ASED http://e-ASED.org
Animal Systematics, Evolution and Diversity

Anim. Syst. Evol. Divers. Vol. 31, No. 4: 296-303, October 2015
http://dx.doi.org/10.5635/ASED.2015.31.4.296

Moth Fauna of Gageodo Island in the Southwestern Sea, Korean Peninsula, including Seven Unrecorded Species (Lepidoptera)

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ABSTRACT

We surveyed moths on Gageodo island in the southwestern sea of the Korean Peninsula over three years (2009, 2012, 2013) and found a total of 253 species in 18 families. Geometridae had the greatest species richness, with 63 species, followed by Noctuidae, Erebidae, Crambidae and Sphingidae. The annual changes in species richness and abundance were not different and seasonal occurrence of species showed a unimodal pattern in which the numbers of species and individuals increased from April and May, peaked in June and decreased to September and October. Seven moth species (Pyralidae: *Herculia drabicilialis* Yamanaka, *Didia striatella* (Inoue); Crambidae: *Clupeosoma pryeri* (Butler), *Demobotys pervulgalis* (Hampson), *Yezobotys dissimilis* (Yamanaka), *Syllepte cissalis* Yamanaka; Erebidae: *Hypena sinuosa* (Wileman)) are reported for the first time in Korea.

Keywords: Gageodo island, moth, fauna, Lepidoptera, unrecorded species, Korea

INTRODUCTION

The Island of Gageodo (old name: Soheuksando), Shinan county of Jeollanamdo province is located on the southwestern tip of the Korean peninsula (34°03′N, 125°07′E, 16.34 km^2). This island is a southwestern national border island between Korea and China (Fig. 1), about 136 km southwest from Mokpo and 70 km southwest from the Island of Heuksan-do. The largest peak on the island is Mt. Doksilsan (elevation 639 m), which is the third highest peak in the islands of Korea. In addition to elevation, the island is important in geography since it is located in the most southwestern part of Korea and a migratory bird passage between the southern China and mainland Korea. Therefore this island harbors diverse flora (783 vascular plants) and avifauna (128 bird species).

Moth fauna of the island was first surveyed by Shin and Nho (1970), and later by others (Ra et al., 1986; Choi and Lee, 1995; Choi et al., 2009). The present study was conducted to investigate the moth fauna by compiling all previous information regarding the distribution of moths. In addition, we report seven new records of moths for the first time in Korea.

MATERIALS AND METHODS

We surveyed moths during three years: 2009, 2012, and 2013. In 2009, three surveys were conducted at eight sites (May, August, and October). Similarly, three surveys were conducted at eight sites in 2012 (April, June, and September), while two surveys were conducted at two sites and on a road between two villages in 2013 (June and September) (Table 1). Moth collections were conducted using an UV light trap (BioQuip, USA) during night and a net during daytime. Specimens were preserved in Mokpo National University and a private collection (Sung-Soo Kim).

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pISSN 2234-6953 eISSN 2234-8190

