

ORIGINAL ARTICLE

A review of the genus *Montescardia* Amsel (Lepidoptera: Tineidae) from Japan, with reference to the genital morphology

Yohei OSADA¹ , Margarita G. PONOMARENKO^{2,3} and Toshiya HIROWATARI¹

¹Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, Japan, ²Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of Russian Academy of Science, Vladivostok, Russia and ³Far Eastern Federal University, Russky Island, Russia

Abstract

The genus *Montescardia* Amsel is redescribed. *Montescardia tessulatellus* (Zeller) and *M. kurenzovi* (Zagulajev) are recorded and redescribed from Japan, with figures of the male and female genitalia. Functional morphology of the male genitalia in *M. tessulatellus*, the type species of *Montescardia*, is studied for the first time. The terminology used in the description is clarified taking into account the features of the skeleto-muscular apparatus of the male genitalia and homologation of genital structures.

Key words: functional morphology, *Montescardia kurenzovi*, *Montescardia tessulatellus*, new record, Scardiinae, taxonomy.

INTRODUCTION

The genus *Montescardia* was established in the subfamily Scardiinae of the Tineidae by H. G. Amsel in Hartig and Amsel (1952). Currently, three species, *M. fuscofasciella* (Chambers, 1875), *M. tessulatellus* (Zeller, 1846) and *M. kurenzovi* (Zagulajev, 1966) have been recognized in the Holarctic region (Petersen 1957; Zagulajev 1973; Robinson 1986). During our taxonomic study of the family Tineidae, two species of *Montescardia* were found in Japan.

The structure of the male genitalia of the genus is very complex. After the initial establishment of the genus *Montescardia*, Petersen (1957) described and illustrated the genitalia of both sexes of *M. tessulatellus*. Zagulajev (1973) illustrated and described the genital structure of *M. tessulatellus* and *M. kurenzovi* on the basis of material from Russia. These authors noted that the male genitalia of this genus were complicated in morphology, and used specific terms for the genitalic sclerites. To clarify the homology of the genital structures we studied the skeleto-muscular apparatus of the male genitalia.

In this paper, the genus *Montescardia* is redescribed, and *M. tessulatellus* and *M. kurenzovi* newly recorded from Japan are redescribed, with figures of the adults and genitalia of both sexes. Functional morphology of the male genitalia in the genus *Montescardia* is discussed on the basis of the type species, *M. tessulatellus*.

MATERIALS AND METHODS

Adult specimens preserved in Osaka Prefecture University (OPU) and Toyota Yahagi River Institute (TYRI), and those collected by Mr. Akihiko Miyano (Kakamihara-shi) were examined.

For preparation of the male and female genitalia, the abdomens were removed and boiled for 5–6 min in 10% aqueous KOH and stained with acetocarmine. Terminology and nomenclature of morphological characters of the adult follows Zagulajev (1973) and Komai *et al.* (2011); terminology of the male genitalia follows Kuznetsov and Stekolnikov (2001), taking into account definitions added in the present functional morphological study.

For functional morphological study the specimens were fixed in 70% ethanol. Dissection of them followed the method described by Kuznetsov and Stekolnikov (2001). The flexibility in dry specimens was obtained by the method proposed by Ponomarenko (2005). Before dissection every specimen was stained with an aqueous

Correspondence: Yohei Osada, Entomological Laboratory, Faculty of Agriculture, Kyushu University, Hakozaki 6-10-1, Fukuoka 812-8581, Japan.
Email: pelopidasmathias1798@gmail.com

Received 7 October 2016; accepted 23 January 2017.

solution of eosin. The skeleton–muscular apparatus in the male genitalia was examined using a stereomicroscope Nikon SMZ-10 (Nikon, Tokyo, Japan). Following dissections the photo of every layer was made with digital camera Nikon Coolpix 8700 (Nikon).

The terminology for the muscles follows Kuznetsov and Stekolnikov (2001).

TAXONOMY

Genus *Montescardia* Amsel, 1952

Montescardia Amsel in Hartig and Amsel, 1952: 139.
Type species: *Euplocamus tessulatellus* Zeller, 1846

Description

Head. Vertex and face roughly clothed with yellowish white hairs. Antenna filiform and strongly ciliated; pecten consisting of 8–10 bristles; flagellomere clothed with brown scales. Maxillary palpus clothed with brownish white scales. Labial palpus covered with brownish white or dark brown scales, 2nd segment with three to five lateral bristles.

Thorax. Mesonotum brownish white, but anterior margin clothed with dark brown scales; tegula clothed with dark brown scales anteriorly and brownish white scales posteriorly; metanotum clothed with brownish white scales on scutellum and posterior part of scutum. Legs extensively covered with dark brown scales, apical portion of tibia and each tarsomere brownish white; hind tibia bearing dense long hairs dorsally and ventrally.

Abdomen. Extensively clothed with pale brownish white scales. Segment VIII without coremata.

