

Identification of Japanese *Lymantria* Species (Lepidoptera: Lymantriidae) Based on Morphological Characteristics of Adults

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Abstract: The morphological characteristics of adult male and female moths of seven Japanese *Lymantria* species which consisted of four Asian gypsy moth (AGM) species [*L. dispar japonica* (Motschulsky), *L. umbrosa* (Butler), *L. albescens* Hori and Umeno, and *L. postalba* Inoue] and three other species [*L. xyliana* Swinhoe, *L. mathura* Moore, and *L. monacha* (Linnaeus)] were shown for species identification. We showed ground color and markings of wings and morphological characteristics of genitalia. These seven *Lymantria* species could be discriminated among species by the above mentioned morphological characteristics except a combination of Hokkaido populations of *L. dispar japonica* and *L. umbrosa*. This result suggests that morphological characteristics of adult male and female moths are useful in identifying these seven Japanese *Lymantria* species.

Key Words: *Lymantria*, AGM, morphological characteristics, species identification

Introduction

Many species in the tussock moth genus *Lymantria* are significant forestry pests, including the gypsy moth *Lymantria dispar* (Linnaeus). Schintlmeister (2004) was the first to perform a worldwide revision of the genus and reported a total of 167 species of *Lymantria*. Pogue and Schaefer (2007) reviewed 31 species and three subspecies of *Lymantria* that could result in severe damage to native forests and economic losses if accidentally introduced into North America. Of these *Lymantria* species, 12 are distributed in Japan (Pogue and Schaefer, 2007).

Pogue and Schaefer (2007) designated European gypsy moth (EGM) and Asian gypsy moth (AGM). According to Pogue and Schaefer (2007), EGM is a single subspecies of *Lymantria dispar dispar* (Linnaeus) which is distributed throughout Europe west of the Ural Mountains and North Africa and has been introduced into North America. AGM is composed of two subspecies of *Lymantria dispar* and other three species, which occur throughout temperate Asia, including Japan. Among these, *Lymantria dispar asiatica* Vnukovskij is distributed widely in continental Asia (China, Korea,

Far East Russia etc.). In Japan, *Lymantria dispar japonica* (Motschulsky) is distributed in Honshu, Shikoku, Kyushu and southwestern Hokkaido; *Lymantria umbrosa* (Butler) is distributed in Hokkaido, especially the eastern part; *Lymantria albescens* Hori and Umeno is distributed in southern Ryukyu Islands; and *Lymantria postalba* Inoue is distributed in southern Kyushu, Tsushima, Yakushima and northern Ryukyu Islands.

Kishida (2011) classified these Asian gypsy moth species into two species (*L. dispar* and *L. albescens*) (Table 1). Kishida (2011) classified *L. dispar* into two subspecies: *L. dispar japonica* for populations from southern Hokkaido, Honshu, Shikoku, and Kyushu; *Lymantria dispar hokkaidoensis* Goldschmidt for populations from northern and eastern Hokkaido. Additionally, Kishida (2011) classified *L. albescens* into three subspecies: *Lymantria albescens albescens* Hori and Umeno for populations from south of Amamioshima; *Lymantria albescens postalba* Inoue for populations from southern Kyushu, Tanegashima and Yakushima; *Lymantria albescens tsushimensis* Inoue for populations from Tsushima.

The biological traits of AGM are different from those

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Table 1 Correspondence table of Japanese *Lymantria* spp. designated as Asian gypsy moth by Pogue and Schaefer (2007) and those classified by Kishida (2011)

Pogue and Schaefer (2007)		Kishida (2011)	
Scientific Name	Distribution	Scientific Name	Distribution
<i>L. dispar japonica</i> (Motschulsky)	Southwestern Hokkaido, Honshu, Shikoku, Kyushu	→ <i>L. dispar japonica</i> (Motschulsky)	Southern Hokkaido, Honshu, Shikoku, Kyushu, Tsushima
<i>L. umbrosa</i> (Butler)	Hokkaido, especially eastern part	→ <i>L. dispar hokkaidoensis</i> Goldschmidt	Eastern and Northern Hokkaido
<i>L. albescens</i> Hori and Umeno	Southern Ryukyu Islands	→ <i>L. albescens albescens</i> Hori and Umeno	Amamioshima, Tokunoshima, Okinoerabujima, Okinawajima, Ishigakijima, Iriomotejima
<i>L. postalba</i> Inoue	Southern Kii Peninsula, Okinoshima in Kochi Prefecture, Danjo-gunto, Southern Kyushu, Tsushima, Tanegashima, Yakushima, Northern Ryukyu Islands	→ <i>L. albescens postalba</i> Inoue	Southern Kii Peninsula, Okinoshima in Kochi Prefecture, Goto-retto, Danjo-gunto, Southern Kyushu, Tanegashima, Yakushima
		↘ <i>L. albescens tsushimensis</i> Inoue	Tsushima

of EGM. For example, larvae of Asian origin have a broader host range (Baranchikov, 1989). In addition, eggs of AGM require shorter exposure to low temperature for diapause completion than EGM (Keena, 1996). Moreover, females of AGM can fly (Schaefer *et al.*, 1984; Baranchikov, 1989), whereas females of EGM can not (Wallner *et al.*, 1995; Keena *et al.*, 2008). Additionally, the gravid females of AGM are attracted to lights in ports and they deposit eggs on ships (Wallner *et al.*, 1995).

Therefore, the U.S. and Canadian governments have become very anxious about the invasion of AGM into their territories (Myers *et al.*, 2000). Consequently, they have requested that countries with AGM to certify that ships destined for the United States and Canada are free from AGM egg masses (NAPPO, 2009). Thus, some of Japanese port authorities initiated an AGM control program in 2007 to reduce the AGM population in ports (Yokochi, 2007).

In addition to four AGM species, eight other *Lymantria* species are distributed in Japan (Pogue and Schaefer, 2007). Identification of these species is important, particularly to determine appropriate control methods and control areas around ports because their biology (host range, flight ability of adult females, and others) differs among species (Pogue and Schaefer 2007; Keena *et al.*, 2008; Iwaizumi and Arakawa, 2010).

Traditionally, *Lymantria* species have been identified by using morphological characteristics of adult male and female moths (Inoue, 1982; Schintlmeister, 2004; Pogue and Schaefer, 2007; Kishida, 2011). In this study, we showed the morphological characteristics of adult male and female moths of seven Japanese *Lymantria*

species which include four AGM species, and discussed identification method for these species.