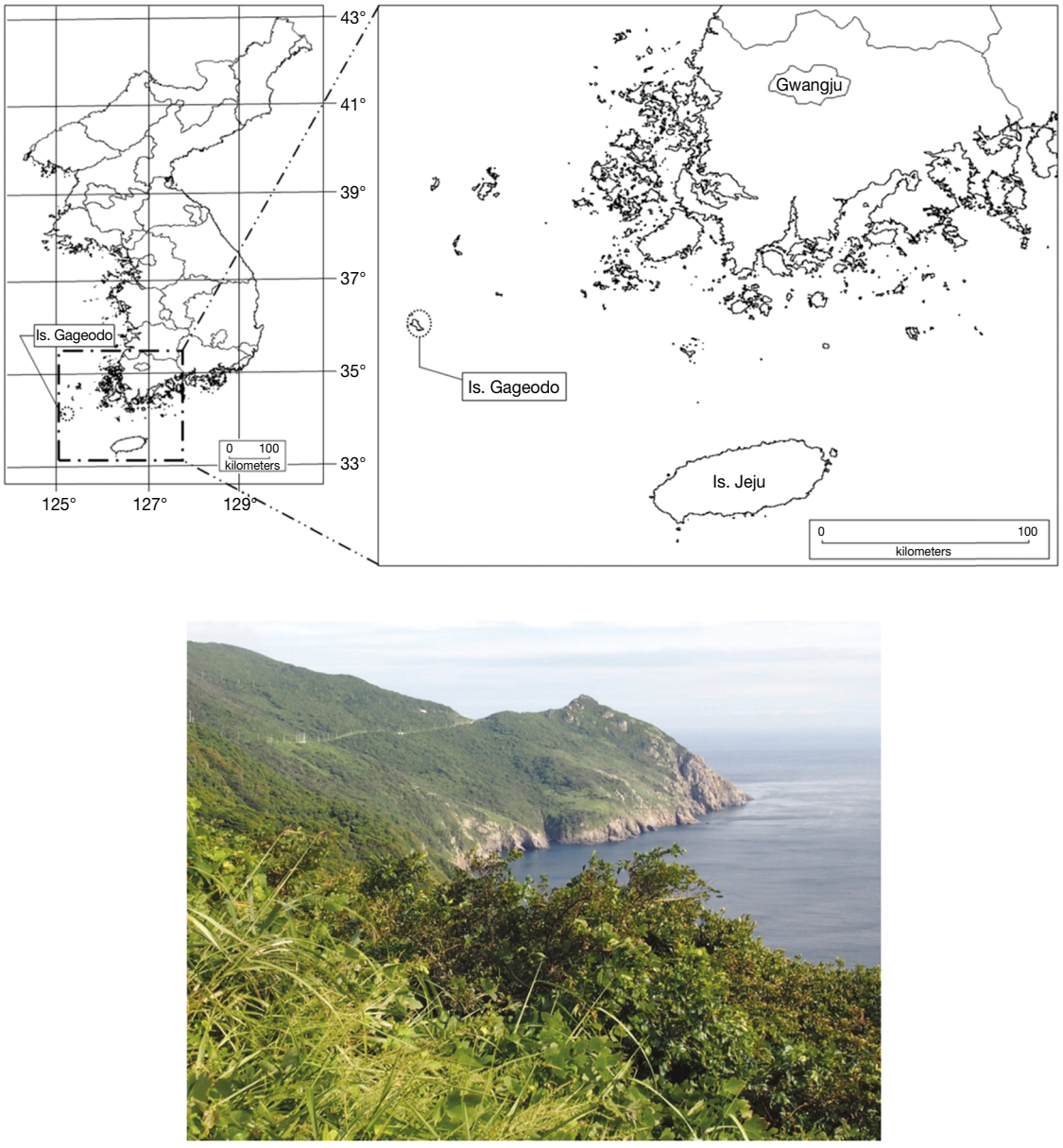

Fig. 1. Map showing the location of the island, Isl. Gageodo, Shinan-gun, Jeollanam-do in South Korea.

RESULTS AND DISCUSSION

A total of 253 species and 2,707 individuals in 18 families were recognized from the three-year-survey on Gageodo Island. During the last 40 years, the moth fauna of the island has been relatively unknown because of limited access to the island. We expected that the total number of moth species would increase since the previous studies were focused on macromoths.

Among 18 families, Geometridae had the greatest species richness, with 63 species (24.9%), followed by Noctuidae (57 species, 22.5%), Erebidae (44 species, 17.4%), Crambidae (38 species, 15.0%), and Sphingidae (10 species, 4.0%). Among individuals, Erebidae (791 individuals, 29.2%) was the dominant taxon, followed by Geometridae (541 individuals, 20.0%), Noctuidae (509 individuals, 18.8%), Crambidae (208 individuals, 7.7%), and Sphingidae (196 individuals, 7.2%). These five families comprised 84 and 83% of the species richness and abundance, respectively (Table 2).

