fig. 244, node Q), respectively. Peculiarly, the common ancestral microhabitat at the node of remaining Oecophorinae spp. including pest species, *Endrosis sarcitrella*, *Borkhausenia fuscescens* and *Hofmannophila pseudospretella*, (Fig. 244, node R) reconstructed as ‘bird’s nest’ with a probability of 89 %, while the Australian genus *Wingia* of Oecophorinae clearly coded as ‘on foliage’.

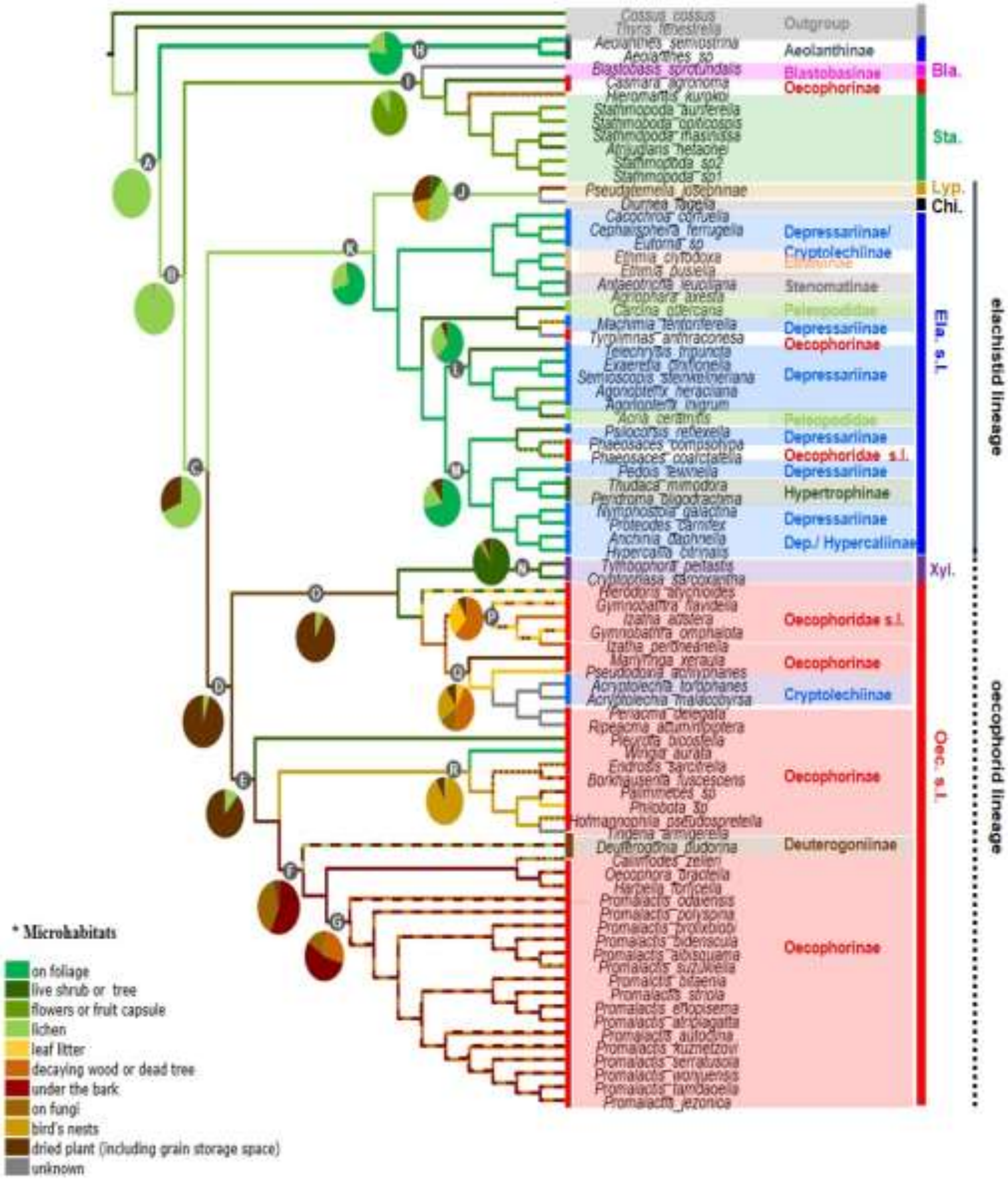


Fig. 244. BayesMultistate analysis results of ancestral microhabitats type reconstructions inferred from Maximum likelihood analysis.

Pie charts under the nodes show the relative likelihoods of each type at respective nodes. The types of each species are color-coded according to the pattern. Each name of family follows Nieukerken et al., (2011).

2.4.4 Ancestral larva sheltering strategy analysis

The ancestral larva sheltering strategy of Oecophoridae and related higher taxa within Gelechioidea were estimated for the 18 nodes shown in the Maximum likelihood tree (Fig. 245). BayesMultistate analyses allowed for free rates of larva sheltering types exchange among the 9 types coded for each species (Table 5).

The larva sheltering type coded as B (mine leaf in Fig 245, node a) at the root of Gelechioidea had a reconstructed probability of greater than 90 % compared to alternative larva sheltering types. The common ancestral larva sheltering types are reconstructed as type B + I, ‘mine leaf’ + ‘make a silk tube (silk + live or dried material)’ at the root of elachistid lineage and oecophorid lineage (Fig. 245, node c) with the reconstructed probabilities of 95 %. The origin of microhabitat type for Elachistid lineage (Fig. 245, node k, including Depressariinae/ Cryptolechiinae or Hypercaliinae, Ethmiinae, Stenomatinae, Peleopodidae, Hypertrophinae, Oecophoridae s.l.), reconstructed as ‘mine leaf’ + ‘open habit’ with a probability of 86 % (mine leaf 50 % + open habit 36 %) , whereas the ancestral microhabitat type for oecophorid lineage (Fig. 245, node d, including Xyloryctidae, Oecophoridae s.l., Oecophorinae, Cryptolechiinae, Deuterogoniinae) reconstructed as ‘make a silk tube (silk + live or dried materials)’ with a probability of more than 99 %. Although the common ancestral larva sheltering strategy type for oecophorid lineage was ‘make a silk tube’, the ancestral larva sheltering strategy types for each constituent groups were different; Xyloryctidae (Fig. 245, node, n) reconstructed as ‘tied or folded or rolled leaves’ + ‘boring stem or trunk’ with a probability of 85 % (tied or folded or rolled leaves 69 % + boring stem or trunk 16 %). The node p (Fig. 245) with *Gymnobathra* and *Izatha* reconstructed as ‘boring stem or trunk’ with a probability of 96 %. The node q (Fig. 245) representing Oecophorinae genera *Martyringa*, *Pseudodoxia*, *Periacma* and *Ripeacma* and *Acryptolechia* of Cryptolechiinae reconstructed as ‘make a silk web on leaf or flowers or stem’ + ‘boring other insect’s gall or frass or eggs’ with a probability of 76 %. The origin of larva sheltering strategy type for the nodes f and g (Fig. 245) representing Deuterogoniinae and oecophorine genera *Callimodes*, *Oecophora*, *Harpella* and *Promalactis*, was reconstructed as ‘burrowing under bark or soil’ + ‘boring stem or trunk’ with a probability of 93 % (burrow under the bark 78 % + bore stem or trunk 15 %).

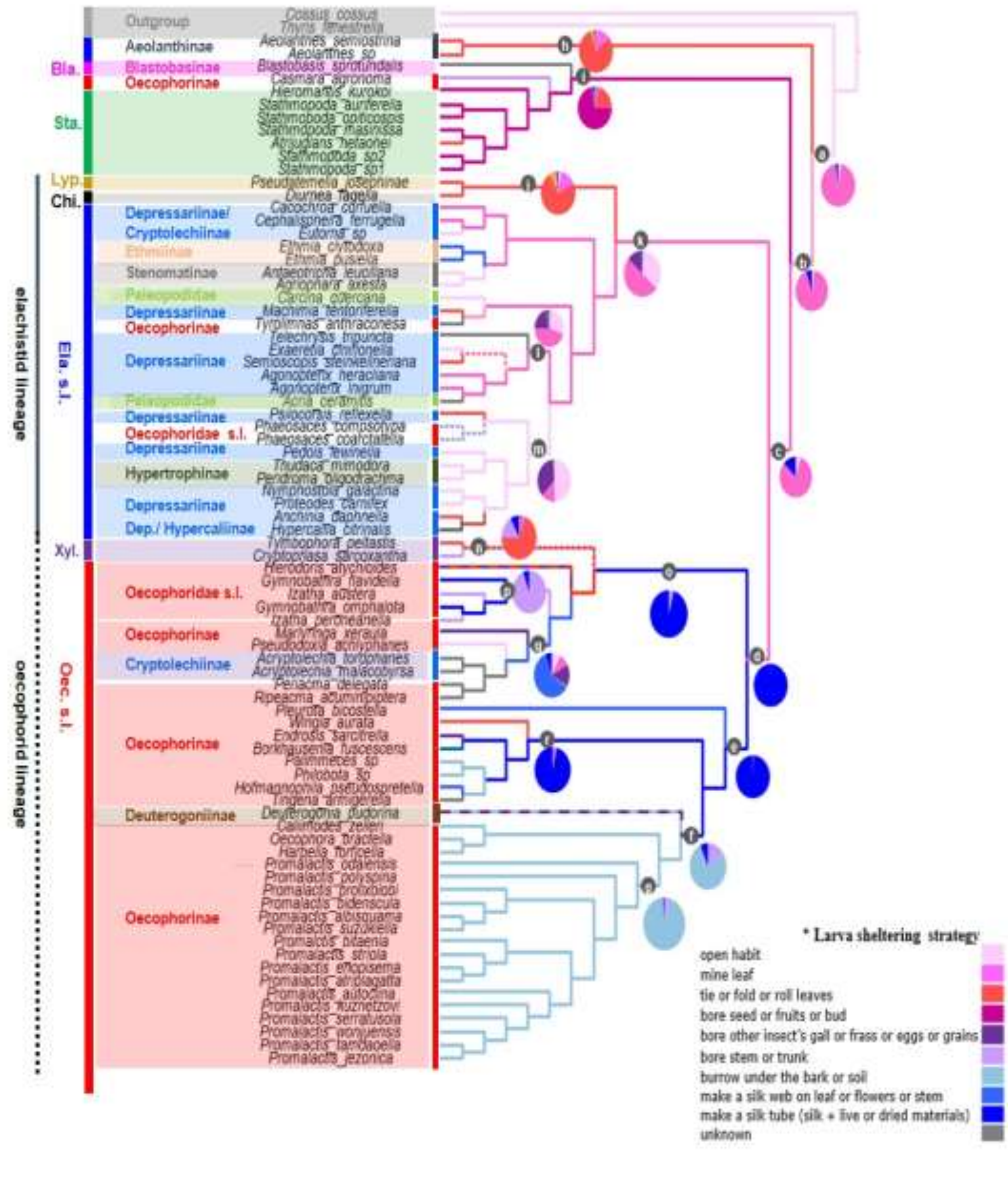


Fig. 245. BayesMultistate analysis results of ancestral larva sheltering strategy type reconstructions inferred from Maximum likelihood analysis.
Pie charts under the nodes show the relative likelihoods of each type at respective nodes. The types of each species are color-coded according to the pattern. Each name of family follows Nieukerken et al., (2011).

2.5 Discussion

2.5.1 Phylogenetic relationship of Oecophoridae, with discussion on morphological characters

From the combined data sets of parsimony, Bayesian, and maximum-likelihood (ML) analyses, the tree supported that Oecophoridae (Nieukerken et al., 2011; red colored in Fig. 246) is polyphyletic. It is largely divided into five branches (Fig. 246).

Genus Casmara

Genus *Casmara* that is separated from the oecophorid lineage (node D in Fig. 246), is closely assigned to the family Stathmopodidae (node I in Fig. 246) and clustering with Blastobasidae within the node H. The *Casmara* is a little known genus comprising more than 15 species in worldwide, with highest diversity in Southeast Asia (Robinson et al. 1994). It is characterized by large-sized and distinct tufts of hind tibia (Byun et al., 2012). The position of *Casmara* in Oecophoridae is accepted by many workers (Wang, 2006; Wang et al., 2012; Byun et al, 2012), and the following this, also for morphological allied genera *Ashinaga*, *Lactistica* and

Aeolarcha (Lvovsky, 2007b). However, the inclusion of *Casmara* in Oecophoridae has been questioned by this author, since it has some features in common with Stathmopodidae, especially the presence of a row of stout scales along the posterior margins of abdominal tergites. This was used as a key character distinguishing Stathmopodinae from Oecophorinae in the suggestions by Hodges (1998) and Wang (2006).

The present topology supports *Casmara* genus group to be an allied group to Stathmopodidae rather than Oecophoridae (node H in Fig. 246). Systematic positions of *Casmara*'s morphological allied genera, *Ashinaga*, *Lactistica* and *Aeolarcha* should subsequently be re-considered.

Genus Tyrolimnas

Tyrolimnas is also separated from oecophoridae lineage (node D in Fig. 246) and is clustered with *Machimia* sp. of Depressariinae + *Carcina* sp. of Peleopodidae (node N in Fig. 246), previously confused to the Oecophorids in morphology (Hodges, 1974). However, the genus *Tyrolimnas* is distinguished from them and other Oecophorids by the absence of vein R_5 of forewing, which is present in all core oecophorids.

Genus Phaeosaces

Our all analyses supports the finding of Kaila et al., (2011) and Heikkila et al. (2014) that *Phaeosaces* spp. belonging to Depressariinae (node O in Fig. 246). The position of *Phaeosaces* is, however, unstable. The genus erected by Meyrick (1885), was synonymized to *Cryptolechia* by Meyrick (1922), but recovered by Dugdale (1988), since the New Zealandian congeneric species did not morphologically match with the type species of *Cryptolechia*. Only four species of *Phaeosaces* are known, all endemic to New Zealand (Dugdale, 1988).

The present topology suggests that *Phaeosaces* spp. are separated from *A*c*ryptolechia* spp., allied genus of *Cryptolechia* (node U in Fig. 246) as well as the other Cryptolechiinae spp. (node K in Fig. 246).

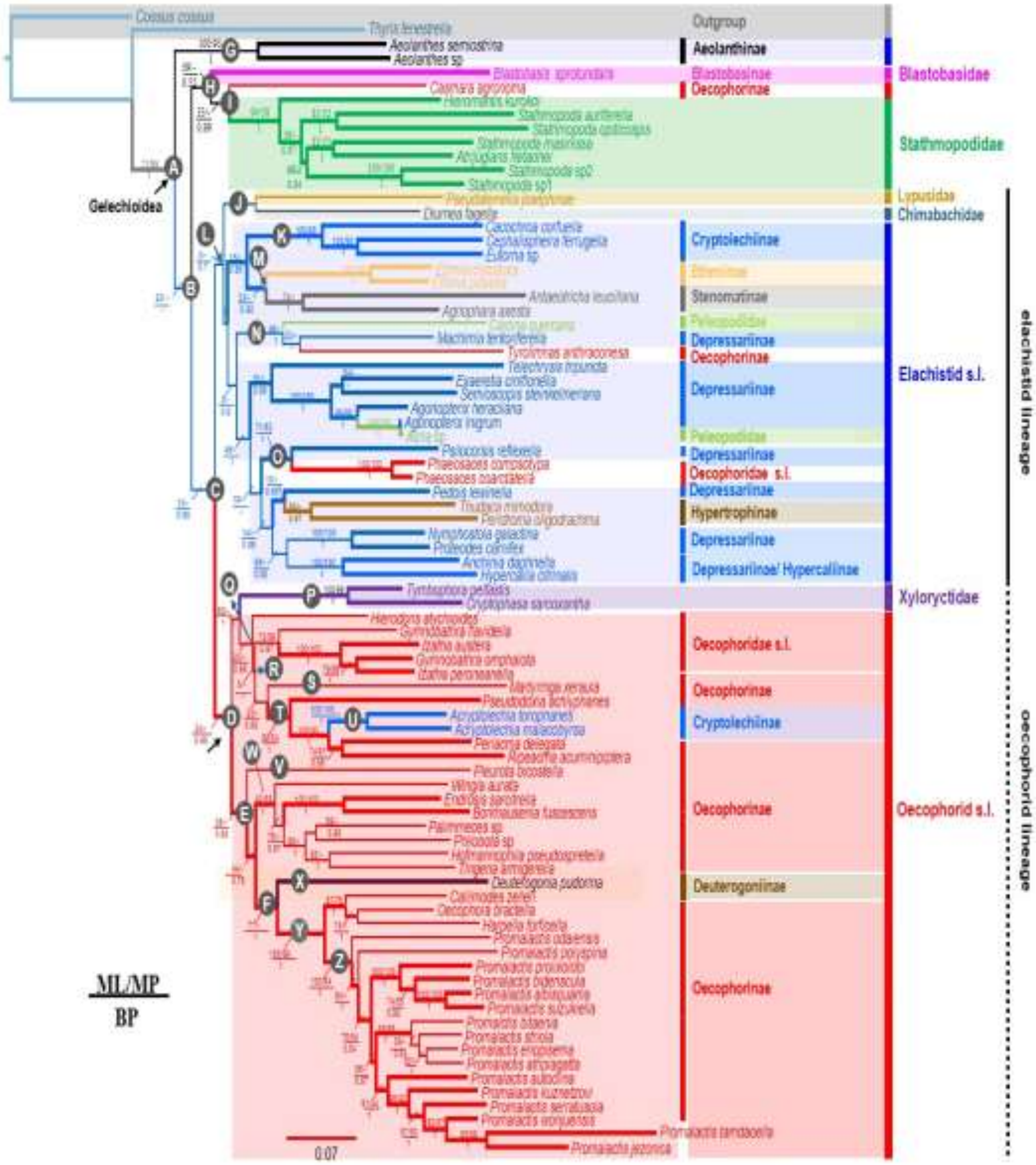


Fig. 246. Phylogenetic relationships inferred from Maximum likelihood analysis.
Numbers on the branches are bootstrap percentages (%) from the ML and MP analysis, posterior probabilities (BP) from the Bayesian phylogenetic analysis under the branches. Thick branches indicate nodes also recovered in the other analyses. Capital letters on the nodes refer to nodes discussed in the text. Each name of family follows Nieukerken et al., (2011).