Materials and Methods

In this study, 12 males of three populations of *L. dispar japonica*, five males of one population of *L. umbrosa*, five males of one population of *L. albescens*, four males of one population of *L. postalba*, five males of one population of *L. xyliana*, five males of two populations of *L. mathura*, and two males of one population of *L. monacha* were used (Table 2). Additionally, one female each of two populations of *L. dispar japonica*, one female each of one population each of *L. umbrosa*, *L. albescens*, *L. xyliana*, *L. mathura*, and *L. monacha* were used. These specimens were collected mainly as adults between 2004 and 2012. Some specimens were collected as egg mass, sixth instar larva, or pupa, and reared in a laboratory until adult emergence. All these specimens were the voucher specimens in Arimoto and Iwaizumi (2014). The specimens are preserved at Yokohama Plant Protection Station under the serial voucher specimen number.

The photographs of adults were taken on polyurethane mat using a digital camera (COOLPIX 5200, Nikon, Tokyo, Japan). The images were enhanced with Adobe Photoshop Elements® 7.0 (Adobe Systems Incorporated, San Jose, CA, USA).

To prepare the genitalia, the abdomen of a male was broken off and put in 10% potassium hydroxide (KOH) in a test tube and heated for 30–40 minutes (depending on size) using a water bath (ISOTEMP 202, Fisher Scientific, Dubuque, Iowa, U.S.A.). The temperature was set at 60°C. The abdomen was then transferred to 70%

Table 2 Sources of *Lymantria* spp.

Species	Japanese Name	Sex	Country	Prefecture	City	Collection date	Collection stage	Voucher specimen No. ^a	Storage condition		
<i>L. (Porthetria) dispar japonica</i>	Maimaiga	♂	Japan	Aichi	Nagoya	8-Jul-2005	adult	17	dry specimen		
		♂	Japan	Aichi	Nagoya	30-Jun-2005	adult	18	dry specimen		
		♂	Japan	Aichi	Nagoya	10-Jul-2005	adult	97	dry specimen		
		♂	Japan	Aichi	Nagoya	13-Jul-2005	adult	98	dry specimen		
		♂	Japan	Aichi	Nagoya	17-Jul-2005	adult	99	dry specimen		
		♂	Japan	Hokkaido	Sapporo	17-Aug-2005	adult	15	dry specimen		
		♂	Japan	Hokkaido	Sapporo	3-Aug-2004	adult	63	dry specimen		
		♂	Japan	Hokkaido	Sapporo	5-Aug-2004	adult	64	dry specimen		
		♂	Japan	Hokkaido	Sapporo	6-Aug-2004	adult	65	dry specimen		
		♂	Japan	Hokkaido	Otaru	25-Jul-2004	adult	9	dry specimen		
		♂	Japan	Hokkaido	Otaru	26-Jul-2004	adult	58	dry specimen		
		♂	Japan	Hokkaido	Otaru	6-Aug-2004	adult	60	dry specimen		
		♀	Japan	Nara	Nara	28-Mar-2012	egg mass	325	dry specimen		
		♀	Japan	Hokkaido	Muroran	2010	egg mass	166	dry specimen		
		<i>L. (Porthetria) umbrosa</i>	Ezo-maimai	♂	Japan	Hokkaido	Otaru	16-Aug-2004	adult	59	dry specimen
				♂	Japan	Hokkaido	Otaru	10-Aug-2004	adult	61	dry specimen
				♂	Japan	Hokkaido	Otaru	6-Aug-2004	adult	180	dry specimen
♂	Japan			Hokkaido	Otaru	7-Aug-2004	adult	181	dry specimen		
♂	Japan			Hokkaido	Otaru	22-Aug-2004	adult	182	dry specimen		
♀	Japan			Hokkaido	Tomakomai	19-Aug-2009	adult	196	dry specimen		
<i>L. (Porthetria) albescens</i>	Shiroshita-maimai	♂	Japan	Okinawa	Naha	9-Jun-2005	adult	268	dry specimen		
		♂	Japan	Okinawa	Naha	9-Jun-2005	adult	281	dry specimen		
		♂	Japan	Okinawa	Naha	7-Jun-2005	adult	282	dry specimen		
		♂	Japan	Okinawa	Naha	6-Jun-2005	adult	283	dry specimen		
		♂	Japan	Okinawa	Naha	9-Jun-2005	adult	284	dry specimen		
		♀	Japan	Okinawa	Naha	20-May-2011	6th inster larva	137	dry specimen		
<i>L. (Porthetria) postalba</i>	Ko-shiroshita-maimai	♂	Japan	Nagasaki	Tsushima	30-Jul-2004	adult	78	dry specimen		
		♂	Japan	Nagasaki	Tsushima	30-Jul-2004	adult	79	dry specimen		
		♂	Japan	Nagasaki	Tsushima	30-Jul-2004	adult	80	dry specimen		
		♂	Japan	Nagasaki	Tsushima	6-Aug-2004	adult	81	dry specimen		
<i>L. (Porthetria) xylina</i>	Mae-guro-maimai	♂	Japan	Okinawa	Naha	20-May-2011	pupa	116	dry specimen		
		♂	Japan	Okinawa	Naha	20-May-2011	pupa	117	dry specimen		
		♂	Japan	Okinawa	Naha	20-May-2011	pupa	118	dry specimen		
		♂	Japan	Okinawa	Naha	20-May-2011	pupa	119	dry specimen		
		♂	Japan	Okinawa	Naha	20-May-2011	pupa	120	dry specimen		
		♀	Japan	Okinawa	Naha	20-May-2011	6th inster larva	135	dry specimen		
<i>L. (Nyctria) mathura</i>	Kashiwa-maimai	♂	Japan	Hokkaido	Otaru	20-Aug-2009	egg mass	124	dry specimen		
		♂	Japan	Hokkaido	Otaru	20-Aug-2009	egg mass	125	dry specimen		
		♂	Japan	Hokkaido	Otaru	20-Aug-2009	egg mass	126	dry specimen		
		♂	Japan	Kanagawa	Yokosuka	22-Jul-2005	adult	254	dry specimen		
		♂	Japan	Kanagawa	Yokosuka	22-Jul-2005	adult	255	dry specimen		
<i>L. (Lymantria) monacha</i>	Nonne-maimai	♀	Japan	Hokkaido	Tomakomai	19-Aug-2010	adult	57	dry specimen		
		♂	Japan	Hokkaido	Tomakomai	19-Aug-2009	adult	150	dry specimen		
		♂	Japan	Hokkaido	Tomakomai	5-Aug-2009	adult	240	frozen specimen		
		♀	Japan	Hokkaido	Tomakomai	5-Aug-2009	adult	239	dry specimen		

^a All voucher specimens are preserved at Yokohama Plant Protection Station under the serial voucher specimen number.

ethyl alcohol and cleaned of internal matter and scales. Then, the genitalia were dissected from the abdomen. The abdominal pelt was slit up the right side with ventral side up and any additional cleaning was done. The aedoeagus was dissected from the male genitalia. The left valve of the male genitalia was removed. All dissections were done with the aid of forceps in 70% ethyl alcohol in a petri dish under stereomicroscope (SZX 16, OLYMPUS, Tokyo, Japan). The same technique was applied to the female. After study, the genitalia was placed in a glass genitalia vial containing glycerin and permanently stored with the remaining body.