Wing markings (Fig. 1). Forewing upperside brownish white in ground color; numerous dark brown maculae on subbasal portion overall; middle and base of costa with large dark speckles; end of discoidal cell with a dark brown speckle. Fringe with brownish white and brown scales alternately. Hindwing upperside glassy grayish white, end of free veins indistinctly darkened. Fringe with

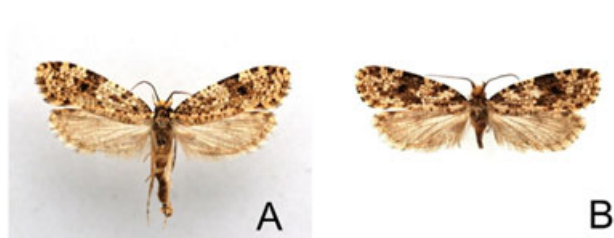


Figure 1 Adults of *Montescardia* species. (A) *Montescardia tessulatellus* (Zeller, 1846); (B) *Montescardia kurenzovi* (Zagulajev, 1966).

brownish white scales posteriorly and brown scales alternately.

Wing venation (Fig. 2). Forewing: all free veins present; R1 arising from about 1/5 of discoidal cell; R5 ending at termen; 1A + 2A about 4 times as long as 1A. Hindwing: all free veins present; M1 ending just posterior to the apex; 1A + 2A arched; M branched within discoidal cell.

Male genitalia (Figs 3,5). Uncus separated from tegumen by membrane, apex and sides with setae, with irregularly serrate caudal margin, venter slightly rounded. Segment IX is not divided into tergite and sternite and forms an annulus, so that the tegumen is not separated from the vinculum. Width of the tegumen about 1/4 as long as saccus; tegumen divided dorsally by a membranous area. Gnathos absent. Vinculum broad and tapered, about 1/3 as long as length of tegumen + uncus, with a small and triangular saccus. Subscaphium developed, more or less triangular. Valvae fused internally to form a united complex, dorsal portion slightly concave, apex rounded, basal process of valva about 1/3 as long as valva. Aedeagus, juxta and anellus fused into a phallic organ, which is shifted dorso-caudally and joined with the valvae ventrally by the juxta. Aedeagus with base almost three times as wide as its distal part, the latter with a movable dorsal side consisting of two triangular plates; vesica of aedeagus without cornuti. Juxta elongate with a hook-like apex and setae basally; anellus slightly sclerotized, enveloping the aedeagus, with a cordiform plate bearing numerous spines antero-dorsally.

Female genitalia (Figs 4,6). Abdominal tergum VIII longer than sternite VIII, caudal 1/2 membranous, with several pairs of subapical setae. Sterigma projecting forwards with a pair of lamellae antevaginales laterally.

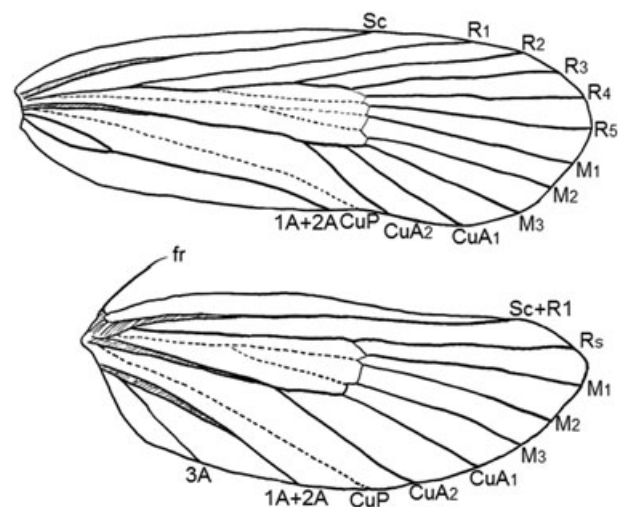


Figure 2 Wing venation of *Montescardia tessulatellus*, male; fr, frenulum.