The annual differences in species richness and abundance were not significant (one-way ANOVA, species richness d.f. $=2, 5$, $F=0.73$, $p=0.53$; abundance d.f. $=2, 5$, $F=0.36$,

Table 1. Sampling dates and survey sites

Year	Date	Julian week	Sites (elevation)
2009	1 May	18	34°03′06″N, 125°07′27″E (18 m)
	16 Aug	34	34°03′01″N, 125°08′01″E (51 m)
	10 Oct	41	34°04′00″N, 125°06′50″E (176 m)
2012	6 Apr	14	34°04′24″N, 125°06′00″E (185 m)
	15 Jun	24	34°04′16″N, 125°06′26″E (228 m)
	10 Sep	37	34°03′50″N, 125°07′18″E (348 m)
2013	9 Jun	24	34°03′47″N, 125°07′22″E (378 m)
	7 Sep	36	34°04′20″N, 125°06′50″E (475 m)
			34°04′28″N, 125°06′41″E (522 m)

Table 2. Total number of species and individuals sampled for three years (2009, 2012, and 2013) from Isl. Gageodo, Jeollanam-do, South Korea

Family	No. of species	No. of individuals
Bombycidae	1	24
Crambidae	38	208
Drepanidae	2	16
Epiplemidae	3	3
Erebidae	44	791
Eutelidae	1	3
Geometridae	63	541
Lasiocampidae	3	39
Limacodidae	2	22
Noctuidae	57	509
Nolidae	1	1
Notodontidae	6	103
Psychidae	1	16
Pyralidae	9	56
Saturniidae	1	155
Sphingidae	10	196
Tortricidae	8	21
Zygaenidae	3	3
Total	253	2,707

$p = 0.71$). Yearly changes in the number of species and individuals showed 130 species and 736 individuals in 2013, 125 species and 1,444 individuals in 2012 and 99 species and 527 individuals in 2009. Annual changes in diversity and evenness indices showed that the Simpson's evenness index was highest in 2009 and other indices were similar during the three years (Table 3). Seasonal occurrence of species showed a unimodal pattern in which the numbers of species and individuals increased from April and May, peaked in June and decreased to September and October (Fig. 2).

Seven species were first recorded from Korea: two pyralids (*Herculia drabicilialis* Yamanaka and *Didia striatella* (Inoue)), four crambids (*Clupeosoma pryeri* (Butler), *Demobotys pervulgalis* (Hampson), *Yezobotys dissimilis* (Yamanaka) and *Syllepte cissalis* Yamanaka), and one erebid (*Hypena sinuosa* Wileman). One crambid *Miyakea raddeella* (Caradja) was also found from this study. This species was not included in the Korean list (Park et al., 2012), but Sasaki (2013) noted that it occurs in the Korean peninsula.

Table 3. Summary of the sampling for three years (2009, 2012, and 2013) from Isl. Gageodo, Jeollanam-do, South Korea

	2009	2012	2013
Species richness	99	125	130
Abundance	527	1,444	736
Simpson's evenness index	0.29	0.18	0.17
Shannon-Wiener diversity index	3.87	3.79	3.79
Berger-Parker dominance index	0.11	0.11	0.12