Photographs of genitalia were taken with a digital camera (FX 380, OLYMPUS, Tokyo, Japan) mounted on a stereomicroscope (SZX 16, OLYMPUS, Tokyo, Japan).

The images were enhanced with Adobe Photoshop Elements® 7.0.

The terms for lines and markings of wings and genitalia follow Pogue and Schaefer (2007).

Results

In the seven Japanese *Lymantria* species used in this study, five species (*L. dispar japonica*, *L. umbrosa*, *L. albescens*, *L. postalba* and *L. xylina*) belong to subgenus *Porthetria* (Fig. 1), one species (*L. mathura*) belong to subgenus *Nyctria* (Fig. 9), and one species (*L. monacha*) belong to subgenus *Lymantria* (Fig. 11). We showed ground colors and markings of wings and genitalia of male and female of these species. In this study, we

could not collect female of *L. postalba*. Therefore, we cited a photograph of a female of *Lymantria dispar postalba* Inoue in Inoue (1958) as *L. postalba* (Fig. 13). Consequently, we could not show the morphological characteristics of genitalia of female of *L. postalba*.

Morphological characteristics of wings and genitalia of seven *Lymantria* species

Lymantria (Porthetria) dispar japonica (Motschulsky)

Japanese name: Maimaiga

Male (Figs. 1, 2-4)

The ground color of the forewing is brown in the Nagoya population (Fig. 2) or cream in Hokkaido populations (Figs. 3, 4). The orbicular spot is black and present in the middle of the discal cell in the Nagoya population (Fig. 2) or minute in Hokkaido populations (Figs. 3, 4). The reniform spot is black, angulate, along the vein at the end of the discal cell. The ground color of the hindwing is brown in the Nagoya population (Fig. 2) or cream heavily suffused with dark brown in Hokkaido populations (Figs. 3, 4). The lateral process is absent from the tegumen of genitalia. The valve is undivided and not fused ventrally. The dorsal process of the valve is contiguous with the costal margin of the valve, straight, and the apex is narrowly rounded. The aedoeagus is slightly bent medially.

Female (Figs. 1, 13)

The ground color of the forewing is brownish-white. The orbicular spot is small, present in the middle of the discal cell. The reniform spot is V-shaped along veins at the end of the discal cell. The ground color of the hindwing is brownish-white. The hindwing has a dirty white fringe with fuscous spots between veins. The shape of papilla analis of genitalia is quadrate.

Lymantria (Porthetria) umbrosa (Butler)

Japanese name: Ezo-maimai

Male (Fig. 5)

The ground color of the forewing is cream. The orbicular spot is minute. The reniform spot is black, angulate, along the vein at the end of the discal cell. The ground color of the hindwing is cream, heavily suffused with dark brown. The lateral process is absent from the tegumen of genitalia. The valve is undivided, not fused ventrally. The dorsal process of the valve is contiguous with the costal margin of the valve, straight, and its apex is narrowly rounded. The aedoeagus is slightly bent medially.

Female (Fig. 13)

The ground color of the forewing is brownish-white. The orbicular spot is a small, black dot, present in the middle of the discal cell. The reniform spot is crescent-shaped along the veins at the end of the discal cell. The ground color of the hindwing is brownish-white. The hindwing has a dirty white fringe with fuscous spots between veins. The shape of the papilla analis of genitalia is quadrate.

Lymantria (Porthetria) albescens Hori and Umeno

Japanese name: Shiroshita-maimai

Male (Fig. 6)

The ground color of the forewing is white suffused with gray, especially along the costa and near the base. The orbicular spot is small, black, and present in the middle of the discal cell. The reniform spot is black, V-shaped, along the vein at the end of the discal cell. The ground color of the hindwing is white. The costa of the hindwing have an elongate band of dark gray from the base to the apex. The lateral process is absent from the tegumen of genitalia. The valve is undivided, not fused ventrally. The dorsal process of the valve is contiguous with the costal margin of the valve, straight, elongate, and its apex is knob-shaped. The aedoeagus is slightly bent medially.

Female (Fig. 13)

The ground color of the forewing is white lightly suffused with reddish-brown. The orbicular spot is black, minute, and present at the middle of the discal cell. The reniform spot is black, crescent-shaped along the veins at the end of the discal cell. The ground color of the hindwing is white. The color of the fringe of the hindwing is white. The shape of the papilla analis of genitalia is quadrate.

Lymantria (Porthetria) postalba Inoue

Japanese name: Ko-shiroshita-maimai

Male (Fig. 7)

The ground color of the forewing is light brown. The color of the area distal to the postmedial line is brown. The orbicular spot is a small dot present in the middle of the discal cell. The reniform spot is black, V-shaped, along the vein at the end of the discal cell. The ground color of the hindwing is light brown. The color of the costal margin of the hindwing is brown. The lateral process is absent from the tegumen of genitalia. The valve is undivided, not fused ventrally. The dorsal process of the valve is contiguous with the costal margin of the valve, straight, and its apex is narrowly rounded. The aedoeagus is slightly bent medially.

Female (Fig. 13)

The ground color of the forewing is white with a pale rufous tint. The orbicular spot is minute, present in the middle of the discal cell. The reniform spot is a faint angulate line present at the end of the discal cell. The ground color of the hindwing is white. The color of the fringe of the hindwing is white.

Lymantria (Porthetria) xyлина Swinhoe

Japanese name: Mae-guro-maimai

Male (Fig. 8)

The ground color of the forewing is white. The orbicular spot is absent. The reniform spot is not evident, incorporated into the postmedial line. The postmedial line is brown, crenulate and extends from the costa to the posterior margin. The ground color of the hindwing is white. The costal margin of the hindwing has a wide black band. The lateral process is absent from the tegumen of genitalia. The valve is undivided, not fused ventrally. The dorsal process of the valve is contiguous with the costal margin of the valve, straight, elongate, and its apex is narrowly rounded. The aedeagus is slightly bent at the middle.