Oecophorid lineage

Within the oecophorid lineage (node D in Fig. 246), the Xyloryctidae is positioned most basally (node P in Fig. 246) and the next branch (node Q in Fig. 246) includes the New Zealandian *Hierodoris* clustering with other remaining members, *Gymnobathra* and *Izatha*, as in Kaila et al. (2011). According to Kaila (2004), they have two homoplastic characters, the presence of a submental pit as sclerotized pair of grooves and a ring-shaped pinaculum on SD1 leaving a non-sclerotized area around the seta at A1-8, in larva morphology. Despite the negligible support (node R in Fig. 246), the other, mainly Palaearctic and Oriental oecophorid genera, *Martyringa*, *Pseudodoxia*, *Periacma* and *Ripeacma*, are closer to the clades of New Zealandian genera, with *Acryptolechia* spp. of Cryptolechiinae (node U in Fig. 246).

Among them, *Martyringa* excluded from the results by Kaila (2004) is positioned closer to oecophorids (nodes S, T in Fig. 246), having characters: i) 2nd segment of labial palpi with rough scales; ii) fuscous dot-like markings of forewing; iii) tongue-shaped gnathos and sclerotized sacculus margin of male genitalia; iv) large lamella postvaginalis with setose and distinct shaped the caudal margin of antrum of female genitlia, in common morphology with the genus *Pseudodoxia*. The characters of male and female genitalia are also similar to those of *Periacma*, *Ripeacma* and *Acryptolechia*.

Three all analyses support that Cryptolechiinae is polyphyletic (node K, U in Fig. 246). The *Acryptolechia* spp. (node U in Fig. 246.) separated from *Cacochroa*, *Orophia* and *Eutorna* of Cryptolechiinae or Depressariinae (node K in Fig. 246), are nested within the oecophorid lineage clustering with genera *Pseudodoxia*, *Periacma* and *Ripeacma* (node T in Fig. 246). The *Acryptolechia* has in common with the three genera, *Pseudodoxia*, *Periacma* and *Ripeacma*, characterized by broad winged or the scape of antenna without a pecten in adult, processus of sclerotized sacculus developed in male genitalia and lamella postvaginalis largely developed in female genitalia. Moreover, those characters are also appeared in *Cryptlechia*, a type genus of Cryptolechiinae, while the *Cacochroa*, *Cephalispheira* and *Eutorna* (node K in Fig. 246) have no character in common with the *Cryptolechia*. *Acyptolechia* and *Cryptolechia* of Cryptolechiinae are probably close to oecophorid lineage genetically and morphologically.

The remaining oecophorids are included in node E in Fig. 246. Genus *Pleurota* basally placed (node V in Fig. 246) is distinguished from other oecophorid genera by erect labial palpi with extraordinarily large and tufted labial palpi. The Pleurota should be upgraded as its own subfamily and it also supported by other authors, e.g. Toll (1964), Lvovsky (2009) and Heikkilä et al., (2014).

The next branch includes genera *Wingia*, *Endrosis*, *Borkhausenia*, *Palimmeces*, *Philobota*, *Hofmannophila* and *Tingena* (node W, Fig. 246). *Wingia aurata* that is basally placed of the branch is externally characterized from remaining species by falcate forewings.

The topology supports that the placement of Deuterogoniinae (node X in Fig. 246) is nested within the oecophorid lineage. So far, the taxonomical status of *Deuterogonia* has been unstable. Previously, the genus was considered a subfamily Deuterogoniinae in Oecophoridae by many authors (Toll, 1964; Saito, 2005; Lvovsky, 2009; Kaila et al., 2011 and Nieukerken et al., 2011), but it belongs to Oecophorinae in the phylogenetic relationship and also has morphological characters with other oecophorines in common. The representatives of Deuterogoniinae and Oecophorinae including *Callimodes*, *Oecophora*, *Harpella* and *Promalactis*, are characterized by bright yellow to yellowish brown forewing ground color with distinct markings, such as metallic, white or fuscous scales and pattern. The genus *Promalactis*, one of the largest genera of Oecophoridae with global distribution, ranging from Palaearctic and Oriental Regions, to Nearctic and Afrotropical Regions (Adamski et al., 2009; Vári and Kroon, 1986), is a monophyletic (node Z in Fig. 246) in the combined data sets.

The genetical relationship and morphological evidence in this study supported that the oecophorid lineage (node D in Fig. 247) comprises three subfamilies of Oecophoridae, Cryptolechiinae, Pleurotinae and Oecophorinae and the family Xyloryctidae as a closest sister group, separating *Casmara*, *Tyrolimnas* and *Phaeosaces*. It supports that Oecophoridae is a paraphyletic.

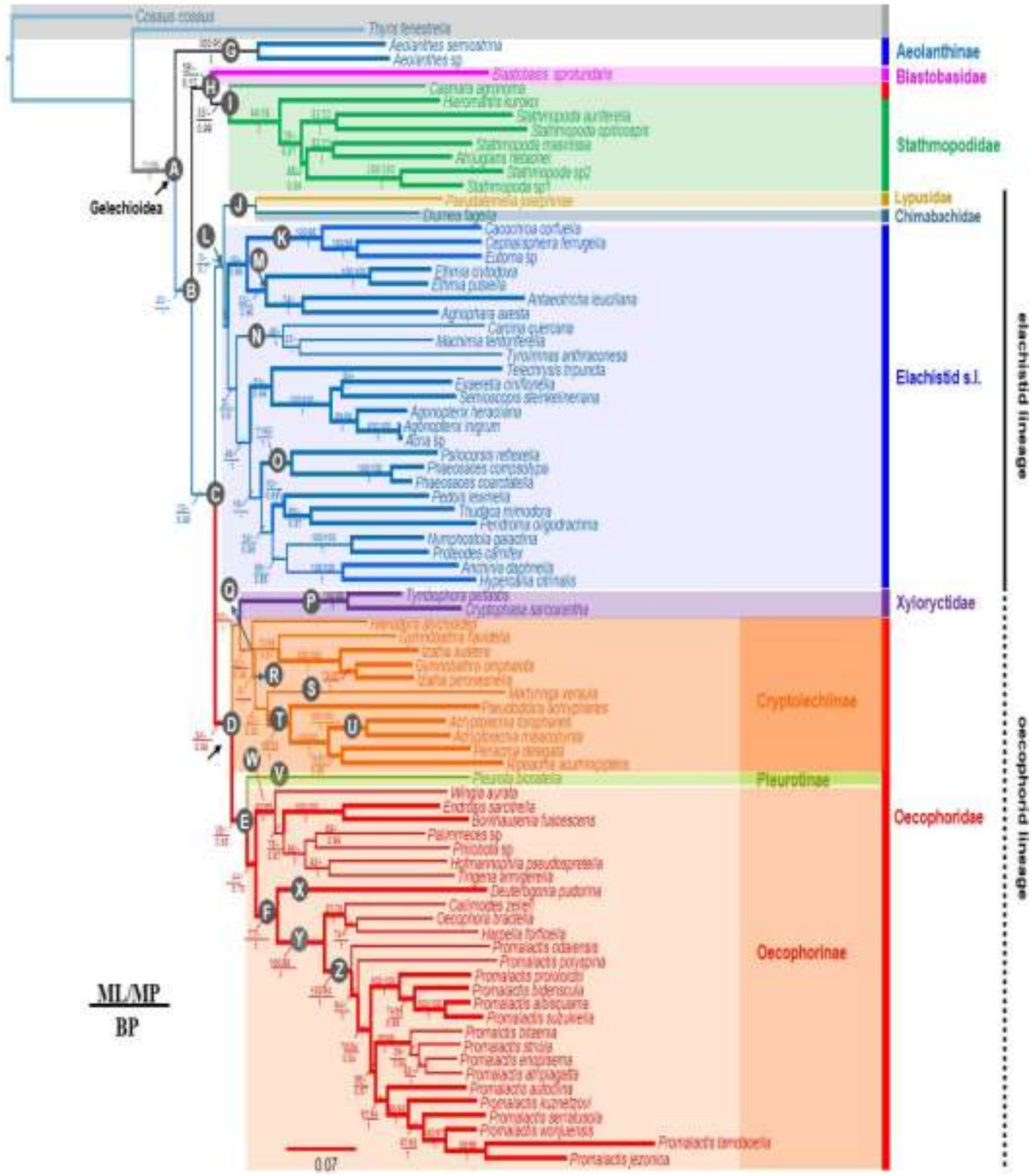


Fig. 247. Re-classification of oecophorids inferred from phylogenetic results. Numbers on the branches are bootstrap percentages (%) from the ML and MP analysis, posterior probabilities (BP) from the Bayesian phylogenetic analysis under the branches. Thick branches indicate nodes also recovered in the other analyses. Capital letters on the nodes refer to nodes discussed in the text. Each name of family follows the results from this study.

2.5.2 Evolutionary history of larva host plant preference, microhabitat and sheltering strategy within the Oecophoridae

Based on our results, the common ancestral states of microhabitat and sheltering strategy of larvae in oecophorid lineage (Xyloryctidae and Oecophoridae) and related higher taxa which contain the elachistid lineage (elachistid s.l., Chimabachidaeand Lypusidae), Blastobasidae and Stathmopodidae, reveals that the larva mostly lives on lichen and mines the leaf as sheltering strategy (each node, A and a in Fig. 248).

The common ancestor of oecophorid lineage (each node, D and d in Fig. 248) which contains Xyloryctidae and Oecophoridae appears to have evolved to live on dried plant with making a silk tube, except the *Casmara*, *Tyrolimnas* and *Phaeosaces* that are each clustered separately.

Genus Casmara

Species in genus *Casmara* are known as stem borers of, e.g., *Camellia sinensis*, *C. oleifera* in Theaceae and *Murraya paniculata* in Rutaceae (Chao et al, 2007; Diakonoff, 1966) like larva of many Blastobasidae and some of Stathmopodidae (Wang, 2006; Adamski et al., 2010; Kaila et al., 2011) that are closely claded with

Casmara in our results. The common ancestor of the groups clustered with *Casmara* appears to have evolved to live on live shrub or tree, and hide inside the seed or fruits or bud by boring (each node, I and i in Fig. 248). The present results suggests that *Casmara* is close to Stathmopodidae rather than Oecophoridae in the biological evolution as well.

Genus Tyrolimnas

The biology of *Tyrolimnas*, clustered with *Machimia* sp. of Depressariinae + *Carcina* sp. of Peleopodidae (nodes, N and n in Fig. 248) is unknown, but, *Machimia* and *Carcina* have similar feeding behavior and host plant preference of larvae. They are known as leaf tiers or rollers (not sheltering) on oak (*Quercus*) and other deciduous plants (Hodges, 1974). The biology of *Tyrolimnas* larva would be crucial to find out to deem its association with *Machimia* and *Carcina*.

Genus Phaeosaces

Phaeosaces are nested within the Depressariinae (nodes, O and o in Fig. 248). Interestingly, the larvae of *Phaeosaces coarctatella* live on lichens on the branches and burrow old wood as borers (http://en.wikipedia.org/wiki/ Phaeosaces_coarctatella).

Pupae of another species, *P. compsotypa* have been found from thin-shelled almond (Davies, 1990). Supposedly the larvae of *Phaeosaces* feed on lichens during the initial stages and then, bore to the bark of trees for pupation or hibernation. Lichens described as 'dual organisms', are symbiotic associations between (or sometimes more) a fungus (mycobiont) and a photosynthetic partner (phytobiont or phycobiont), so, they are 'lichenised fungi' (Dobson, 2000; http://archive.bio.ed.ac.uk/jdeacon/microbes/lichen.htm). However, *Phaeosaces* feeding on lichens are clustered with phytophagous Depressariinae rather than the predominantly detritivorous or fungivorous core oecophorids. Likewise, other lichenivores Lepidoptera, i.e., some glaphyrines of Pyraloidea, the lithosiine, Arctiinae, Lycaenidae and Geometridae, have derived from phytophagous groups (Powell, 1980; Scoble, 1992).

Oecophorid lineage

Species within the oecophorid lineage (each node, D and d in Fig. 248) shifted from two mixed microhabitats (pie chart of node D in Fig. 248), dried plant + lichen, to more than three various microhabitats (pie chart of node G in Fig. 248). The ancestral sheltering strategy is also evolved from one sheltering type, making a silk tube, to more than three various sheltering types.

The common ancestor of Xyloryctidae, the basal clade of the oecophorid lineage, mostly lived on live shrub or tree, with performing to tie or fold or roll leaves for sheltering (each node, N and n in Fig. 248).

Hierodoris atychioides clustered with Xyloryctidae, has gregarious larvae, which are moderately polyphagus on Gymnospermae and not only feed on live shrub or tree, i.e., *Kunzea* and *Leptospermum* of Myrtaceae and *Ozothamnus* of Asteraceae, but also consume leaf litter. Additionally, they roll dead leaves and bore woody stem, sometimes galls (Hoare, 2005). *Hierodoris atychioides* and Xyloryctidae are close to each other both regarding biology and genetic relationship in our results, as like in Kaila et al., (2011). In the next branch including *Gymnobathra* and *Izatha*, *G. flavidella* and *G. omphalota* live on bark or dead wood or leaf litter and make silken nests covered with frass and leaf fragments. *Izatha* are also found from dead wood (Hoare, 2005). These New Zealand genera were clustered with Oecophorinae genera, *Martyringa*, *Pseudodoxia*, *Periacma* and *Ripeacma*, and *Acryptolechia* of Cryptolechiinae. The common ancestor of them evolved to various microhabitats and sheltering strategies, but mainly live on decaying wood or tree and make a silk web on leaf or flowers or stem, although the biology of *Acryptolechia* of Cryptolechiinae, *Periacma* and *Ripeacma* is unknown.

Martyringa xeraula is a polytrophic pest using various vegetable food in houses and storages, damage carpets, leather goods, and insect collections by boring

(Zagulajev, 1965; Lvovsky, 1994). *Pseudodoxia achlyphanes*, the larvae found from leaf litter without sheltering.

The biology of *Acryptolechia* spp. is unknown. Leraut (1993) excluded *Cacochroa* and *Orophoia* from Oecophoridae, due to their larval feeding on living plants. They were synonymized with Depressariinae of Depressariidae by Hodges (1998) and Lvovsky (2002, 2009). Presumably, *Acryptolechia* spp. here nested within the oecophorids (nodes, Q and q in Fig. 248), may not feed on living plants. It supposed to have similar biology as *Pseudodoxia*, *Periacma* and *Ripeacma*, as do they have similartities on their morphology.

Pleurota bicostella basally placed of remaining oecophorids (each node, E and e in Fig. 248) in our results, has been collected from under white web on stems of heather, and the other *Pleurota* spp., i.e., *P. pyropella* and *P. schlaegeriella*, have been found on *Salvia officinalis* L., near the neck of the root of the plant, and other various herbs (Toll, 1964). The species in genus *Pleurota* probably have evolved to live from dried plant + lichen to live shrub or tree with making a silk web on leaf or stem.