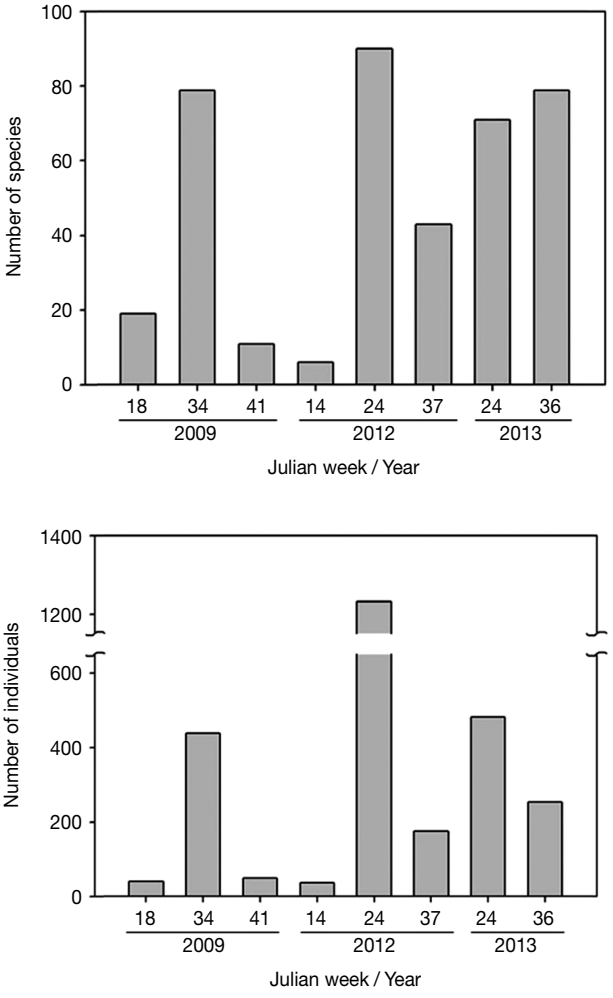

Fig. 2. Temporal changes of numbers of species and individuals for three years (2009, 2012, and 2013) from Isl. Gageodo, Shinan-gun, Jeollanam-do, South Korea.

SYSTEMATIC ACCOUNTS

Family Zygaenidae Latreille, 1809

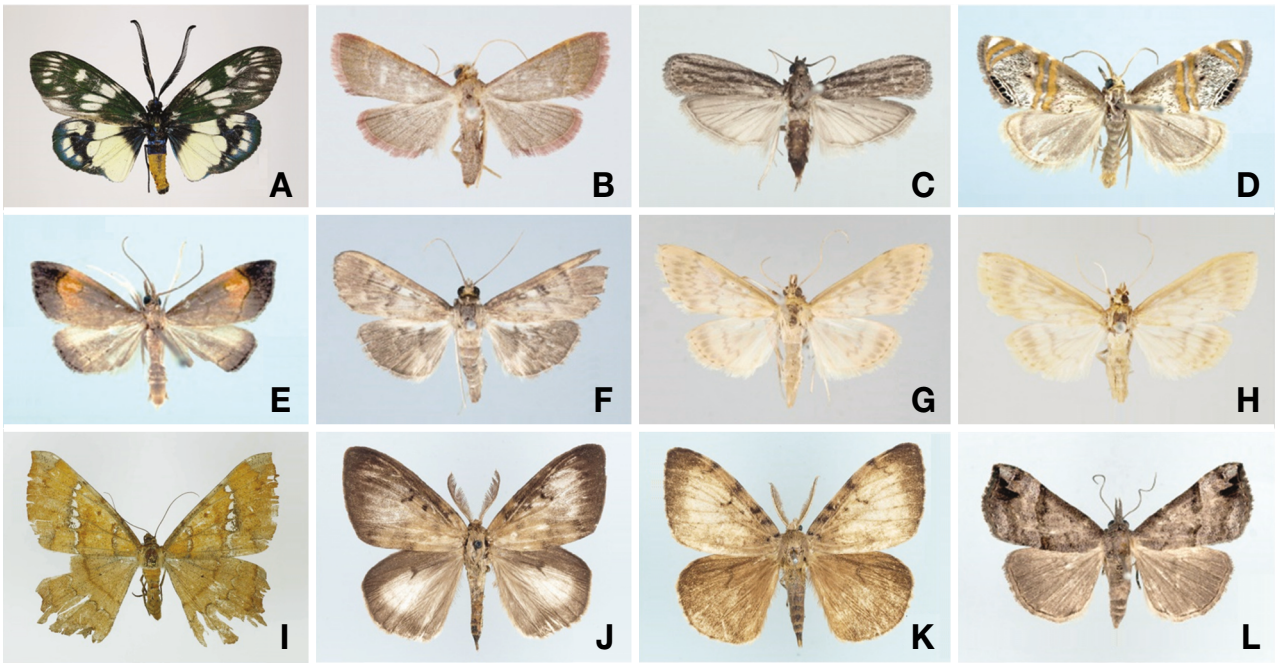

Fig. 3. Adult moths from Isl. Gageodo, Shinan-gun, Jeollanam-do, South Korea. A, *Eterusia aedea*; B, *Herculia drabicilialis*; C, *Didia striatella*; D, *Miyakea raddeella*; E, *Clupeosoma pryeri*; F, *Syllepte cissalis*; G, *Demobotys pervulgalis*; H, *Yezobotys dissimilis*; I, *Amblychia angeronaria*; J, *Lymantria albescens*; K, *Lymantria dispar*; L, *Hypena sinuosa*.

