

SYNOPSIS OF THE GENUS HALICTOPHAGUS
(STREPSIPTERA : HALICTOPHAGIDAE) OF JAPAN, WITH
DESCRIPTION OF A NEW SPECIES (Studies on the
Japanese Strepsiptera VIII)

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SYNOPSIS OF THE GENUS *HALICTOPHAGUS*
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(Studies on the Japanese Strepsiptera VIII)*

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Abstract

Five species of *Halictophagus* are recognized from Japan. Of these, *H. (H.) bipunctatus* Yang, 1955 and *H. (H.) spectrus* Yang, 1964 are new to Japan. *Halictophagus (Halictophagus) yaeyamanus* Kifune, new species, is described from the Iriomote Island, the Ryukyus.

Recently we had a good chance to examine Strepsiptera specimens of the Ryukyus from two sources. One is from Dr. Y. Wada, National Institute of Health, Tokyo. His material includes a male specimen collected by Prof. I. Miyagi, University of the Ryukyus, on the Iriomote Island. Another is from Dr. H. Satomi, Okinawa Branch of Tropical Agricultural Research Centre. His material includes a number of Strepsiptera associated with Homoptera which were collected by himself at light on the Ishigaki Island. As a result of our study, we found a new species and two species new to Japan. The result is given in this paper.

1. *Halictophagus (Halictophagus) yaeyamanus* Kifune, new species
[Nom. Jap. : Yaeyama-kushihige-nejirebane (new name)]

Male

Size. Body length 2.2 mm excluding genital capsule ; head breadth 0.75 mm ;
metathoracic breadth 0.70 mm ; length of head and thorax together 1.43 mm ; radial

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length of hind wing 1.50 mm ; length of aedeagus 0.125 mm.

Structure. Head transversely expanded, its posterior margin remarkably arcuate anteriorly ; eyes hemispherical, each composed of about 15 large facets ; antennae 7-segmented ; 3rd to 6th segments and 7th segment itself flabellate, flabellae of 3rd to 5th segments subequal in length, those of 6th and 7th a little longer than those of the preceding segments ; mandibles short, triangular ; maxillary palpi Z-segmented, basal segment short, apical segment very long and slender, ensiform, about two and a half times as long as basal segment, thickest at about 1/4 of its length from tip, and narrowest at about 2/5 of its length from base. Pronotum transverse, belt-like ; acrotergite long, almost square, slightly tapered towards posterior margin ; mesonotum trapezoidal, its anterior margin remarkably arched posteriorly ; prescutum triangular, its anterolateral angles rounded ; scuti quadrilateral with rounded angles ; scutellum pentagonal ; postlumbium transverse, its anterior margin gently arcuated, posterior margin almost straight ; postscutellum thick, posterior portion semicircularly rounded. Legs slender ; first tarsal segments broad, hemispherical ; 2nd and 3rd tarsal segments normal. Hind wing typical for the subgenus ; Rf rather long, but not so strongly curved along the wing margin as seen in a sympatric species, *H. iriomoensis*. Aedeagus with prominent ventral projection and slender stem.

