Oriental Insects, Vol. 29: 33-45, 1995.

THE TAXONOMY OF THE *ENCARSIA FLAVOSCUTELLUM* SPECIES-GROUP (HYMENOPTERA: APHELINIDAE) PARASITOIDS OF HORMAPHIDIDAE (HOMOPTERA: APHIDOIDEA)

GREGORY A. EVANS, ANDREW POLASZEK* & FRED D. BENNETT
Entomology & Nematology Department, University of Florida, Gainesville, Florida 32611, USA
*International Institute of Entomology, 56, Queen's Gate, London SW7 5JR, UK.

ABSTRACT. Four species of *Encarsia*, two of which are described as new, are assigned to the *flavoscutellum* species-group, which is diagnosed. *Encarsia cerataphivora* Evans, **sp. nov.** and *Encarsia noordami* Polaszek, **sp. nov.** are described from *Cerataphis brasiliensis* (Hempel) from Thailand, and from *Astegopteryx nipae* (van der Goot) from Malaysia, respectively. *Encarsia flavoscutellum* Zehntner and *Encarsia thoracaphis* (Ishii) are redescribed. A key is provided to separate these four species, and their distributions and host relationships are summarized.

Key words: Aphelinidae, *Encarsia*, Hormaphididae, *Astegopteryx*, *Cerataphis*, *Ceratovacuna*, *Thoracaphis*, parasitoids, hosts, Southeast Asia.

Introduction

The aphelinid genus *Encarsia* is primarily known as a source of biological control agents for pests belonging to the homopterous families Diaspididae (Coccoidea) and Aleyrodidae (Aleyrodoidea). Less familiar host records include males of a few species which have been recorded as probably facultative parasitoids of Psyllidae (Polaszek *et al.*, 1992) and lepidopterous eggs (Polaszek, 1991). The most closely related genera *Dirphys* and *Encarsiella* are known from Aleyrodidae, with one species recorded from eggs of Plataspidae (Polaszek & Hayat, 1992) and another (*Encarsiella* sp., undescribed) from *Trioza* sp. (Psyllidae). Four *Encarsia* species are now known to be specifically parasitoids of Aphidoidea: Hormaphididae. These species form a monophyletic group, are geographically closely distributed, and are all related to *Encarsia flavoscutellum* Zehntner, a species described from the aphid *Ceratovacuna lanigera* Zehntner. *E. flavoscutellum* was previously assigned to the *E. tricolor* group (Hayat, 1989) but is thought by us to have little in common with *E. tricolor*, either morphologically or biologically. We therefore recognize here a new species group of *Encarsia*, the *E. flavoscutellum*-group. Morphological terminology follows Hayat (1989).

Diagnosis of the *Encarsia flavoscutellum* species-group

Females: Coloration: Variable; scutellum always pale, fore wing hyaline to moderately infuscate below the marginal vein. Third valvulae dark in contrast to the second valvifers, as in *E. lutea*-group.

Morphology: F1 with or without longitudinal sensilla. Club 3-segmented. Mandibles with two teeth and a truncation. Mid-lobe of mesoscutum with 3-5 pairs of setae medially, an additional pair of lateral setae as in most *Encarsia*. Each side lobe with three setae. Axillae large, long, approximating those of *Encarsiella* spp. Each axilla with a single robust seta centrally, towards the inner margin of the axilla. Scutellum very large, as broad as and more than half as long as the mid-lobe of the mesoscutum. Scutellar sensillae widely separated. Sculpture of dorsal mesothorax reticulate and generally robust, scutellum centrally with elongate cells, as in most *Encarsia*. Tarsal formula 5-5-5. Fore wing uniformly setose. Ovipositor short (less than half the length of the gaster) to moderately robust [*E. thoracaphis* (Ishii)].

Males: Morphology as for females except genitalic characters and the following: Antenna with F2 ventrally bearing a distinctive sensorial complex (Figs. 2, 13, 19). F5 either partially or completely fused with F6.

Primary parasitoids of Aphidoidea: Hormaphididae.