The common ancestor of the next branch (each node, R and r in Fig. 248) including *Wingia*, *Endrosis*, *Borkhausenia*, *Palimmeces*, *Philobota*, *Hofmannophila* and *Tingena*, has perhaps mostly shifted to living in bird's nest with performing to make a silk tube. *Wingia aurata*, *Palimmeces* sp., and *Philobota* sp., are endemic to Australia. They are associated with eucalypt forests or woodlands (Common, 1990). Larva of *W. aurata* lives in strong silk shelter amongst the green leaves of *Eucalyptus* and *Philobota* spp. live on dead eucalypt leaves for feeding them and burrow into the soil (Common, 1990). Eucalypt leaves, especially when dead, are exceptionally low in nitrogen and high in tannins, and in a relatively dry climate do not break down rapidly. Common (1990) assumed that Australian oecophorids probably had the potential to utilize these leaves, even under the very dry conditions.

Among the other three oecophorids, *Endrosis sarcitrella*, *Borkhausenia fuscescens* and *Hofmannophila pseudospretella*, found in bird's nests (Waters, 1929; Ford, 1949; Klimesch, 1961), *E. sarcitrella* and *H. pseudospretella* are very widespread and known as pests. The larvae of *E. sarcitrella* feed mainly on a wide variety of dried grains and seeds by boring (http://museumpests.net). The larva of *H. pseudospretella* is a common omnivorous scavenger and is known as textile pest in dwellings (Cole, 1962), live among various seeds in storages or stored in attics or dry leaves, and make a silk web around several seeds constructing a sack (Toll, 1964). *B. fuscescens* live and feed on fungi growing on the tree trunks (Schütze, 1931; Toll, 1964; Harper et al., 2002; Lvovsky, 2006). Considering the common microhabitat, bird's nest, of those species, they are probably evolved from arid environment to rather moist environment.

The common ancestor of the next branch (each node, F and f in Fig. 248) appears to have mostly lived under the bark and fungi, rarely on dried plant, and sheltered burrowing under the bark or soil. Some bored stem or trunk, rarely made a silk tube. *Deuterogonia pudorina* is known to live under bark and on lichens. The species has also been bred from oak galls evoked by Cynipidae (Toll, 1964). Usually, the galls are rich in resins and tannic acid. Probably, the larvae in galls used the materials for a survival food using the tannin acid and resins. In the next branch clustered with *Callimodes zelleri*, *Oecophora bractella* and *Harpella forficella*, those species live under the bark of decaying trees and shelter burrowing under the bark or soil, in common (Toll, 1964). The former species also live on lichen whereas the two latter species live on fungi, additionally (Schätze, 1931; Harper et al., 2002; Lvovsky, 2006).

The common ancestor of *Promalactis* (each node, G and g in Fig. 248), shifted from living on dried plant and lichen to live under bark and decaying wood or dead tree. The larva sheltering strategy of that has also shifted from a silk tube to burrow under bark or in soil, rarely to bore stem or trunk. Among *Promalacits*, larvae of *P. suzukiella* have been found under bark of rotting logs of chokecherry (*Prunus virginiana* L.) and oak (*Quercus* sp.) in USA (Adamski et al., 2009) and also collected under bark of peach, *Prunus persica* (L.) (Park, 1981) and from shiitake mushroom plantation (observation and collection by this author).

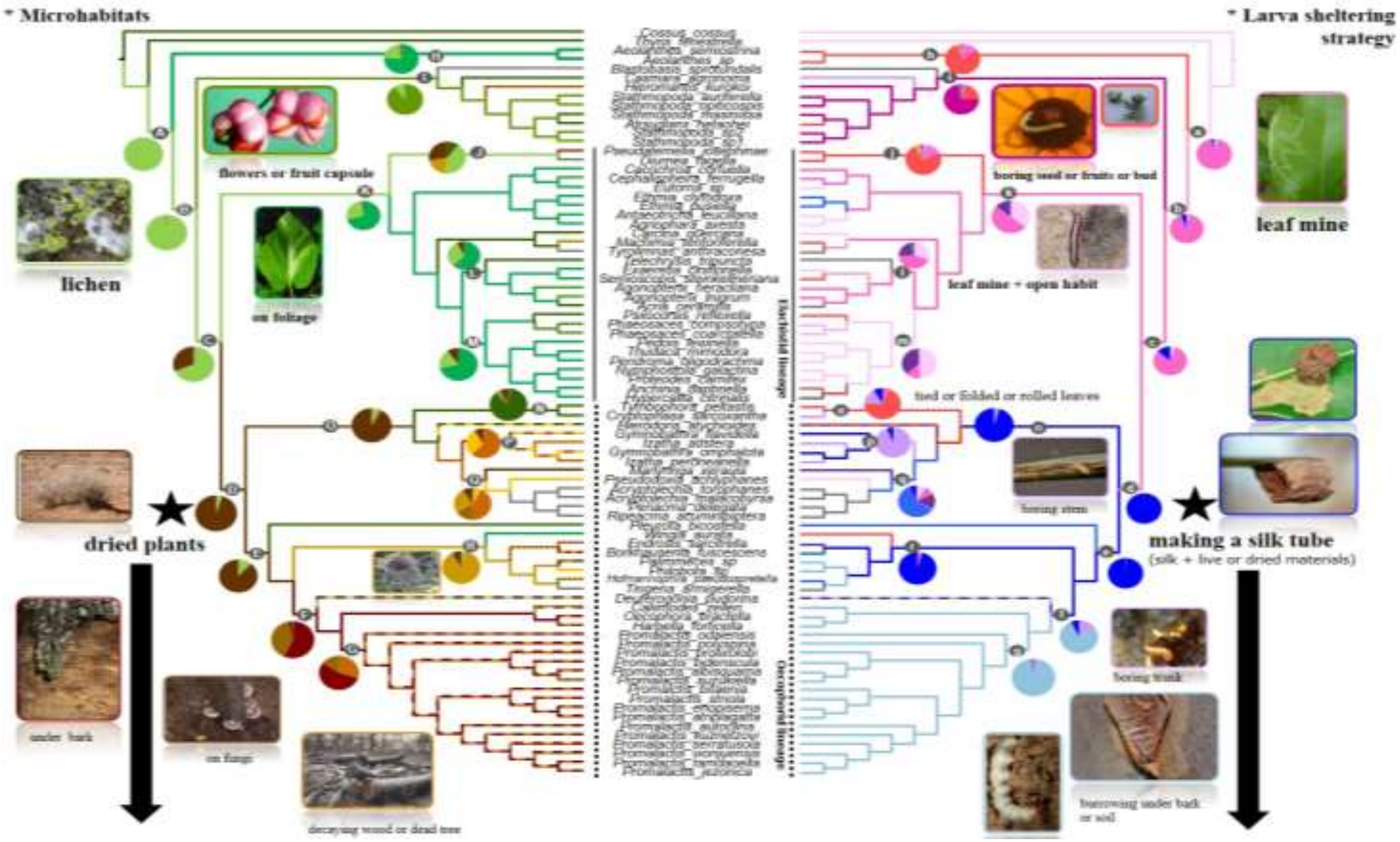


Fig. 248. BayesMultistate analysis results of ancestral microhabitats (left) and larva sheltering strategy (right) type reconstructions inferred from Maximum likelihood analysis.
Pie charts under the nodes show the relative likelihoods of each type at respective nodes. The types of each species are color-coded according to the pattern: eleven types of microhabitats (left) and ten types of larva sheltering strategy (right).

2.5.3 Molecular dating and biogeographical approach on oecophorid lineage

Divergence time estimation

The relaxed molecular clock analyses via Beast yielded the similar tree topology as the BP tree topology obtained via MrBayes 3.2.1., except for the position of Lypusidae + Chimabachidae and *Gymnobatrha flavidella* and *Palimmeces* sp. of Oecophoridae. Posterior probability support values are usually maximal for the main groupings of Oecophoridae. The Beast 95% highest posterior density (HPD) credible intervals were relatively normal (Fig. 249).

The split of oecophorid lineage and related higher taxa in this study probably occurred in the Late Cretaceous after angiosperm radiations at 97 Mya, but can not be assigned to a more definite point in time. The split-off between the oecophorid lineage (Xyloryctidae + Oecophoridae) and elachistid lineage occurred in the Middle Eocene about 43.4 Mya with a 95% HPD from 41.7 to 49.1 Mya. Estimated divergence time for the oecophorid lineage indicates that most radiations are after Late Eocene, whereas that for the closest higher taxa, elachistid s.l., indicates that most radiations are after Late Oligocene.

The oecophorid lineage diverged into two main clades after 41.9 Mya with a short 95% HPD from 41.5 to 42.3 Mya. The first clade including Xyloryctidae and oecophorids including Pleurotinae and Cryptolechiinae took place at 22.7 (22.7845) Mya. After the split-off Xyloryctidae (including *Palimmeces* sp.) about 22.7 (22.8936) Mya, the radiation of the following oecophorids including Pleurotinae and Cryptolechiinae occurred during the Late Miocene to Pliocene, and the split-off of remaining oecophorids (*Hofmannophila*, *Philobota*, *Tingena*, *Wingia*, *Endrosis*, *Borkhausenia*) occurred in the Early Miocene about 20.4 Mya. The second clade representing Oecophorinae took place nearly at 37.2 Mya with a short 95% HPD: 37.2-37.3 Mya. *Callimodes*, *Harpella* and *Oecophora* occurred from 18.2 to 9.1 Mya, while *Promalacits* occurred from 36.2 Mya. Most radiations at species level within the *Promalactis* occurred from 13.2 Mya.

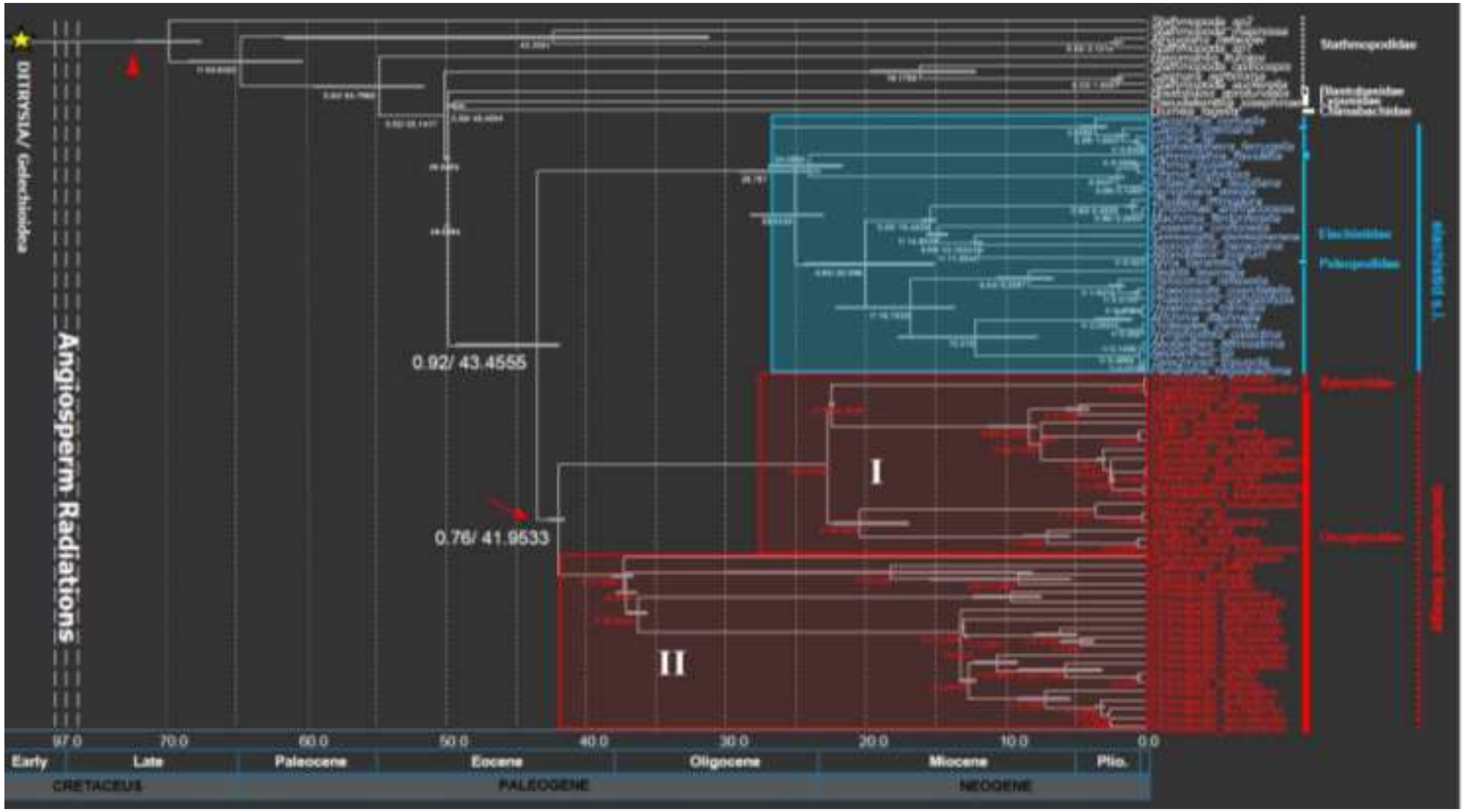


Fig. 249. Maximum clade credibility tree displaying results of the relaxed molecular clock analyses

Posterior probabilities and age estimations (in Milion years) are provided at the branches. Grey node bars indicate 95% HPD (highest posterior density) credible intervals. Geological time scale is based on the International Stratigraphic chart by the International Commission on Stratigraphy (2008). (Plio., Pliocene).

Historical biogeography reconstructions

The results of the BayesTraits to reconstruct the historical biogeography of the Oecophoridae and related higher taxa are presented in Fig. 250. The ancestral area of oecophorid lineage and related higher taxa within Gelechioidea were estimated for the 6 nodes shown in the Beast tree (MCC tree: Maximum clade credibility tree) using a Bayesian relaxed molecular clock analyses. BayesMultistate analyses allowed for free rates of area types exchange among the 6 types coded for each species (Table 5). The ancestral area reconstruction shows ambiguous results regarding the origin of node A (Fig. 250), representing the Oecophoridae and all related higher taxa (Stathmopodidae, Blastobasidae, Lypusidae, Chimabachidae, Elachistidae s.l., Peleopodidae and Xyloryctidae) of Gelechioidea. Palaearctic Europe, Australasian, Nearctic and Afrotropical are slightly favoured as ancestral area with each reconstructed probabilities of around 20 % (total 82 %).

The oecophorid lineage and elachistid s.l. in node B (Fig. 250) probably originated from diverse regions, but Nearctic is slightly favoured as ancestral area. The next node, C (Fig. 250) at the roots of elachistid s.l. had a reconstructed as Nearctic with probability of 40% compared to alternative area types, whereas the oecophorid lineage (node D in Fig. 250) probably originated from Afrotropical and Oriental with probability of 47 % (Afrotorpical: 24%, Oriental: 23%).

Within the oecophorid lineage (node D in Fig. 250), the ancestral area of the first clade including Xyloryctidae (including *Palimmeces* sp.), Pleurotinae, Cryptolechiinae and oecophorids (node E in Fig. 250) reconstructed as Palaearctic Europe and Australasian with probability of 53% (Palaearctic Europe: 27 %, Australasian: 26 %). The node F (Fig. 250) representing the remaining Oecophorinae probably originated from Oriental with reconstructed probability of 83 %.

Age and origin of oecophorid lineage with discussion on ancient climate changes

The early evolution of Lepidoptera representing mostly leaf miners is assumed contemporaneous with initial angiosperm diversification (Zwölfer & Herbst, 1988), therefore, the radiation of major lepidoptera, Gelechioidea and related taxa, Gracillaroidea and Yponomeutoidea, of Ditrysia, the most derived lepidopteran lineage, no later than the Late Jurassic on a gymnospermous dominated flora (Labanderia et al., 1994).

The results suggest that the oecophorid lineage and related higher taxa originated from possible mixed area, Palearctic Europe, Australasian, Nearctic and Afrotropical at Late Cretaceous and probably radiated during the Cenozoic.

According to Grimaldi and Engel (2005), several diverse lineages of insects radiated in the Cenozoic, such as the higher mantises, termite, bees, ants and also large lineages of ditrysian Lepidoptera. After split of the clade of Lypusidae and Chimabachidae at 49.4 Mya in Early Eocene, the oecophorid lineage and the closest taxa, elachistid s.l. were diverged at 43.4 Mya in Late Eocene from Nearctic (more favoured than the other area).

