

A REVISION OF THE *ELACHISTA PRAELINEATA*-
GROUP (LEPIDOPTERA, ELACHISTIDAE) IN JAPAN,
WITH COMMENTS ON MORPHOLOGY OF THE
PUPA IN *ELACHISTA*

Sugisima, K., 2005. A revision of the *Elachista praelineata*-group (Lepidoptera, Elachistidae) in Japan, with comments on morphology of the pupa in *Elachista*. – Tijdschrift voor Entomologie 148: 1-19, figs. 1-48. [ISSN 0040-7496]. Published 1 June 2005.

Japanese *Elachista* species belonging to the *E. praelineata*-group of the subgenus *Elachista* are revised. Five species are recognized: *E. amamii* Parenti, 1983, *E. caliginosa* Parenti, 1983, *E. fasciocaliginosa* sp. n., *E. kurokoi* Parenti, 1983, and *E. miscanthi* Parenti, 1983. *Elachista amamii* and *E. miscanthi* are for the first time recorded from Taiwan. *Elachista fasciocaliginosa* is a very close relative of *E. caliginosa*. The female of *E. caliginosa* is described for the first time. The *E. praelineata*-group shows a considerable diversity in the pupal morphology, and hypotheses are proposed to explain this diversity in relation to the genus as a whole.

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Key words. – Pupal ornamentation; camouflage; projection of spiracles; mobility of abdomen; density of cocoon; fixation of pupa; new species; Poaceae.

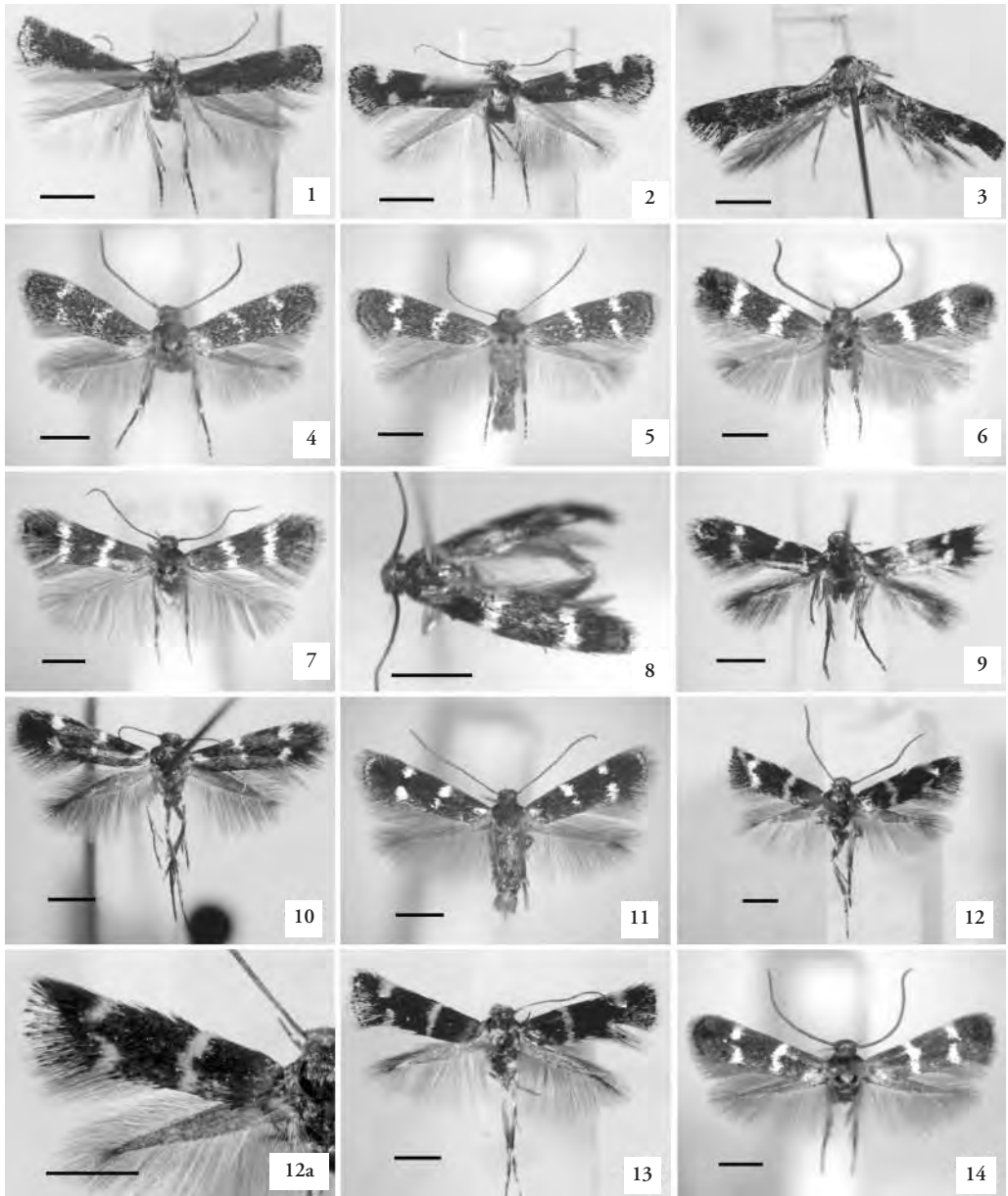
The *Elachista praelineata*-group was established by Kaila (1999a, 1999b) as a monophyletic subunit in the subgenus *Elachista* on the basis of a phylogenetic analysis within the family Elachistidae s. str. This species-group is best diagnosed by the female abdomen with distally a pair of huge dense tufts of very long hair-like scales, which arise from the seventh abdominal tergite. In the male, this taxon is diagnosed by the valva with an indistinct hump of the costa and indistinct valval process. Approximately 30 species have hitherto been known in tropical, subtropical and temperate regions of the world.

In Japan, four species have been known, all of which were described by Parenti (1983): *E. amamii*; *E. caliginosa*; *E. kurokoi*; *E. miscanthi*. The available material and information in his study was insufficient. Each species was described on specimen(s) from a single locality, and the female of *E. caliginosa* was unknown.

These years, I revised the Japanese species belonging to the *Elachista praelineata*-group. In contrast to the earlier study, numerous additional specimens are now available. Several males and females of *E. caliginosa* were reared from *Eccoilopus cotulifer* A. Camus

(Poaceae) in Tusima; an unnamed close relative of *E. caliginosa* was found in Nagano-ken, Honsyū; and *E. amamii* and *E. miscanthi* were found in Taiwan. Most adult specimens examined here were reared from larvae. Consequently, specimens of the pupal exuvia were obtained in many cases and pupation habits including cocoon structures were also observed. A considerable diversity of the pupal morphology is found in the *E. praelineata*-group of Japan. The diversity contains some forms that have never been reported within Elachistidae before.

In the present paper, the four species described by Parenti (1983) are redescribed. A new close relative of *E. caliginosa* is described. The female of *E. caliginosa* is described for the first time. Biological notes are given for each species, emphasizing the morphology of the pupa and cocoon. The variation in the pupa and cocoon among the species of the *E. praelineata*-group is summarized. To explain the diversity of the pupal morphology of the *E. praelineata*-group, hypotheses are proposed from the viewpoint of relations between the pupal morphology and the cocoon structures, taking the genus as a whole into consideration.



Figs. 1-14. *Elachista* species, adult moths; scale lines 1 mm. – 1-2, *E. amamii* (1, holotype; 2, ♀, paratype, Amami-ôshima); 3-5, *E. caliginosa* (3, holotype; 4, ♂, Tusima; 5, ♀, Tusima); 6-8, *E. fasciocaliginosa* (6, holotype; 7, ♀, paratype, Yamagata-mura; 8, ♂, paratype, Azusagawa-mura); 9-11, *E. kurokoi* (9, holotype; 10, ♀, paratype, Hiko-san; 11, ♀, Okinawa-hontô); 12-14, *E. miscanthi* (12, holotype, left wing magnified in 12a; 13, ♀, paratype, Hiko-san; 14, ♂, Hiko-san).

DEPOSITORIES OF SPECIMENS

Although Parenti (1983) stated that the holotypes of *E. amamii*, *E. caliginosa*, *E. kurokoi*, and *E. miscanthi* were deposited in the Entomological Laboratory of Kyushu University, Hukuoka, Japan (KUEC), these holotypes have actually been deposited in the Entomological Laboratory, School of Agriculture, Osaka Prefecture University, Sakai, Ōsaka, Japan (UOPJ) together with the paratypes during the last twenty years. I re-designate UOPJ as the depository of these holotypes.

A large part of specimens including the holotype designated here are deposited in UOPJ. Other specimens are deposited in the following collections: Systematic Entomology Laboratory, Hokkaido University, Sapporo, Japan (EIHU); Finnish Museum of Natural History, Helsinki, Finland (MZHF); National Museum of Natural Science, Taichung, Taiwan (NMNS); Osaka City Museum of Natural History, Ōsaka, Japan (OMNH); and personal collection of U. Parenti, Torino, Italy (PCUP).

TAXONOMY

The *Elachista (Elachista) praelineata*-group**Diagnosis**

Detailed diagnoses and phylogenetic position of the *E. praelineata*-group are given by Kaila (1999a, 1999b). In addition to the diagnoses given by Kaila, another diagnostic character in the male genitalia is provided here. The vestiture of the ventral surface of the uncus lobes can be divided into two groups: a dense group of short and robust scales covering the apical area of the lobe, and long hair-like scales on the remaining area.

Biology

The larval foodplants belong exclusively to the Poaceae (Kaila 1999b: 3; Kaila & Karsholt 2002; Traugott-Olsen 1999).

Distribution

Approximately 30 species are found in all zoogeographic regions: twelve species in southern parts of the Nearctic region (Kaila 1999b); one in the Neotropic region (Colombia) (Kaila 2000); four in western parts of the Palearctic region (Kaila & Karsholt 2002); one in the Afrotropic region (Congo) (Parenti 1983); ten or more in a wide range of Asia including northern Australia (Parenti 1983; Sruoga 1995; Traugott-Olsen 1999; L. Kaila, personal communication; K. Sugisima, unpublished data). On the basis of genital characters illustrated in redescrptions

by Parenti (1973, 1988), *E. tebhgaella* Amsel, 1935 from Israel and *E. merimnaea* Meyrick, 1920 from South Africa should be added to the *praelineata*-group.

Remarks

Before Kaila (1999b), groupings similar to the *E. praelineata*-group were proposed by Braun (1948), Parenti (1983), Nielsen & Traugott-Olsen (1987), and Parenti & Varalda (1991). Concepts of these earlier authors were, however, narrower than the *praelineata*-group.