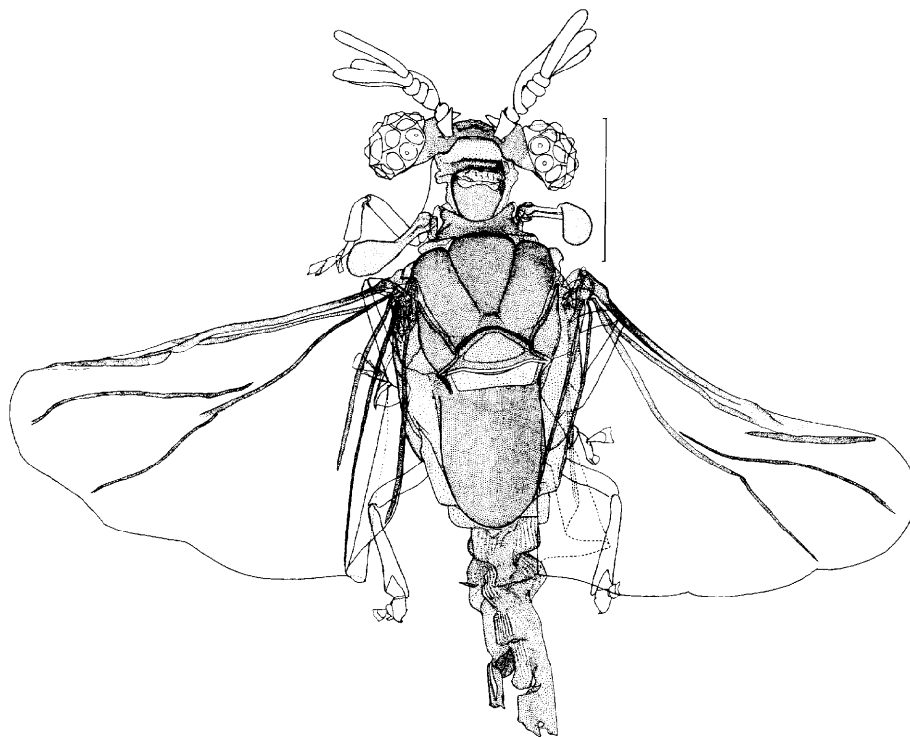


Fig. 1 *Halictophagus (H.) yaeyamanus* Kifune, new species, male, dorsal view. Scale : 0.5 mm.

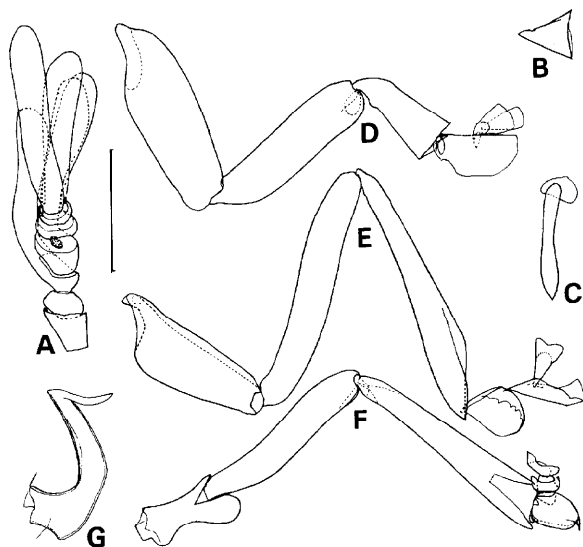


Fig. 2 *Halictophagus (H.) yaeyamanus* Kifune, new species, male. — A : Right antenna, dorsal view. B : Right mandible, dorsal view. C : Right maxillary palpus, dorsal view. D : Right fore leg, dorsal view. E : Right mid leg, dorsal view. F : Right hind leg, dorsal view. G : Aedeagus, left lateral view. Scale : 0.1 mm for G, 0.2 mm for others.

No information is available for the female, 1st instar larva and host of this new species.

TYPE MATERIAL : Holotype male (Type No. 2452, Kyushu Univ.), mounted, Funaura, Iriomote Is. (Yaeyama Isls.), Okinawa Pref., 3. vii. 1977, I. Miyagi leg. (light trap).

TYPE DEPOSITORY : Holotype is deposited in the Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, Japan.

DISTRIBUTION : Japan-Okinawa (Iriomote Is.).

REMARKS. This new species is distinguishable from a sympatric species, *H. (H.) iriomotensis* Hirashima et Kifune, 1978, by the facets of each eye fewer in number and the apical segment of maxillary palpus longer. By the long maxillary palpus, this resembles *H. schwarzi* Perkins, 1905, from Australia, *H. barberi* (Pierce, 1908), from U.S.A., *H. regina* Fox, 1967, and *H. irwini* Riek, 1975, from Africa, but differs from them by the combinations of other characters. This is allied to *H. piperi* Bohart, 1943, from the Philippines, in the shape of aedeagus, but differs from it by the longer maxillary palpus. This is the third species of the genus from Japan.