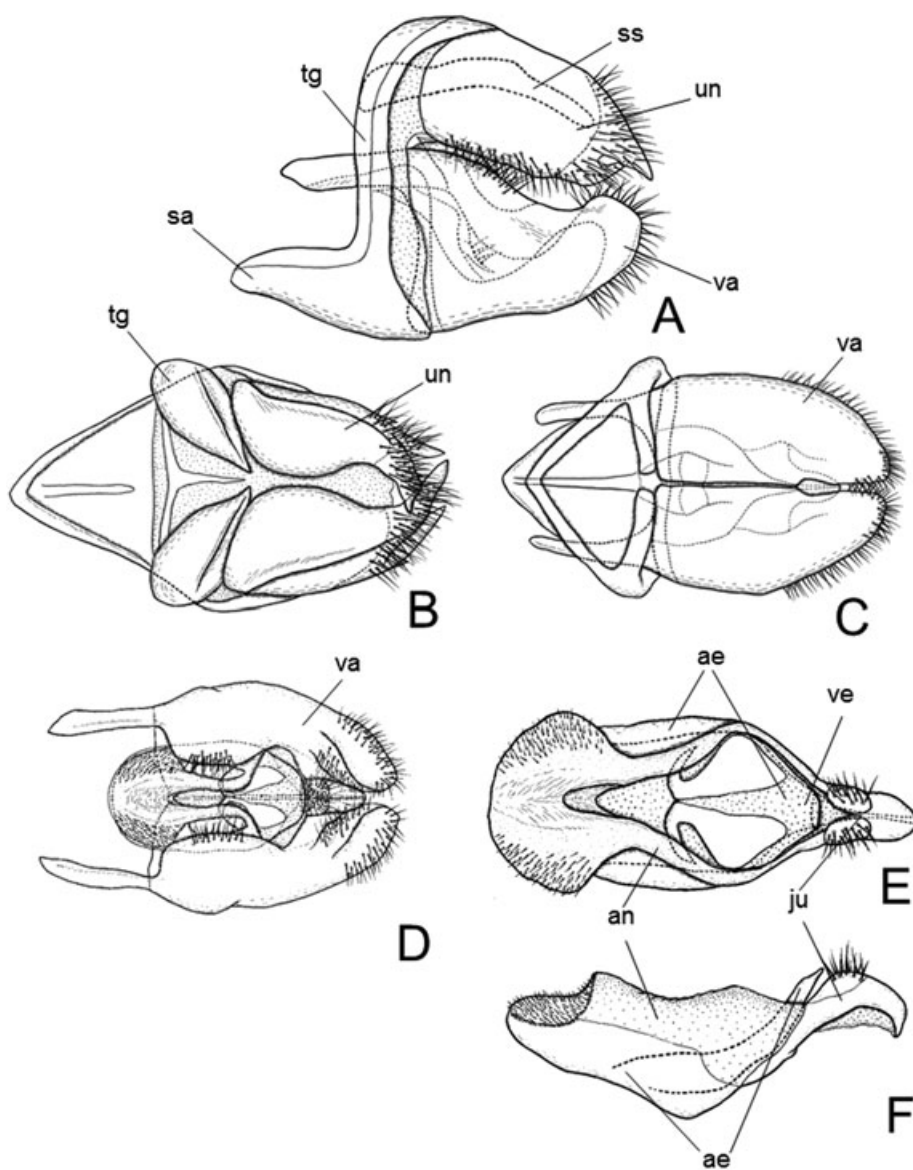


Figure 3 Male genitalia of *Montescardia tessulatellus*. (A) Whole genitalia, lateral view; (B) *ditto*, dorsal view; (C) *ditto*, ventral view; (D) valva with phallic organ, dorsal view; (E) phallic organ, dorsal view; (F) *ditto*, lateral view. Abbreviations: an, anellus; ae, aedeagus; gn, gnathos; ju, juxta; sa, saccus; ss, subscaphium; tg, tegumen; un, uncus; va, valva; ve, vesica.

Antrum not developed. Ductus bursae and corpus bursae 1.5 times as long as apophysis anterioris, corpus bursae without signa.

Remarks

The wing markings of this genus resemble those of the genus *Morphogoides* Petersen, but the wing color pattern is paler, the maculae are smaller and there is a dark spot on the apex of the discoidal cell, unlike in *Morphogoides*. In addition, the male genitalia have a unique phallic organ consisting of the aedeagus, juxta and slightly sclerotized anellus and shifted dorso-caudally, which is unusual in moths. Such a configuration of the phallus is not seen in

the other genera of the subfamily Scardiinae (Zagulajev 1973; Robinson 1986). This configuration is here considered to be an autapomorphy for the two species occurring in Japan.

Montescardia fuscofasciella distributed in North America was described based on only the female, but the male has been unknown (Robinson 1986). The structure of its female genitalia illustrated by Robinson (1986) is very different from those of *M. tessulatellus* and *M. kurenzovi*. Therefore, *M. fuscofasciella* may not belong to this genus. In order to review the generic assignment of *M. fuscofasciella*, further research including examination of the male morphology is required.