Female (Fig. 13)

The ground color of the forewing is white. The orbicular spot and reniform spot are absent. The postmedial line is wide, light brown, angulate, and extends from the costa to the posterior margin. The ground color of the hindwing is white. The shape of the papilla analis of genitalia is quadrate. The length of the ductus bursae is very short, shorter than the length of the ventral plate of the ostium bursae.

Lymantria (Nyctria) mathura Moore

Japanese name: Kashiwa-maimai

Male (Figs. 9, 10)

The ground color of the forewing is white. The color of all markings of the forewing is gray. The orbicular spot is round and adjacent to the reniform spot. The ground color of the hindwing is yellow. The color of all markings of the hindwing is gray. The lateral process is arising from the tegumen of genitalia. The valves are deeply divided to the dorsal and ventral processes. The dorsal process is bifurcated with the dorsal-most process shorter than the ventral process. The valves are fused ventrally. The aedeagus is straight. The width of the aedeagus is uniformly equal.

Female (Figs. 9, 13)

The ground color of the forewing is white. The orbicular spot is ovate. The reniform spot is present

at the end of the discal cell. The ground color of the hindwing is white irrorated with pink. The shape of the papilla analis of genitalia is kidney-shaped.

Lymantria (Lymantria) monacha (Linnaeus)

Japanese name: Nonne-maimai

Male (Figs. 11, 12)

The ground color of the forewing is white. The color of all markings of the forewing is black. The reniform spot is chevron-shaped at the end of the discal cell. The ground color of the hindwing is pale gray. The lateral process is arising from the tegumen of genitalia. The valve is undivided, not fused ventrally. The thumb-like basal projection is present at the base of the valve. The dorsal process of the valve is contiguous with the costal margin of the valve, slightly curved, and slightly shorter than the valve. The aedeagus is slightly bent and narrowed just before the middle. The front shape of the aedeagus is triangular.

Female (Figs. 11, 13)

The ground color of the forewing is white. The color of all markings of the forewing is black. The reniform spot is chevron-shaped at the end of the discal cell. The ground color of the hindwing is pale gray. The shape of the papilla analis of genitalia is rectangulate.

Discussion

1. Identification of adult male by ground color and marking of wings

In seven Japanese *Lymantria* species used in this study, *L. mathura* (Fig. 10) which belong to subgenus *Nyctria* could be discriminated among the other six species by the yellow ground color of the hindwing. *L. monacha* (Fig. 12) which belong to subgenus *Lymantria* could be discriminated among the other six species by the white ground color of the forewing with all black markings. In five species which belong to subgenus *Porthetria*, *L. xyлина* (Fig. 8) could be discriminated among the other species by the white ground color of its forewing with an unclear reniform spot incorporated into the postmedial line. The forewing postmedial line of *L. xyлина* (Fig. 8) was brown, crenulate and extended from the costa to the posterior margin. *L. albescens* (Fig. 6) could be discriminated among other species by the white hindwing with a dark gray band that extended from the base to apex of the costa. *L. postalba* (Fig. 7) could be discriminated among other species by the light brown hindwing with brown costal margin. *L. dispar japonica* (Fig. 2) could be discriminated among other species by

the brown ground color of the hindwing. *L. umbrosa* (Fig. 5) could be discriminated among other species by the cream hindwing that was heavily suffused with dark brown. However, the color of the hindwing of the Sapporo population (Fig. 3) and Otaru population (Fig. 4) of *L. dispar japonica* were the same as *L. umbrosa* (Fig. 5). The ground color and markings of forewing of these Hokkaido populations of *L. dispar japonica* (Figs 3, 4) were also the same as *L. umbrosa* (Fig. 5). Therefore, Hokkaido populations of *L. dispar japonica* could not be discriminated from *L. umbrosa*.

As mentioned above, the seven Japanese *Lymantria* species could be discriminated by ground color and markings of wings of adult males except for a combination of Hokkaido populations of *L. dispar japonica* and *L. umbrosa*.

2. Identification of adult male by morphological characteristics of genitalia

In seven Japanese *Lymantria* species used in this study, *L. mathura* (Fig. 10) which belong to subgenus *Nyctria* could be discriminated among other six species by the tegumen with lateral process, deeply divided valve with prominent dorsal and ventral processes, and valves fused ventrally. *L. monacha* (Fig. 12) which belong to subgenus *Lymantria* could be discriminated among the other six species by the tegumen with lateral process, undivided valve with thumb-like basal projection, and dorsal process slightly shorter than the valve. The five species which belong to subgenus *Porthetria* (Figs 2-8) could be discriminated among *L. mathura* (Fig. 10) and *L. monacha* (Fig. 12) by the tegumen without lateral processes. In five species which belong to subgenus *Porthetria*, *L. albescens* (Fig. 6) could be discriminated among *L. dispar japonica* (Figs. 2-4), *L. umbrosa* (Fig. 5), and *L. postalba* (Fig. 7) by a more elongated dorsal process of valve. Although the dorsal process of *L. xylyna* (Fig. 8) was also elongated the same as *L. albescens* (Fig. 6), *L. albescens* could be discriminated from *L. xylyna* by the knob-shaped tip of the dorsal process. *L. xylyna* (Fig. 8) could be discriminated among *L. dispar japonica* (Figs 2-4), *L. umbrosa* (Fig. 5), and *L. postalba* (Fig. 7) by a more elongated dorsal process of valve. Although the dorsal process of *L. albescens* (Fig. 6) was also elongated the same as *L. xylyna* (Fig. 8), *L. xylyna* could be discriminated from *L. albescens* by a narrowly rounded tip of the dorsal process. *L. dispar japonica* (Figs 2-4), *L. umbrosa* (Fig. 5) and *L. postalba* (Fig. 7) could not be discriminated among species because morphological characteristics of the valve were very similar in these

species.

In this study, we showed the morphological characteristics of aedoeagus of seven Japanese *Lymantria* species. Among these, *L. mathura* (Fig. 10) which belong to subgenus *Nyctria* could be discriminated among the other six species by the uniformly equal width of aedoeagus. The aedoeagus of *L. monacha* (Fig. 12) which belong to subgenus *Lymantria* was slightly bent and narrowed just before the middle. Additionally, the front shape of aedoeagus of *L. monacha* was triangular (Fig. 12). *L. monacha* could be discriminated among the other six species by the above mentioned morphological characteristics of aedoeagus. The aedoeagus of five species which belong to subgenus *Porthetria* were slightly bent medially (Figs 2-8). In these five species, *L. xylyna* (Fig. 8) may be discriminated among other four species (Figs. 2-7) by wider width of the front of the aedoeagus. However, the shapes of aedoeagus of the other four species which belong to subgenus *Porthetria* were very similar (Figs. 2-7). Therefore, these four species could not be discriminated by the shape of aedoeagus.