2. *Halictophagus (Halictophagus) orientalis* (Esaki et Hashimoto, 1931)

[Nom. Jap. : Kushihiige-nejirebane]

Tettigoxenos orientalis Esaki et Hashimoto, 1931. *Ent. Lab., Fac. Agr., Kyushu Imp. Univ., Publ.*, (2) : 48, pl. 4, figs. 4-11 (♂, ♀, 1st larva). Japan-Kyushu (Fukuoka). Host : *Parabolocetratus prasinus*. -- : Esaki et Hashimoto, 1932 (partim). *Ibid.*, (3) : 37, fig. 7. Kyushu (Fukuoka). Host : Same as above. — : Esaki, 1932. In : Uchida, S. et al. : *Icon. Ins. Jap.* : 479, fig. 935. Kyushu and

Yakushima Is. Host : Same as above. —: Esaki, 1950 (partim). In : Ishii, T. *et al.* (ed.) : *Do.*, 2nd ed. : 1325, fig. 3818. Kyushu and Yakushima Is. Host : Same as above.

Halictophagus orientalis: Bohart, 1943. *Ann. ent. Soc. Amer.*, 36 : 359. Japan. Host : a species of rice leafhopper. —: Kinzelbach, 1971. *Zoologica*, (119) : 153. Japan. Host : ?

As shown above, this species was described from the material taken from *Parabolocratrus prasinus* Matsumura (Homoptera : Jassidae) [= Homoptera : Hecalidae]. Later, Esaki and Hashimoto thought that *Halictophagus orientalis* is also parasitic on *Nephotettix cincticeps*. Accordingly, their identification of *H. orientalis* taken from *Nephotettix cincticeps* has been believed to be correct and cited in various subsequent literatures. However, so far as we know, *H. orientalis* is associated only with *Parabolocratrus prasinus*, and the species parasitic on *Nephotettix* and probably on *Inazuma* should be known as *H. bipunctatus* Yang, as shown below. Fig. 3 was drawn from the original specimens of Esaki and Hashimoto (1931).

HOST. *Parabolocratrus prasinus* Matsumura [Homoptera : Hecalidae].

DISTRIBUTION. Japan-Kyushu (Fukuoka, Yakushima Is.).

REMARKS. Esaki (1932) added Yakushima Is as a distributional area but we could not see the very specimen from Yakushima in the collection of Kyushu University.

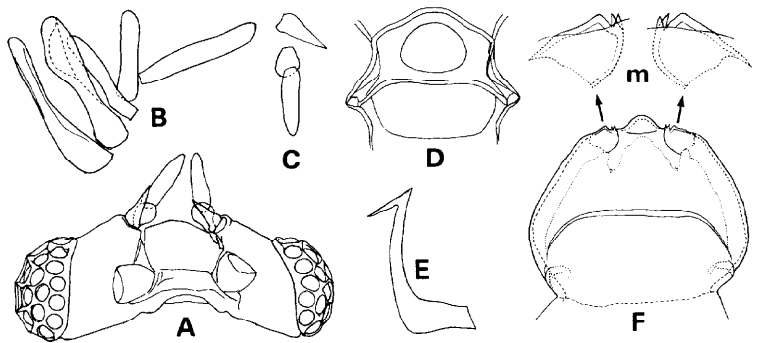


Fig. 3 *Halictophagus (H.) orientalis* (Esaki et Hashimoto, 1931), A-E : Male. F : Female. — A : Head, dorsal view. B : Right antenna (basal 2 segments omitted), dorsal view. C : Right mandible (top) and maxillary palpus, dorsal view. D : Scutellum and postlumbium, dorsal view. E : Aedeagus, right lateral view. F : Cephalothorax, ventral view, m : mandibles. Scale : 0.2 mm for E & m, 0.5 mm for others. (Drawn from type specimens)

3. *Halictophagus (Halictophagus) bipunctatus* Yang, 1955

[Nom. Jap. : Futaten-kushihige-nejirebane (new name)]