***Elachista (Elachista) amamii* Parenti**

(figs. 1, 2, 15, 16, 35, 36, 39, 40, 43)

Elachista amamii Parenti, 1983: 11-12, pls 2, 4. Holotype ♂: JAPAN: Amami-ōsima (Akaogi), Ryūkyū, [col.] 16.x.1965, [em.] 30.x.1965, host *Thuarea involuta* [in Japanese], H. Kuroko [leg.], Genitalia slide U. Parenti 5803 (UOPJ) [examined].

Material examined. – Paratypes: JAPAN: RYŪKYŪ: 4♂ 4♀, same locality as holotype, em. 17.x.-9.xi.1965, host *Thuarea involuta*, *Digita radicata* (UOPJ). – Other specimens examined: TAIWAN: 2♂ 11♀, National Taiwan Normal University, Taipei City (1♂ 9♀, em. 11-16.x.2002, host *Digitaria radicata* (HSU 02 K 24); 1♂ 2♀, em. 9-23.xii.2002, host *Digitaria* (HSU 02 L 35)) (2♀ UOPJ; 1♂ 3♀ EIHU; 1♂ 6♀ NMNS).

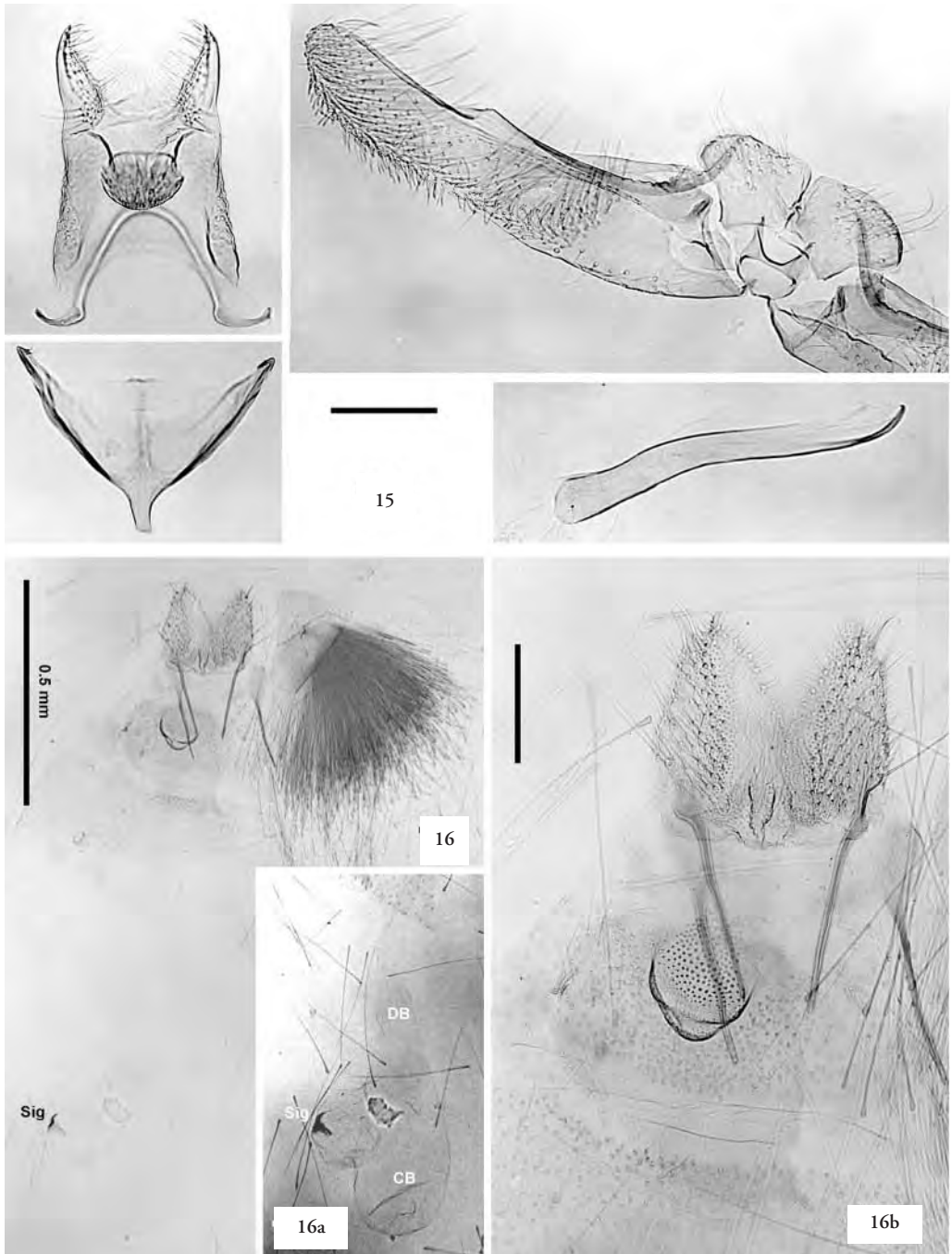
Identification

I identified specimens from Taiwan as *E. amamii* on the following characters: sexually dimorphic coloration of the forewing, in male the dark grey-brownish wing bearing two indistinct whitish costal spots on $\frac{1}{3}$ and $\frac{2}{3}$, in female the blackish wing with four distinct silvery spots (on $\frac{1}{3}$ and $\frac{2}{3}$ of the costa, around the middle of the fold, and on the tornus); the male genitalia with digitate process reduced into a naked triangular lobe, the aedeagus apically acute, and the vesica lacking cornuti; the female genitalia with shallow bowl-shaped antrum and corpus bursae bearing a pouch-like swollen part, which has a small plate-like signum.

Redescription

Forewing length: ♂ 2.4-3.0 mm (holotype 2.8 mm), ♀ 2.5-3.0 mm. Coloration (figs. 1, 2, 35, 36) generally as described in Parenti (1983), except for coloration of face. In type series, face whitish in all males, sometimes suffused with dark grey in females; in specimens from Taiwan, face strongly suffused with grey-brownish scales in both sexes.

Male genitalia (figs. 15, 39). – Uncus lobes apically somewhat acute; setae on ventral surface thin and long, except for those on apical part of uncus lobe that are scale-like and short; socius ornamented with



Figs. 15-16. *Elachista amarii*, genitalia; scale lines 0.1 mm, except for that is indicated. – 15, ♂, holotype; 16, ♀, paratype, slide no. U. Parenti 3797, ductus bursae (DB) and corpus bursae (CB) emphasized in 16a, signum (Sig), caudal part magnified in 16b.

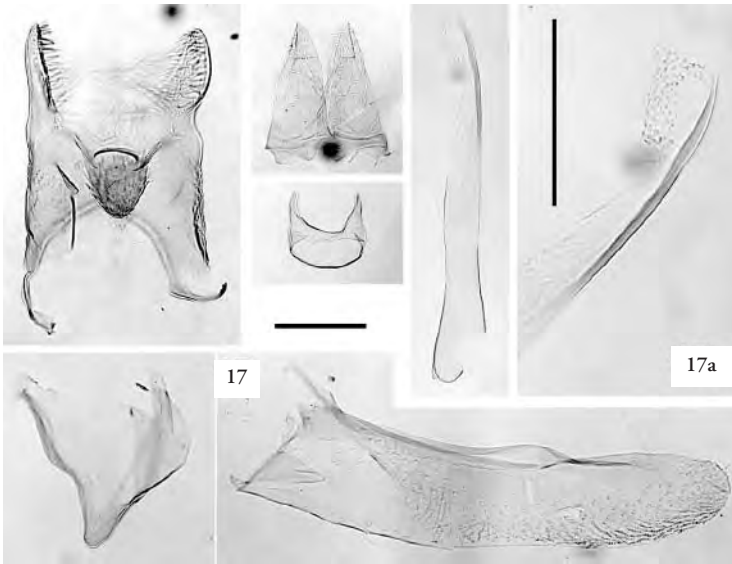


Fig. 17.
Elachista caliginosa, holotype,
genitalia, cornuti magnified
in 17a; scale lines 0.1 mm.

long stout setae. Gnathos knob large, round. Valva elongate, with distinct costal hump around $3/5$; ventral margin slightly concave around $3/5$. Juxta lobes protruding laterally. Digitate process reduced into a small, bluntly triangular lobe, without setae. Vinculum with short saccus. Aedeagus slightly sinuate, apically acute, without any sclerotized ornamentations on vesica.

Female genitalia (figs. 16, 40). – Apophyses almost equal in length. Seventh and eighth sternites indistinct from each other. Antrum shallow bowl-shaped, inner surface entirely covered with spines. Ductus bursae narrowest near middle, widening towards corpus bursae. Corpus bursae in caudal part with a pouch-like swelling; signum recognized as a small lozenge-shaped plate on top of caudal swelling of corpus bursae.

Foodplants

Poaceae: *Thuarea involuta* (Forst.) R. Br., *Digitaria timorensis* (Kunth) Balansa (= *D. radicata*), and *D. ascendens* (H. B. K.) Henr.

Biology

The larva is a leaf-miner, and makes a full-depth mine. The mine is at first linear, and then becomes an elongate blotch. It extends towards the leaf-base or towards leaf-apex. Excrements form a line indicating in what way the larval anus moved. The pupa (fig. 43) is in a cocoon of a sparse silk-web composed of not only transverse but also longitudinal series of silk-filaments, and attached to the surface by a silk-girdle surrounding its abdomen and the cremaster. In the

pupal abdomen (fig. 43a), the fourth and fifth segments are mobile, and the spiracles are set on the dorso-lateral keel. The area around the spiracle slightly produced and forms a blunt tubercle, on the top of which the spiracle is situated (fig. 43a). More than one generation occurs a year in Taiwan.

Distribution

Japan: Ryūkyū (Amami-ōsima) (Parenti 1983).
Taiwan: Taipei.

Remarks

According to L. Kaila (personal communication), *Elachista amamii* is perhaps a junior synonym of *Elachista brachyplectra* Meyrick, 1921, described from Indonesia. I have not yet examined any specimens of *E. brachyplectra* and thus I can not make any decision here.

Elachista (Elachista) caliginosa Parenti (figs. 3-5, 17-20, 23, 24, 44)

Elachista caliginosa Parenti, 1983: 12, pl. 1. Holotype ♂:
JAPAN: Tino-si ([Yatu-ga-take]Minodoguti), Nagano-ken, Honsyū, [col.] 30.ix.1969, [em.] 10.iii.1970, host *Spodiopogon sibiricus* [written in Japanese], H. Kuroko [leg.], Genitalia slide U. Parenti 5816 (UOP) [examined].