[1]****Eterusia aedea sugitanii*** **Matsumura, 1927 (Fig. 3A)**

Eterusia aedea sugitanii Matsumura, 1927: 83; Choi and Owada, 2010: 95. Type locality: Japan.

Note. This species has not been found since the first specimen was caught from this island (Choi and Owada, 2010). Although Gageodo island is closer to southern China, the morphological characteristics of the specimen more closely resemble those from Japan than China (Choi and Owada, 2010). This could support the hypothesis that the moth fauna in the southern Korean sea are similar to those on the islands of Japan. However, further study is needed to confirm this.

Family Pyralidae Linnaeus, 1758
Subfamily Pyralinae Linnaeus, 1758

[2]****Herculia drabicilialis*** **Yamanaka, 1968 (Figs. 3B, 5A)**

Herculia drabicilialis Yamanaka, 1968: 131, Pl. 23, fig. 9, Pl. 24, fig. 18, Pl. 25, fig. 21. Type locality: [Japan] Mt. Takao, Tokyo.

Material examined. 4♀, Korea, Jeollanam-do, Gageodo Island, 7 Sep 2013, Kim SS.

Diagnosis. Wing expanse 19 mm. This species shows short, upturned and reddish brown labial palpi, dark brown or ash-gray wing ground color, slender, pale yellow medial lines, gently excurved postmedial lines of forewing and slender, blackish medial lines of hindwing. This species can be distinguished from other congeners in Korea by its small size and pinkish wing cilia. The female genitalia can be distinguished by the strongly tapered papillae anales, long apophyses, simple ostium bursae, long, slender and membranous ductus bursae and the small ovate corpus bursae without a signum.

Distribution. Korea (new record), Japan.

Subfamily Phycitinae Zeller, 1839

[3]****Didia striatella*** **(Inoue, 1959) (Figs. 3C, 5B, C)**

Apomyelois striatella Inoue, 1959: 294, figs. 2, 3. Type locality: Japan.

Material examined. 1♀, Korea, Jeollanam-do, Gageodo Island, 7 Sep 2013, Kim SS.

Diagnosis. Wing expanse 22 mm. The adults show cuspid-like, upturned labial palpi that are covered with blackish brown scales, filiform antennae, grayish forewings with long blackish horizontal strips from the costa to termen and whit-

Korean name: [1]*맵시흑백알락나방(신칭), [2]*가붉은비단명나방(신칭), [3]*검얼룩알락명나방(신칭)

ish hindwings with blackish scales on veins. This species is superficially similar to *Trisides fasciatellus* (Inoue, 1982), but can be distinguished by the brown or dark ground color of the forewing, narrow grayish costa, blackish long horizontal strips and the whitish hindwing with blackish scales on veins. The female genitalia can be distinguished by the small papilla anales, long apophyses, weakly sclerotized ostium bursae, anteriorly expanded ductus bursae and large ovate corpus bursae with a large patch of dense processes of signa.

Distribution. Korea (new record), Japan.

Family Crambidae Latreille, 1810

Subfamily Crambinae Latreille, 1810

[1]****Miyakea raddeella*** **(Caradja, 1910) (Fig. 3D)**

Eromene raddeella Caradja, 1910: 115, 116. Type locality: [Russia] Radde, Amur.

Miyakea expansa Butler, 1881: 590; Bae et al., 2008: 45. Type locality: Japan.

Material examined. 1♀, Korea, Jeollanam-do, Gageodo Island, 9 Apr 2013, Kim SS.

Diagnosis. Wingspan 19 mm. This species can be distinguished by male genitalia that show two pairs of long thin processes from the basal part of the valva costa and three spinular processes in the aedeagus. This species was not listed in the Korean literature (Bae et al., 2008; Park et al., 2012). In Japan, this species was found in Hokkaido, Kyushu and Tsushima (Sasaki, 2013). Sasaki (2013) noted that this organism occurs in the northern part of the Korean peninsula. However we found this species in the southern part of Korea.

Distribution. Korea, Japan, Taiwan, China, Russia (Siberia).

Subfamily Odontiinae Guenée, 1854

[2]****Clupeosoma pryeri*** **(Butler, 1881) (Figs. 3E, 4C–E)**

Hydrorybina pryeri Butler, 1881: 588. Type locality: Japan.