Key to the species of the *Encarsia flavoscutellum* group (females)

1. Ovipositor clearly longer than hind tibia (Figs. 10, 11). Mandibles weakly dentate (Fig. 9). Coxae and femora dark brown. ..... 2. ***E. thoracaphis*** (Ishii)
-. Ovipositor equal to, or clearly shorter than hind tibia (Figs. 5, 6). Mandibles strongly dentate (Fig. 3). Legs entirely yellow. 2
2. Antennal segment F1 without longitudinal sensilla (Fig. 12). Gaster pale brown, thoracic setae pale (Fig. 15). Male with F5 and F6 completely fused (Fig. 13).....3. ***E. noordami*** Polaszek, sp. nov.
-. Antennal segment F1 with one to three longitudinal sensilla (Fig. 1, 18). Gaster dark brown, thoracic setae dark (Fig. 21). Male with F5 and F6 separated or only partially fused (Fig. 19) 3
3. Antennal segment F1 clearly shorter than pedicel or F2, with one to two longitudinal sensilla (Fig. 18), Male with F5 and F6 partially fused. ..... 4. ***E. cerataphivora*** Evans, sp. nov.
-. Antennal segment F1 as long as pedicel or F2, with 3 longitudinal sensilla (Fig. 1). Male with F5 and F6 separated. ..... 1. ***E. flavoscutellum*** Zehntner

1. *Encarsia flavoscutellum* Zehntner (Figs. 1-6)

Encarsia flavo-scutellum Zehntner, 1900: 12. Syntypes? F, M : [INDONESIA]: Java, *ex. Ceratovacuna lanigera* Zehntner (presumed lost). *Neotype* F, (here designated): JAVA: Pasoeroean, Apr. 1930, E. H. Hazelhoff, *ex. Oregma* (=*Ceratovacuna*) *lanigera* Zehntner. [examined].

Diagnostic features

Female: Coloration: Head pale brown, occiput and frons darker brown. Thorax and gaster brown except the following, which are pale yellow: Posterior mid-lobe, scutellum, legs and intersegmental bands of gaster. Wings slightly infuscated below marginal vein. Third valvulae strikingly darker than any other part of the body.

Morphology: Structural details as illustrated (Figs. 1-6); the following may be noted: Eyes with long, extremely fine setae. Mandibles with two strong teeth and a truncation. Maxillary palps 1-segmented. Antennal formula 1,1,3,3; F1, F2 and F3 all approximately equal in both length and width (Fig. 1). Flagellum with the following numbers of longitudinal sensilla: F1:3, F2:4, F3:4, F4:5, F5:5, F6:3. Mid-lobe of mesoscutum (Fig. 4) with 10 setae, four central pairs and a lateral pair. Each lateral lobe of mesoscutum with 3 setae. Mid-lobe of mesoscutum and axillae with reticulate sculpture, scutellar sculpture much finer, with more longitudinal cells centrally. Fore wing (Fig. 25) with 2 setae on submarginal vein, 3 setae in basal cell, anterior margin of marginal vein with 10 setae. Second valvifers approximately 2.4x length of third valvulae (Fig. 6). Length of second valvifer and third valvula combined about 0.75x the length of hind tibia. Valvulae III 0.3x as long as ovipositor. Tibia II 0.7x as long as ovipositor. Midtibial spur as long as basitarsus II. Gastral terga II-VII with 1+1, 1+1, 2+2, 2+2+2, 2+2+2 and 4 setae, respectively.

Male: Coloration: Head and body generally brown as in female, the mesoscutum more extensively brown, legs yellow.

Morphology: As for female, except the following: antennae 7-segmented, F5 completely fused with F6 (Fig. 2). F2 expanded and with an extensive sensorial complex, contrasting strikingly in size and width with F3.

Distribution: India, Indonesia (Java).

Host: *Ceratovacuna lanigera* Zehntner, *Astegopteryx nipae* (van der Goot).

Specimens examined: INDONESIA: Java: Buitenzorg [Bogor], 8 F and 8 M (paratypes) and one neotype, Oct. 1938, R. Awibowa, *ex. Oregma (=Astegopteryx) nipae*; one slide bearing the name H. L. Dozier (USNM). INDIA: Assam: Dimapur, 1F, 1M, ii.1987 G. Tripathi, *ex [Ceratovacuna lanigera]* on sugarcane, CIE A19977/N/13 (BMNH).