From the Late Eocene to Early Oligocene, a rapid radiation of oecophorids was occurred. Oecophorid lineage including Xyloryctidae and Oecophoridae was originated from Afrotropical and Oriental and diverged at 41.9 Mya, and other oecophrids were originated from Oriental and radiated from 37.2 Mya. The ocene, climatically, is the most dramatic period in the Tertiary. Changes during this time had profound impact on the global distributions of insects (Grimaldi & Engel, 2005). During the Early Eocene, the near North Pole and southern Alaska of North America and central Eurasia were warm and humid by the distribution of alligators and palm trees. By the Late Eocene and the Early Oligocene, the climate was warmer than today and the glaciation of Antarctica had begun. India was covered by tropical rainforest and warm temperate forests covered much of Australia (http://www.scotese.com/Default.htm; Grimaldi & Engel, 2005). After then, during the Oligocene, warm temperate forests covered northern Eurasia and North America. The elachistid s.l. was originated from Nearctic and diverged at this period. Probably those species of elachistid s.l. were adapted to the warm temperate climate and evolved.

In the Early Miocene, remaining oecophorids, Xyloryctidae and Cryptolechiinae had Palaearctic Europe and Australasian origin and diverged from 22.7 Mya. At that time, the temperature of Northern Europe and England was warm that the alligators and palm trees were suitable to live, and the Australia was less arid than it is now. Considering the origin between 35 and 55 Mya, and distribution of *Eucalyptus*, recent Oecophorids endemic to Australasian Regions evolved with radiation with *Eucalyptus* and also adapt to dried condition of that.

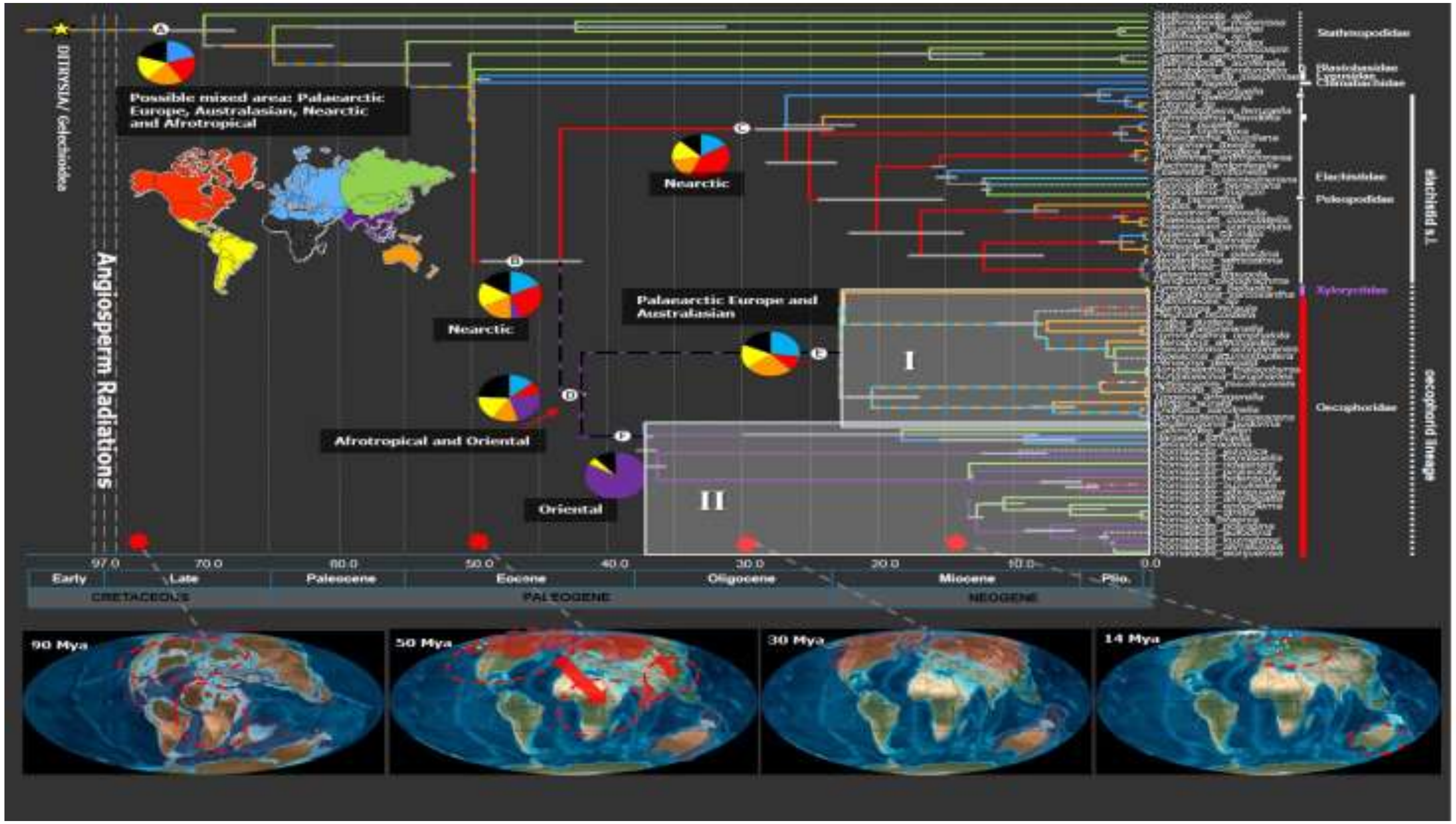


Fig. 250. Results of the Bayesian approaches to reconstruct historical biogeography of the Oecophoridae and related higher taxa plotted on a cladogram of Beast tree (MCC) using a Bayesian relaxed molecular clock analyses. Output of the Bayesian approach is displayed as pie chart. Distribution of each extant species indicated color-coded according to the pattern

2.6 A revised classification of Oecophoridae based on results of current study

Blastobasidae Meyrick, 1894

Stathmopodidae Meyrick, 1913

Casmara **stat.n.**

Lypusidae Herrich-Schaffer, 1857

Chimabachidae Heinemann, 1870

Peleopodidae Hodges, 1974,

Elachistidae Bruand, 1850

Aeolanthinae Kuznetsov and Stekolnikov, 1984

Agonoxeninae Meyrick, 1926

Depressariinae Meyrick, 1883

Tyrolimnas **stat. n.**

Phaeosaces **stat.n.**

Ethmiinae Busck, 1909

Hypercalliinae Leraut, 1993

Hypertrophinae Fletcher, 1929

Stenomatinae Meyrick, 1906

Xyloryctidae Meyrick, 1890

Oecophoridae Bruand, 1850

Cryptolechiinae Meyrick, 1833, **stat. n.**

Pleurotinae Toll, 1956, **stat. n.**

Oecophorinae Bruand, 1850

Martyringa **stat. n.**

III. Conclusion

In the first part, the family Oecophoridae reviewed from Korea comprising thiry-three species of twelve genera belonging to two subfamilies, Cryptolechiinae stat. n. and Oecophorinae. One new and four un-recorded genera and nine new and three un-recored species were newly added. Keys to subfamiliy, genus and species, diagnosis, description and illustration of all species were also provided with distribution information.

The phylogenetic results in the second part revealed that oecophorid lineage includes three subfamilies, Cryptolechiinae, Pleurotinae and Oecophorinae, and Xyloryctidae as a closest related family. *Casmara* is closely clustered with Stathmopodidae, and *Tyrolimnas* and *Phaeosaces* are clustered with Depressariinae in the elachistid lineage. Far relationship between those three groups and oecophorids was supported by phylogenetical, morphological and biological results. From evolutionary and biogeographical approaches, oecophorids may have evolved from ancestor living in dried plants with making a silk shelters, and the radiation of them is estimated from Late Eocene at 41.9 Mya, originated from mixed area, Afrotopical and Oriental Regions.

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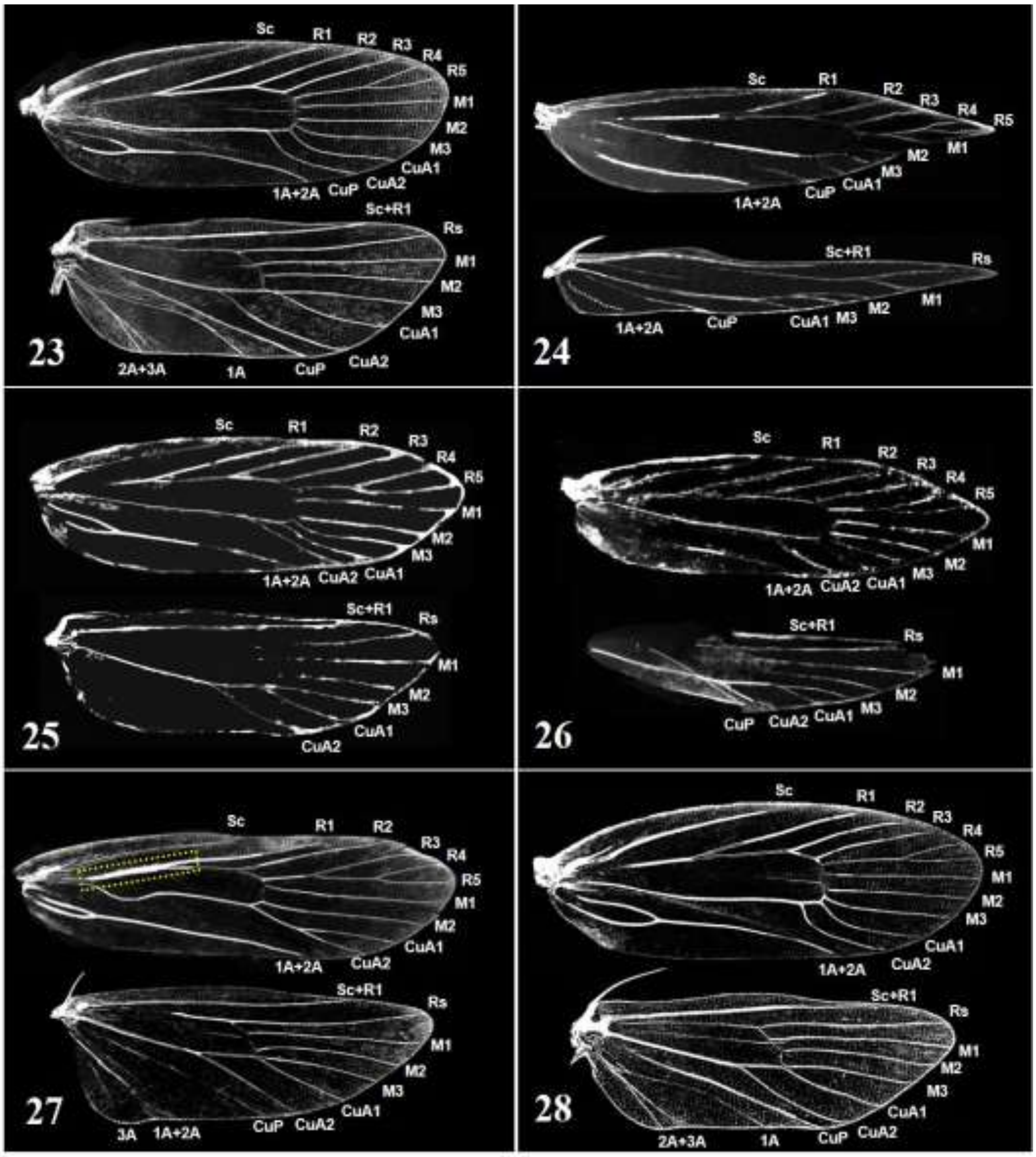
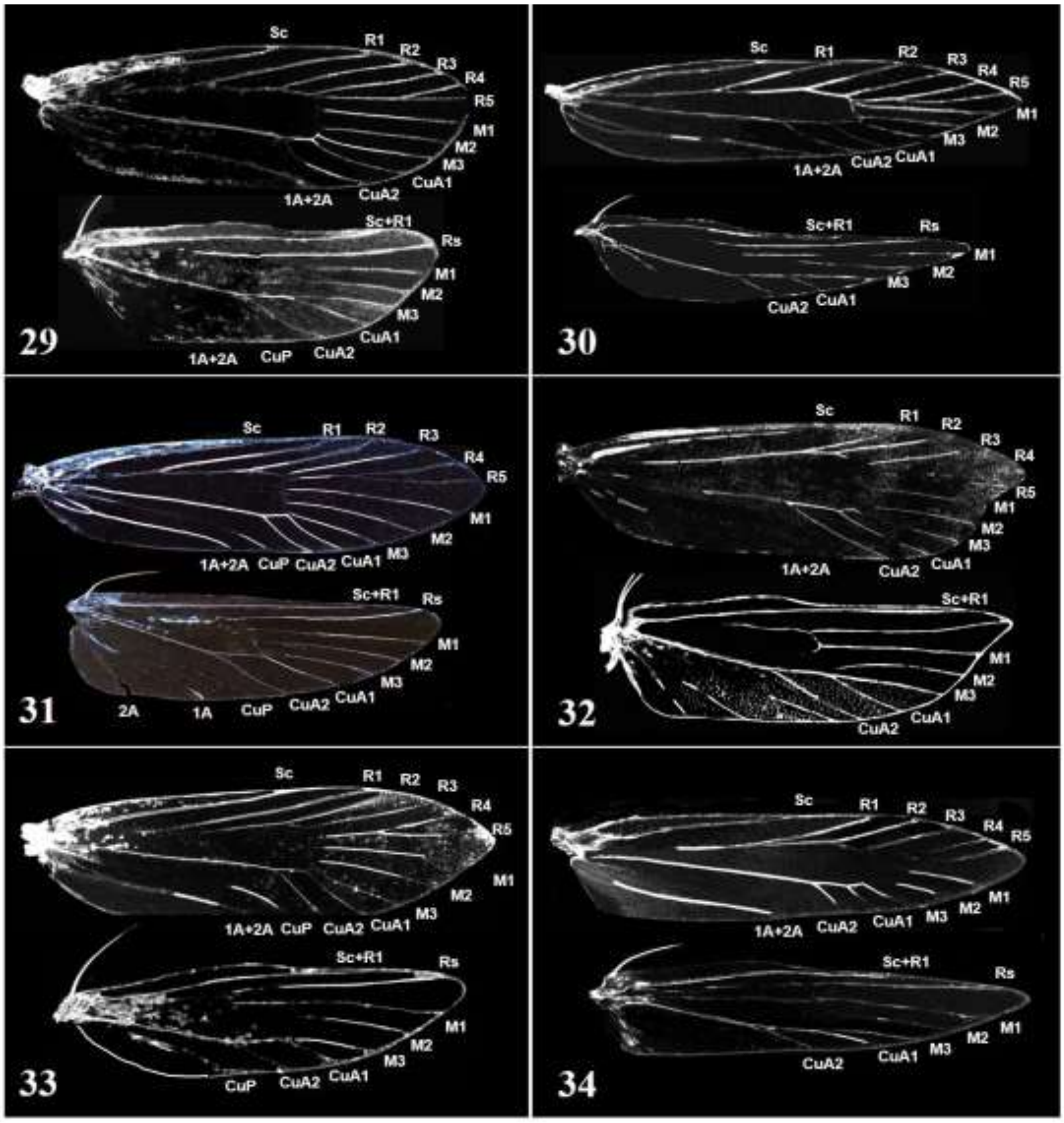


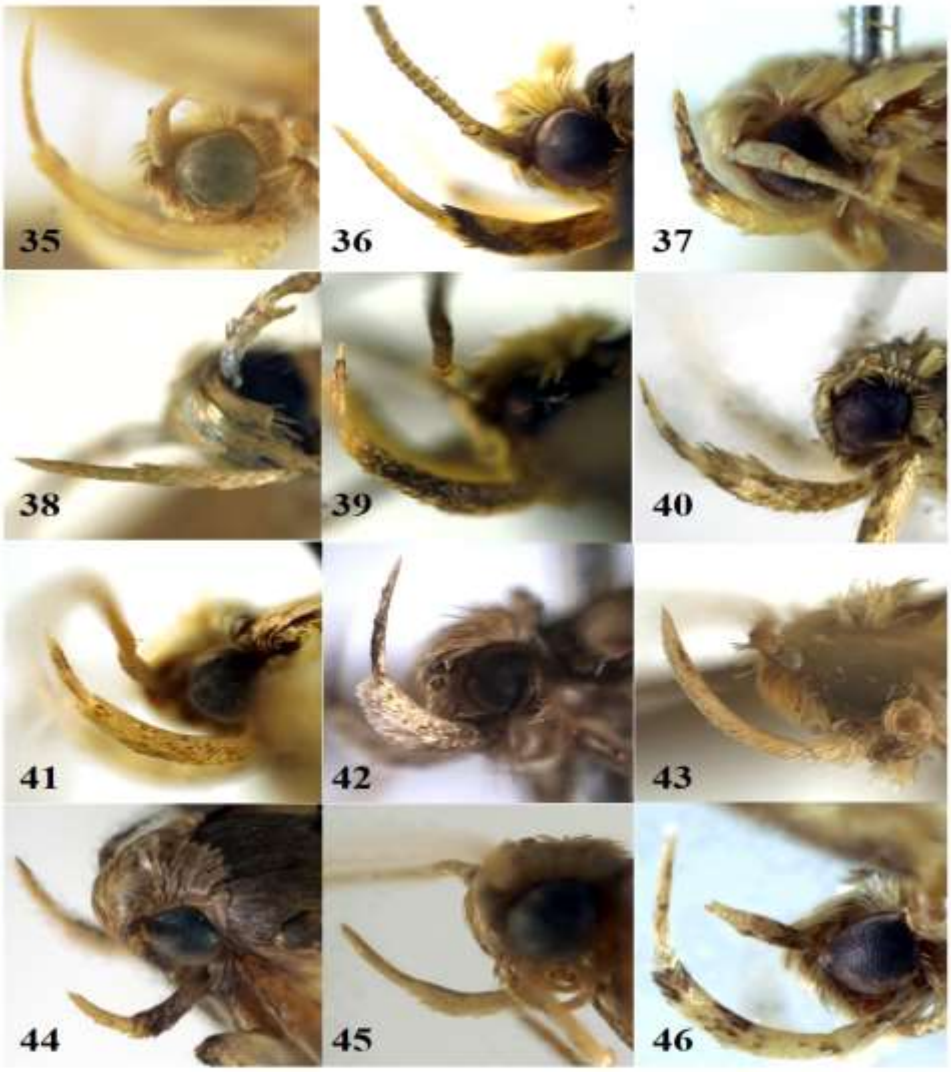
Figs. 23-28. Wing venation (continued).