Material examined. – JAPAN: HONSYŪ: 1 ♂, Tino-si (Yatugatake-nōzyō), Nagano-ken, em. 3.ii.1966, host Poaceae (UOP); TUSIMA: 11 ♂ 7 ♀, Tusima-si (Yutaka-Waniura or Kamisaka), em. 9.x.1997-2.iv.1998, host *Eccoilopus cotulifer* (00255, 00258) (3 ♂ 2 ♀ UOP; 7 ♂ 4 ♀ EIHU; 1 ♂ 1 ♀ MZHF).

Identification

I identified non-type males as *E. caliginosa* on the basis of the mottled grey-brownish forewing with three blurred and indistinct whitish markings (a transverse fascia on $\frac{1}{3}$, a costal spot at $\frac{3}{4}$, and a tornal spot opposite to the costal one), and on the following characters of the genitalia: the uncus lobes bluntly quadrangular and apically rounded; the juxta lobe being elongate sub-conical, nearly $\frac{1}{3}$ as long as valva, and ornamented with somewhat scale-like setae; the aedeagus being apically acute; the vesica bearing a group of minute spines. I regarded females from Tusima as conspecific with the Tusima males, because both sexes emerged from the same rearing. The females have the following characters in the genitalia: antrum deep bowl-shaped and lined with coarse spines on the dorsal surface; the spines on the dorsal surface of the antrum extending caudally along a medial ditch; the spined area of the dorsal surface of the antrum almost twice as long as wide; the corpus bursae caudally bearing a pouch-like swollen part, which has the signum of a cross-form plate with a dentate ridge along one axis.

Redescription

Forewing length: ♂ 2.5-3.0 mm (holotype 3.0 mm), ♀ 2.7-3.2 mm. Female darker, with forewing markings larger and more distinct. Head and thorax dark grey-brownish, mottled with basally greyish scales; face pale grey-brownish, mottled with apically dark brownish scales to a various extent. Labial palpi dark brownish on underside, pale grey-brownish on upperside. Forewing dark grey-brownish, mottled as in thorax, with following silver-whitish markings: an outwards bent transverse fascia beyond $\frac{1}{3}$, often interrupted around fold (in male, blurred and distant from hind margin), a narrow sub-triangular spot on $\frac{3}{4}$ of costa sometimes outwards oblique, and opposite to this costal spot a similar but smaller tornal spot (in male very indistinct frequently); the costal and tornal spots distant from each other.

Male genitalia (figs. 17-20). – Uncus lobes bluntly quadrangular, apically round; setae on ventral surface somewhat scale-like, short and dense in apical part of uncus lobe, long and sparse in basal part of uncus lobe; socius with a short fine setae. Valva moderately elongate, less than 4.5 times as long as wide, with costal hump of moderate distinctness beyond middle of its length. Juxta lobe elongate sub-conical, nearly $\frac{1}{3}$ as long as valva, ornamented with scale-like setae; lateral pocket of ventral shield of juxta deep. Digitate process reduced into a small, naked, sub-triangular lobe. Vinculum with short saccus. Aedeagus almost straight, $\frac{3}{4}$ as long as valva, apically acute; vesica with a group of minute spines.

Female genitalia (figs. 23, 24). – Apophyses almost

equal in length. Ostium opening on seventh sternite; antrum deep bowl-shaped, lined with coarse spines densely on dorsal surface, with ventral margin concave; spines lining dorsal surface of antrum extending caudally along a medial ditch, spined area being twice as long as its largest width. Ductus bursae equally wide in whole length; ductus seminalis branching off from ductus bursae on $\frac{1}{3}$ from antrum. Corpus bursae on its caudal part with a pouch-like swollen part, which is lined with fine spines and has the signum as a cross-shaped sclerotized plate with a dentate ridge along one axis.

Foodplants

Poaceae: *Eccoilopus cotulifer* A. Camus; the holotype has a foodplant label, *Spodiopogon sibiricus* Trin.

Biology

The larva is a leaf-miner and makes a full-depth and linear mine extending almost straight towards the leaf-apex. Excrements form a line indicating in what way the larval anus moved. The full-grown larva leaves the mine and pupates in a cocoon made of a sparse silk-web. In the field, pupae are sometimes found on the upperside of the basal part of the mined leaf, with its head directed towards the stem of the plant. The pupa (fig. 44) is attached to the surface by a silk-girdle surrounding its abdomen and the cremaster. In the pupal abdomen (fig. 44a), the fourth and fifth segments are mobile, and the spiracles are situated on the low and simple dorso-lateral keel, with no indication of the spiracular projections. Probably *E. caliginosa* has more than one generation a year, and hibernates as a pupa.

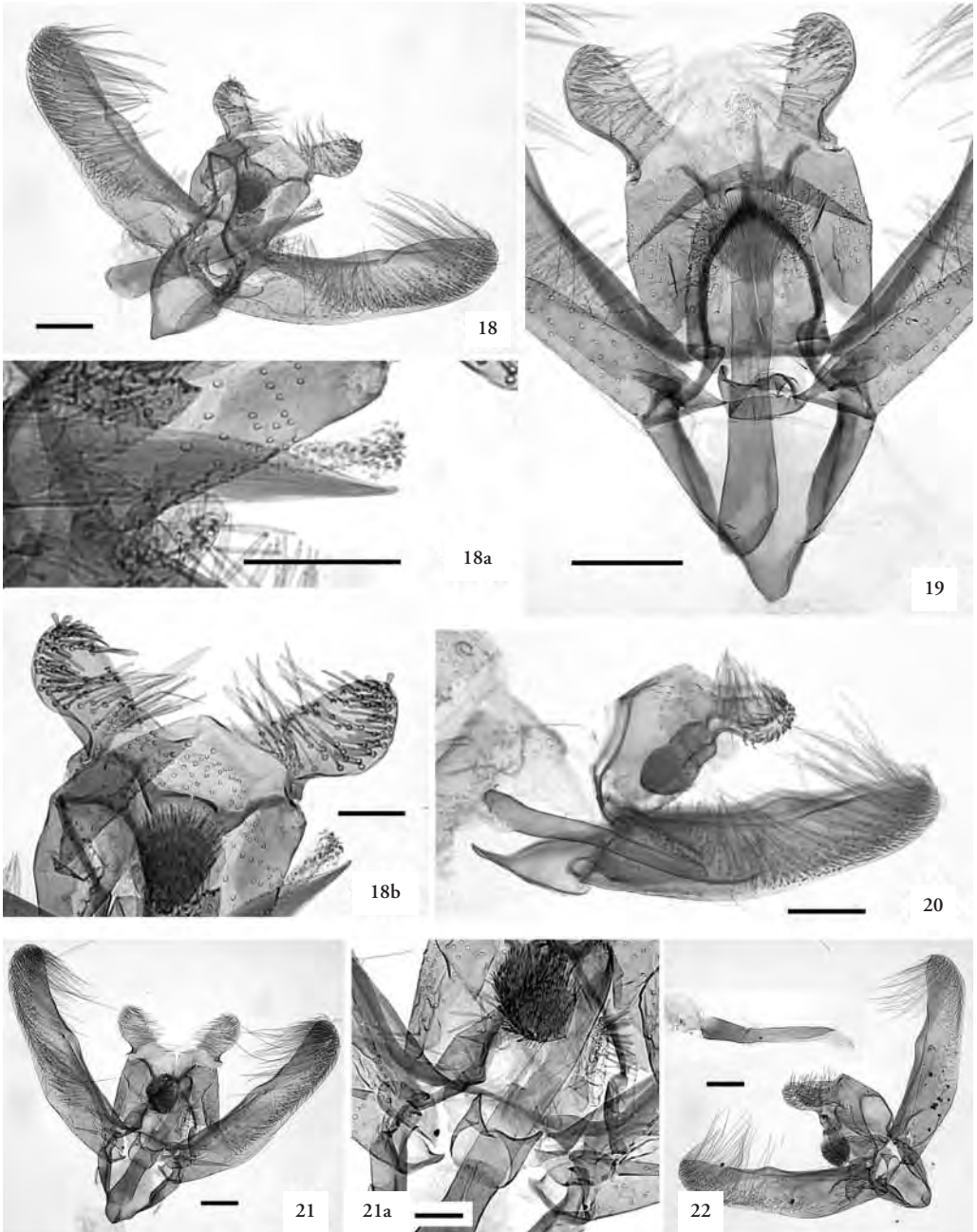
Distribution

Japan: Honsyū (Nagano-ken); Tusima. Far Eastern Russia: Primorsky Kray (Sruoga 1995).