As mentioned above, the seven Japanese *Lymantria* species could be discriminated by morphological characteristics of male genitalia except combinations among *L. dispar japonica*, *L. umbrosa* and *L. postalba*.

3. Identification of adult female by ground color and marking of wings

In seven Japanese *Lymantria* species used in this study, *L. mathura* which belong to subgenus *Nyctria* could be discriminated among the other six species by white irrorated with pink color of the hindwing (Fig. 13). *L. monacha* which belong to subgenus *Lymantria* could be discriminated among the other six species by white ground color of forewing with all black markings (Fig. 13). In five species which belong to subgenus *Porthetria*, *L. xylyna* did not have orbicular spot and reniform spot on forewing (Fig. 13). The postmedial line on the forewing of *L. xylyna* was wide, light brown, angulate and extended from the costa to the posterior margin (Fig. 13). *L. xylyna* could be discriminated among other species by these markings of forewing (Fig. 13). The ground color of forewings of *L. dispar japonica* and *L. umbrosa* were brownish-white and these two species had orbicular spot and reniform spots on forewings (Fig. 13). The ground color of hindwings of these two species were brownish-white and the hindwings of these two species had a dirty white fringe with fuscous spots between veins (Fig. 13). These two species could be discriminated among other species by the above mentioned ground color and

markings of wings (Fig. 13). However, these two species could not be discriminated because ground color and markings of wings of these two species were very similar (Fig. 13). The ground color and fringe of hindwings of *L. albescens* and *L. postalba* were white and the fringes of hindwings of these two species did not have spots between veins (Fig. 13). These two species could be discriminated among other species by these ground color and markings of hindwings (Fig. 13). However, these two species could not be discriminated because ground color and markings of wings of these two species were very similar (Fig. 13).

As mentioned above, the seven Japanese *Lymantria* species could be discriminated by ground color and markings of wings of adult females except combinations of *L. dispar japonica* and *L. umbrosa*, and *L. albescens* and *L. postalba*.

4. Identification of adult female by morphological characteristics of genitalia

In this study, we could not collect female of *L. postalba*. Therefore, we could not show the genitalia of female of *L. postalba*.

In six Japanese *Lymantria* species used in this study, *L. mathura* which belong to subgenus *Nyctria* could be discriminated among the other five species by kidney-shaped papilla analis (Fig. 13). *L. monacha* which belong to subgenus *Lymantria* could be discriminated among the other five species by rectangular shaped papilla analis (Fig. 13). The four species which belong to subgenus *Porthetria* could be discriminated among *L. mathura* and *L. monacha* by quadrate shaped papilla analis (Fig. 13). In four species which belong to subgenus *Porthetria*, *L. xyliana* could be discriminated among the other three species (*L. dispar japonica*, *L. umbrosa*, and *L. albescens*) by very short ductus bursae (Fig. 13). However, the morphological characteristics of genitalia of *L. dispar japonica*, *L. umbrosa* and *L. albescens* were similar among species (Fig. 13). Therefore, these three species could not be discriminated among species.

As mentioned above, the six Japanese *Lymantria* species could be discriminated by morphological characteristics of female genitalia except combinations among *L. dispar japonica*, *L. umbrosa* and *L. albescens*.

In this study, the seven Japanese *Lymantria* species which include four AGM species could be discriminated among species by morphological characteristics of adult male and female moths except a combination of Hokkaido populations of *L. dispar japonica* and *L. umbrosa*.

The information about morphological characteristics of adult male and female moths of seven Japanese *Lymantria* species which were shown in this study is useful to identify adult male and female moths of those *Lymantria* species which occur in and around port areas. In the future, the investigation for clarification of the biology about occurrence of those *Lymantria* species in and around port areas is expected.

Acknowledgments

We thank to Dr. S. Yoshimatsu, National Institute for Agro-Environmental Sciences who gave us useful suggestions.

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和 文 摘 要

日本産*Lymantria*属 (チョウ目：ドクガ科)の成虫の
形態的特徴による識別 (英文)有本 誠・岩泉 連¹⁾

横浜植物防疫所調査研究部

種を識別するため、日本産*Lymantria*属7種、即ち、アジ
ア型マイマイガ (AGM) 指定4種 (マイマイガ、エゾマイマイ、
シロシタマイマイ及びコシロシタマイマイ) 及びその他3種 (マエ
グロマイマイ、カシワマイマイ及びノンネマイマイ) の雌雄成虫
の形態的特徴を示した。翅の地色及び斑紋、及び交尾器の

形態的特徴を示した。これらの日本産*Lymantria*属7種は上
述の形態的特徴により、北海道産のマイマイガ及びエゾマイマ
イの組み合わせを除き種間で識別出来た。この結果は雌雄成
虫の形態的特徴がこれらの日本産*Lymantria*属を同定するた
めに有用であることを示唆する。

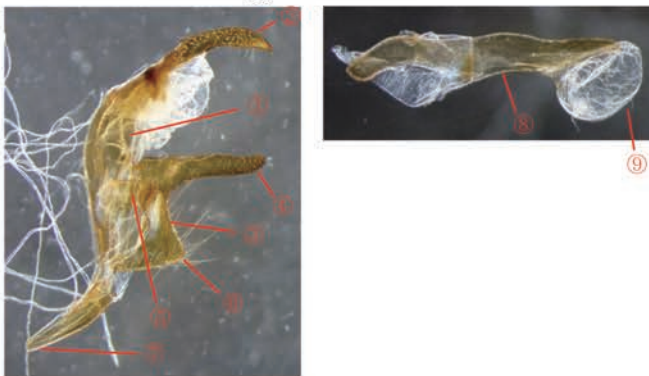
¹⁾ 横浜植物防疫所

1. Male: Lines and Markings of Wings



- ① basal line
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ fringe
- ⑧ discal spot
- ⑨ marginal band
- ⑩ fringe

2. Male: Terminology of Genitalia



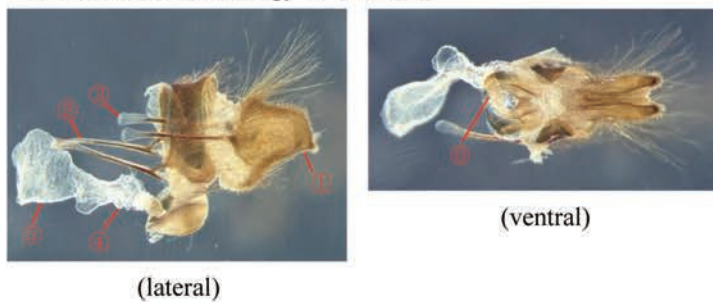
- ① tegumen
- ② uncus
- ③ valve
- ④ dorsal process
- ⑤ juxta
- ⑥ sacculus
- ⑦ saccus
- ⑧ aedoeagus
- ⑨ vesica