Tettigoxenos orientalis : Esaki et Hashimoto, 1932 (partim, nec Esaki et Hashimoto, 1931). *Ent. Lab., Fac. Agr., Kyushu Imp. Univ., Publ.*, (3) : 35, fig. 6 (styloized host). Japan-Kyushu (Oita). Host : *Nephotettix bipunctatus cincticeps* [= *N. cincticeps*]. — ? : Sakai, 1933 (probably nec Esaki et Hashimoto, 1931). *Jap. J. appl. Zool.*, 5 : 126. Kyushu (Oita). Host : *Deltocephalus* [= *Inazuma*] *dorsalis*. —: Esaki et Mochizuki, 1941 (nec Esaki et Hashimoto, 1931). *Ent. Lab., Fac. Agr., Kyushu Imp. Univ., Publ.*, (13) : 31. Honshu (Nagano). Host : *Nephotettix bipunctatus cincticeps* [= *IV. cincticeps*]. —: Nagasaki Pref. Agr. Exp. Stat., 1941 (nec Esaki et Hashimoto, 1931). *Byochugai Zasshi*, 28 : 867. Kyushu (Nagasaki). Host : Same as above.

Halictophagus bipunctatus Yang, 1955. *Acta ent. Sinica*, 5: 328, pl. 1, figs. 1-7 (♂, ♂-cephalotheca, ♀). China-Kwantung, Kiangsu. Hosts: *Nephotettix bipunctatus* (incl. subsp. *cincticeps*) [= *N. virescens* & *N. cincticeps*]. —: Kinzelbach, 1971. *Zoologica*, (119): 152. Kwantung (Kiangsu, China) (sic!). Host: *Nephotettix bipunctatus* [= *N. virescens* & *N. cincticeps*].

Several males and females of a halictophagid species associated with *Nephotettix*, which were collected by Dr. H. Satomi on the Ishigaki Island, are identified here as *Halictophagus bipunctatus* Yang originally described from China.

At the same time, we found that Esaki and Hashimoto (1931) mixed up the two species. The type material of *Tettigoxenos orientalis* includes 15 specimens. The

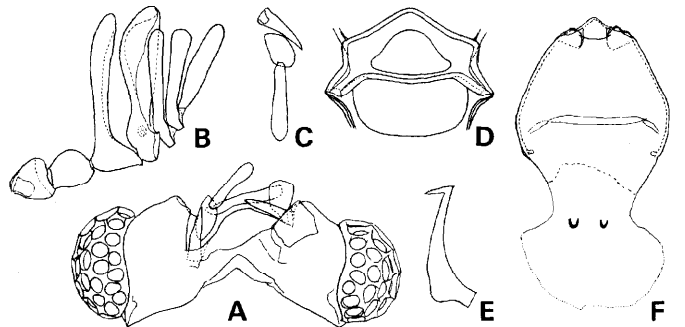


Fig. 4 *Halictophagus (H.) bipunctatus* Yang, 1955, from Kyushu, A-E: Male. F: Female. — A: Head, dorsal view. B: Left antenna, ventral view. C: Right mandible (top) and maxillary palpus, ventral view. D: Scutellum and postlumbium, dorsal view. E: Aedeagus, right lateral view. F: Cephalothorax and anterior portion of abdomen, ventral view. Scale: 0.2 mm for E, 0.5 mm for others. (Drawn from Esaki & Hashimoto's specimens)