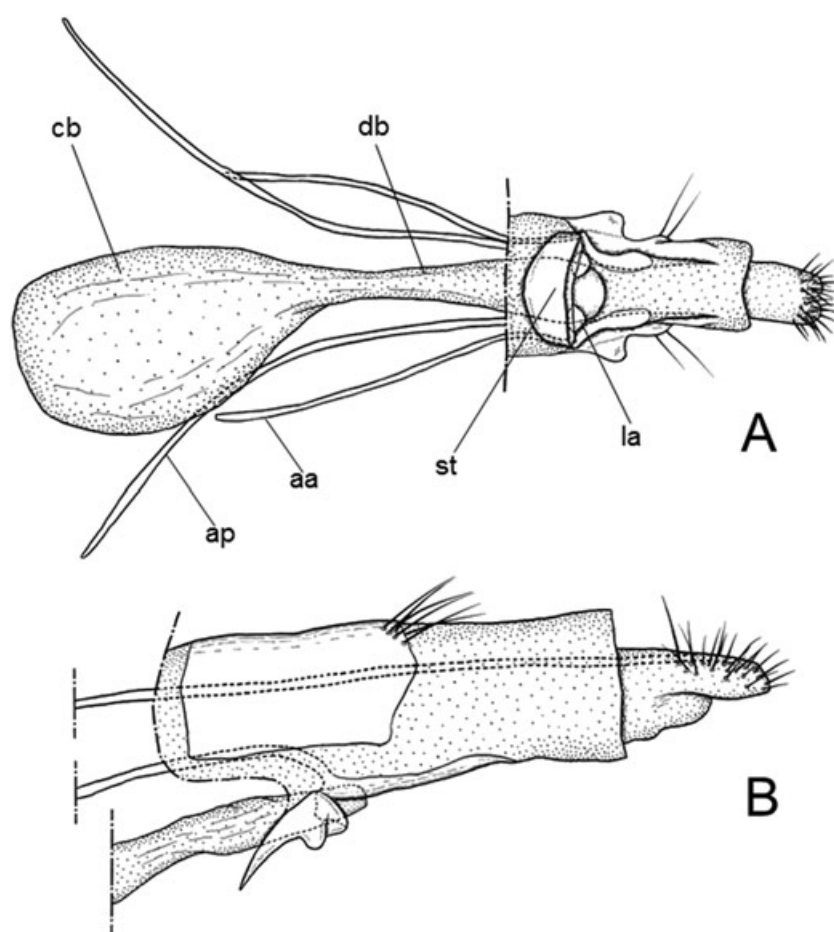


Figure 4 Female genitalia of *Montescardia tessulatellus*. (A) Whole genitalia, ventral view; (B) genitalia without corpus bursae, lateral view. Abbreviations: aa, apophysis anterioris; ap, apophysis posterioris; cb, corpus bursae; db, ductus bursae; la, lamella antevaginalis; st, sterigma.

Key to Japanese species of the genus *Montescardia*

Wing markings

1. Apical end of discoidal cell of forewing with a large pale brown speckle (Fig. 1A) *M. tessulatellus*
- Apical end of discoidal cell of forewing with a large dark brown speckle (Fig. 1B) *M. kurenzovi*

Labial palpus

1. Covered with brownish white scales mesally and dark brown scales laterally *M. tessulatellus*
- Covered with dark brown scales *M. kurenzovi*

Male genitalia

1. Ventral margin of valva slightly rounded, dorsal margin of valva slightly concave, anterior ventral margin of phallic organ slightly swollen and height of phallic organ 1/3 of length (Fig. 3) *M. tessulatellus*
- Ventral margin of valva rounded, dorsal margin of valva concave, ventral margin of phallic organ

anteriorly concave and height of phallic organ 2/3 of length (Fig. 5) *M. kurenzovi*

Female genitalia

1. Sterigma U-shaped (Fig. 4) *M. tessulatellus*
- Sterigma W-shaped (Fig. 6) *M. kurenzovi*

Montescardia tessulatellus (Zeller, 1846)

[Newly proposed Japanese name: *Usuiro-ohirozukoga*].
Euplocamus tessulatellus Zeller, 1846: 178. [Type locality: Austria]

Montescardia tessulatellus: Petersen, 1957: 591, figures 242–243; pls. 1–2; Robinson, 1986: 141, figure 18.

Scardia tessulatellus: Zagulajev, 1973: 101–105, figures 16A, 80–83.

Diagnosis. Length of forewing 9.5–14.0 mm; forewing expanse 18.5–27.0 mm. The labial palpus is covered with brownish white scales mesally and dark brown scales laterally. In the forewing, a dark brown speckle is present

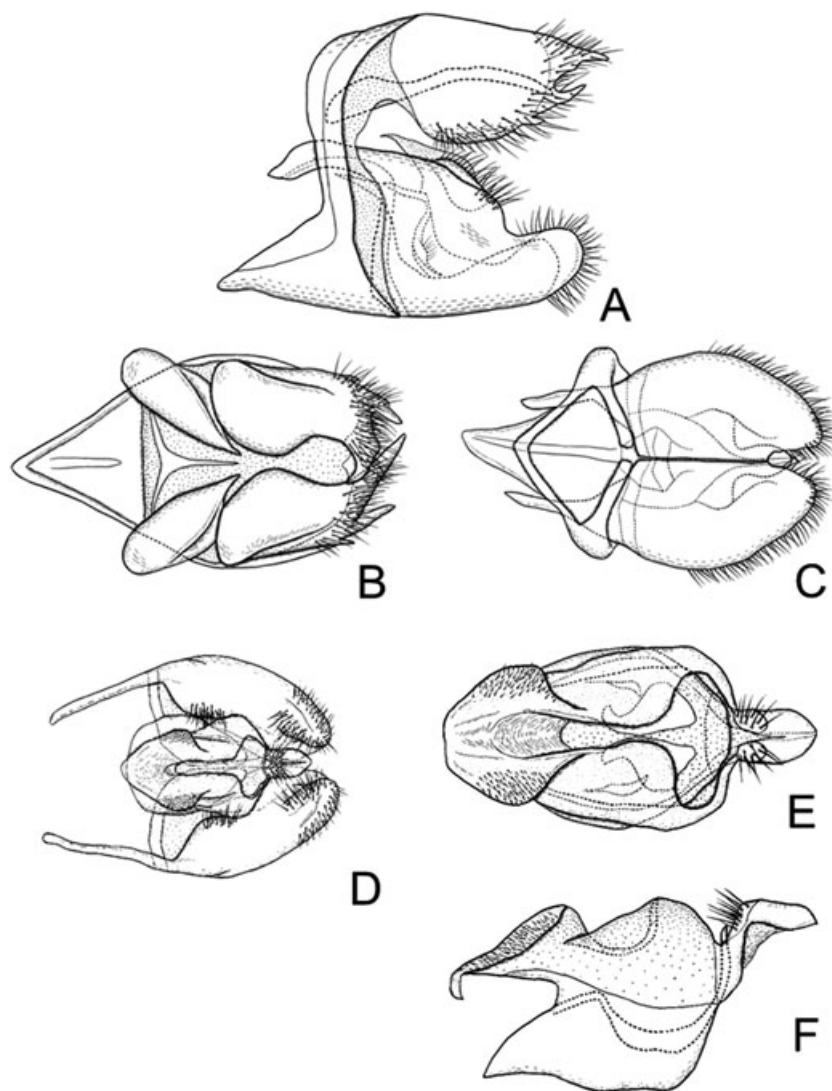


Figure 5 Male genitalia of *Montescardia kurenzovi*. (A) Whole genitalia, lateral view; (B) *ditto*, dorsal view; (C) *ditto*, ventral view; (D) valva with phallic complex, dorsal view; (E) phallic complex, dorsal view; (F) *ditto*, lateral view.