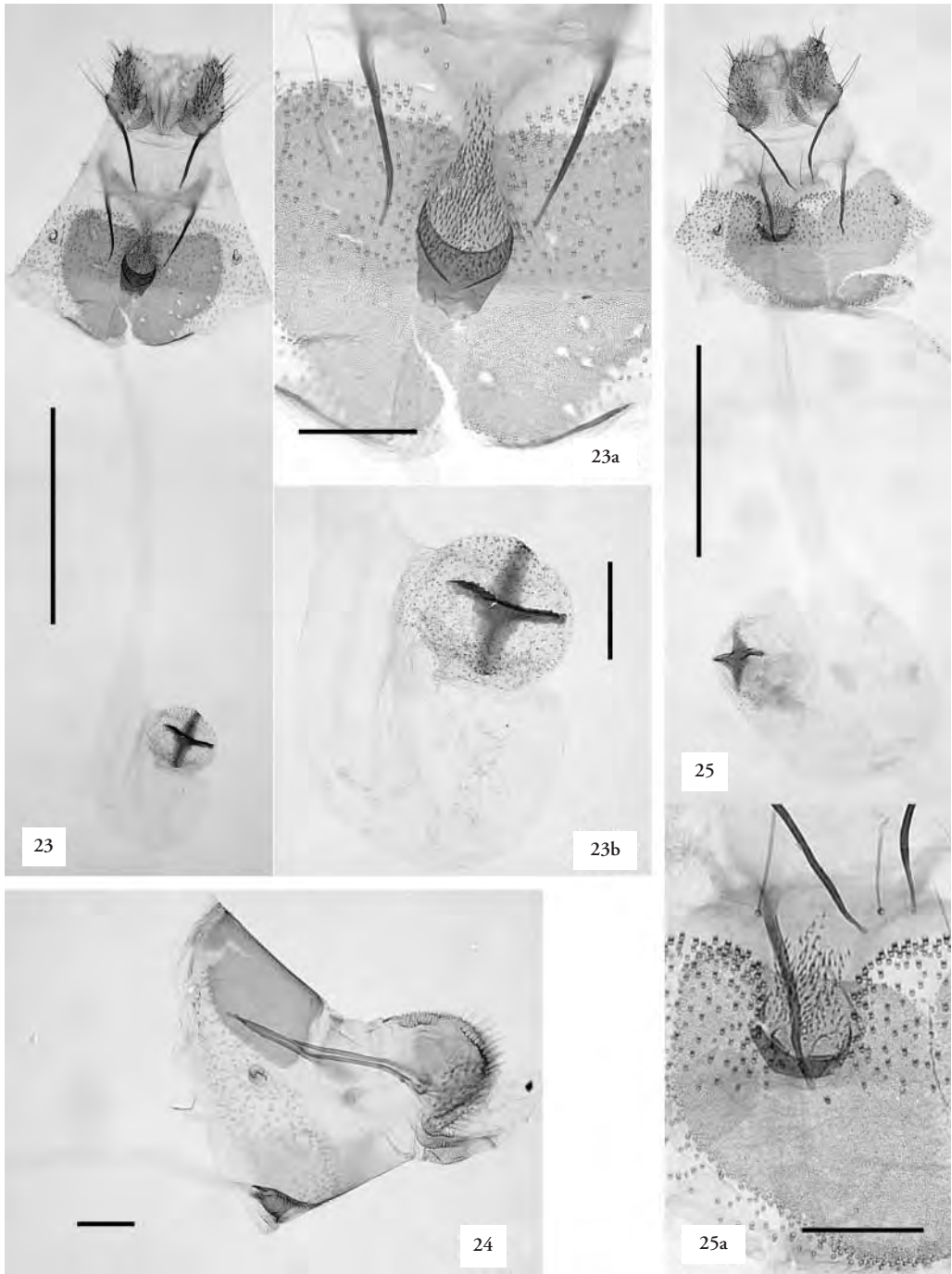
Remarks

Elachista caliginosa shares with *E. nepalensis* Traugott-Olsen, 1999 the following genital characters in addition to coloration: the elongate sub-conical juxta lobes; the apically acute aedeagus; the vesica with a group of minute spines; the deep bowl-shaped antrum; the spined area of the dorsal surface of the antrum twice as long as wide. *Elachista caliginosa* can be separated from *E. nepalensis*, in male by presence of the digitate process, and in female by the cross-shaped signum. In *E. nepalensis*, the digitate processes are absent and the signum is a linear dentate plate.

Elachista caliginosa is probably also close to the next species. For discrimination between *E. caliginosa* and the next species, see there.



Figs. 18-22. *Elachista* species, ♂ genitalia; scale lines 0.1 mm for whole genitalia, 0.05 mm for magnified view. – 18-20, *E. caliginosa*, Tusima (18, slide no. KS 0770, cornuti magnified in 18a, uncus lobes magnified in 18b; 19, genitalia excluding distal part of valva, slide no. KS 0535; 20, lateral view, slide no. KS 1138); 21-22, *E. fasciocaliginosa* (21, holotype, area around juxta magnified in 21a; 22, paratype, Azusagawa-mura, slide no. KS 1381).



Figs. 23-25. *Elachista* species, ♀ genitalia; scale lines 0.5 mm for whole genitalia, 0.1 mm for others. – 23-24: *E. caliginosa*, Tusima (23, slide no. KS 0664, sterigma magnified in 23a, corpus bursae magnified in 23b; 24, caudal part, lateral view, slide no. KS 1441); 25, *E. fasciocaliginosa*, paratype, Azusagawa-mura, slide no. KS 0730, antrum magnified in 25a.

Elachista (Elachista) fasciocaliginosa sp. n.
(figs. 6-8, 21, 22, 25, 45)

Type material. – Holotype ♂: JAPAN: Yamagata-mura (Karasawa), Nagano-ken, Honsyû, 13.vi.1999, N. Hirano leg., Genitalia slide KS 0728 (UOPJ). – Paratypes: JAPAN: HONSYÛ: 1♂2♀, Azusagawamura (Ueno) (1♀, 22.vii.1982; 1♀, 16.vi.1995; 1♂, em. 1.viii.2003, host *Miscanthus sinensis* (00668)) (1♀ UOPJ; 1♂1♀ EIHU); 1♀, Yamagata-mura (Karasawa), 5.vi.1999 (UOPJ).

Diagnosis

Head and thorax lead-greyish. Forewing blackish, not mottled, with two silvery transverse fasciae on $\frac{1}{3}$ and beyond $\frac{2}{3}$, fasciae running from costal margin to hind margin of wing without interruptions. Male genitalia: uncus bluntly quadrangular; juxta lobes elongate, sub-conical, without a distinct projection extending laterally; valva almost five times as long as wide; saccus little developed. Female genitalia: apophysis anterioris somewhat shorter than apophysis posterioris; antrum shallow bowl-shaped; spined area of dorsal surface of antrum at most 1.5 times as long as wide; signum cross-shaped, with a dentate ridge along one axis.

Description

Forewing length: ♂ 2.8 mm (2.8 mm in holotype), ♀ 2.9-3.1 mm. Head, thorax, and forewing black-brownish, not mottled, with face and upperside of labial palpi lead-greyish; forewing with two white-silvery fascia totally traversing the wing around $\frac{1}{3}$ and $\frac{3}{4}$; fasciae sometimes outwards bent.

Male genitalia (figs. 21, 22). – As those of *E. caliginosa*, except for valva more elongate (4.5 times as long as wide or longer) and saccus less developed.

Female genitalia (fig. 25). – As those of *E. caliginosa*, except for characters around antrum: antrum shallow bowl-shaped, spined area of dorsal surface of antrum at most 1.5 times as long as its largest width.

Foodplants

Poaceae: *Miscanthus sinensis* Anderss.

Biology

The larva is a leaf-miner. The mine starts from just above the egg laid on the underside of the leaf. It is purplish and linear during earlier instars of the larva, and later becomes greenish and elongate blotch-like; it is full-depth from the beginning to the end of larval growth. The excrements form a line indicating in what way the larval anus moved. The full-grown larva leaves the mine and pupates in a cocoon of a sparse silk-web. The pupa (fig. 45) is attached to the surface by a silk-girdle surrounding its abdomen and

the cremaster. The pupal morphology is as in *E. caliginosa*, except that it looks relatively short and flattened, with dorso-lateral tubercles on the mesothorax somewhat larger. Probably more than one generation occurs a year.

Distribution

Japan: Honsyû (Nagano-ken).

Remarks

In the genitalia, *Elachista fasciocaliginosa* is extremely similar to the preceding *E. caliginosa*, and only slight differences are detected in the following characters: in the male, the shape of the valva and the saccus; in the female, the depth of the antrum and the shape of the spined area on the dorsal surface of the antrum. In contrast with a very close similarity in the genitalia, the wing markings are quite different between *E. fasciocaliginosa* and *E. caliginosa*. In *E. fasciocaliginosa*, the forewing has two distinct silvery fasciae, both of which run from the costal margin to the hind margin without any interruptions. In *E. caliginosa*, the forewing has only one light-colored fascia, which is blurred beyond the fold, often interrupted around the fold, and rarely reaches the hind margin: the light-colored markings beyond $\frac{2}{3}$ are always distinctly divided into two spots and do not form a transverse fascia.

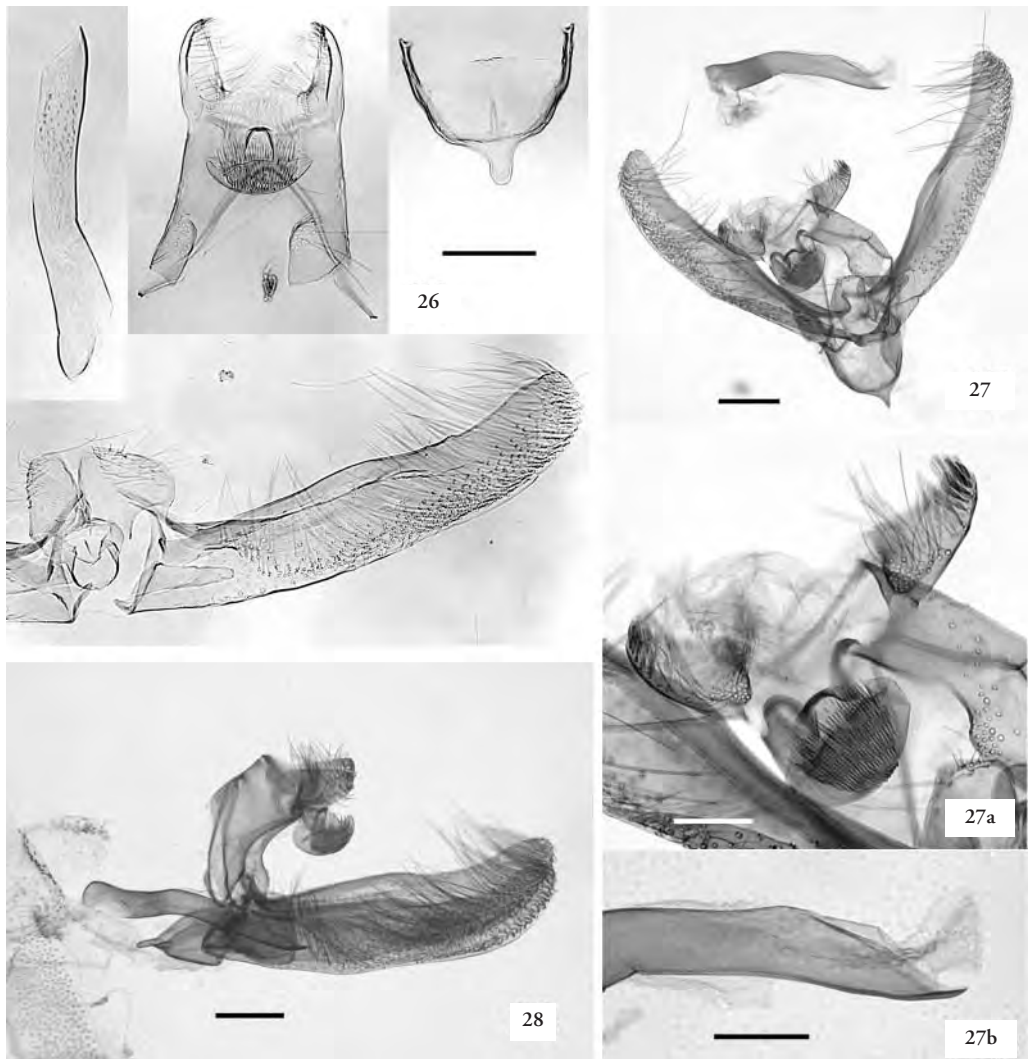
Etymology

The species name, *fasciocaliginosa*, means that this new species is close to *E. caliginosa*, but differs in possessing two distinct fasciae on the forewing.