Material examined. 1♂, Korea, Jeollanam-do, Gageodo Island, 9 Jun 2013, Kim SS.

Diagnosis. Wing expanse 16 mm. The species can be distinguished by the filiform antennae, long, porrect labial palpi, orange ground color of the forewing that shows the medially curved ante- and postmedial lines, lunular discocellular dot and blackish broad termen, and pale blackish hindwing with blackish postmedial line and termen. The male genitalia can be distinguished by the large fan-shaped valva with blackish stripes, triangular uncus, long, tongue-shaped juxta and short saccus, as well as the medially curved aedeagus without a cornutus. The 8th male abdomen showed a M-shaped strongly sclerotized plate anteriorly and a tri-pod shaped process posteriorly.

Distribution. Korea (new record), Japan.

Subfamily Pyraustinae Meyrick, 1890

[3]****Syllepte cissalis*** **Yamanaka, 1987 (Figs. 3F, 5D, E)**

Syllepte cissalis Yamanaka, 1987: 194, figs. 2, 4, 5, 5a. Type locality: [Japan] Tsurugi, Ishikawa Pref.

Material examined. 1♀, Korea, Jeollanam-do, Gageodo Island, 7 Sep 2013, Kim SS.

Diagnosis. Wing expanse 22 mm. The adults can be distinguished by the filiform antennae, the blackish forewing with long blackish discocellular spot and the medially strongly bent postmedial line and the blackish hindwing with blackish ante- and postmedial lines. The female genitalia can be distinguished by the simple small papillae anales, short apophyses, tube-shaped weakly sclerotized antrum, long ductus bursae and ovate corpus bursae with an elliptical signum patch and a short triangular process.

Distribution. Korea (new record), Japan.

[4]****Demobotys pervulgalis*** **(Hampson, 1913) (Figs. 3G, 4F, G, 5F, G)**

Pyrausta pervulgalis Hampson, 1913: 24. Type locality: Japan, China.

Material examined. 1♂1♀, Korea, Jeollanam-do, Gageodo Island, 9 Jun 2013, Kim SS.

Diagnosis. Wing expanse 22 mm. The adults can be distinguished by the yellowish filiform antennae, projected labial palpi beyond frons, yellowish body, yellowish white ground color of the forewing that shows pale blackish costa, central fascia with dark grayish horizontal lines on veins, medially strongly projected postmedial line and dark grayish horizontal lines on the termen and the yellowish white hindwing with grayish postmedial line and dots on the termen. The male genitalia can be distinguished by the strongly tapered uncus with apical hairs, slender valva with a long, button-shaped harpe, thin, hooked sacculus process and medially projected saccus, and the rod-shaped aedeagus with spinular cornuti. The female genitalia can be distinguished by the small papillae anales, simple ostium bursae, long, twisted ductus bursae and sac-shaped corpus bursae with a large, diamond-shaped signum.

Distribution. Korea (new record), Japan.

Korean name: [1]*칠점두줄포충나방(신칭), [2]*속주홍들명나방(신칭), [3]*섬연무늬들명나방(신칭), [4]*톱날들명나방(신칭)