in the end of the discoidal cell. In the male, the ventral part (or margin) of the uncus is slightly rounded, the dorsal part of the valva is slightly concave, the anterior venter of the phallic organ is slightly swollen and the height of the phallic organ is 1/3 of its length. In the female, the sterigma is U-shaped.

Distribution. Sweden, Norway, Finland, Italy, Sardinia, German, Yugoslavia, Austria, Rumania, Hungary, Czechoslovakia, Poland, Russia (European part, Ural, Irkutsk region, Buryatia, Transbaikalia, Primorskii krai), Mongolia, Japan (Iwate, Gifu, Wakayama and Fukuoka Prefs).

Specimens examined. [Honshu] (Iwate Pref.) 1♂, Kurosawa, Ohasama-machi, 3.vi.2001, U. Jinbo leg.; (Gifu Pref.) 1♂, Iodo, Yamagata-shi, 9.v.2008, A. Miyano

leg.; (Wakayama Pref.) 1♂, Mt. Koya, Koya-cho, 3.vi.2003, S. Koshino leg.; 1♀, Esuzaki, Susami-cho, 23.vii.1986, T. Mano leg.; (Fukuoka Pref.) 1♀. Mt. Hiko, Soeda-machi, 11.vi.1958, H. Kuroko leg.

Remarks. The larvae were recorded from pore-fungi and dead wood of *Picea* and *Fagus* (Robinson 1986), but in Japan the biology of this species is unknown.

***Montescardia kurenzovi* (Zagulajev, 1966)**

[Newly proposed Japanese name: Ezo-usuiro-ohirozukoga].

Scardia kurenzovi Zagulajev, 1966: 637, figures 2a, 2b, 2b [Type locality: Primorskii krai, Russia]; 1973: 105–108, figures 15A, 15b, 16B, 17A, 17b, 19A, 84–86.

Montescardia kurenzovi: Robinson, 1986: 75–76.

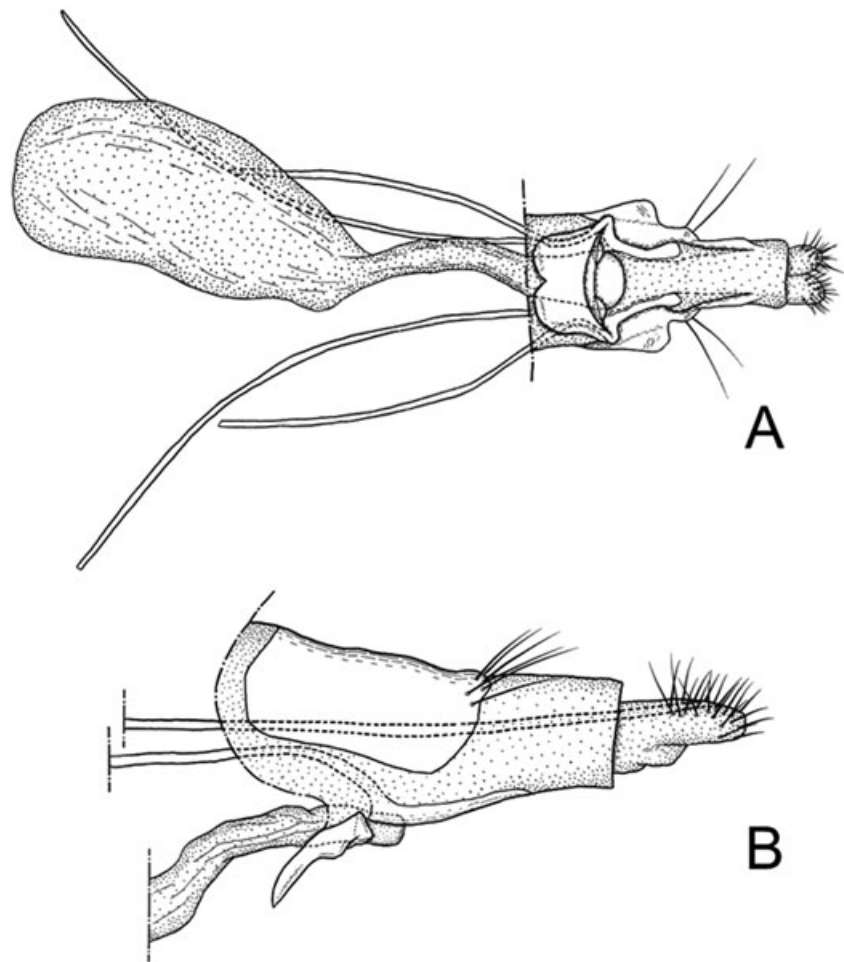


Figure 6 Female genitalia of *Montescardia kurenzovi*. (A) Whole genitalia, ventral view; (B) genitalia without corpus bursae, lateral view.