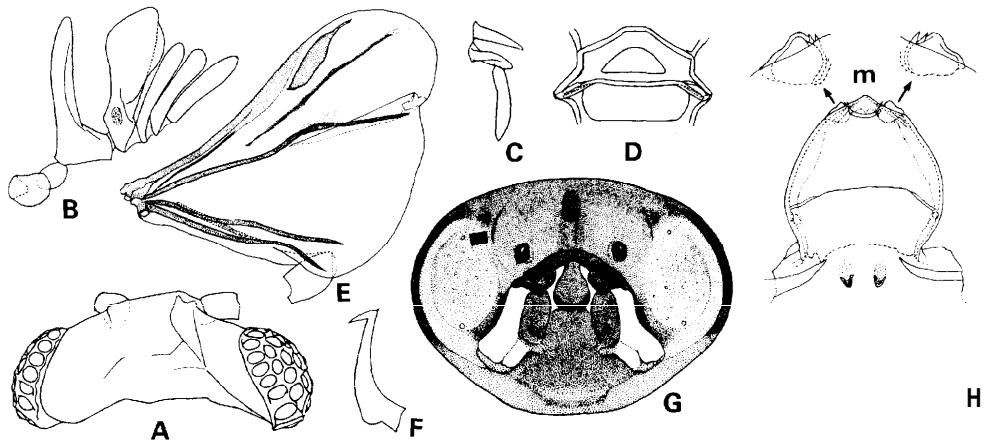


Fig. 5 *Halictophagus (H.) bipunctatus* Yang, 1955, from Okinawa, A-G: Male. H: Female. — A: Head, dorsal view. B: Left antenna, ventral view. C: Left mandible (top) and maxillary palpus, dorsal view. D: Scutellum and postlumbium, dorsal view. E: Right hind wing, dorsal view. F: Aedeagus, right lateral view. G: Cephalotheca, frontal view. H: Cephalothorax and anterior portion of abdomen, ventral view, m: mandibles. Scale: 1 mm for E, 0.2 mm for F and m, 0.5 mm for others.

holotype of it is being mounted on a slide with 8 paratypes. One paratype, however, should be identified as *Halictophagus bipunctatus*. Five out of 6 undesignated specimens in the type series should also be known as *bipunctatus*.

So far as our study goes, the halictophagid parasitic on *Nephotettix* in Japan is known as *Halictophagus bipunctatus*. Sakai (1933) recorded *Tettigoxenos orientalis* from *Deltocephalus* (= *Inazuma*) *dorsalis*. Although his record has been neglected by Japanese authors, the species may also be identified as *Halictophagus bipunctatus*.

It is interesting to note that Esaki and Hashimoto (1932 *et seq.*) often remarked the absence of stylopids on *Nephotettix* in Fukuoka Pref. notwithstanding the presence of them on *Parabolocratulus* there.

SPECIMENS EXAMINED: [Locality : Hegina, Ishigaki City, Ishigaki Island (Yaeyama Islands), Okinawa Pref.] [Host : *Nephotettix cincticeps*] 1 ♂*-puparium from a male, 5. vi. 1931 ; 1 ♀ from a male 11. vi. 1981 ; 1 ♀ from a male, 13. vi. 1981 ; 1 ♀ from a female, same date ; 1 ♀ from a female, 16. vi. 1981 ; 1 immature ♂ from a female, 17. vi. 1981 ; 1 ♂-puparium from a female, same date ; 3 ♀♀ from 3 females, 18. vi. 1981 ; 1 ♂ from a female, same date : 1 ♀ from a female, 24. vi. 1981 ; 1 immature ♂ from a female, 13. x. 1981 ; 1 immature ♂-puparium from a male, 2. v. 1982 ; 1 immature ♂-puparium from a female, 3. v. 1982 ; 1 immature ♂-puparium from a female, 16. v. 1982 ; 1 immature ♂-puparium from a female, 7. vi. 1982 ; 1 ♀ from a female, same date ; 3 ♀♀ from 3 females, 9. vi. 1982 ; 1 ♀ from a female, 13. vi. 1982. [Host : *N. nigropictus*] 2 immature ♂♂ from a female, 7. vii. 1977 ; 2 ♂♂-puparia from 2 females, same date ; 1 immature ♂ from a female, 10. ix. 1977 ; 1 ♂-cephalotheca from a female, 7. xi. 1977 ; 1 immature ♂ from a male, 18. vi. 1981 ; 1 ♂-puparium from a female, 16. x. 1981.

HOSTS. *Nephotettix nigropictus* (Stål), *N. cincticeps* (Uhler), *N. virescens* (Distant), and ? *Inazuma dorsalis* (Motschulsky) [Homoptera : Deltocephalidae] .

DISTRIBUTION. China-Kwantung (Kwangchow), Kiangsu (Soochow) ; Japan—Honsu (Nagano), Kyushu (Oita, Nagasaki), Okinawa (Ishigaki Is.).