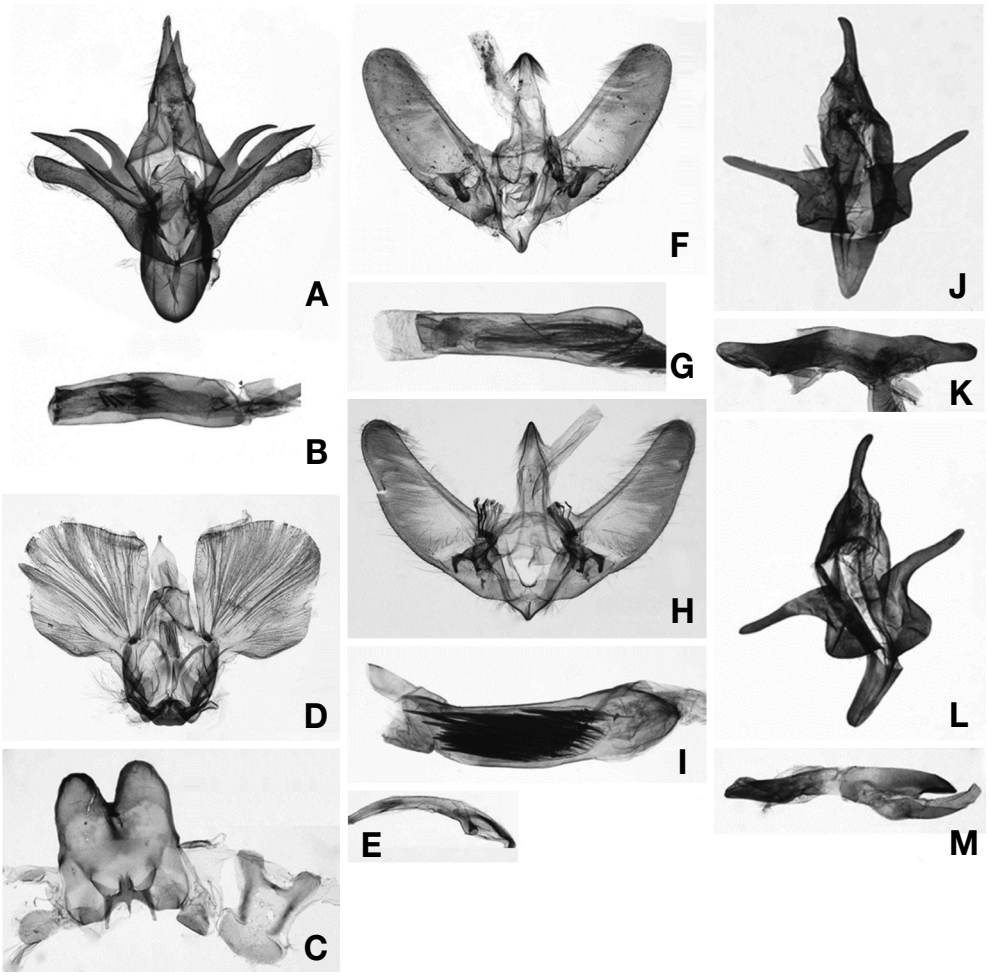

Fig. 4. Male abdomen and genitalia. A, B, *Miyakea raddeella*; C–E, *Clupeosoma pryeri*; F, G, *Demobotys pervulgalis*; H, I, *Yezobotys dissimilis*; J, K, *Lymantria albescens*; L, M, *Lymantria dispar*.