23, *Acryptolechia malacobyrsa*; **24**, *Batia clavata* **sp. nov.**; **25**, *Cryptolechia obtusa* **sp. nov.**; **26**, *Exiguacma forcipis* **sp. nov.**; **27**, *Martyringa xeraula*; **28**, *Periacma delegata*



Figs. 29-34. Wing venation.

29, *Pseudodoxia achlyphanes*; **30**, *Ripeacma acuminiptera*; **31**, *Callimodes zelleri*; **32**, *Deuterogonia pudorina*; **33**, *Epicallima conchylidella*; **34**, *Promalactis suzukiella*

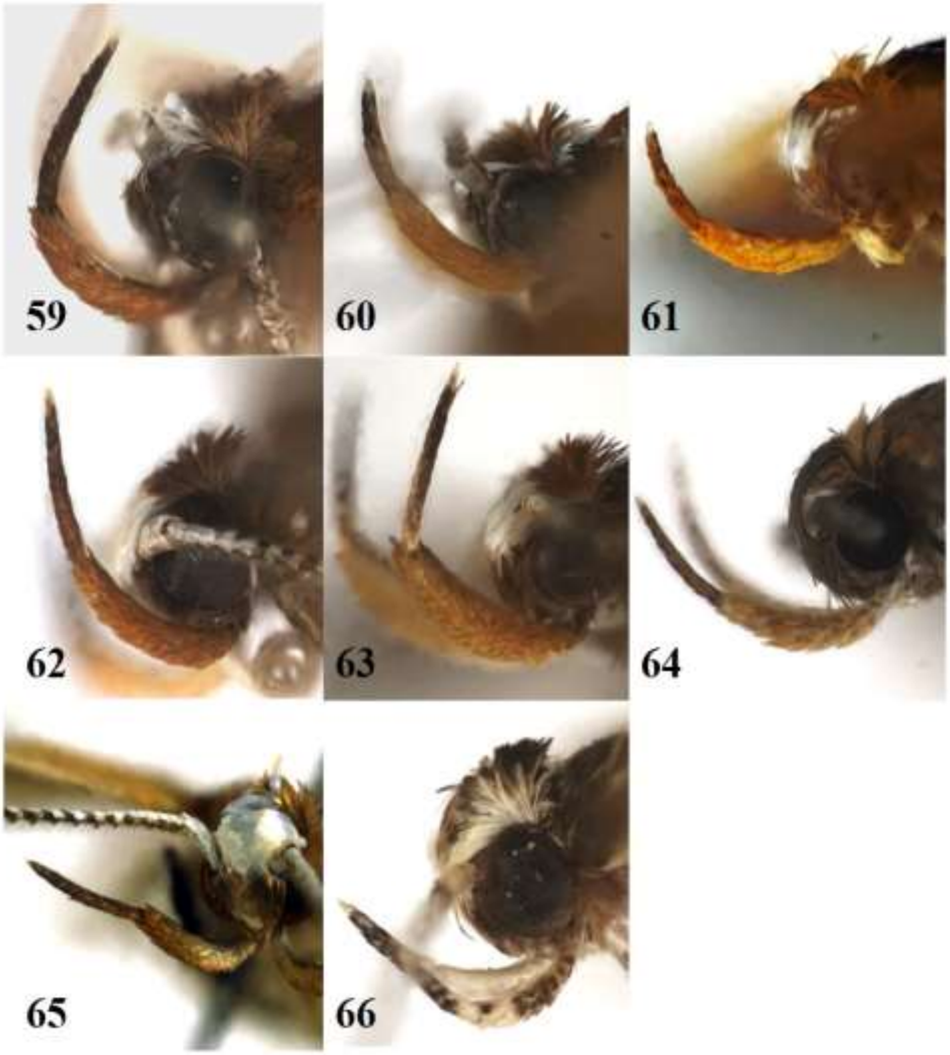


Figs. 35-46. Head (Continued).

35, *Acryptolechia malacobyrsa*; **36**, *A. torophanes*; **37**, *Batia clavata* **sp. nov.**; **38**, *B. flavatus* **sp. nov.**; **39**, *Cryptolechia albulus* **sp. nov.**; **40**, *C. obtusa* **sp. nov.**; **41**, *Exiguacma forcipis* **sp. nov.**; **42**, *Martyringa xeraula*; **43**, *Periacma delegata*; **44**, *Pseudodoxia achlyphanes*; **45**, *P. gahakensis* **sp. nov.**; **46**, *Ripeacma acuminiptera*.

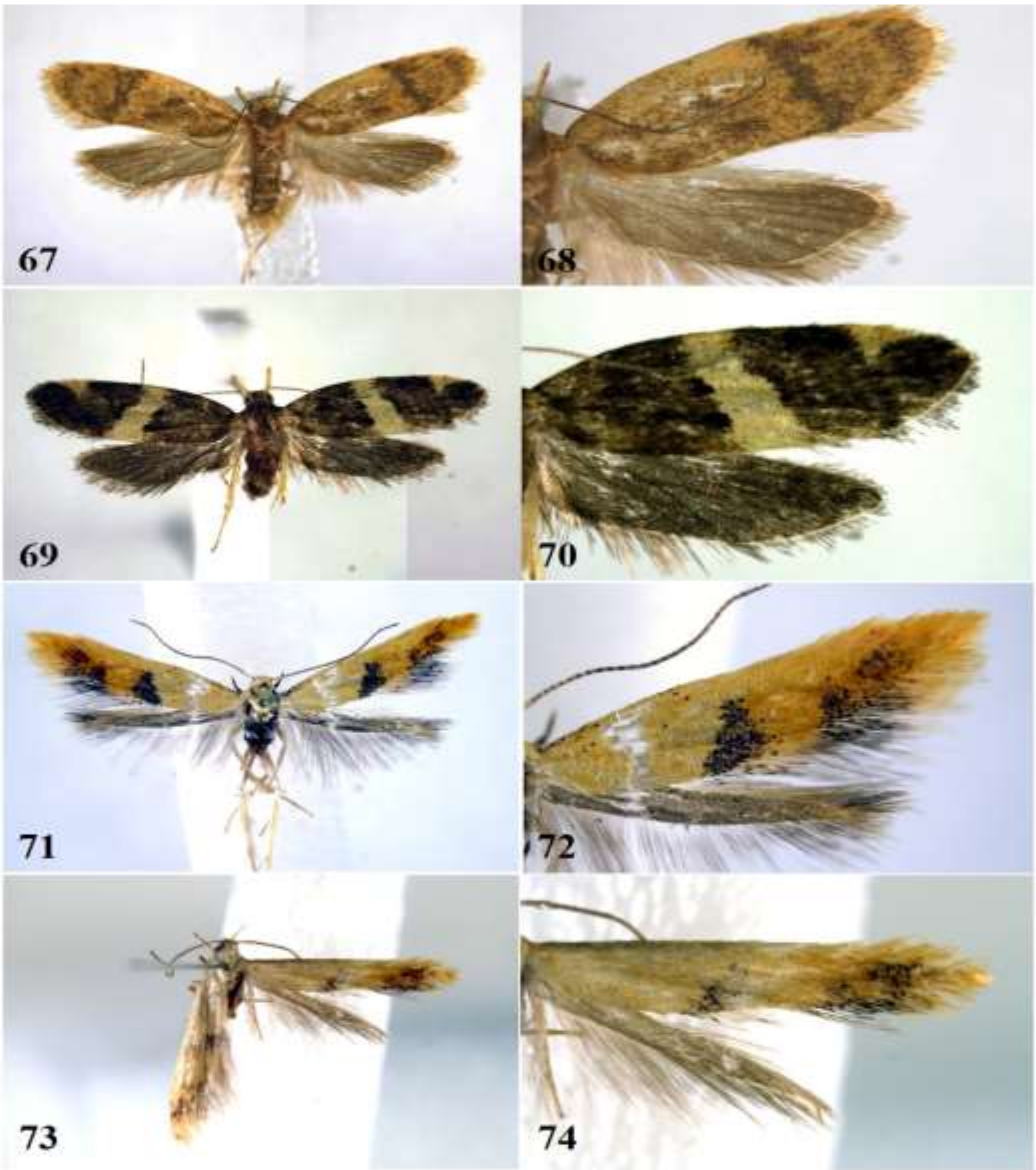
Figs. 47-58. Head (Continued).

47, *Ripeacma adamantis* **sp. nov.**; **48**, *R. longior* **sp. nov.**; **49**, *Callimodes zelleri*; **50**, *Deuterogonia pudorina*; **51**, *Epicallima conchylidella*; **52**, *Promalactis albipunctata*; **53**, *P. atriplagata*; **54**, *P. auriella*; **55**, *P. autoclina*; **56**, *P. bitaenia*; **57**, *P. candidifascia* **sp. nov.**; **58**, *P. enopisema.*



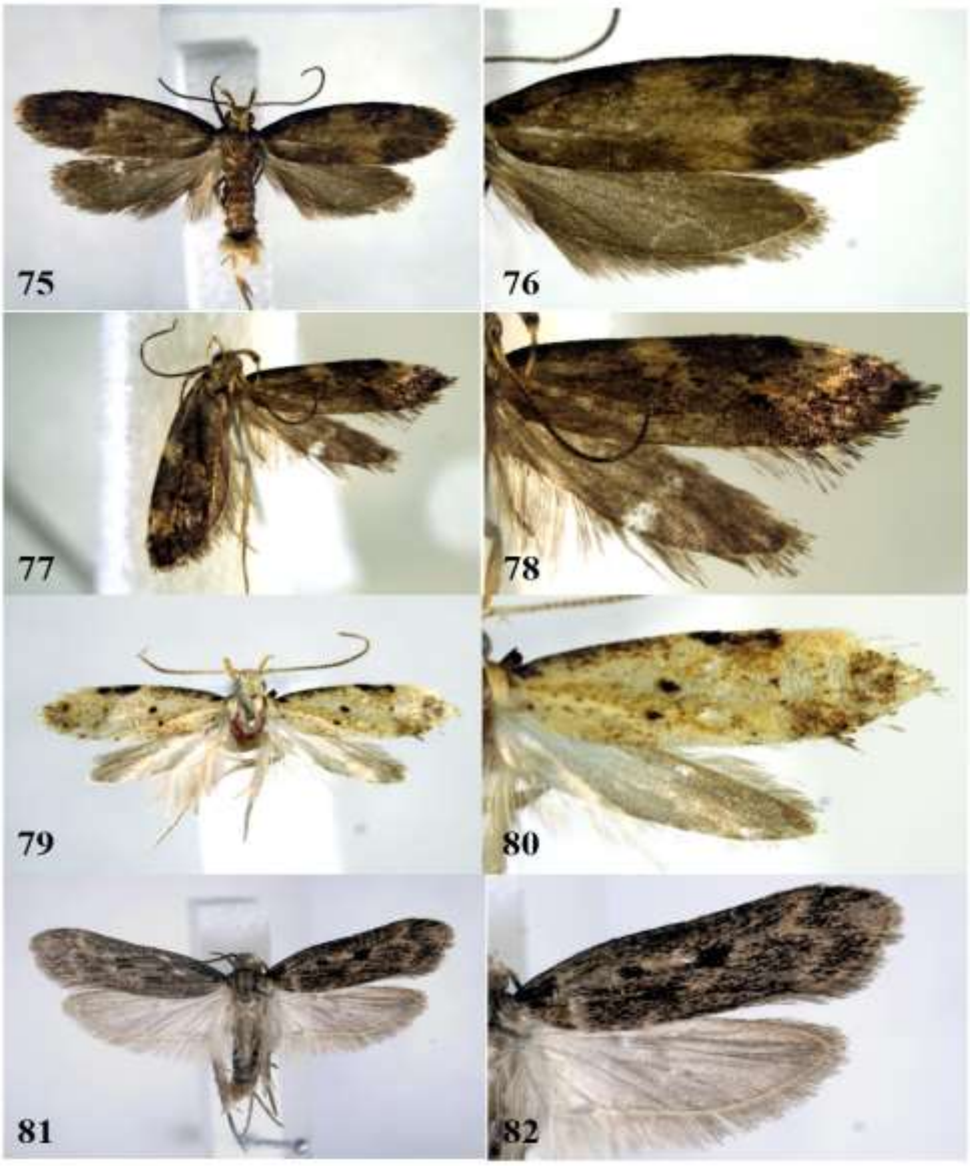
Figs. 59-66. Head.

59, *Promalactis jezonica;* **60**, *P. odaiensis*; **61**, *P. striola*; **62**, *P. subsuzukiella;* **63**, *Promalactis suzukiella*; **64**, *P. svetlanae*; **65**, *P. wonjuensis*; **66**, *P. xianfengensis.*



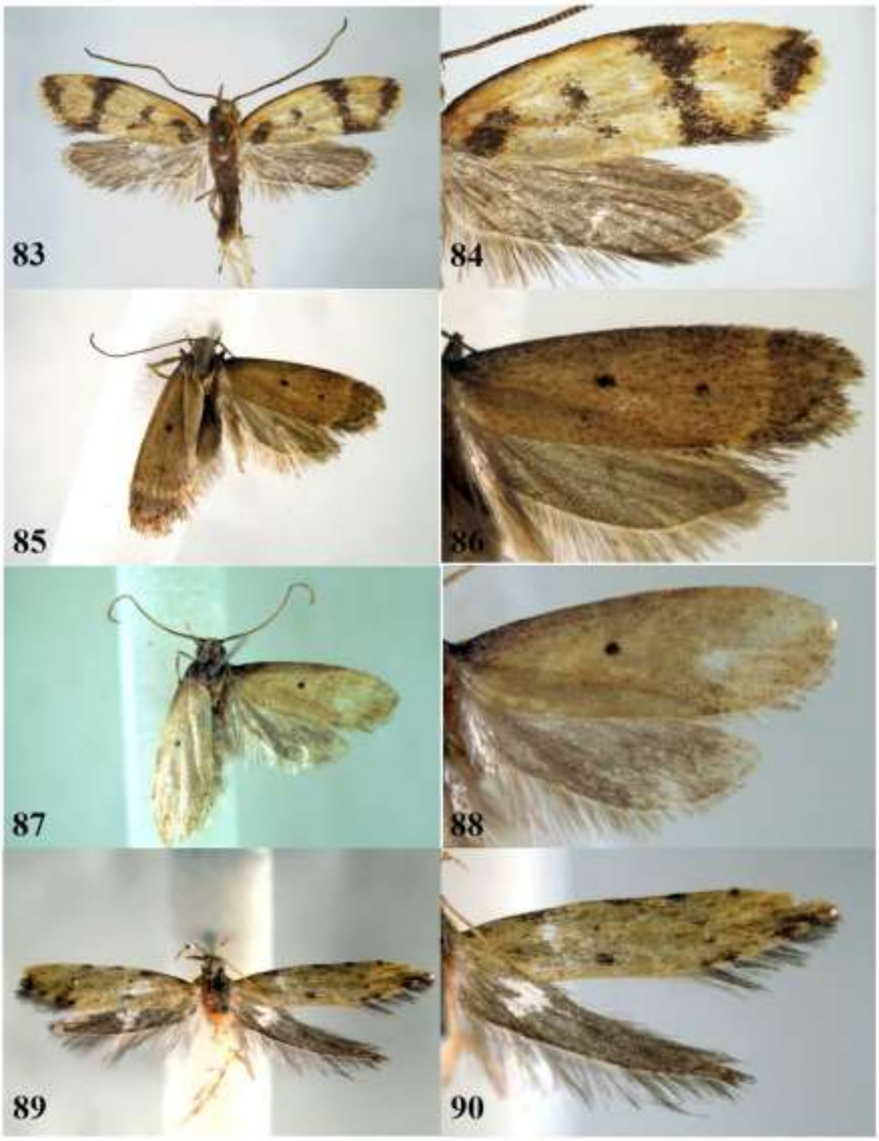
Figs. 67-74. Adult (Continued).