3. Female: Lines and Markings of Wings



- ① basal spot
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ fringe
- ⑧ discal spot
- ⑨ submarginal band
- ⑩ fringe

4. Female: Terminology of Genitalia



- ① papilla analis
- ② anterior apophysis
- ③ posterior apophysis
- ④ ductus bursae
- ⑤ corpus bursae
- ⑥ ostium bursae

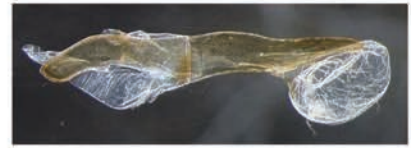
Fig. 1 Lines and markings of wings and terminology of genitalia of male and female of subgenus *Porthetria*. All figures are *L. dispar japonica*.



No.17



No.17



No.17



No.18



No.18



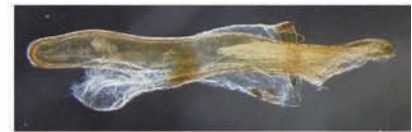
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Fig. 2 Males and their genitalia of *L. dispar japonica* (Nagoya population).



No.15



No.15



No.15



No.63



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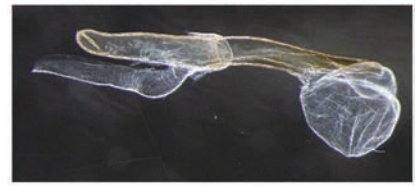
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Fig. 3 Males and their genitalia of *L. dispar japonica* (Sapporo population).

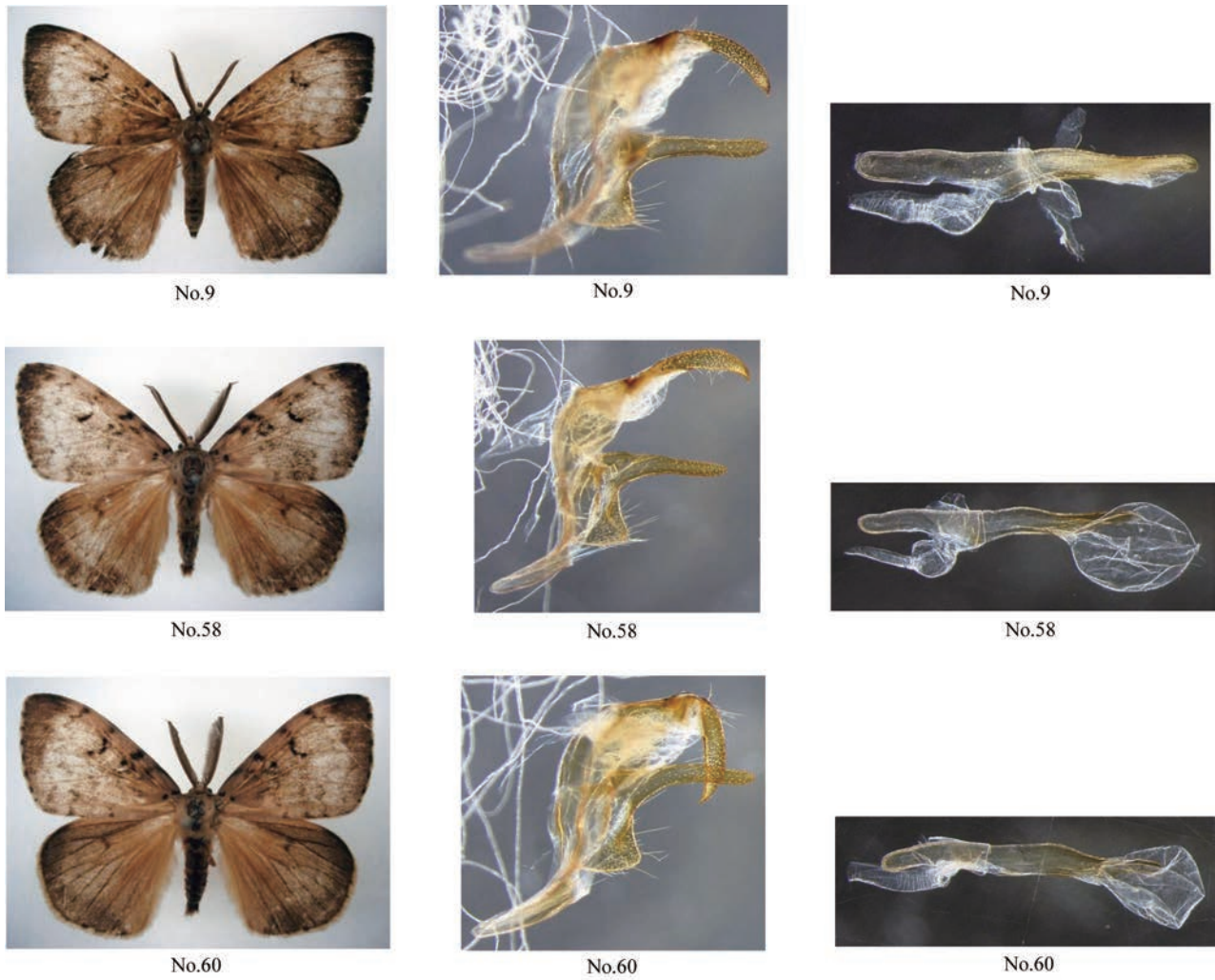


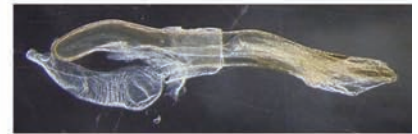
Fig. 4 Males and their genitalia of *L. dispar japonica* (Otaru population).