Elachista (Elachista) kurokoi Parenti
(figs. 9-11, 26-30, 46, 47)

Elachista kurokoi Parenti, 1983: 9-10, pls 2, 4. Holotype ♂: JAPAN: Hiko-san, Hukuoka-ken, Kyûsyû, [em.] 10.v.1954, [reared from] leaf-miner on *Oplismenus undulatifolius* [written in Japanese], H. Kuroko [leg.], Genitalia slide U. Parenti 5797 (UOPJ) [examined].

Material examined. – Paratypes (all were collected and reared from larvae on *Oplismenus undulatifolius* at the same locality as the holotype): 1♂1♀, em. 12.iv.1954; 1♀, em. 24.v.1954; 3♀, em. 6-25.v.1955; 1♂, em. 25.vi.1955 (in UOPJ). – Other specimens examined (all reared specimens are from *Oplismenus undulatifolius*, except for those mentioned): JAPAN: HONSYÛ: 1♂, Daitô-tyô, Sizuoka-ken, May (UOPJ); 6♂4♀, Hamamatu-si, Sizuoka-ken, December (em.) (2♂1♀ UOPJ; 1♂1♀ EIHU; 2♂1♀ MZHF; 1♂1♀ PCUP); 1♂, Hikimi-tyô, Simane-ken, May (EIHU); 2♂, Kozagawa-tyô, Wakayama-ken, May (EIHU); 2♂4♀, Kyôto-si (Oku-kibune), Kyôto-hu, February and May (em.) (EIHU); 1♂2♀, Maki-mura, Niigata-ken, from April to May (em.) (1♀ UOPJ; 1♂1♀ EIHU); 1♂, Mori-mati, Sizuoka-ken, June (UOPJ); 4♂3♀, Morioka-si, Iwate-ken, May (em.)

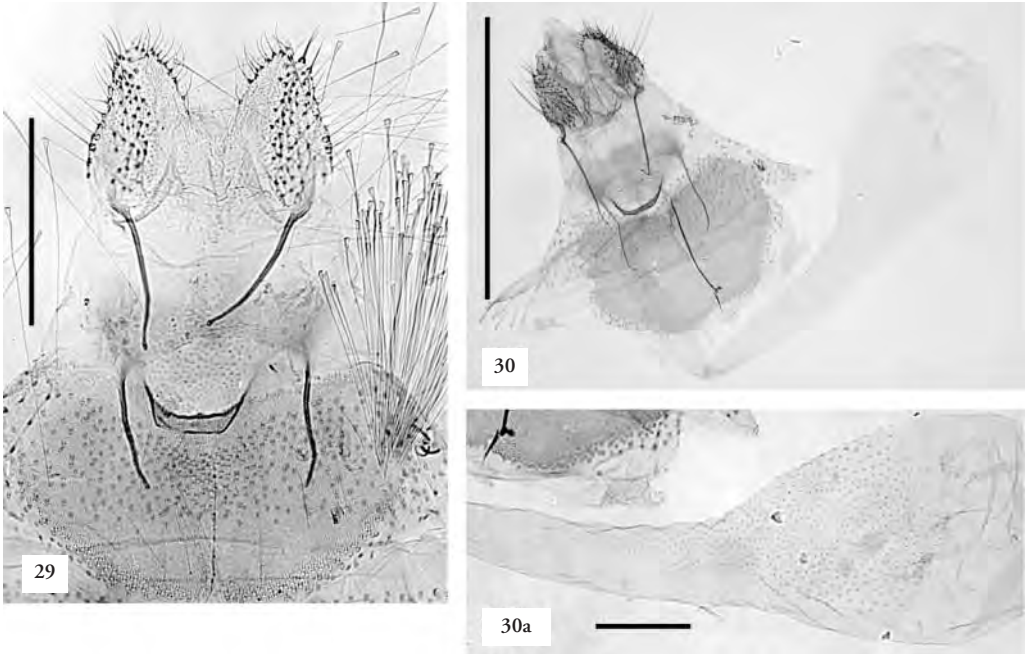


Figs. 26-28. *Elachista kurokoi*, ♂ genitalia; scale lines 0.1 mm for whole genitalia, 0.05 mm for magnified organs. – 26, holotype; 27, Okinawa-hontô, slide no. KS 1135, uncus and gnathos magnified in 27a, cornuti magnified in 27b; 28, lateral view, Hiko-san, slide no. KS 1134.

(EIHU); 1♂1♀, Oki-no-sima, Simane-ken, May (em.), host Poaceae sp. (EIHU); KYŪSYŪ: 4♂1♀, Hiko-san, Hukuokaken (1♂, June; 3♂1♀, from November to December (em.)) (2♂1♀ EIHU; 1♂ MZHF); 1♂, Miyakonozyô-si, Miyazaki-ken, August (em.), host *Digitaria timorensis* (UOPJ); RYŪKYŪ: 3♀, Sumiyô-son, Amami-ôshima, em. 23.iii.2004, host *Microstegium vimineum?* (EIHU); 7♂, Arangati-no-taki, Amami-ôshima, March (3♂ UOPJ; 3♂ EIHU; 1♂ MZHF); 5♂7♀, Okinawa-hontô (Yonaha-dake), April (em.) (1♂2♀ UOPJ; 2♂3♀ EIHU; 1♂1♀ MZHF; 1♂1♀ NMNS); SIKOKU: 11♂, Ino-si, Kôti-ken, June (EIHU); TUSIMA: 30♂23♀, Tusima-si, May, October, and December (em.) (1♂1♀ UOPJ; 28♂21♀ EIHU; 1♂1♀ MZHF).

Identification

I identified the non-type specimens examined here as *E. kurokoi* on the following characters: the blackish forewing with five small silver-whitish spots, one at base on fold being distant from both costal and hind margins, two on $\frac{1}{3}$ and beyond $\frac{2}{3}$ of costa, one around $\frac{2}{3}$ of fold, and tornal one opposite to distal one of costal spots; the male genitalia with the semi-circular gnathos knob bearing a pair of wide naked areas laterally, and with the elongate triangular digitate processes; the female genitalia with the shallow



Figs. 29-30. *Elachista kurokoi*, ♀ genitalia; scale lines 0.5 mm for 30, 0.1 mm for others. – 29, paratype, Hiko-san, slide no. U. Parenti 5798; 30, Hamamatu-si, slide no. KS 1147, area around border between ductus bursae and corpus bursae magnified in 30a.

cup-shaped antrum bearing blunt cephalo-lateral corners, and with the ductus bursae and corpus bursae being indistinctly separable from each other and bearing a patch of fine spines.

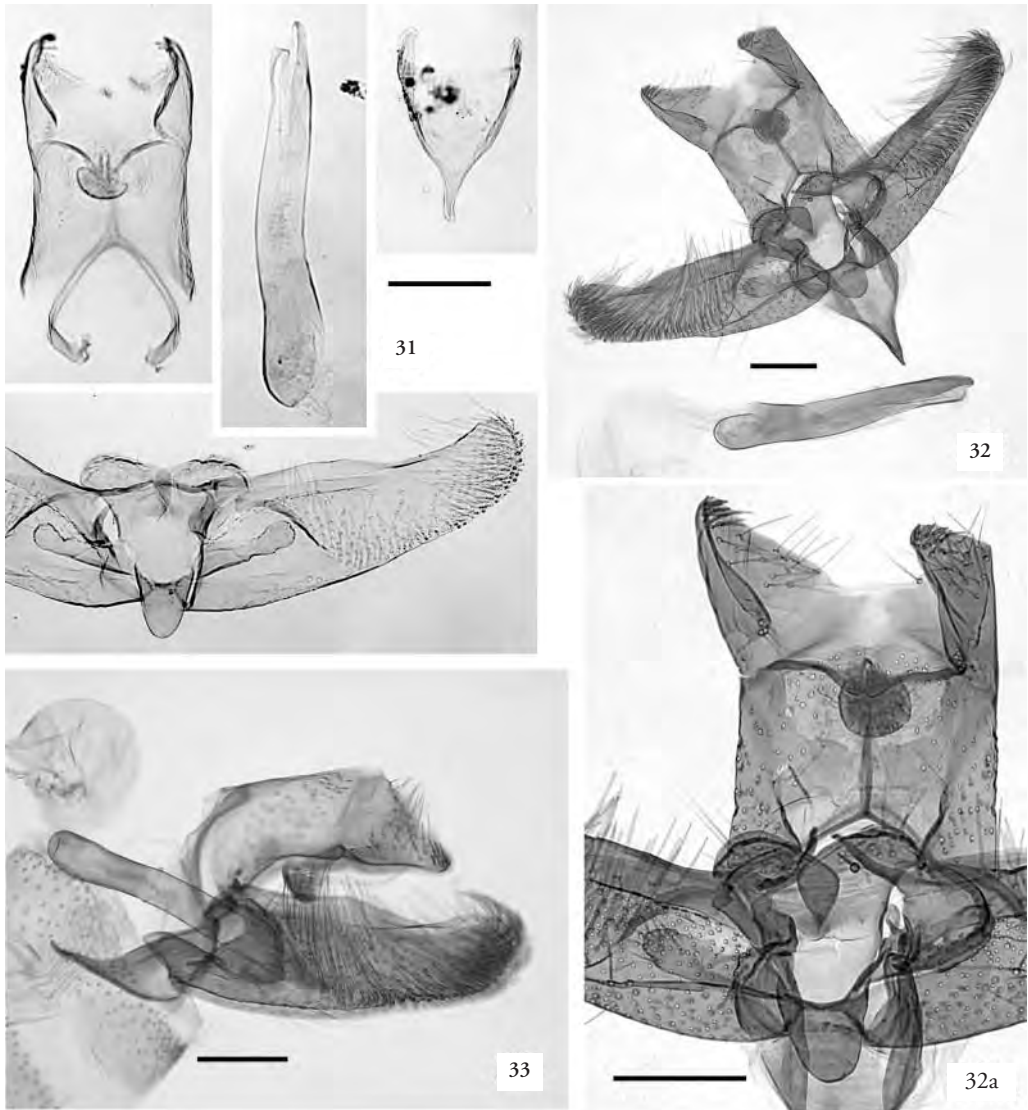
Redescription

Forewing length: ♂ 2.4-3.0 mm (holotype 2.9 mm), ♀ 2.5-3.2 mm. Head metallic greyish, with dark brownish neck tufts. Labial palpus metallic greyish on dorsal surface, dark brownish on ventral surface, with apex of second segment dark brownish. Thorax dark brownish. Forewing blackish, with the following five small silver-whitish spots, which are clearly separated from each other: one at base of wing on fold being distant from both costal and hind margins, two costal ones on $\frac{1}{5}$ and beyond $\frac{2}{3}$, one around $\frac{2}{3}$ of fold being smallest, very close to but distinct from basal one of two costal spots, tornal one opposite to distal one of two costal spots, not extending into cilia.