67, *Acryptolechia malacobyrsa*; **68**, wing pattern of *ditto*; **69**, *A. torophanes*; **70**, wing pattern of *ditto*; **71**, *Batia clavata* **sp. nov.**; **72**, wing pattern of *ditto*; **73**, *B. flavatus* **sp. nov.**; **74**, wing pattern of *ditto.*



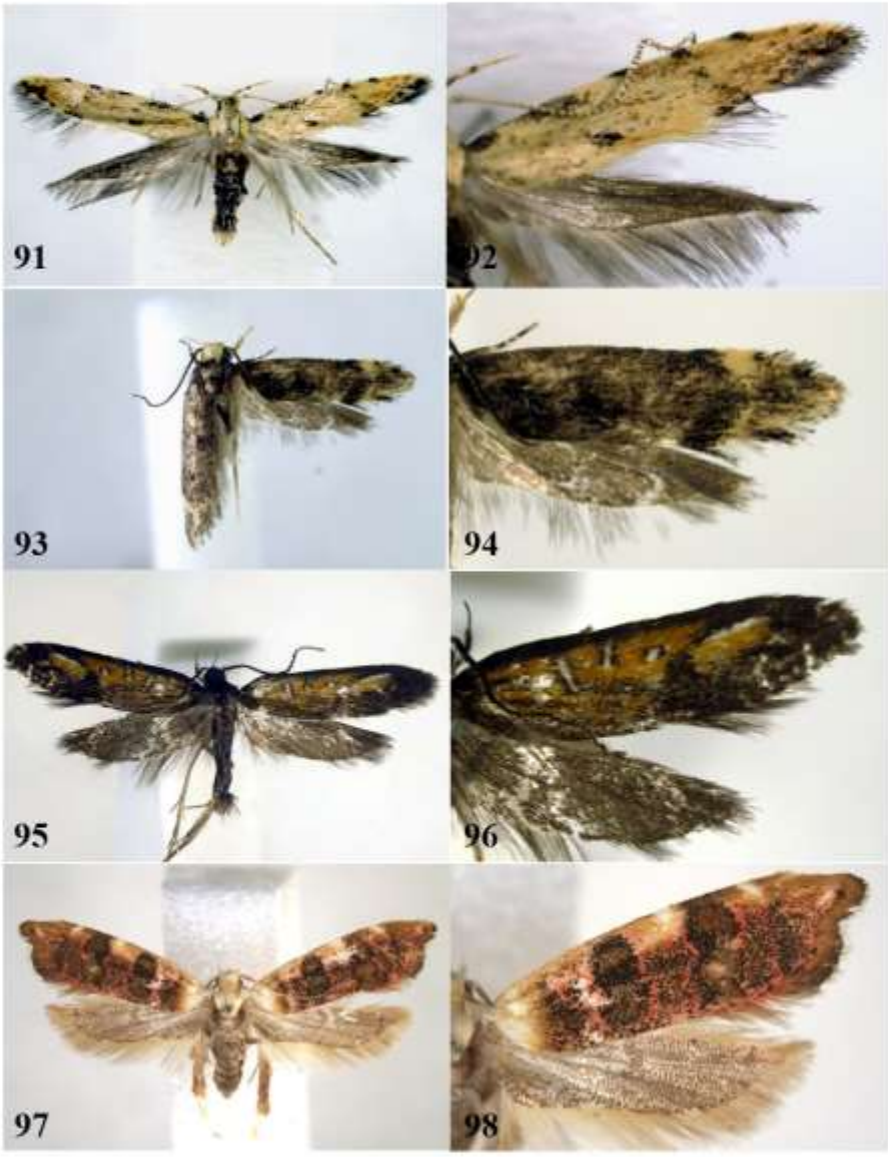
Figs. 75-82. Adult (Continued).

75, *Cryptolechia albulus* **sp. nov.**; **76**, wing pattern of *ditto*; **77**, *C. obtusa* **sp. nov.**; **78**, wing pattern of *ditto*; **79**, *Exiguacma forcipis* **sp. nov.**; **80**, wing pattern of *ditto*; **81**, *Martyringa xeraula*; **82**, wing pattern of *ditto.*



Figs. 83-90. Adult (Continued).

83, *Periacma delegata*; **84**, wing pattern of *ditto*; **85**, *Pseudodoxia achlyphanes*; **86**, wing pattern of *ditto*; **87**, *P. gahakensis* **sp. nov.**; **88**, wing pattern of *ditto*; **89**, *Ripeacma acuminiptera*; **90**, wing pattern of *ditto.*



Figs. 91-98. Adult (Continued).

91, *Ripeacma adamantis* **sp. nov.**; **92**, wing pattern of *ditto*; **93**, *R. longior* **sp. nov.**; **94**, wing pattern of *ditto*; **95**, *Callimodes zelleri*; **96**, wing pattern of *ditto*; **97**, *Deuterogonia pudorina*; **98**, wing pattern of *ditto.*

Figs. 99-106. Adult (Continued).

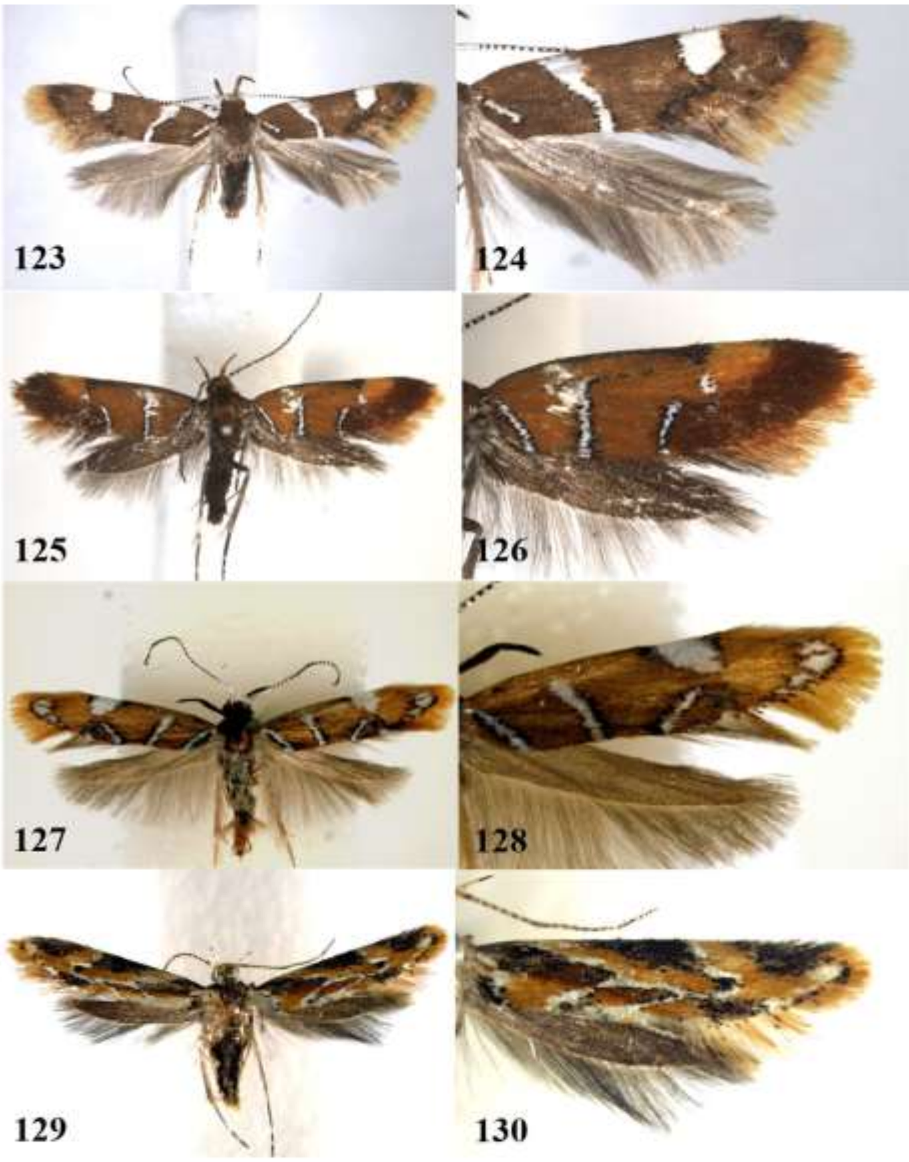
99, *Epicallima conchylidella*; **100**, wing pattern of *ditto*; **101**, *Promalactis albipunctata*; **102**, wing pattern of *ditto*; **103**, *P. atriplagata*; **104**, wing pattern of *ditto*; **105**, *P. auriella;* **106**, wing pattern of *ditto.*

Figs. 107-114. Adult (Continued).

107, *Promalactis autoclina*; **108**, wing pattern of *ditto*; **109**, *P. bitaenia*; **110**, wing pattern of *ditto*; **111**, *P. candidifascia* **sp. nov.**; **112**, wing pattern of *ditto*; **113**, *P. enopisema*; **114**, wing pattern of *ditto.*

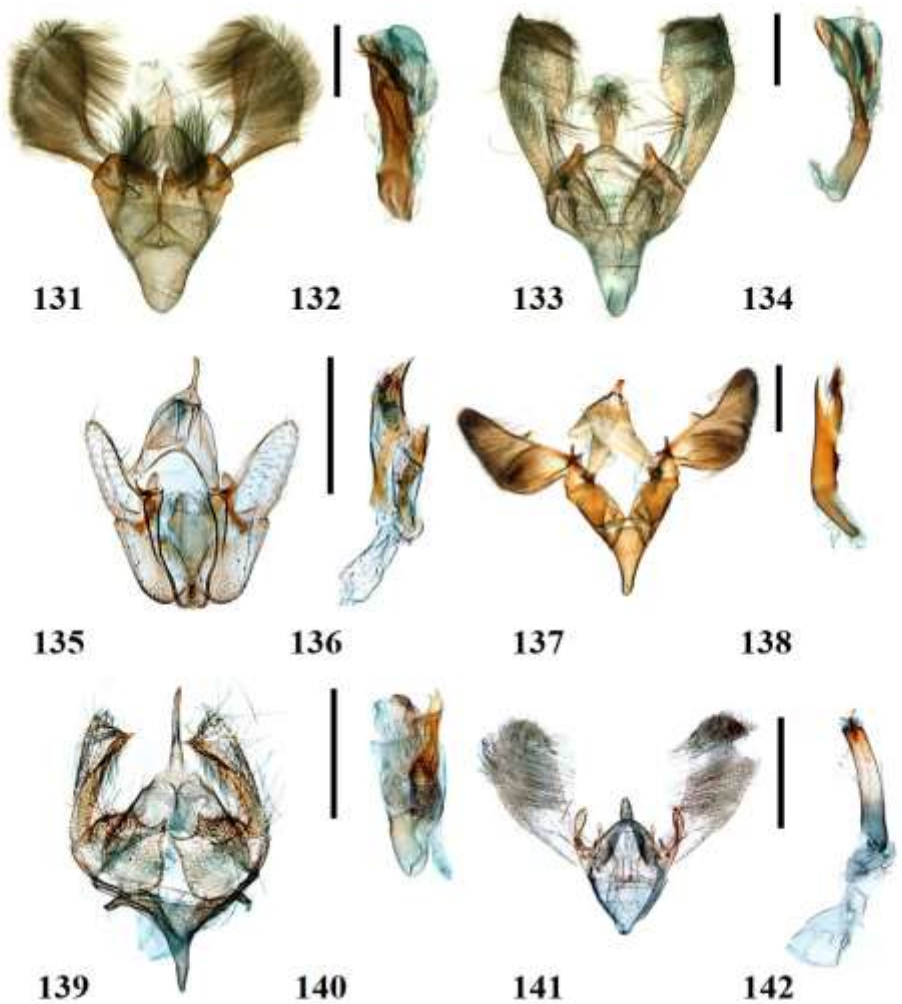
Figs. 115-122. Adult (Continued).

115, *Promalactis jezonica*; **116**, wing pattern of *ditto*; **117**, *P. odaiensis*; **118**, wing pattern of *ditto*; **119**, *P. striola*; **120**, wing pattern of ditto; **121**, *P. subsuzukiella*; **122**, wing pattern of *ditto.*



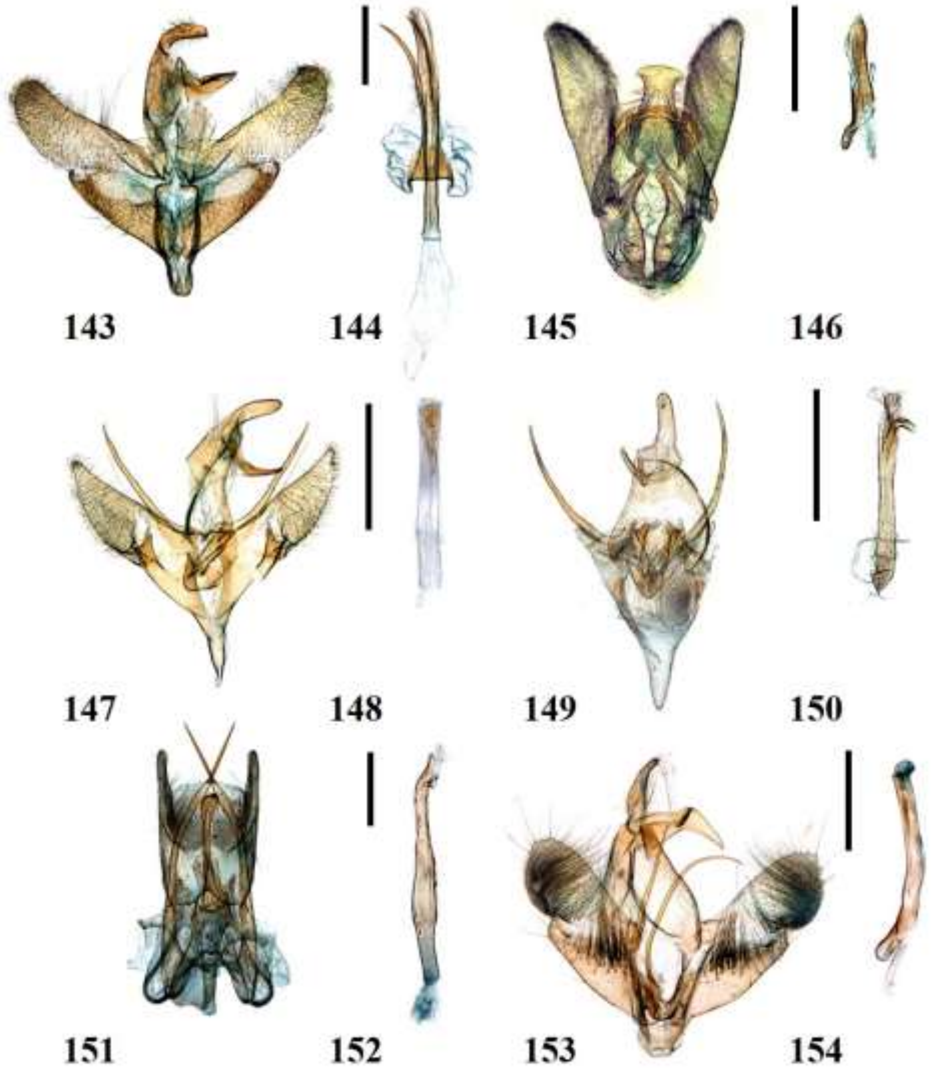
Figs. 123-130. Adult.

123, *Promalactis suzukiella*; **124**, wing pattern *of ditto*; **125**, *P. svetlanae*; **126**, wing pattern of *ditto*; **127**, *P. wonjuensis*; **128**, wing pattern of *ditto*; **129**, *P. xianfengensis*; **130**, wing pattern of *ditto*.