Diagnosis. Length of forewing 12.5–13.0 mm; forewing expanse 23.0–24.5 mm. The labial palpus is covered with dark brown scales. In the forewing, a large brown speckle is present in the lower discoidal cell. In the male, the ventral part of the uncus is rounded, the dorsal part (or margin) of the valva is concave, the anterior ventral part of the phallic organ is concave and the height of the phallic complex is 2/3 of its length. In the female, the sterigma is W-shaped. Head, thorax and abdomen resembling those of *M. tessulatellus*, but different as follows. Labial palpus covered with dark brown scales.

Distribution. Russia (Khabarovskii krai, Primorskii krai, Kurile Isl.), Korea, China, Japan (Hokkaido).

Specimens examined. [Hokkaido] 1♂, Mt. Peipan, Asahikawa-shi, 28.vi.1987, Y. Kusunoki leg.; 1♀, Shikotsuko-han, Ishikari-shi, 25.vi.1981, T. Tanabe leg.

Remarks. The biology of this species is unknown.

FUNCTIONAL MORPHOLOGY OF THE MALE GENITALIA

Montescardia tessulatellus (Zeller, 1846)

Material

Russia. Primorskii krai, Shkotovskii distr., 6 km SW Anisimovka, ski depot Gribanovka, 43°07'28 N, 132°47'42 E. 480 m above sea level, 11.viii.2016 (Ponomarenko leg.).

Description

The skeleto-muscular apparatus of the genitalia differs from those of all other genera of the subfamily Scardiinae, by having the valvae fused ventrally into a single sclerite; by the copulatory organ being shifted dorso-caudally and joined with the valva ventrally. In addition, the copulatory organ cannot be protruded or retracted. In the skeleto-muscular apparatus there are eight paired muscles (m_1 , m_2 , m_{4a} , m_{4b} , m_5 , m_6 , m_7 (? m_3), m_{10}) and

one unpaired muscle (m_{21}): m_1 (musculus tergalis intersegmentalis IX–X), muscles stretched from the dorsal part of the annulus to the dorsal side of the anterior half of the uncus (Fig. 7A); m_2 (musculus gonopodalis externus dorsolateralis), muscles stretched from the dorsal part of the annulus to the basal process of the valva (Fig. 7A,C); m_4 (musculus gonopodalis externus dorsomedialis), muscles represented by three branches: m_{4a} consisting of two branches, one of which is very wide, attached to the lateral longitudinal flap of the vinculum and the other one arising from the apex of the saccus, both branches stretched to the basal process of the valva, and muscles m_{4b} stretched from the saccus to the base of the basal process of the valva (Figs 7A,B,8A); m_5 (musculus phallicus externus posterior), muscles stretched from the dorsal margin of the valva to the wide basal part of the

aedeagus (Figs 7B,8A,B); m_6 (musculus phallicus externus anterior), muscles stretched from the medial side of the saccus to the side of the aedeagus (Figs 7B,8A,B); m_7 (? m_3) (musculus gonopodalis internus medialis (?musculus laminae mediale anterior), muscles stretched from the medial side of the vinculum to the small excurved plate on the medial side of the valva (Figs 7A,B,8A); m_{10} (musculus tergalis intersegmentalis), joining uncus and subsclerophium in the caudal half (Fig. 7C); m_{21} (musculus phallicus internus longitudinalis), muscles placed within the basal part of the aedeagus (Fig. 8B,C).

Homologation of genital sclerites and muscles

The muscles m_1 , m_2 , m_{4a} , m_{4b} , m_5 , m_6 , m_{10} and m_{21} have their usual positions in the genitalia of *M. tessulatellus*,