Male genitalia (figs. 26-28). Uncus lobes bluntly triangular, apically round; setae on ventral surface dense and short scale-like near apex of uncus lobe, becoming sparser, longer, and thinner towards base of uncus lobe. Socius recognized as a hump orna-

mented with a mixed group of long scale-like hairs and short pointed setae. Gnathos knob semi-circular, $\frac{1}{2}$ as wide as tegumen, naked on $\frac{1}{5}$ from lateral ends. Valva elongate, with indistinct costal hump around middle. Juxta lobe roundly produced in lateral margin, with about 15 setae. Digitate process elongate triangular, nearly $\frac{1}{5}$ as long as valva; apical part round, with at most three setae. Vinculum with short saccus. Aedeagus $\frac{2}{3}$ as long as valva, bent ventrally around $\frac{2}{5}$, apically acute; vesica with a group of small teeth.

Female genitalia (figs. 29-30). Apophysis anterioris $\frac{4}{5}$ as long as or almost equally long to apophysis posterioris. Ostium opening on membrane between seventh and eighth sternite; antrum shallow cup-shaped, angular cephalo-laterally, lined with spines, with ventral margin evenly curving; spines on dorsal surface of antrum extending towards caudal margin of eighth sternite as a gradually widening band of spines. Ductus bursae widening cephalically, almost smoothly continued to round corpus bursae; colliculum absent; minute spines scattered as an elongate patch from cephalic $\frac{1}{4}$ of ductus bursae to middle of corpus bursae.



Figs. 31-33. *Elachista miscanthi*, ♂ genitalia, Hiko-san, Hukuoka-ken; scale lines 0.1 mm. – 31, holotype; 32, slide no. KS 0799, uncus, juxta, and digitate process magnified in 32a; 33, lateral view, slide no. KS 1120.

Foodplants

Poaceae: *Oplismenus undulatifolius* (Ard.) P. Beauv., *Digitaria timorensis* Balansa, *Microstegium vimineum* A. Camus. The latter two hosts may be erroneous; Y. Sakamaki (personal communication), who collected the specimens from these two plants, informed me that he may have misidentified the plants.

Biology

In Japan, south of Tôhoku district, *E. kurokoi* is commonly found in shady places, where *Oplismenus undulatifolius* grows, and has two or more generations a year, hibernating as a pupa.

The larva is a leaf-miner. The mine is full-depth and elongate blotch-like, starts generally from near the leaf-edge, and becomes wider gradually. Excrements are pushed into older part of mine behind the

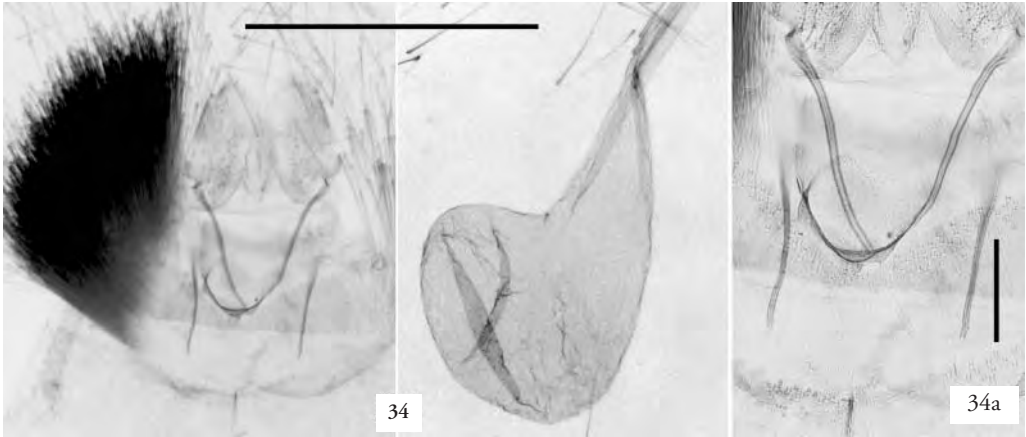


Fig. 34. *Elachista miscanthi*, ♀ genitalia, slide no. U. Parenti 3799, caudal part (left), cephalic part (right), sterigma magnified in 34a; scale lines 0.5 mm for 34, 0.1 mm for 34a.

larva. The full-grown larva leaves the mine and pupates in a moderately dense cocoon (fig. 46), which is constructed on an angled place and composed of sub-transverse series of strong silk-filaments. The pupa (figs. 46, 47) is attached to the surface by a single silk-girdle surrounding its abdomen and the cremaster. In the pupal abdomen (fig. 47a), no segments are mobile, and the dorso-lateral keel is modified into a row of long triangular fin-like projections. The abdominal spiracle is set on the top of the fin-like projection, and caudally accompanied by a thorn.

Distribution

Japan: Honsyū; Sikoku; Kyūsyū; Tusima; Ryūkyū (Amami-ōsima, Okinawa-hontō).

Remarks

This species can be distinguished from other congeneric species by the blackish forewing with a silver-whitish basal spot, which is on the fold and distant from both the costal and hind margins. In other congeneric species, when the blackish forewing has a whitish basal spot, it reaches at least one of the two margins.

Elachista (Elachista) miscanthi Parenti (figs. 12-14, 31-34, 37, 38, 41, 42, 48)

Elachista miscanthi Parenti, 1983: 10-11, pls 2, 4. Holotype ♂: JAPAN: Hiko-san, Hukuoka-ken, Kyūsyū, 14.v.1956, [host] *Miscanthus sinensis* [written in Japanese], H. Kuroko [leg.], Genitalia slide U. Parenti 5809 (UOPJ) [examined].

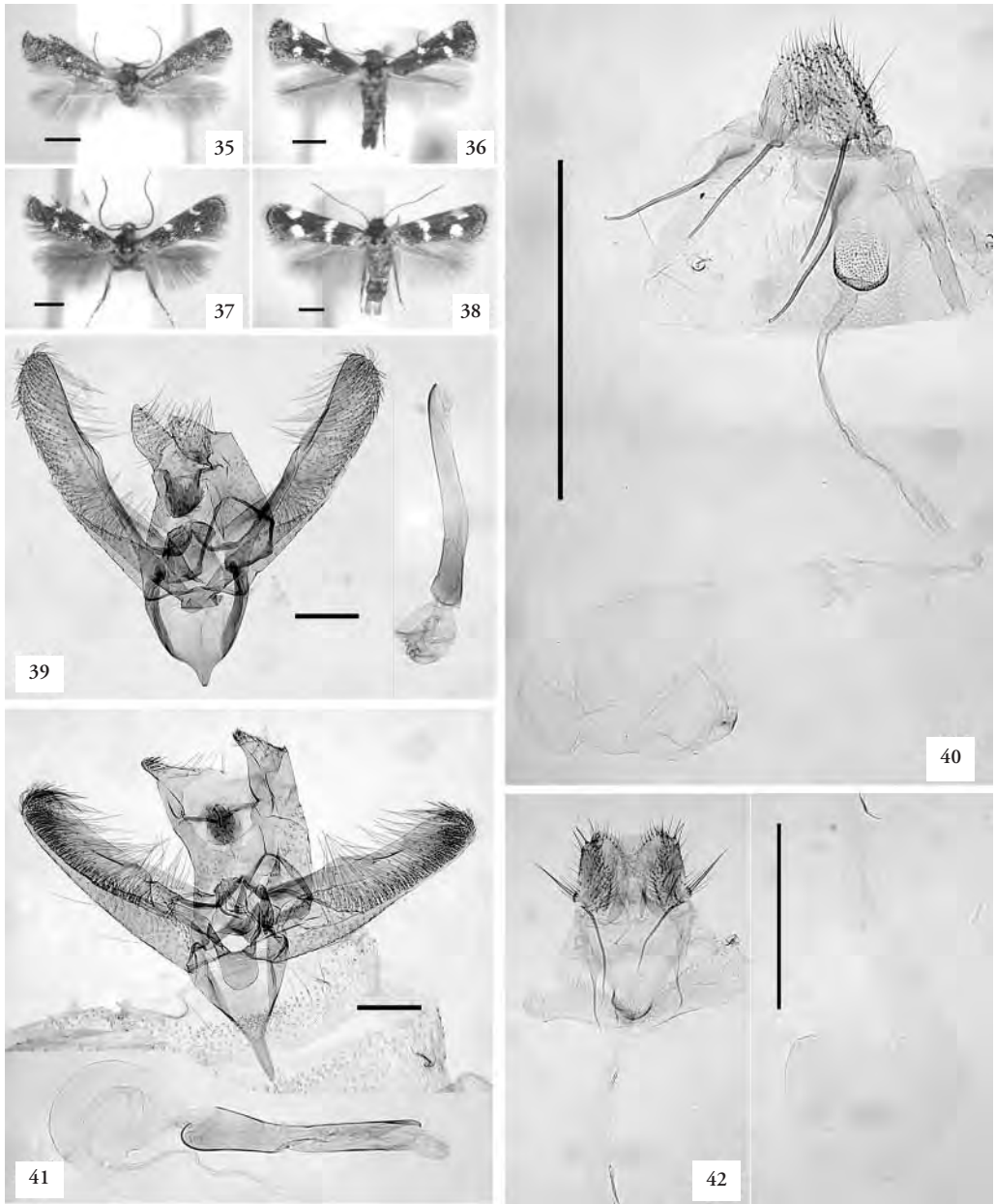
Material examined. – Paratypes (all collected and reared from larvae on *Miscanthus sinensis* at the same locality as the holotype): 2♀, em. 4-9.vi.1955; 1♀, em. 19.vi.1956 (UOPJ). – Other specimens examined: JAPAN: HONSYŪ: 1♂, Azusagawa-mura (Ueno), Nagano-ken, 28.v.1985 (UOPJ); 1♀, Kamiako-dani, Hyōgo-ken, 28.v.1978 (UOPJ); KYŪSYŪ: 5♂, Hiko-san, Hukuoka-ken, em. 18.xi.-10.xii.1998, host *Miscanthus sinensis* (00313) (4♂ EIHU; 1♂ MZHF); 1♂ 1♀, Yaku-sima (Ōkawa-rindō), Kagosima-ken, 21.iv.1981 (OMNH); TAIWAN: 1♂, Henglongshan (1200 m), Taian, Miaoli, em. 16.iii.2003, host *Miscanthus sinensis* (HSU 03 B 36.1) (NMNS); 2♀, Lanyu, col. 3.iv.1996, em. 12-20.v.1996, ex *Miscanthus* sp. (00193) (1♀ EIHU; 1♀ NMNS).