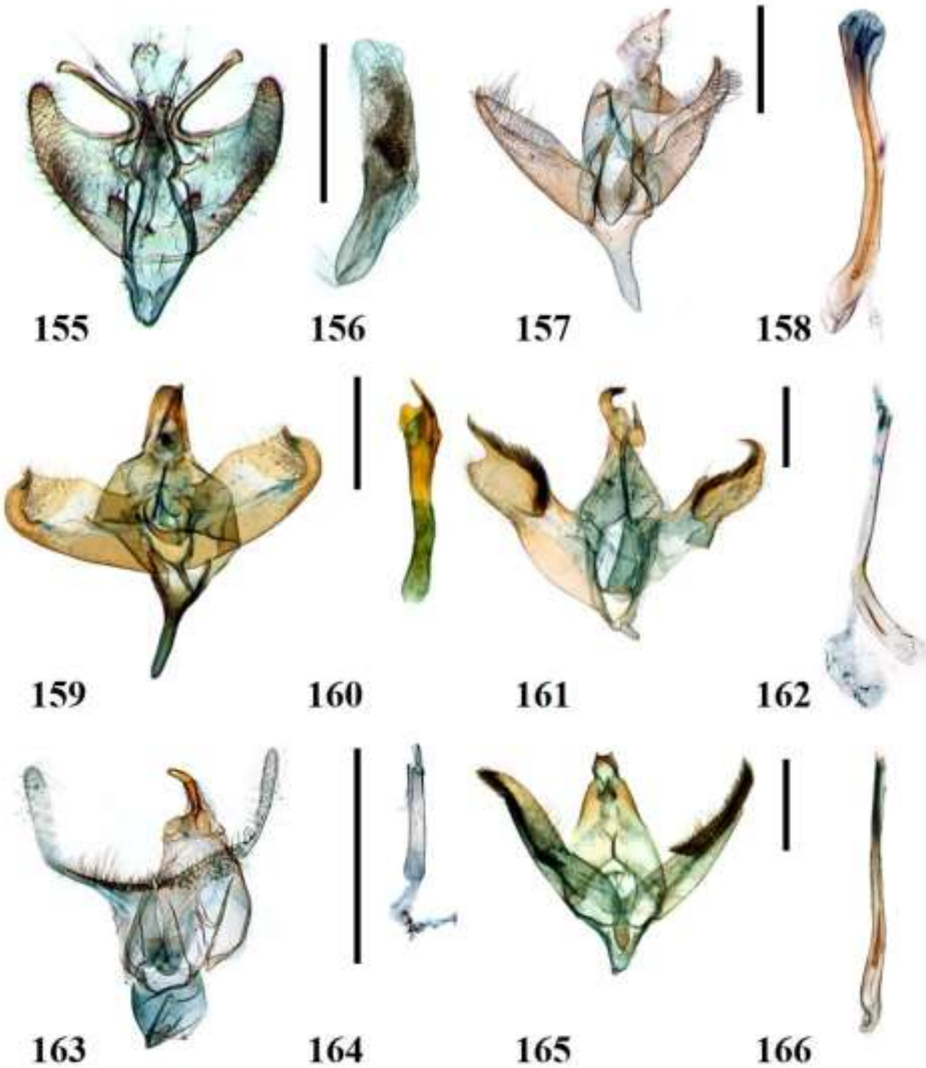
Figs. 131-142. Male genitalia (continued).

131, *Acryptolechia malacobyrsa*; **132**, aedeagus of *ditto*; **133**, *A. torophanes*; **134**, aedeagus of ditto; **135**, *Batia flavatus* **sp. nov.**; **136**, aedeagus of *ditto*; **137**, *Cryptolechia albulus* **sp. nov.**; **138**, aedeagus of *ditto*; **139**, *C. obtusa* **sp. nov.**; **140**, aedeagus of *ditto*; **141**, *Exiguacma forcipis* **sp. nov.**; **142**, aedeagus of *ditto*. **Scale bar**, 0.5 mm.



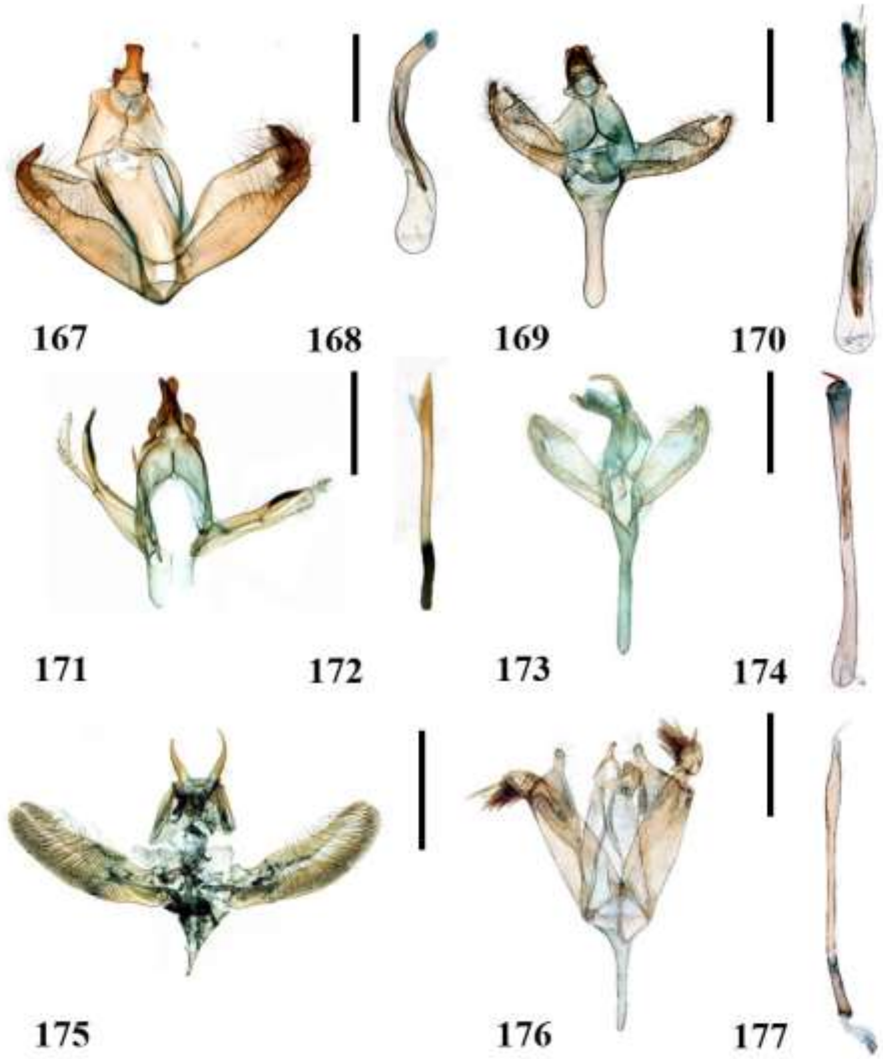
Figs. 143-154. Male genitalia (continued).

143, *Martyringa xeraula*; **144**, aedeagus of *ditto*; **145**, *Periacma delegata*; **146**, aedeagus of *ditto;* **147**, *Pseudodoxia achlyphanes*; **148**, aedeagus of *ditto*; **149**, *P. gahakensis* **sp. nov.**; **150**, aedeagus of *ditto*; **151**, *R. longior* **sp. nov.**; **152**, aedeagus of *ditto*; **153**, *Callimodes zelleri*; **154**, aedeagus of *ditto*. **Scale bar**, 0.5 mm.



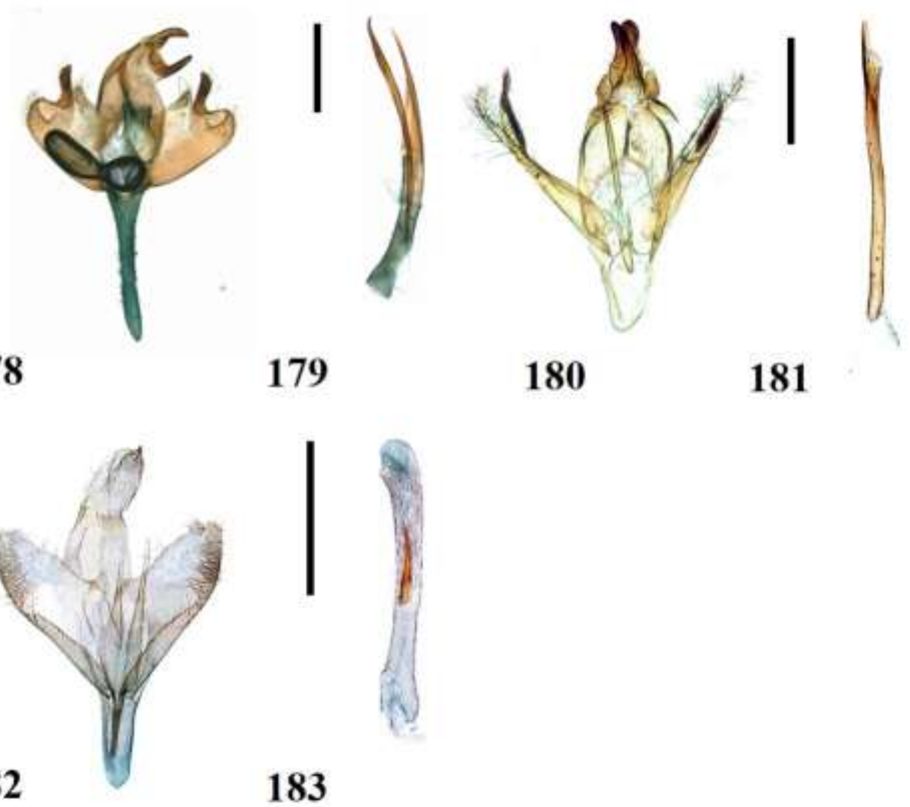
Figs. 155-166. Male genitalia (continued).

155, *Deuterogonia pudorina*; **156**, aedeagus of *ditto*; **157**, *Epicallima conchylidella*; **158**, aedeagus of *ditto*; **159**, *Promalactis albipunctata*; **160**, aedeagus of *ditto*; **161**, *P. auriella*; **162**, aedeagus of *ditto*; **163**, *P. autoclina*; **164**, aedeagus of *ditto*; **165**, *P. bitaenia*; **166**, aedeagus of *ditto*. **Scale bar**, 0.5 mm.



Figs. 167-177. Male genitalia (continued).

167, *Promalactis candidifascia* **sp. nov.**; **168**, aedeagus of *ditto*; **169**, *P. enopisema*; **170**, aedeagus of *ditto*; **171**, *P. jezonica*; **172**, aedeagus of *ditto*; **173**, *P. odaiensis*; **174**, aedeagus of *ditto*; **175**, *P. subsuzukiella*, (aedeagus missing); **176**, *P. suzukiella*; **177**, aedeagus of *ditto*. **Scale bar**, 0.5 mm.

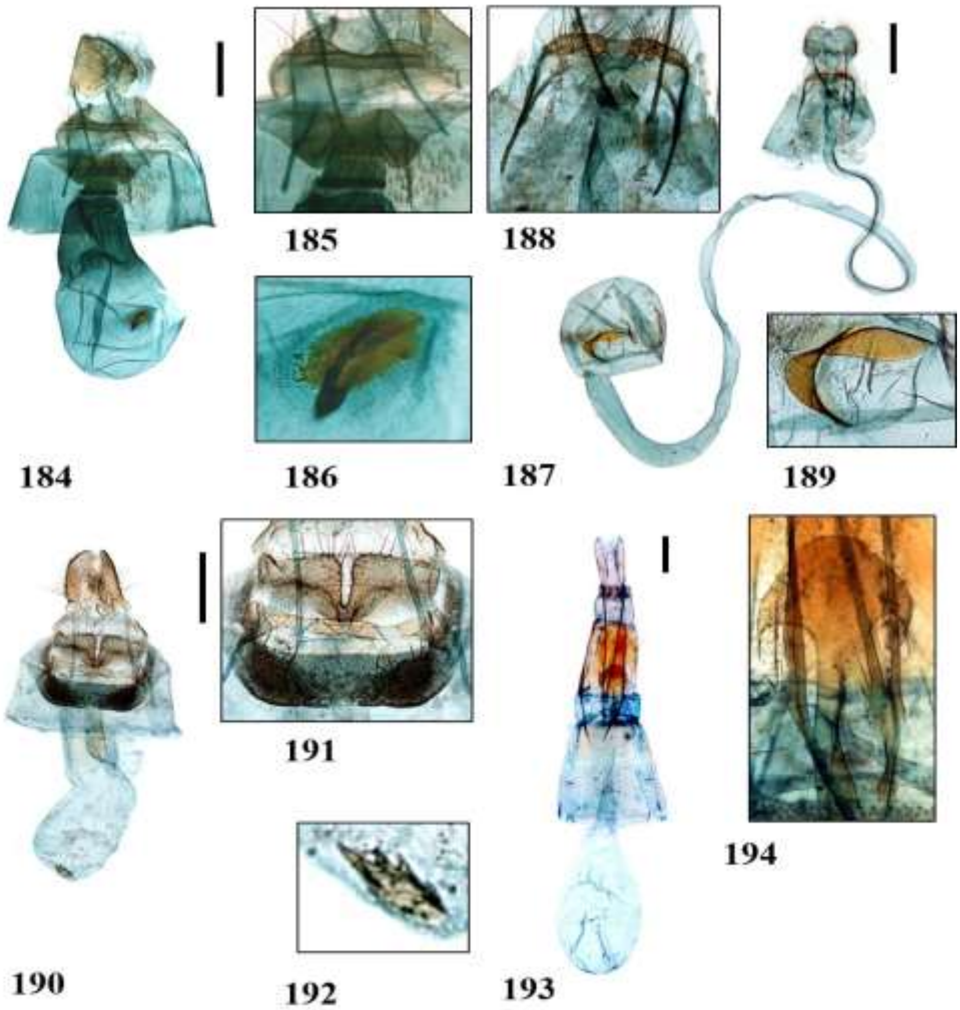


178 179 180 181

182 183

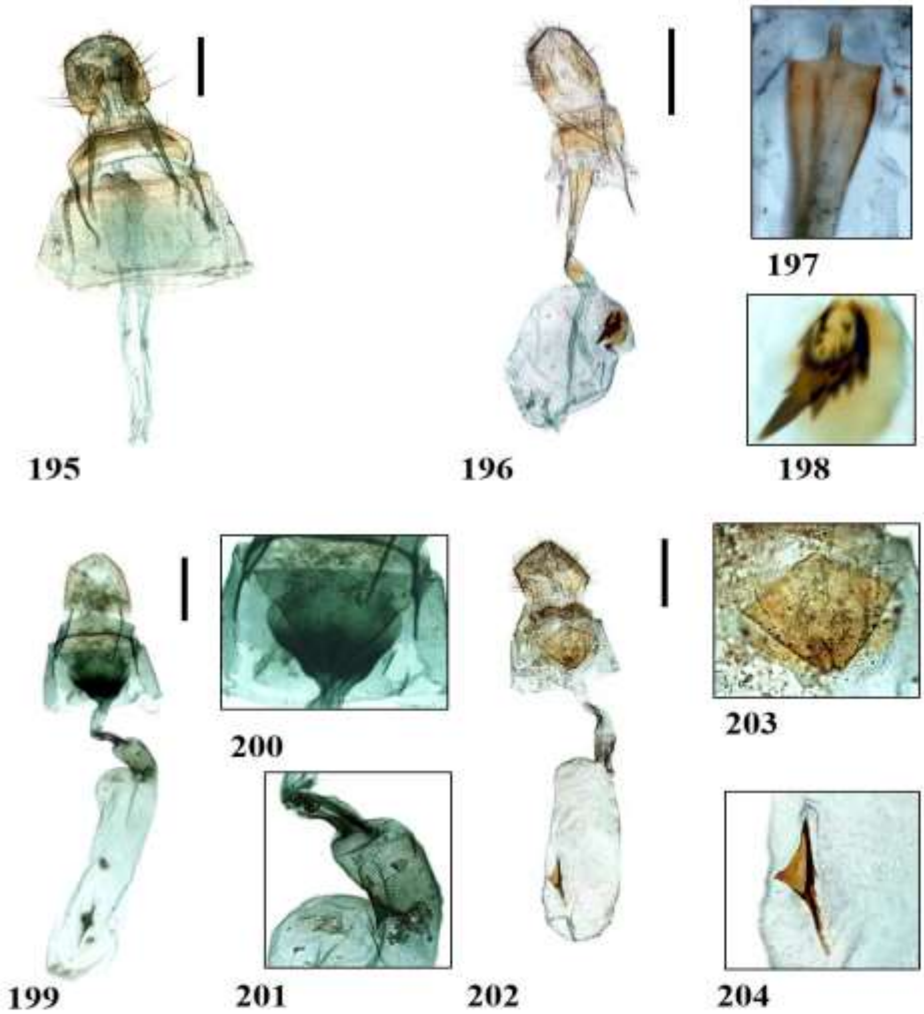
Figs. 178-183. Male genitalia.

178, *Promalactis svetlanae*; **179**, aedaegus of *ditto*; **180**, *P. wonjuensis*; **181**, aedeagus of *ditto;* **182**, *Promalactis xiangengensis*; **183**, aedeagus of *ditto.* **Scale bar**, 0.5 mm.