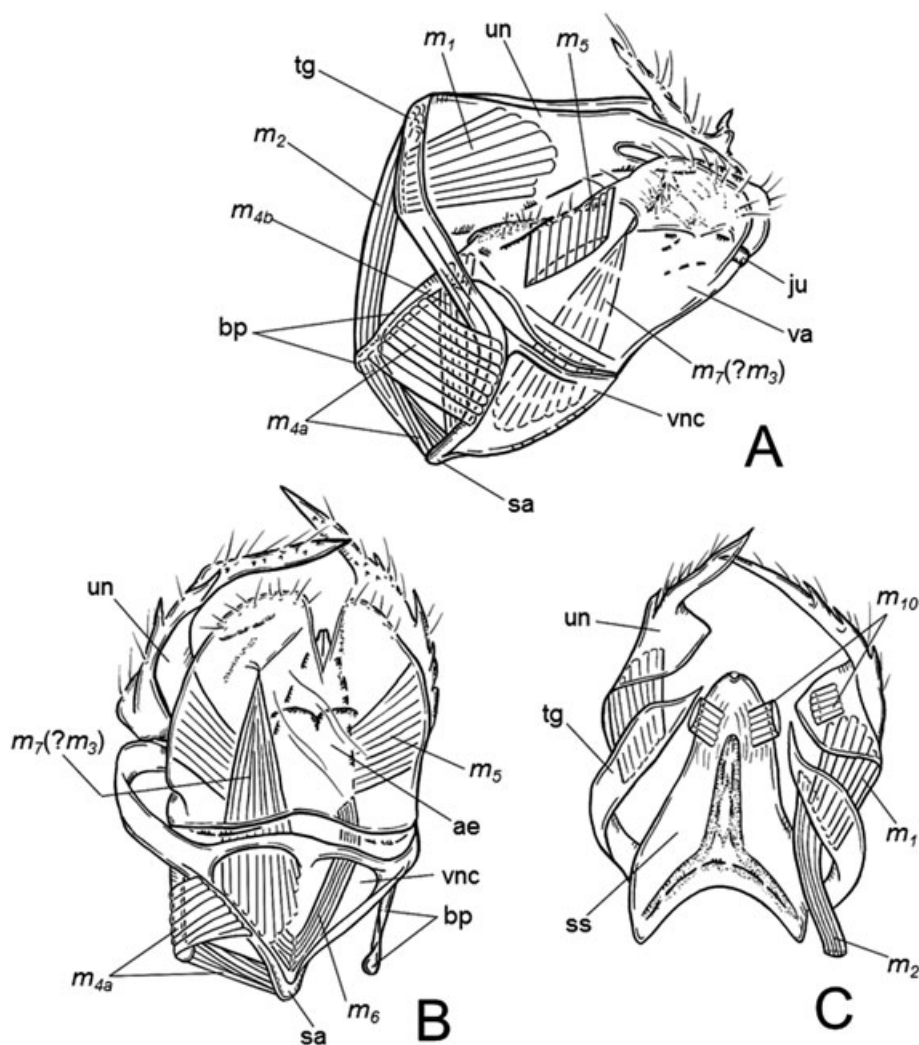


Figure 7 Male genitalia of *Montescardia tessulatellus*, functional morphology. (A) Skeleton–muscular apparatus, lateral view; (B) ditto, ventral view; (C) uncus and subsclerophium, dorsal view. Abbreviations: m_1 , m_2 , m_{4a} , m_{4b} , m_5 , m_6 , m_7 (? m_3), m_{10} – muscles (see text); bp, basal process of valva; vnc, vinculum; the others as in Figure 3.

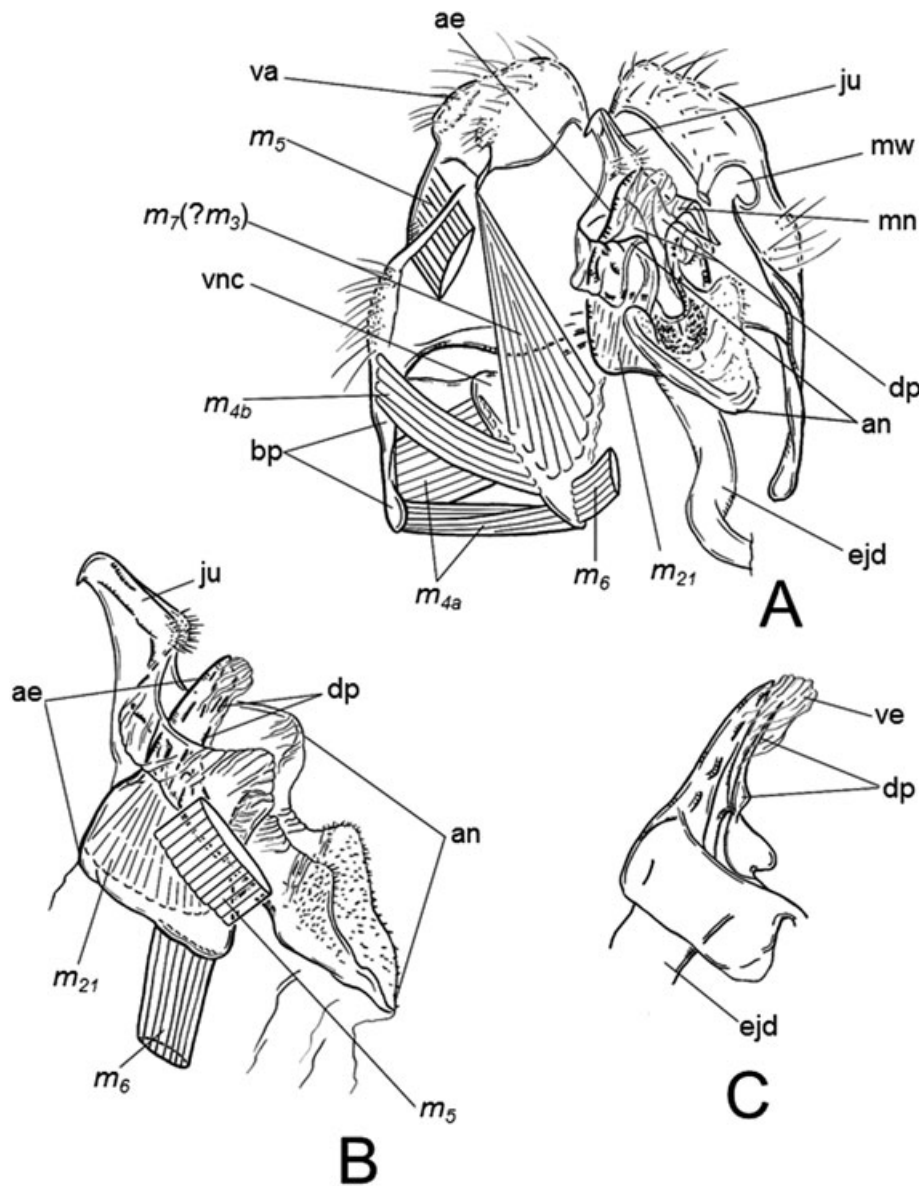


Figure 8 Male genitalia of *Montescardia tessulatellus*, functional morphology. (A) Valvae and phallic organ, medial view; (B) phallic organ, lateral view; (C) aedeagus and vesica, lateral view. Abbreviations: m_2 , m_{4a} , m_{4b} , m_5 , m_6 , m_7 (? m_3), m_{21} – muscles (see text); dp, dorsal plate of aedeagus; ejd, ejaculatory duct; mn, manica; mw, membranous window; the others as in Figures 3 and 7.