Identification

I identified the non-type specimens examined here as *E. miscanthi* on the following characters in the genitalia: the male with the medial part of the uncus recognized as a moderately sclerotized area between the triangular uncus lobes, the relatively short valva, the ventral shield of the juxta strongly concave and forming a tongue-shaped pouch, and the digitate process less reduced and apically ornamented with about ten setae; the female with the very shallow bowl-shaped antrum, and with the ductus bursae and corpus bursae being totally membranous and P-shaped as a whole.

Redescription

Forewing length: ♂ 2.9-3.1 mm (holotype 3.1 mm), ♀ 3.0-3.5 mm (♀ from Lanyu 3.6-3.8 mm). Head metallic greyish or pale grey-brownish, with neck tufts dark grey-brownish. Labial palpi metallic greyish on dorsal surface, dark grey-brownish on ventral surface. Thorax dark grey-brownish. Forewing



Figs. 35-42. *Elachista* species, Taiwan. – 35-38, adult moths; scale lines 1 mm (35, *E. amamii*, ♂, Taipei; 36, *E. amamii*, ♀, Taipei; 37, *E. miscanthi*, ♂, Miaoli; 38, *E. miscanthi*, ♀, Lanyu); 39-42, genitalia; scale lines 0.1 mm for males, 0.5 mm for females (39, *E. amamii*, ♂, Taipei, slide no. KS 1437; 40, *E. amamii*, ♀, Taipei, slide no. KS 1426; 41, *E. miscanthi*, ♂, Miaoli, slide no. KS 1419; 42, *E. miscanthi*, ♀, Lanyu, slide no. KS 1420).

black-brownish, copper-reflecting to a various extent, lead-greyish at base around caudal angle, with the following silvery markings: a transverse fascia on $\frac{1}{3}$ (usually reaching but sometimes distant from hind margin, and sometimes interrupted around fold), a spot on tornus, and a costal spot slightly beyond tornal spot; costal and tornal spots narrow triangular in male, larger and quadrangular in female, and distant from each other in both sexes. Dense paired hair tuft of female whitish or pale ochreous.

Male genitalia (figs. 31–33, 41). – Uncus lobe triangular; setae on ventral surface dense, short, and thick on apical part, sparse and slender on medial part; indentation between uncus lobes incomplete, its depth only half length of uncus lobe. Socius with less than ten sort setae. Tegumen with a medial ridge extending from cephalic margin. Valva short, tapering towards round cucullus, with indistinct costal hump around middle. Juxta lobe ornamented with about 20 setae, with latero-caudal part produced distinctly; ventral shield of juxta strongly concave, forming a tongue-shaped pouch. Digitate process longer than $\frac{1}{4}$ length of valva, little tapering towards round apex, with about ten setae on apical part. Vinculum with distinct saccus. Aedeagus almost as long as valva, nearly straight, apical end of dorsal surface truncate, ventral surface ending as blunt apex; vesica with a group of indistinct teeth.

Female genitalia (figs. 34, 42). – Apophysis anterioris $\frac{1}{2}$ – $\frac{3}{5}$ as long as apophysis posterioris. Ostium opening on membrane between seventh and eighth sternites; antrum very shallow bowl-shaped, lined with fine spines. Ductus bursae and corpus bursae P-shaped as a whole, entirely smooth; ductus bursae widening towards corpus bursae; colliculum absent. Ductus seminalis branching off from ductus bursae around $\frac{3}{20}$ from antrum.

Foodplants

Poaceae: *Miscanthus sinensis* Anderss. and an unidentified species of *Miscanthus*.

Biology

The larva is a leaf-miner and makes a full-depth and straight-linear mine extending towards the leaf-base. Excrements are pushed into older part of mine behind the larva. The full-grown larva leaves the mine and pupates on an angled place in a moderately dense cocoon of a coarse silk-roof composed of sub-transverse silk-filaments. The pupa (fig. 48) is attached to the surface by a single silk-girdle and the cremaster. In the pupal abdomen (fig. 48a), the fourth and fifth segments are mobile, and the spiracles are set on the top of a blunt fin-like projection, which results from modification of the dorso-lateral keel.

Distribution

Japan: Honsyû; Kyûsyû. Taiwan: Miaoli; Lanyu.

Remarks

In appearance, *Elachista miscanthi* might be confused with *E. kurokoi* in the male, and with *E. amamii* in the female. In the male, *E. miscanthi* can be distinguished from *E. kurokoi* by the absence of a silver-whitish spot at base of the forewing. In the female, *E. miscanthi* can be distinguished from *E. amamii* by the genitalia with the ductus bursae and corpus bursae, which are as a whole P-shaped and smoothly membranous.

DISCUSSION

Diversity of the pupae and cocoons in the *E. praelineata*-group

Pupal morphology is considerably variable in the five species of the *Elachista praelineata*-group examined in this study: *E. amamii* (fig. 43), *E. caliginosa* (fig. 44), *E. fasciocaliginosa* (fig. 45), *E. kurokoi* (figs. 46, 47) and *E. miscanthi* (fig. 48). The abdomen has no mobile segments in *E. kurokoi*, while the fourth and fifth segments are mobile in the other four species. The dorso-lateral keel of the abdomen is modified into a row of fin-like plates in *E. amamii*, *E. kurokoi*, and *E. miscanthi*. Abdominal spiracles are set on the top of a sub-conical spiracular projection arising from a low fin-like plate in *E. amamii*, and set on the top of a prolonged fin-like plate in *E. kurokoi* and *E. miscanthi*. Spiracular projections are not recognized in *E. kurokoi* and *E. miscanthi*, while the fin-like plate of these two species could actually be a fusion of the dorso-lateral keel and spiracular projection. In *E. caliginosa* and *E. fasciocaliginosa*, the dorso-lateral keel is low and simple, with no indication of fin-like plates or spiracular projections.

The cocoon varies in density and directions of silk-filaments covering the pupa. The filaments are sparse in *E. amamii*, *E. caliginosa*, and *E. fasciocaliginosa*, but they are moderately dense in *E. kurokoi* and *E. miscanthi*. The filaments run longitudinally as well as sub-transversally in *E. amamii*, while they run only sub-transversally in the other four species. Fixation of the pupa is achieved by a silk-girdle surrounding its abdomen and the cremaster in *E. amamii*, *E. caliginosa*, and *E. fasciocaliginosa*. The cocoon may serve as a supplementary fixation mechanism in *E. kurokoi* and *E. miscanthi*, while fixation is apparently achieved mainly by the silk-girdle in these two species.

Among other species of the *E. praelineata*-group, information on the pupa and cocoon is available for four species. Braun (1948: figs. 42, 44, 46) described the pupa and cocoon of three Nearctic species:

E. praelineata Braun, 1915, *E. radiantella* Braun, 1922, and *E. solitaria* Braun, 1922. In these Nearctic species, the pupa is in a flimsy cocoon of sparse silk-web and attached to the surface by a silk-girdle and the cremaster. In their pupal abdomen, the dorso-lateral keels are low and simple, with no indication of fin-like plates or spiracular projections, and the fourth and fifth segments are mobile. Parenti & Varalda (1991: fig. 15) described the pupa and cocoon of a Mediterranean species, *E. sicula* Parenti, 1978. According to their description, the pupa of *E. sicula* is under a silk-covering and has abdominal spiracles situated on the top of a conical projection. Judging from the figure of the pupa, the dorso-lateral keel of *E. sicula* seems to be low and simple, and the spiracular projections are situated near the keel rather than on the keel. Mobility of the pupal abdomen, density of the cocoon, and the mechanisms of pupal fixation of *E. sicula* are undescribed.

The dorso-lateral keel of the pupal abdomen is modified into a row of fin-like plates in *E. amamii* (fig. 43a), *E. kurokoi* (fig. 47a), and *E. miscanthi* (fig. 48a). This character has not been reported previously in Elachistidae. The very long fin-like plates of *E. kurokoi* are superficially similar to the very long spiracular projections known in species of the *E. saccharella*-group. In this species-group, however, the spiracular projections are clearly recognized as tubular projections arising from the low and simple dorso-lateral keel (e.g. Braun 1948: fig. 51; Bradley 1974: figs. 7, 8; Sugisima & Kaila in press: fig. 24). In the *E. praelineata*-group, spiracular projections similar to those of *E. amamii* have been reported only in *E. sicula* (Parenti & Varalda 1991). The projections are on the keel in *E. amamii* and somewhat dorso-medially of the keel in *E. sicula*. Although immobility of the pupal abdomen is sometimes reported in *Elachista* (Kaila 1999a), *E. kurokoi* is the first example in the *E. praelineata*-group.