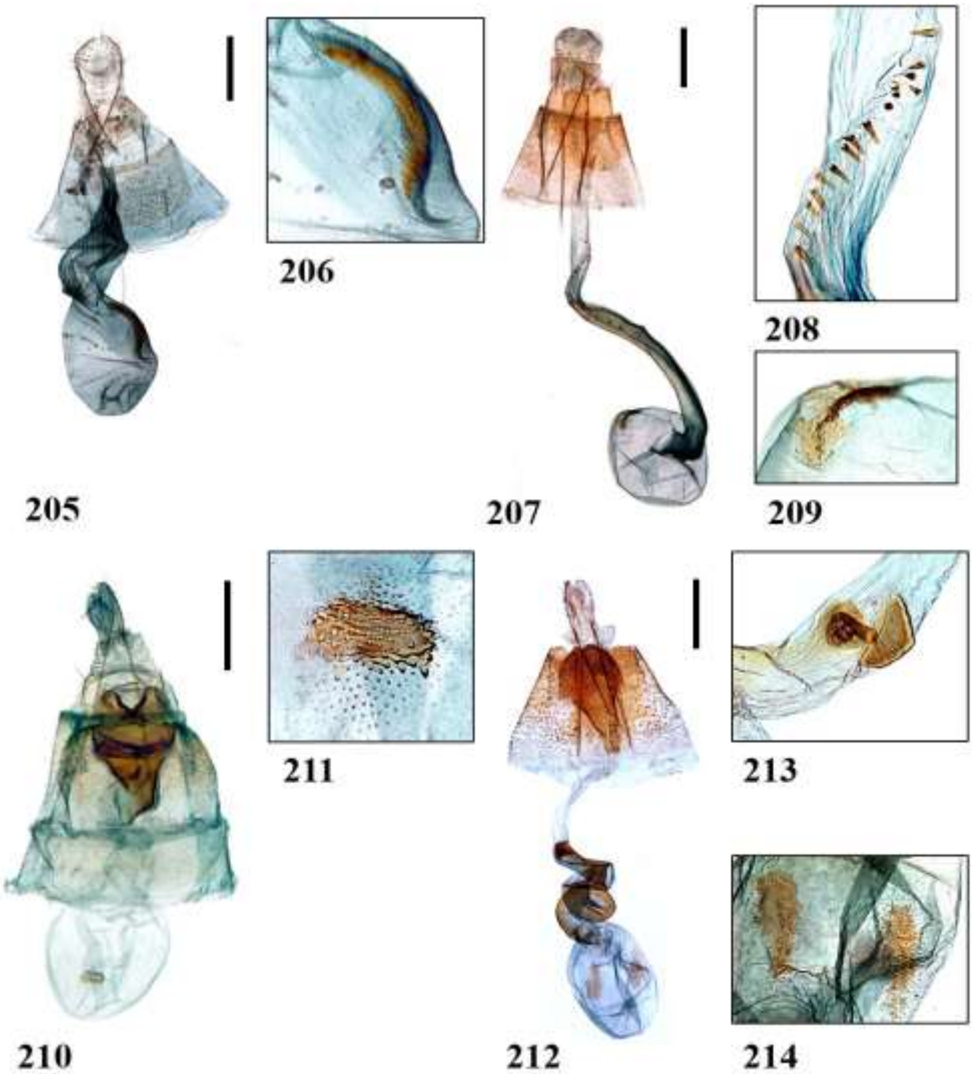
Figs. 184-194. Female genitalia (continued).

184, *Acryptolechia torophanes*; **185**, lamella postvaginalis and antevaginalis of *ditto*; **186**, signum of *ditto*; **187**, *Batia clavata* **sp. nov.**; **188**, lamella postvaginalia of *ditto*; **189**, signum of *ditto*; **190**, *Cryptolechia obtusa* **sp. nov.**; **191**, lamella postvaginalis and antevaginalis of *ditto*; **192**, signum of *ditto*; **193**, *Martyringa xeraula*; **194**, antrum of *ditto*. **Scale bar**, 0.5 mm.



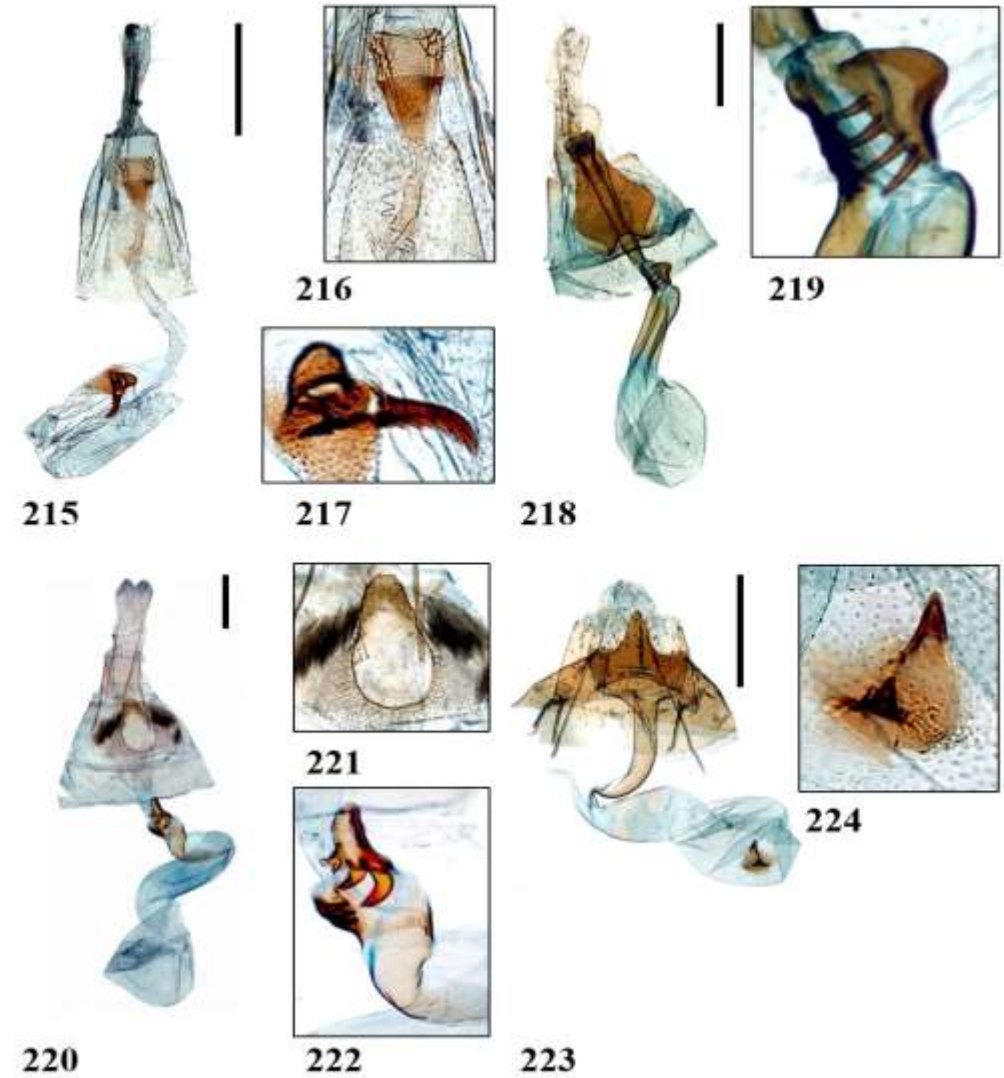
Figs. 195-204. Female genitalia (continued).

195, *Periacma delegata*; **196**, *Pseudodoxia achlyphanes*; **197**, caudal margin in antrum of *ditto*; **198**, signum of *ditto*; **199**, *Ripeacma acuiniptera*; **200**, lamella antevaginalis and antrum of *ditto*; **201**, anterior part in ductus bursa of *ditto*; **202**, *R. adamantis* **sp. nov.**; **203**, lamella antevaginalis and antrum of *ditto*; **204**, signum of *ditto*. **Scale bar**, 0.5 mm.



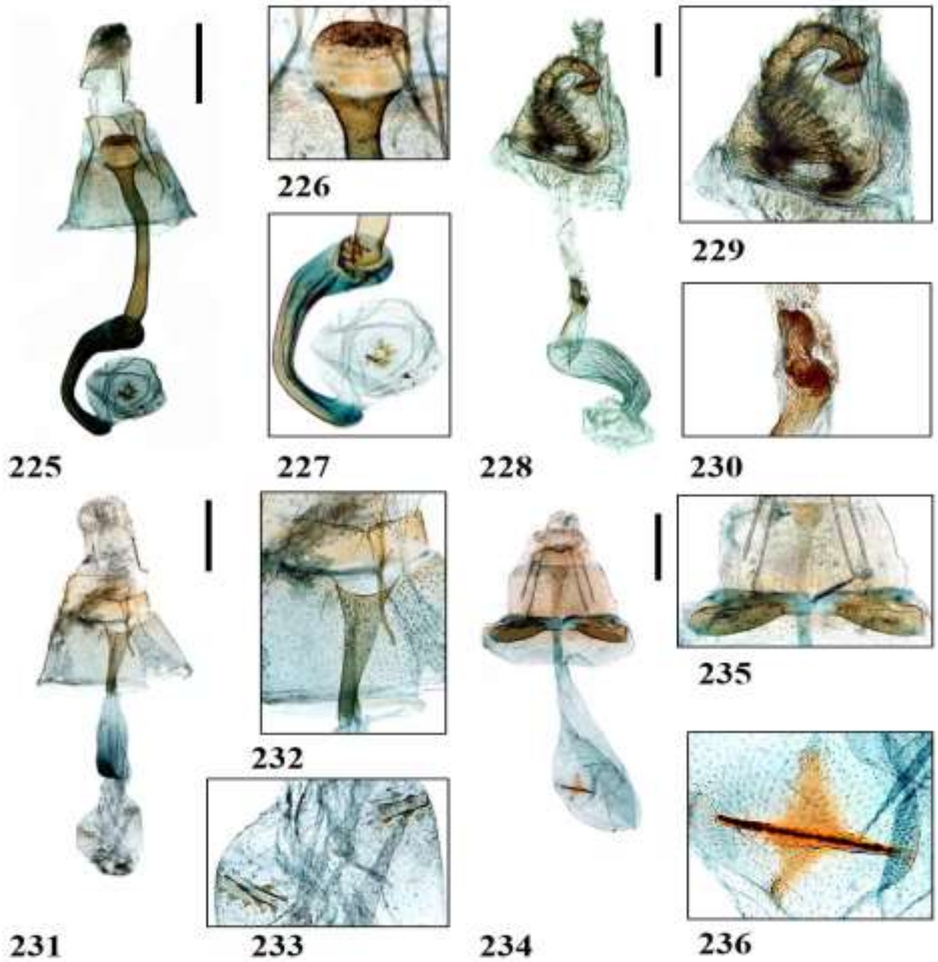
Figs. 205-214. Female genitalia (continued).

205, *Deuterogonia pudorina*; **206**, signum of *ditto*; **207**, *Epicallima conchylidella*; **208**, ductus bursa of *ditto*; **209**, signum of *ditto*; **210**, *Promalactis albipunctata*; **211**, signum of *ditto*; **212**, *P. atriplagata*; **213**, spines in ductus bursa of *ditto*; **214**, signum of *ditto.* **Scale bar**, 0.5 mm.



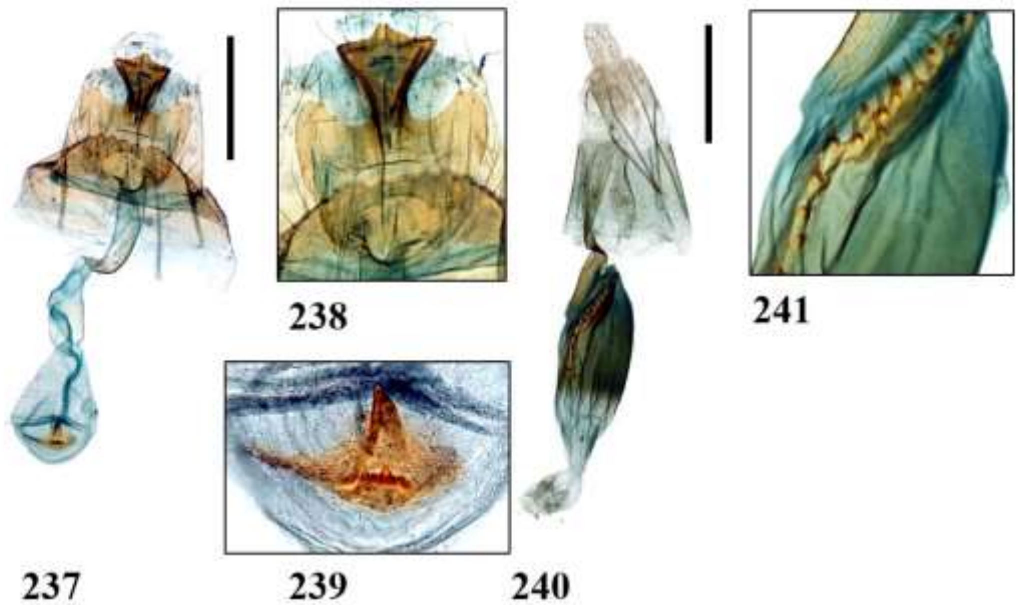
Figs. 215-224. Female genitalia (continued).

215, *Promalactis autoclina*; **216**, antrum of *ditto*; **217**, signum of *ditto*; **218**, *P. bitaenia*; **219**, spine in ductus bursa of *ditto*; **220**, *Promalactis enopisema*; **221**, lamella postvaginalis of *ditto*; **222**, spines in ductus bursa of *ditto*; **223**, *P. jezonica*; **224**, signum of *ditto*. **Scale bar**, 0.5 mm.



Figs. 225-236. Female genitalia (continued).

225, *Promalactis odaiensis*; **226**, lamella postvaginalis of *ditto*; **227**, spines in ductus bursa and signum of *ditto*; **228**, *P. striola*; **229**, lamella postvaginalis of *ditto*; **230**, spines in ductus bursa of *ditto*; **231**, *P. subsuzukiella*; **232**, lamella postvaginalis and antrum of *ditto*; **233**, signum of *ditto*; **234**, *P. suzukiella*; **235**, antrum and 7th sternum of *ditto*; **236**, signum of *ditto*. **Scale bar**, 0.5 mm.



Figs. 237-241. Female genitalia.

237, *Promalactis wonjuensis*; **238**, lamella postvaginalis of *ditto*; **239**, signum of *ditto*; **240,** *P. xianfengensis*; **241**, spines in ductus bursa of *ditto.* **Scale bar**, 0.5 mm.

원뿔나방과(나비목: 뿔나방상과)의 계통분류학적 연구

서울대학교 대학원

농생명공학부 곤충학 전공

김소라

국문초록

본 연구는 한반도산 원뿔나방과에 대한 계통분류학적 연구로써, 총 두 가지 연구로 구성되어 있다. 첫번째는 한반도에 서식하는 원뿔나방과의 분류학적 검토, 두번째는 분자마커를 이용한 원뿔나방과의 계통분석, 원뿔나방류의 미소서식처와 은신을 하는 행동변화의 조상형질을 탐색하여 이들의 진화론적 변화를 유추하는 연구이다. 그리고 분자시계기법을 이용한 원뿔나방과의 분화시기와 원산지역 탐색에 관한 연구도 함께 수행하였다.

첫번째 연구에서는 2아과(원뿔나방아과, 숨은원뿔나방아과), 12속에 속하는 총 33종의 한반도산 원뿔나방과에 대한 분류학적 및 형태학적 연구가 수행되었다. 한 개의 신속, 미기록 속 4속, 신종 9종과 미기록 3

종이 본 연구로부터 국내에 첫 보고되었다. 두번째 연구에서는 분자마커를 이용하여 원뿔나방과의 단계통여부 및 근연그룹에 대한 계통관계를 규명하였다. 그리고 원뿔나방류의 미소서식처 선택과 은신을 하는 행동전략의 조상형질을 탐색하여 진화론적 추론을 이끌어내었다. 결과로써, 원뿔나방과는 측계통을 형성하는 것을 확인하였고, 원뿔나방류는 건조한 식물에서부터 그 서식처가 변화되어왔고, 자신의 실크를 이용하여 은신처를 만드는 무리들로부터 진화되었음을 유추할수 있었다. 그리고 화석기록과 분자시계기법을 활용하여 원뿔나방류의 연대기 측정과 이들의 원산지를 탐색하는 연구도 수행하여, 원뿔나방과는 후기 에오세 시대에서부터 분지되었고 오늘날의 아프리카열대구와 동양구를 원산지로 진화되었음을 유추해 볼수 있었다.

검색어: 원뿔나방, 계통분류, 진화, 분자시계, 한반도, 조상형질