which makes it possible to confirm with certainty the homology of such sclerites as the uncus, tegminal part of the annulus (= tegumen), ventral part of the annulus (= vinculum) and valva. The valvae are fused ventrally and unable to move outwards. On the ventral margin of each valva a membranous window is present (Fig. 8A). The distal part of the valva is probably bent medially by reason of traction by the muscle m_7 (? m_3). The membranous window is at the site of that bend. For the aedeagus (Fig. 8), its homology with the sclerotized phallic tube in other Lepidoptera is confirmed by the joining of two paired phallic muscles, m_5 and m_6 , which usually

function respectively as the protractor and retractor of the aedeagus. Apart from this, muscles m_{21} are placed inside the basal wide part of the aedeagus, and function as retractor of the vesica. The aedeagus in this genus has a complicated structure, with a flexible dorsal plate (Fig. 8B,C) which probably turns upwards when the vesica is filled by hemolymph. A wide slightly sclerotized fold envelopes the aedeagus. From the general plan of morphology of the phallus, the phallic sclerotized tube (aedeagus) is surrounded by the phallobasa. The latter is represented by a fold consisting of the manica (inner part) and anellus (external part). Both manica and anellus are

easy identified on the genitalia, and are shown on the illustrations. The juxta (medial plate) is usually placed on the ventral part of the anellus in Lepidoptera. In the examined genus the ventral sclerotized plate is present but does not join with any muscles. Based on the fact that it is in the traditional position, that plate should be homologous with the juxta in other Lepidoptera. The most difficult homology to establish is that of the muscles stretched from the excurved plate on the medial side of the valva. Their distal part has a position similar to muscles m_7 in other Lepidoptera, but the proximal part is attached to the vinculum, which is more typical for muscles m_3 . The muscles m_3 were not found in *Montescardia*, but are present in related genera from the subfamily Scardiinae. Exact homologation of these muscles may be possible after a wider comparative morphological study within the Tineidae.

ACKNOWLEDGMENTS

We express our thanks to Dr S Kobayashi (OPU), Mr T Mano (TYRI), Mr A Miyano (Kakamihara-shi) and Mr Y Kusunoki (Asahikawa-shi) for valuable specimens. Dr M Ishii, Dr N Hirai (OPU), Dr S Kamitani (Kyushu University), Dr M Sakai (Kyoseikagaku) and Dr Huang G-H (Hunan Agricultural University) gave us kind advice and supported this study. Mr A C Galsworthy (Natural History Museum, London) kindly edited the English of an early version of this manuscript. This study was partly supported by the Research Fellowships of the Japan Society for the Promotion of Science (JSPS) for Young Scientists (No. JAG5J07389). This is a contribution from

the Entomological Laboratory, Kyushu University, Fukuoka (Series 7, No. 48).

REFERENCES

- Hartig F, Amsel HG (1952) Lepidoptera Sardinica. *Fragmenta entomologica* 1, 1–152. (In Italian.)
- Komai F, Hashimoto S, Yoshiyasu Y (2011) Morphology. In: Komai F, Yoshiyasu Y, Nasu Y, Saito T (eds) *A Guide to the Lepidoptera of Japan*, pp 3–36. Tokai University Press, Kanagawa. (In Japanese.)
- Kuznetsov VI, Stekolnikov AA (2001) New approaches to the system of Lepidoptera of world fauna (on the base of the functional morphology of abdomen). *Proceedings of the Zoological Institute, Russian Academy of Sciences* 282, 1–462. (In Russian.)
- Petersen G (1957) Die Genitalien der palaarktischen Tineiden (Lepidoptera: Tineidae). *Beiträge zur Entomologie* 7, 557–595.
- Ponomarenko MG (2005) Gelechiid moths (Lepidoptera, Gelechiidae) of the Palaearctics: functional morphology of the male genitalia, phylogeny and taxonomy. *Meeting in memory of N.A. Cholodkovsky* 58, 1–139. (In Russian.)
- Robinson GS (1986) Fungus moths: a review of the Scardiinae (Lepidoptera: Tineidae). *Bulletin British Museum (Natural History)* 52, 37–181.
- Zagulajev AK (1966) The subfamily Scardiinae (Lep., Tineidae) and its new species. *Entomologicheskoe Obozrenie* 45, 634–644. (In Russian.)
- Zagulajev AK (1973) Tineidae; part 4-subfamily Scardiinae. *Fauna SSSR* 104, 1–126. (In Russian.)
- Zeller PC (1846) *Euplocamus boleti* und *Eupl. tessulatus*. *Stettiner entomologische Zeitung* 7, 178–182.