Remarks: Zehntner (1900) described *Encarsia flavoscutellum* in reasonable detail, accompanied by illustrations. However, he did not mention specifically the locality or localities at which he found this species, and more importantly, he did not mention any type material or a depository where he might have left specimens. After several inquiries in the Netherlands (Java was at that time a colony), and reliable information concerning the fate of Zehntner's specimens in Java, it seems unlikely that Zehntner's material of

E. flavoscutellum will ever be located. Since we know there are several species closely related to *E. flavoscutellum*, it would seem appropriate in this case to designate a neotype. The specimen we have chosen was collected in Java from *Ceratovacuna lanigera* Zehntner, the same (presumed) locality and host as the specimens on which the original description was based.

2. *Encarsia thoracaphis* (Ishii) (Figs. 7-11)

Prospaltella thoracaphis Ishii, 1938: 29. *Lectotype*: Female, (here designated), JAPAN: Nagasaki, 28.v.1926, *ex. Thoracaphis takahashii* Strand on *Quercus glauca* (NIAT) [examined].

Diagnostic features

Female: Coloration: Head and body brown except the following, which are pale yellow: Sides of middle lobe of mesoscutum, lateral lobes of mesoscutum, scutellum. Occiput, pronotum and third valvulae noticeably darker brown. Wings with a very slight infuscation below marginal vein.

Morphology: Structural details as illustrated (Figs. 8-11); the following may be noted: Eyes with long, fine setae. Mandibles rather blunt, with only a single small apical tooth and a broad truncation (Fig. 9). Maxillary palps not visible. Antennal formula 1,1,3,3; F1 slightly shorter than F2, F2 approximately equal to F3 (Fig. 7). Flagellum with the following numbers of longitudinal sensilla: F1:4/5, F2:5, F3:6/7, F4:6, F5:7, F6:4. Mid-lobe of mesoscutum (Fig. 8) with 11 or 12 setae, five central pairs and a lateral pair. Each lateral lobe of mesoscutum with 3 setae. Mid-lobe, axillae and scutellum with distinct reticulate sculpture. Fore wing (Fig. 25) with 2 setae on submarginal vein, 3-4 setae in basal cell, anterior margin of marginal vein with 10-11 setae. Second valvifers approximately 2.7x as long as third valvulae (Fig. 10). Second valvifer and third valvula combined about 1.5x as long as hind tibia. Valvulae III 0.3x as long as ovipositor, tibia II 0.7x as long as ovipositor, basitarsus II equal to midtibial spur. Gastral terga II-VII with 1+1, 1+1, 1+1, 1+2+1, 2+2+2 and 4 setae, respectively.

Male: Unknown.

Distribution: Japan.

Host: *Thoracaphis takahashii* Strand.

Specimens examined: JAPAN: Nagasaki, Lectotype female, 28.v.1926 and a paralectotype female (here designated), 21.v.1926 (BMNH).

3. *Encarsia noordami* Polaszek, sp. nov. (Figs. 12-17)

Description

Female: Coloration: Head and thorax pale yellow brown. Gaster darker brown except the pale intersegmental bands. Anterior pronotum and midlobe and the apices of axillae, dark brown. Wings hyaline, legs entirely pale. Third valvulae strikingly darker than any other part of the body.

Morphology: Structural details as illustrated (Figs. 12-17); the following may be noted: Eyes with long, extremely fine setae. Mandibles with two strong teeth and a truncation. Maxillary palps 1-segmented. Antennal formula 1,1,3,3; F1 slightly shorter and noticeably narrower than F2, F2 approximately equal to F3 (Fig. 12). Flagellum with the following numbers of longitudinal sensilla: F1:0, F2:2, F3:4, F4:3, F5:5, F6:4. Mid-lobe of mesoscutum (Fig. 15) with 7-10 setae, usually four central pairs and a lateral pair. Each lateral lobe of mesoscutum with 3 setae. Mid-lobe of mesoscutum, axillae and scutellum with delicate, reticulate sculpture. Fore wing (Fig. 25) with 2 setae on submarginal vein, 3-5 setae in basal cell, anterior margin of marginal vein with 9-10 setae. Second valvifers approximately 3.0x length of third valvulae (Fig. 17). Length of second valvifer and third valvula combined very slightly shorter than hind tibia. Valvulae III 0.2-0.3x as long as ovipositor, tibia II 1.1x as long as ovipositor, mid tibial spur longer than basitarsus II. Gastral terga II-VII with 1+1, 2+2, 2+2, 1+2/3+1, 1+2/3+1 and 4 setae, respectively.