REMARKS. Yang (1955) describes the female mandibles of *bipunctatus* as "blunt at tips" in the Chinese text (p. 329) but he does not mention the character in the English text (p. 333). Both of the female specimens of *bipunctatus* from Kyushu and Okinawa have clear bidentate mandibles as shown in Fig. 5H. We suppose that Yang might overlook the teeth overlapping to the cephalothoracic margin. This species is distinguishable from *orientalis* by the long basal portion of 3rd and broad flabella of 4th antennal segments and the shape of aedeagus in male and longer cephalothorax and two brownish spots on the anterior portion of the abdomen in female.

4. *Halictophagus (Halictophagus) spectrus* Yang, 1964

[Nom. Jap. : Futo-kushihige-nejirebane (new name)]

Halictophagus spectrus Yang, 1964. *Acta zootax. Sinica*, 1 : 78, figs. 7-8 (♀). China-Szechuan. Host : *Cicadella spectra*. — : Hirashima et Kifune, 1978. *Esakia*, (11) : 57 (♂-puparium, ♀). Malaysia-Borneo (Sarawak). Host : Same as above.

* The symbols, ♂ and ♀, are used for the parasites only.

Halictophagus helleri Kinzelbach, 1971. *Stutt. Beitr. Naturk.*, (230) : Abb. 2 (♂, ♀, ♂-cephalotheca).
Ceylon (= Sri Lanka). Host : Same as above.

As listed above, this species was first described from China and then recorded from Sri Lanka and Malaysia. All of the host was *Cicadella spectra* (Distant) which is widely distributed in the Oriental Region. The following specimens were obtained from the same source as the preceding species.

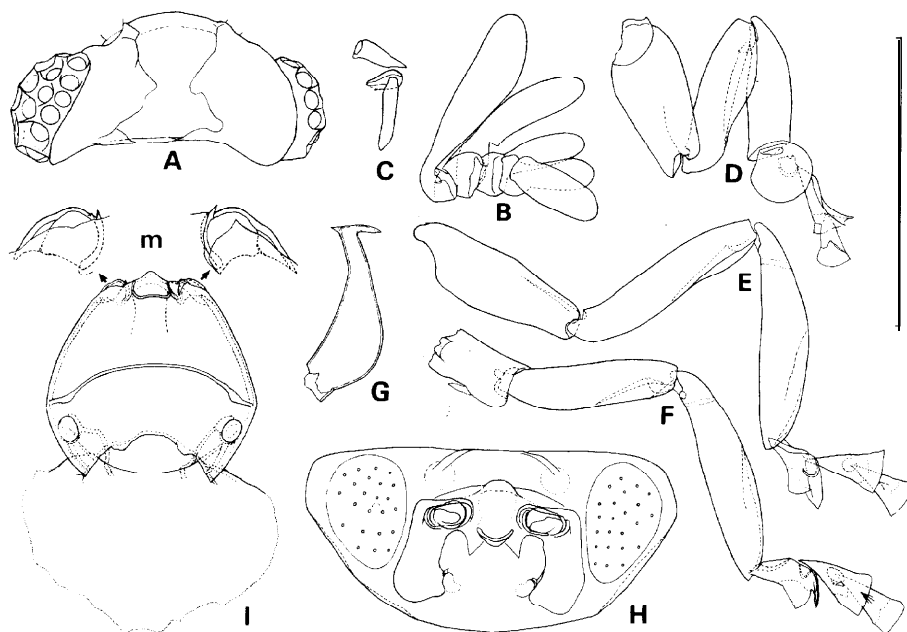


Fig. 6 *Halictophagus (H.) spectrus* Yang, 1964, A-H : Male. I : Female. — A : Head, dorsal view. B : Right antenna (basal 2 segments omitted), dorsal view. C : Right mandible (top) and maxillary palpus, dorsal view. D : Right fore leg, dorsal view. E : Right mid leg, dorsal view. F : Right hind leg, dorsal view. G : Aedeagus, left lateral view. H : Cephalotheca, frontal view. I : Cephalothorax and anterior portion of abdomen, m : mandibles, ventral view. Scale : 0.2 mm for G and m, 0.5 mm for others.