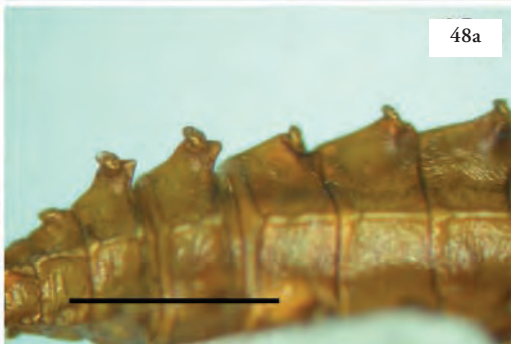
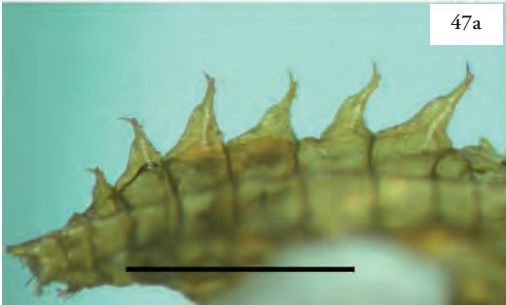
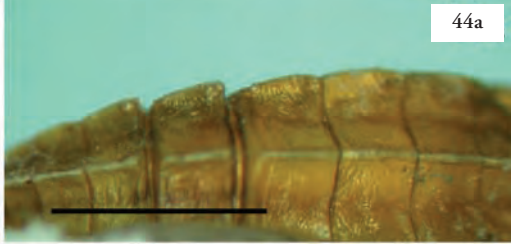
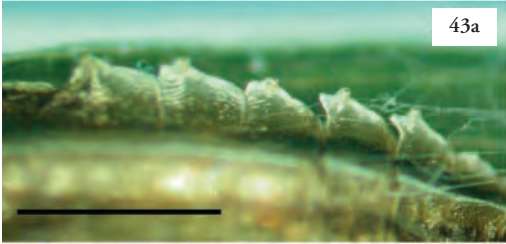
In the current phylogenetic hypothesis (Kaila 1999a, 1999b), the *Elachista praelineata*-group is the sister-clade of a clade comprising the *E. saccharella*- and *E. freyerella*-groups, and together with these two species-groups forms the sister-clade of *E. bifasciella*-group. The pupa of *E. bifasciella*-group is almost invariable in morphology (e.g. Braun 1948: figs. 35-38;

Kaila 1999a: table 1). It is in an extremely flimsy cocoon of very sparse silk filaments and attached to the surface by a silk-girdle and the cremaster, with the only exception of *E. poae* Stainton, 1855, the cocoon of which is composed of somewhat stout silk-filaments. In the pupal abdomen of the *E. bifasciella*-group, the dorso-lateral keel is low and simple, the fourth and fifth segments are mobile, and spiracles are on the dorso-lateral keel, with no indication of spiracular projections. In the *E. praelineata*-group, the same characters are observed in *E. caliginosa*, *E. fasciocaliginosa*, and the three Nearctic species. These species probably represent ancestral pupal morphologies within the *E. praelineata*-group. On the other hand, *E. amamii*, *E. kurokoi*, *E. miscanthi*, and *E. sicula* have supposedly derived characters in comparison with the *E. bifasciella*-group.

Hypotheses to explain pupal diversity

Besides the species of the *E. praelineata*-group, the genus *Elachista* is considerably diversified in the pupal morphology when compared to other Gelechioidea including other genera of Elachistidae s. str. (i.e. *Perittia* Stainton, 1854 and *Stephensia* Stainton, 1858). The pupal surface is quite elaborately and variously ornamented with tubercles, projections, and ridges on the head and thorax, and with a dorsal keel and a pair of dorso-lateral keels on the abdomen. In the abdomen of some species, the dorso-lateral keels are modified into rows of fin-like plates, or spiracular projections are developed. The fourth and fifth abdominal segments are mobile in most species, though one or both of them are immobile in some species. A few authors have paid attention to this diversity in the *Elachista* pupae. Braun (1948: 22) stated that the pupal characters are reliable criteria for species identification. Kaila (1999a) used many pupal characters in a phylogenetic analysis within Elachistidae of strict sense. Nevertheless, no biological explanations have been proposed with regard to the diversity of the *Elachista* pupae. On observations of pupae and cocoons in many *Elachista* species, I found that there may be a correlation between the pupal morphology and the cocoon structures. While the elaborately ornamented pupal surface is common in *Elachista*, conspicuous projecting of abdominal

Figs. 43-48. *Elachista* species, pupal features; scale lines 1 mm. – 43, *E. amamii*, exuvia and cocoon, dorsal view, Taipei, Taiwan, right end of abdomen magnified in 43a focusing on dorso-lateral keel and fourth to sixth segments; 44, *E. caliginosa*, exuvia, dorso-lateral view, Tusima, left end of abdomen magnified in 44a focusing on dorso-lateral keel and fourth to sixth segments; 45, *E. fasciocaliginosa*, exuvia, dorso-lateral view, Azusagawa-mura; 46-47, *E. kurokoi*, Okinawa-hontô (46, exuvia and cocoon, dorsal view; 47, exuvia, lateral view, left end of abdomen magnified in 47a focusing dorso-lateral keel and fourth to sixth segments); 48, *E. miscanthi*, exuvia, Hiko-san, left end of abdomen magnified in 48a focusing dorso-lateral keel and fourth to sixth segments.



spiracles (i.e. long tubular projections or long fin-like projections) and poorer mobility of the abdomen tend to occur in species with a relatively dense cocoon. Here I propose an explanation for the diversity of pupal morphology in *Elachista* in the context of the functional morphology mainly associated with the cocoon structures.

The cocoon of *Elachista* is generally a sparse silk-web over the pupa, so that one can see the pupa through the cocoon easily. The pupa is attached to the pupation surface by a silk-girdle surrounding its abdomen and the cremaster, and the cocoon apparently contributes little towards fixation of the pupa. In some species, however, the cocoon is a relatively dense silk-web over the pupa, and prevents one from freely observing the pupa through it: e.g. *Elachista enitescens* Braun, 1921 (Braun 1948: fig. 31), *E. planicara* Kaila, 1998 (Sugisima & Kaila in press: fig. 24), *E. coloratella* Sinev & Sruoga, 1995 (K. Sugisima unpublished data), and species of the *E. freyerella*-group, in addition to *E. kurokoi* and *E. miscanthi*. Dense cocoons seem exceptional in *Elachista*; the dense cocoon will probably contribute towards fixation of the pupa, because the pupa is fixed to the pupation-surface by the cocoon, sometimes without a silk-girdle surrounding its abdomen. Even though there is variation in the density, the *Elachista* cocoons are very flimsy when compared to those of most Gelechioidea, in which the pupa can not be seen through the cocoon even as a silhouette.

As the cocoon becomes flimsier and the pupa becomes more exposed, a camouflage will perhaps be one of effective alternatives for avoiding predation. An elaborately ornamented pupal surface will certainly serve as a camouflage. This will explain a large part of the presence of the tubercles, projections, ridges, and keels on the pupal surface in *Elachista*. A similar diversity of the pupal surface is reported in butterflies. The papilionoids make a very flimsy cocoon or even do not make a cocoon, and their pupae are often attached to the surface by a silk-girdle and the cremaster as in *Elachista* (e.g. Fukuda et al. 1982). The similarity between *Elachista* and Papilionoidea is plainly homoplastic, and does not contradict the idea that a necessity of a camouflage caused by a flimsier cocoon will promote diversification of the pupal surface.

Projecting of abdominal spiracles may be explained by the camouflage at least partly, but it is doubtlessly an incomplete explanation. The conspicuous projecting of abdominal spiracles is observed in species with a relatively dense cocoon, and is not observed in those with a sparse cocoon. A camouflage is likely to be less necessary in species with a dense cocoon than in those with a sparse cocoon, and thus functions of the conspicuous projecting of spiracles need another explanation. The dense silk-web usually touches the dorsal

surface of the pupa tightly, and when humid, it very frequently becomes like a water membrane covering the dorsal surface of the pupa (K. Sugisima unpublished data). In order to avoid pupal suffocation in humid habitats such as forest floors, it is reasonable to place the spiracles out of the cocoon by elongate spiracular projections or elongate fin-like plates. This view does not contradict the fact that the apices of long spiracular projections are always set out of the web (e.g. Sugisima & Kaila in press: fig. 24b, c). Another evidence supporting this view is the fact that the pupa of a semi-aquatic noctuid moth, *Spodoptera pectinicornis*, has long spiracular projections, which Yoshiyasu & Sugi (1999) considered to be a protection mechanism against water penetration. On the other hand, the conspicuous projection of spiracles could contribute towards a fixation of the pupa by their sticking into the cocoon, because a silk-girdle surrounding the pupal abdomen is sometimes absent in species with a dense cocoon.

Mobility of *Elachista* pupae is restricted into dorso-ventral movements of the fourth and fifth abdominal segments by lateral condyles (Minet 1990) and the cohesion of the sixth and seventh segments (Kaila 1999a). When the pupa has a smaller number of mobile segments, the number is always zero, except for *E. planicara* with only the fifth segment mobile (Sugisima & Kaila in press). A poorer mobility is almost always observed in species with a dense cocoon, though there is one exception: *E. miscanthi* is in a dense cocoon and has mobile fourth and fifth segments. In species with a sparse cocoon, the mobile segments are likely to be advantageous. When the pupa is disturbed, it threatens the disturber with dorso-ventral movements of the upper half of the body (K. Sugisima unpublished data), and may sometimes be able to make loud snapping sounds (L. Kaila personal communication). These movements are due to the mobile fourth and fifth abdominal segments. In contrast, in species with a dense cocoon, even if the pupa were potentially mobile, its dorso-ventral movements would be inhibited because the cocoon is tightly touching the dorsal surface of the pupa. In this case, mobility of the pupa may well be neutral with regard to natural selection. Given that mobility of the pupa is neutral in a dense cocoon, the number of mobile segments is expected to vary from zero to two. Before this study, no species with a dense cocoon were reported to have mobile segments, except for *E. planicara* alone having one. In this study, it was found that *E. miscanthi* has two mobile segments in spite of its dense cocoon. The number of mobile segments certainly varies from zero to two in species with a dense cocoon, as expected above. However, the idea that poorer mobility of the pupa is due to the neutrality of a mobile abdomen in a dense cocoon may

not be a very successful explanation. Among the species with a dense cocoon, too few species have mobile segments, which is against expectation. This may suggest that there is a selection for an immobile pupa when the cocoon becomes dense. Dorso-ventral movements of the pupa in a dense cocoon might damage the silk-web over the pupa, and make the pupa unstably fixed and exposed to moisture. This risk could select for an immobile pupa.

ACKNOWLEDGEMENTS

I thank Prof. M. Suwa (SEHU) for critically reading the manuscript and giving many comments. I thank Dr L. Kaila (MZHF) for giving many valuable suggestions to an earlier draft and showing me his unpublished data. I thank Dr Y. Sakamaki (Entomological Laboratory, Kagoshima University) for giving many comments on an earlier draft and offering specimens. Mr M. Sano (EIHU), is also appreciated for giving comments to an earlier draft. I thank Dr T. Hirowatari and Mr B. W. Lee at UOPJ, for helping me to examine specimens of UOPJ. For the same reason, I thank Dr H. Kuroko at Han'nan-si, Ôsaka-hu. For offering specimens, I thank the following people: Mr N. Hirano (Hata-mati, Nagano-ken, Japan), Dr Yu-Feng Hsu (National Taiwan Normal University, Taiwan), Dr U. Jinbo (Department of Natural History, Tokyo Metropolitan University), Dr T. Kumata (Ebetu-si, Hokkaidô, Japan), Dr Y. Nasu (Hashimoto-si, Wakayama-ken, Japan). For loan of specimens, I thank OMNH and its staff, Dr I. Kanazawa. For letting me know the literature concerning a noctuid pupa with spiracular projections, I thank Dr Y. Yoshiyasu (Entomological Laboratory, Kyoto Prefecture University).

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Received: 6 January 2005

Accepted: 21 February 2005