Male: Coloration: Head and body generally darker brown than in female, mid-lobe more extensively brown, otherwise as in female.

Morphology: Similar to female, except antennae 7-segmented, F5 fused with F6 (Fig. 13). F2 expanded and with an extensive sensorial complex.

Distribution: Malaysia, Sumatra.

Hosts: *Astegopteryx nipae* (van der Goot), *A. rhaphidis* (van der Goot).

Holotype: Female, [MALAYSIA]: Malaya: Btg. [Batang] Berjuntai (03.22N 101.25E), 16.xii.1933, Ent. Div. Agric. Dept., *ex Oregma (=Astegopteryx) nipae*, v.d.G. [IIE] 9390 (BMNH). *Paratypes:* 2F, 3M, same data as in holotype (BMNH, USNM). SUMATRA: Lepar, viii.1938, Tjoa Tjien Mo, ex. *Oregma (=Astegopteryx) rhaphidis* larva.

4. *Encarsia cerataphivora* Evans, sp. nov. (Figs. 18-23)

Description

Female: Coloration: Head yellow, with occiput and basal portion dark brown. Eyes dark red with stout, dark setae. Antenna light brown. Anterior two-thirds of mid-lobe of mesoscutum, axillae and gaster dark brown; posterior third of mid-lobe, lateral lobes (except dark brown spot on anterior margin), scutellum, metanotum, propodeum and intersegmental bands of gaster, pale yellow. Wings hyaline except for slightly infuscate basal area, marginal vein and costal cell of fore wing. Legs yellow. Second and third valvulae brown, the latter much darker.

Morphology: Structural details as illustrated (Figs. 18-23); the following may be noted: Mandibles tridentate with apical tooth deeply incised. Maxillary and labial palps 1-segmented. Antennal formula 1,1,3,3; F1 distinctly shorter than F2, F2-F6 subequal (Fig. 18). Flagellum with the following numbers of longitudinal sensilla: F1:2, F2:3, F3:5, F4:5, F5:5, F6:3. Mid-lobe

of mesoscutum (Fig. 21) with 10-12 dark, setae, usually in 2 rows of five (rarely 4) central setae and a lateral pair. Each lateral lobe of mesoscutum with 3 setae. Mid-lobe of mesoscutum, axillae and scutellum with reticulate sculpture. Fore wing (Fig. 27) with 2 setae on submarginal vein, 5-7 long, stout setae in basal cell, anterior margin of marginal vein with 9 setae, disk densely covered with large setae, marginal fringe short about 0.20 x as wide as the fore wing. Second valvifers approximately 2.8x as long as third valvulae (Fig. 23). Length of second valvifer and third valvula combined 0.75x as long as hind tibia. Valvulae III 0.25x as long as ovipositor, midtibia 1.3x as long as ovipositor, midtibial spur 0.9x as long as basitarsus II. Gastral terga II-VII with 1+1, 1+1, 1+1, 2+2, 2+2+2 and 4 setae, respectively.

Male: Coloration: Head and body darker brown than in female. Face and fronto-vertex pale yellow to yellow brown, ocellar triangle dark brown, mid-lobe more extensively brown, nearly black, scutellum pale, middle and hind coxae and hind femora dark brown.

Morphology: Similar to female, except the following: Antennae 7-segmented, F5 partially fused with F6 (Fig. 19). F2 expanded and with an extensive sensorial complex.

Distribution: Thailand.

Host: Cerataphis brasiliensis (Hempel).

Holotype: Female, THAILAND: Chiang Mai, Doi Suthep 16.i.1993, F. D. Bennett, ex. *Cerataphis brasiliensis* (Hempel) on palm (USNM). *Paratypes*: 8F, 2M, same data as in holotype (AMU, BMNH, FSCA, USNM and the National Biological Control Research Center, Bangkok, Thailand).