SPECIMENS EXAMINED : [Locality : Hegina, Ishigaki City, Ishigaki Island (Yaeyama Islands), Okinawa Pref.] [Host : *Cicadella spectra*] 1 ♀ from a female, 24. vi. 1981 ; 1 ♂ -puparium & 1 ♀ from a male, 26. vii. 1981 ; 1 immature ♂ & its puparium from a male, 9. viii. 1981 ; 1 ♂-puparium from a female, 29. x. 1981 ; 1 ♂-puparium from a male, 1. xi. 1981 ; 1 ♂-puparium from a male, 6. xi. 1981 ; 1 ♂-puparium & 1 ♀ from a female, same date ; 1 ♂ & its puparium from a male, 30. iv. 1982 ; 1 ♂-puparium from a male, 9. v. 1982.

Host. *Cicadella spectra* (Distant) [Homoptera : Cicadellidae].

DISTRIBUTION. China-Szechuan (Yaan) ; Sri Lanka (Kandy) ; Malaysia-Borneo (Sarawak) ; Japan-Okinawa (Ishigaki Is.).

REMARKS. The present specimens well agree with the description of *spectrus* by

Yang (1964) and of *helleri* by Kinzelbach (1971). Distribution of this species may depend on that of the host species. This is the fifth species of the genus and the nineteenth species of the Strepsiptera from Japan (Cf. Miyamoto & Kifune, 1984).

5. **Halictophagus (Halictophagus) iriomotensis** Hirashima et Kifune, 1978

[Nom. Jap. : Iriomote-kushihige-nejirebane (new name)]

This species was described on a single dried male specimen. Until today, no additional material has been collected. The holotype is compared with the above-mentioned specimens of *H. yaeyamanus* sp. nov. and several differences were found in the number of facets and the length of the maxillary palpi as stated in the description of *yaeyamanus*.

The host of this species is unknown.

DISTRIBUTION : Japan-Okinawa (Iriomote Is.).

KEY TO THE JAPANESE SPECIES OF *Halictophagus*

Males

- Flabella of 5th and 6th antennal segments shorter than other flabella 2
 Flabella of 5th and 6th antennal segments subequal to others 4
 Basal portion of 3rd antennal segment about twice as long as that of 4th. Hosts :
Nephotettix nigropictus, *N. cincticeps*, *N. virescens*, & (probably) *Inazuma dorsalis*.
 Distribution : China (Kwantung, Kiangsu), Japan (Honshu, Kyushu, Okinawa)
 *H. (H.) bipunctatus* Yang, 1955
 Basal portion of 3rd antennal segment subequal to that of 4th in length 3
 Aedeagus rectangularly curved at the middle ; flabella of antennae slender. Host :
Parablocratus prasinus. Distribution : Japan (Kyushu incl. Yakushima Is.)*
 *H. (H.) orientalis* (Esaki at Hashimoto, 1931)
 Aedeagus triangularly thickened at the middle ; flabella of antennae more or less
 thickened. Host : *Cicadella spectra*. Distribution : China (Szechuan), Sri Lanka,
 Malaysia (Borneo), Japan (Okinawa) *H. (H.) spectrus* Yang, 1964
 Apical segment of maxillary palpi short, as long as basal segment ; numbers of facets of
 each eye about 20. Host : Unknown. Distribution : Japan (Okinawa)
 *H. (H.) iriomotensis* Hirashima et Kifune, 1978
 Apical segment of maxillary palpi long, about two and a half times as long as basal
 segment ; numbers of facets of each eye about 15. Host : Unknown. Distribution :
 Japan (Okinawa) *H. (H.) yaeyamanus* Kifune, new species

Females

(Those of *iriomotensis* and *yaeyamanus* are unknown)

- Cephalothorax as long as broad *H. (H.) orientalis* (Esaki et Hashimoto, 1931)
 Cephalothorax longer than broad 2
 Mandible with 1 tooth *H. (H.) spectrus* Yang, 1964
 Mandible with 2 teeth *H. (H.) bipunctatus* Yang, 1955