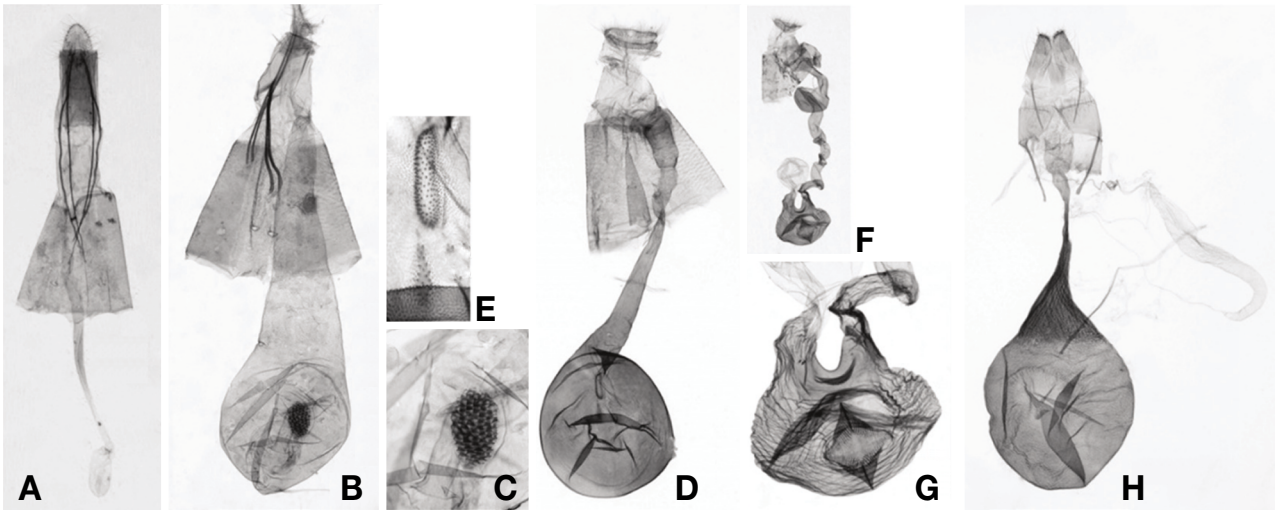

Fig. 5. Female genitalia. A, *Herculia drabicilialis*; B, C, *Didia striatella*; D, E, *Syllepte cissalis*; F, G, *Demobotys pervulgalis*; H, *Hypena sinuosa*.

[1]*__*Yezobotys dissimilis*__ **(Yamanaka, 1958) (Figs. 3H, 4H, I)**

Pyrausta dissimilis Yamanaka, 1958: 265, Pl. 35, figs. 1, 2, 4. Type locality: Japan.

Material examined. 3♂, Korea, Jeollanam-do, Gageodo Island, 9 Jun 2013, Kim SS.

Diagnosis. Wing expanse 24–28 mm. This species is very similar to *Demobotys pervulgalis* (Hampson), but can be distinguished by the broad central fasica of the forewing and the strongly dentate postmedial line of fore- and hindwings. The male genitalia are similar to those of *Demobotys pervulgalis*, but can be distinguished by the short spinular harpe and sacculus of valva, and the dense spinular cornuti of the male aedeagus.

Distribution. Korea (new record), Japan.

Family Geometridae Leach, 1815

Subfamily Ennominae Duponchel, 1845

[2]*__*Amblychia angeronaria*__ **Guenée, [1858] (Fig. 3I)**

Amblychia angeronaria Guenée, [1858], in Boisduval & Guenée: 215; Choi et al., 2013: 92. Type locality: [India] Central.

Amblychia sinibia Wehrli, 1938: 88. Type locality: [China] Sichuan, Tachien-lu (Kangding).

Amblychia torrida Moore, 1877: 621. Type locality: [Andaman Island] South Andaman (Port Blair).

Note. The largest geometrid species in Korea was first found from this island (Choi et al., 2013). In 2014, we also found few specimens hiding under leaves during daytime and flying at night.

Family Erebidae Leach, [1815]

Subfamily Lymantriinae Hampson, 1893

[3]*__*Lymantria albescens*__ **Hori and Umeno (Figs. 3K, 4J, K)**

Lymantria dispar ab. *albescens* Matsumura, 1927: 25. Type locality: [Japan] Okinawa.

Lymantria dispar albescens Hori and Umeno, 1930: 18. Type locality: [Japan] Yakushjima Island, Ishigakijima.

Lymantria dispar: Shin and Noh, 1970: 36.

Lymantria dispar postalba Inoue, 1956: 141; Kim, 2002: 7.

Note. This species is externally similar to *L. dispar* (Figs. 3K, 4L, M), but can be distinguished by the smaller wingspan, darker ground color of the male wing, and the smaller male genitalia and short aedeagus. We suspected that this species occurs on the island, but no specimens were found during this survey.

Subfamily Hypeninae Herrich-Schäffer, [1851]

[4]*__*Hypena sinuosa*__ **Wileman, 1911 (Figs. 3L, 5H)**

Hypena sinuosa Wileman, 1911: 263. Type locality: [Japan] Kagoshima, Satsuma.

Material examined. 1♀, Korea, Jeollanam-do, Gageodo Island, 7 Sep 2013, Kim SS.

Diagnosis. Wing expanse 23 mm. The adults can be distinguished by the filiform antennae, long porrect labial palpi, dark brownish ground color of forewing that shows the medially strongly curved antemedial line, blackish, transverse parallel postmedial lines and slanted apical streak with two large triangular dots, and the dark brownish hindwing. The female genitalia can be distinguished by the small papillae anales, tube-shaped antrum, thin ductus bursae, and large ovate corpus bursae that show strongly sclerotized stripes posteriorly and no signum.

Distribution. Korea (new record), Japan, Taiwan.

ACKNOWLEDGMENTS

This study was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR 201501203).

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Received September 4, 2015
Revised October 19, 2015
Accepted October 21, 2015