Comments: In view of the seriousness of the palm aphid, *Cerataphis brasiliensis* as a pest of ornamental palms and coconut (Reinert & Woodiel, 1974) in Florida and the Caribbean, the specialized parasitoid *E. cerataphivora* should be introduced as a biological control agent into the New World from Thailand.

Discussion

The four species treated here as constituting the *Encarsia flavoscutellum* species group no doubt represent a small fraction of the total number of species still to be described in this group. During this study, it was not possible to check all described *Encarsia* species, particularly those described without hosts, for possible inclusion in this group. What little data we have suggest the group is specific to Hormaphididae (also treated as subfamily Hormaphidinae). Hormaphididae are an unusual group of aphids in that the adult wingless morphs of many species tend to be more sessile than in other aphid families, and are often coated with abundant wax (e.g. see Noordam, 1991). In this way, they can superficially resemble whiteflies or scale insects, the more usual hosts of *Encarsia* species. The stage in *Encarsia* evolution at which the acquisition of Hormaphididae as hosts, and the manner in which it

occurred, are matters about which we can only speculate. The general morphology of this group is plesiomorphic, in particular the robust thorax and very large axillae, which resemble those of *Encarsiella* species (Polaszek & Hayat, 1992). The form and coloration of the ovipositor, and the modified male antenna are suggestive of the *Encarsia lutea* species group. However, sensorial modifications of the male funicle occur in several species not generally thought to be closely related, and having diverse host associations (Viggiani & Laudonia, 1988). For example in *E. gigas* (Tchumakova) and *E. perniciosi* (Tower), both scale insect parasitoids, and in the *E. cubensis, E. lutea,* and *E. opulenta* groups, which are all whitefly parasitoids. Further investigations of antennal modification in male *Encarsia* may eventually furnish usefully phylogenetic characters.

Encarsia brimblecombei (Girault) may also belong to the *E. flavoscutellum* species group. The third valvulae of this species are dark and stout, the axilla setae are centrally located, and its club is three segmented. However, F1 of the female is very short, more characteristic of members of the *Encarsia aurantii* or *Encarsia lutea* species groups and its reported host is a diaspine scale insect "*Chionaspis citri*". For these reasons and because males of this species are unknown, we are unable to determine if this species possesses a similar sensory complex of the male F2 antennal segment. Therefore, we refrain from including this species within the *Encarsia flavoscutellum* species group at this time.

Acknowledgments

We thank the following for their help during this study: Mr. Konishi, National Institute of Agro-environmental Sciences (NIAT), Tsukuba, Japan; G. L. Prinsloo, Plant Protection Research Institute (PPRI), Pretoria, South Africa; M. J. Sharkey, Biosystematics Research Institute, Ottawa, for locating the types of Ishii's *Encarsia* species. P. Lambkin, Queensland Museum, Brisbane, Australia for the loan of *Encarsia brimblecombei* (Girault) type specimens. M. Hayat, Department of Zoology, Aligarh Muslim University, for his opinion of, and comments on, *Encarsia cerataphivora,* and for a review of the manuscript.

References

HAYAT, M., 1980. Taxonomic notes on some oriental Aphelinidae with some new records (Hym: Chalcidoidea). Oriental Ins., 14: 461-472.

HAYAT, M., 1989. A revision of the species of *Encarsia* Foerster (Hymenoptera: Aphelinidae) from India and the adjacent countries. Oriental Ins., 23: 1-131.

ISHII, T., 1938. Descriptions of six new species belonging to the Aphelinae from Japan. *Kontyu,* 12: 27-32.

NOORDAM, D., 1991. Hormaphidinae from Java. Zool. Verha., 270: 1-525.

POLASZEK, A., 1991. Egg parasitism in Aphelinidae (Hymenoptera: Chalcidoidea) with special reference to *Centrodora* and *Encarsia* species. Bull. Entomol. Res., 81: 97-106.

POLASZEK, A., EVANS, G. E. & BENNETT, F. D., 1992. *Encarsia* parasitoids of *Bemisia tabaci* (Hymenoptera: Aphelinidae, Homoptera: Aleyrodidae) - a preliminary guide to identification. Bull. Entomol. Res., 8: 375-392.