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References

- Bohart, R. M., 1943. New species of *Halictophagus* with a key to the genus in North America (Strepsiptera, Halictophagidae). *Ann. ent. Soc. Amer.*, 36 : 341-359.
- Esaki, T., 1932. Strepsiptera. In: Uchida, S. et al. : *Icon. Ins. Jap.* : 477-480, Hokuryukan, Tokyo. (In Japanese)
- 1950. Ditto. In: Ishii, T. et al. (ed.) : *Ditto*, 2nd. ed. : 1322-1325, Do. (In Japanese)
- & S. Hashimoto, 1931. Report on the leaf-hoppers injurious to the rice plant and their natural enemies. No. 2 (for the year 1930). *Ent. Lab., Dept. Agr., Kyushu Imp. Univ., Publ.*, (2) : 1-59, pls. 1-5. (In Japanese ; English for plate explanation)
- & —— 1932. Ditto. No. 3 (for the year 1931). *Ibid.*, (3) : 1-42. (In Japanese)
- & —— 1934. Ditto. No. 5 (for the year 1933). *Ibid.*, (5) : 1-40, pls. 1-3. (In Japanese ; English for plate explanation)
- & M. Mochizuki, 1941. Ditto. No. 12 (for the year 1940). *Ibid.*, (13) : 1-33. (In Japanese)
- Fox, J. W., 1967. Report on some Strepsiptera in the British Museum (Natural History), including new species of Halictophagidae and Elenchidae. *Proc. R. ent. Soc. Lond.*, (B)36 : 41-49.
- Hirashima, Y., & T. Kifune, 1978. Strepsipterous parasites of Homoptera injurious to the rice plant in Sarawak, Borneo, with description of a new species (Notulae Strepsipterologicae-III). *Esakia, Fukuoka*, (11) : 53-58.
- & —— 1978a. A new species of the genus *Halictophagus* from Iriomote island, Okinawa, Japan (Strepsiptera : Halictophagidae) (Studies on the Japanese Strepsiptera IV). *Ibid.*, (11) : 59-61.
- Kinzelbach, R., 1971. *Halictophagus helleri* n. sp. von Ceylon (Insecta : Strepsiptera). *Stutt. Beitr. Naturk.*, (230) : 1-8.
- Miyamoto, S., & T. Kifune, 1984. Descriptions of a new genus and two new species of the Strepsiptera parasitic on Japanese Heteroptera (Strepsiptera, Corioxenidae) (Studies on the Japanese Strepsiptera VII). *Kontyû, Tokyo*, 52: 137-149.
- Nagasaki Pref. Agr. Exp. Stat., 1941. [Surveys on the natural enemies of the leafhoppers.] *Byochugai Zasshi*, 38: 867-868. (In Japanese)
- Perkins, R. C. L., 1905. Leaf-hoppers and their natural enemies (Pt. III. Stylopidae). *Rept. Wk. Exp. Stat. Hawaii. Sugar Pl. Assoc., Bull.*, (1): 90-111, pls. I-IV.
- Pierce, W. D., 1909. A monographic revision of the twisted winged insects comprising the order Strepsiptera Kirby. *U.S. Natn. Mus., Bull.*, (66) : I-XII, 1-232, 15 pls.
- Riek, E. F., 1975. A new Strepsiptera from Natal (Insecta : Halictophagidae). *Ann. Natal Mus.*, 22: 465-469.
- Sakai, K., 1933. [Natural enemies of the planthoppers in Oita and their seasonal fluctuations (2nd report), with additional informations on the natural enemies of leafhoppers.] *Jap. J. appl. Zool.*, 5 : 125-128. (In Japanese)
- Yang, C.-k., 1955. Description of a new species of Strepsiptera parasitic on the rice leaf-hoppers. *Acta ent. Sinica*, 5: 327-333, pl. 1. (In Chinese with English summary)
- 1964. Note on the genus *Halictophagus* of China (Strepsiptera : Halictophagidae). *Acta zootax. Sinica*, 1: 76-93. (In Chinese with English summary)