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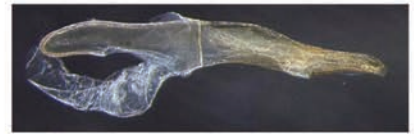
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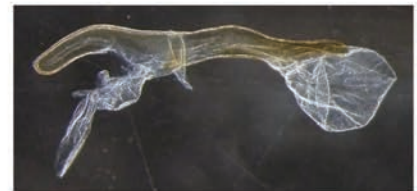
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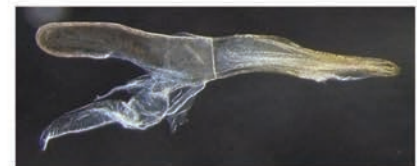
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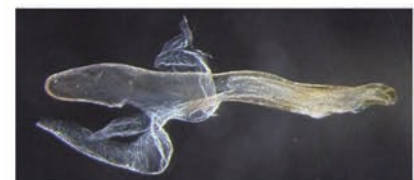
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No.182



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No.182

Fig. 5 Males and their genitalia of *L. umbrosa* (Otaru population).



No.268



No.268



No.268



No.281



No.281



No.281



No.282



No.282



No.282



No.283



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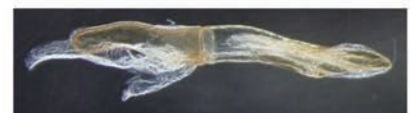
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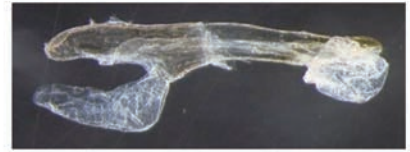
Fig. 6 Males and their genitalia of *L. albescens* (Naha population).



No.78



No.78



No.78



No.79



No.79



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No.81



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No.81

Fig. 7 Males and their genitalia of *L. postalba* (Tsushima population).



No.116



No.116



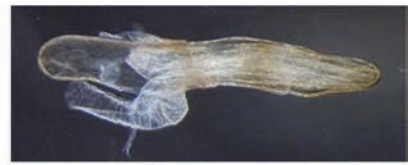
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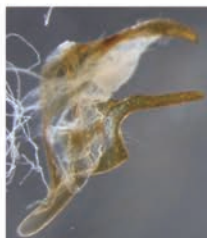
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No.120



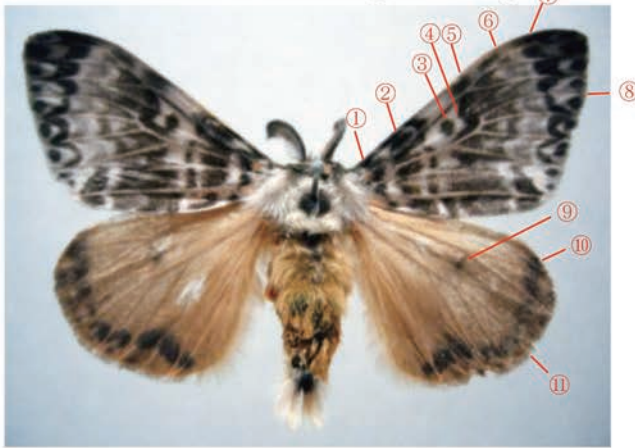
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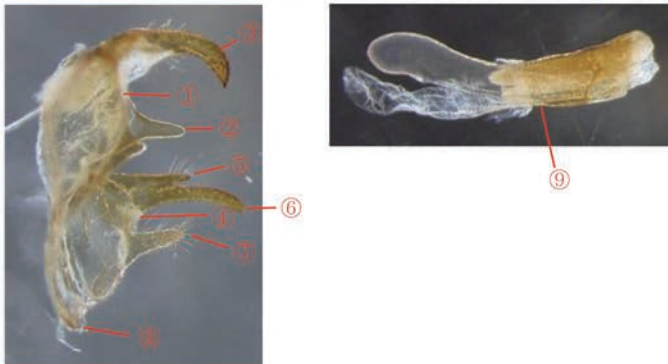
Fig. 8 Males and their genitalia of *L. xyli* (Naha population).

1. Male: Lines and Markings of Wings



- ① basal line
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ patches of terminal area
- ⑧ fringe
- ⑨ discal spot
- ⑩ submarginal band
- ⑪ fringe

2. Male: Terminology of Genitalia



- ① tegumen
- ② lateral process
- ③ uncus
- ④ valve
- ⑤ dorsal process (dorsal-most process)
- ⑥ dorsal process (ventral process)
- ⑦ ventral process
- ⑧ saccus
- ⑨ aedoeagus

3. Female: Lines and Markings of Wings



- ① basal line
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ terminal line
- ⑧ fringe
- ⑨ submarginal band
- ⑩ fringe

4. Female: Terminology of Genitalia



- ① papilla analis
- ② anterior apophysis
- ③ posterior apophysis
- ④ ductus bursae
- ⑤ corpus bursae
- ⑥ ostium bursae

Fig. 9 Lines and markings of wings and terminology of genitalia of male and female of subgenus *Nyctria*. All figures are *L. mathura*.



No.124 (Otaru)



No.124 (Otaru)



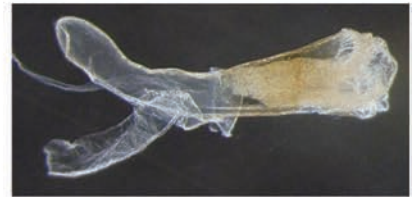
No.124 (Otaru)



No.125 (Otaru)



No.125 (Otaru)



No.125 (Otaru)



No.126 (Otaru)



No.126 (Otaru)



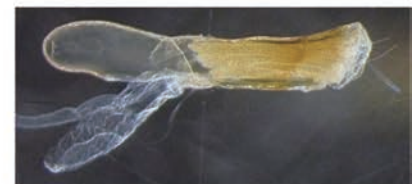
No.126 (Otaru)



No.254 (Yokosuka)



No.254 (Yokosuka)



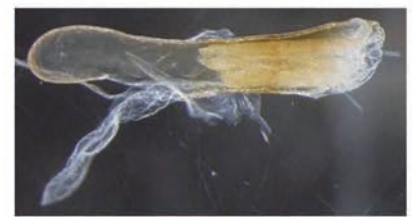
No.254 (Yokosuka)



No.255 (Yokosuka)



No.255 (Yokosuka)



No.255 (Yokosuka)

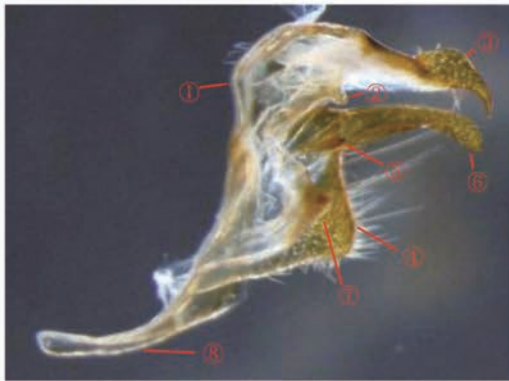
Fig. 10 Males and their genitalia of *L. mathura* (Otaru and Yokosuka population).

1. Male: Lines and Markings of Wings

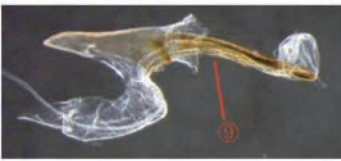


- ① bar of basal area
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ terminal line
- ⑧ fringe
- ⑨ marginal band
- ⑩ fringe

2. Male: Terminology of Genitalia



- ① tegumen
- ② lateral process
- ③ uncus
- ④ valve
- ⑤ basal projection of valve
- ⑥ dorsal process
- ⑦ juxta
- ⑧ saccus
- ⑨ aedoeagus

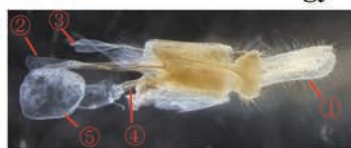


3. Female: Lines and Markings of Wings



- ① bar of basal area
- ② antemedial line
- ③ orbicular spot
- ④ reniform spot
- ⑤ postmedial line
- ⑥ subterminal line
- ⑦ terminal line
- ⑧ fringe
- ⑨ marginal band
- ⑩ fringe

4. Female: Terminology of Genitalia



(lateral)



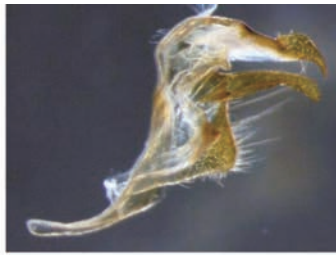
(ventral)

- ① papilla analis
- ② anterior apophysis
- ③ posterior apophysis
- ④ ductus bursae
- ⑤ corpus bursae
- ⑥ ostium bursae

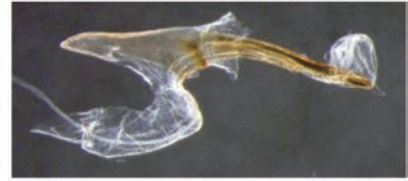
Fig. 11 Lines and markings of wings and terminology of genitalia of male and female of subgenus *Lymantria*. All figures are *L. monacha*.



No.150



No.150



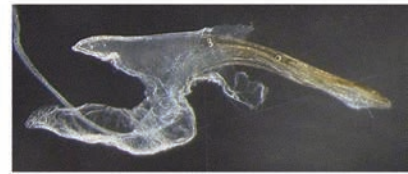
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No.240



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No.240

Fig. 12 Male and their genitalia of *L. monacha* (Tomakomai population).

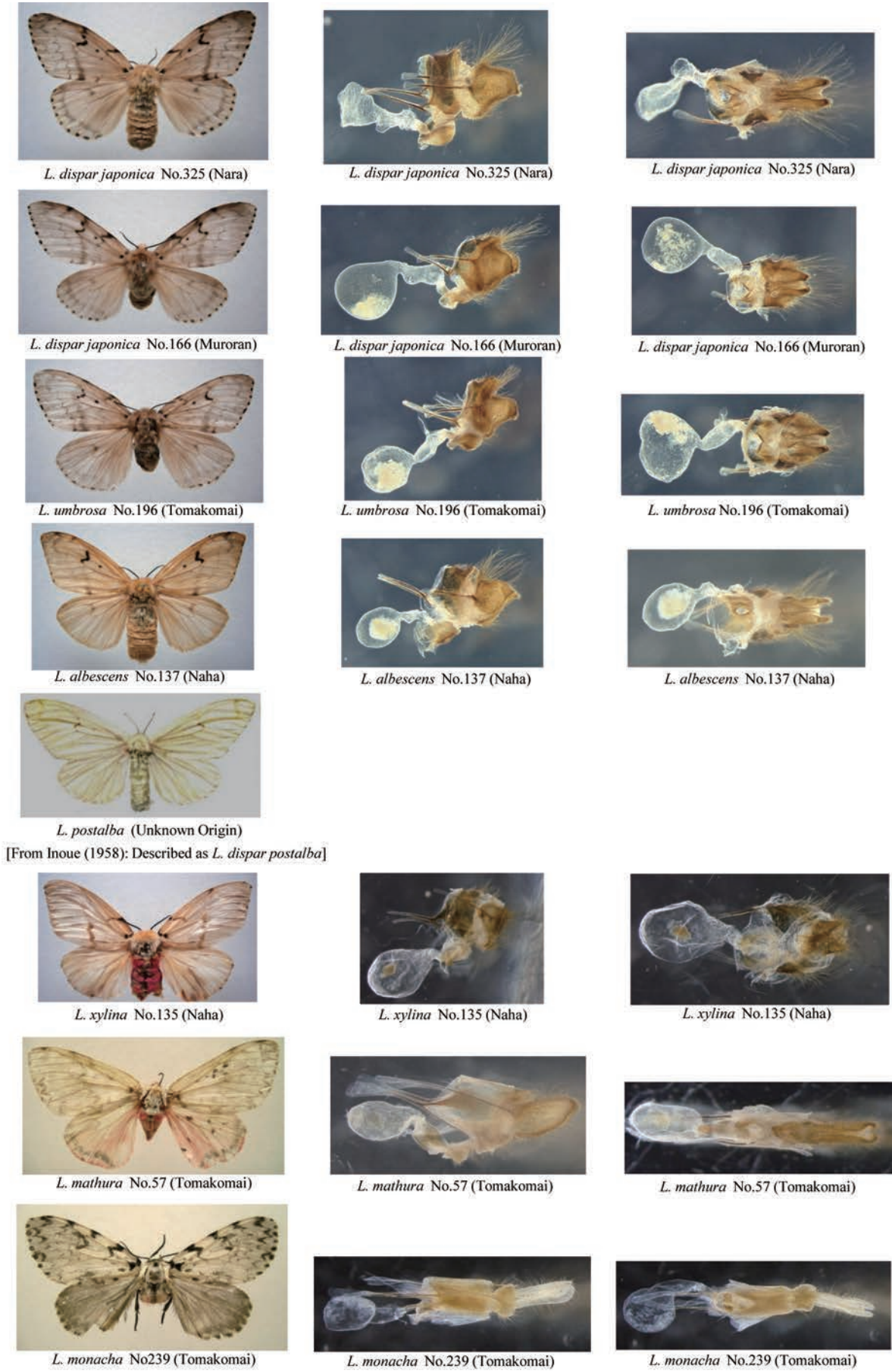


Fig. 13 Females and their genitalia of seven *Lymantria* species. The photographs of genitalia are shown laterally and ventrally.