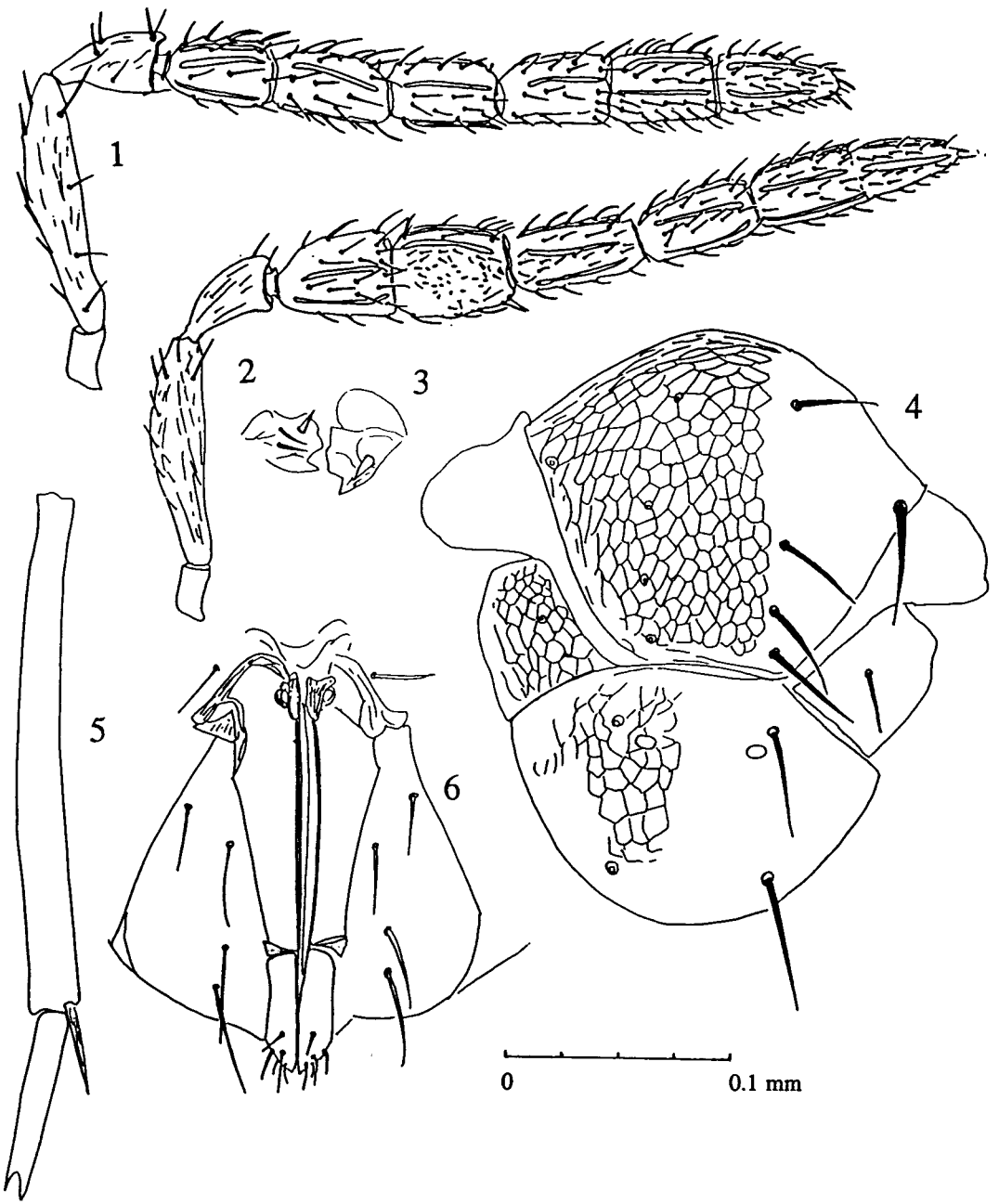
POLASZEK, A. & HAYAT, M., 1990. *Dirphys boswelli* (Hymenoptera: Aphelinidae) an egg-parasitoid of Plataspidae (Heteroptera). J. Nat. Hist., 24: 1-5.

POLASZEK, A. & HAYAT, M., 1992. A revision of the genera *Dirphys* Howard and *Encarsiella* Hayat (Hymenoptera: Aphelinidae). Syst. Entomol., 17: 181-197.

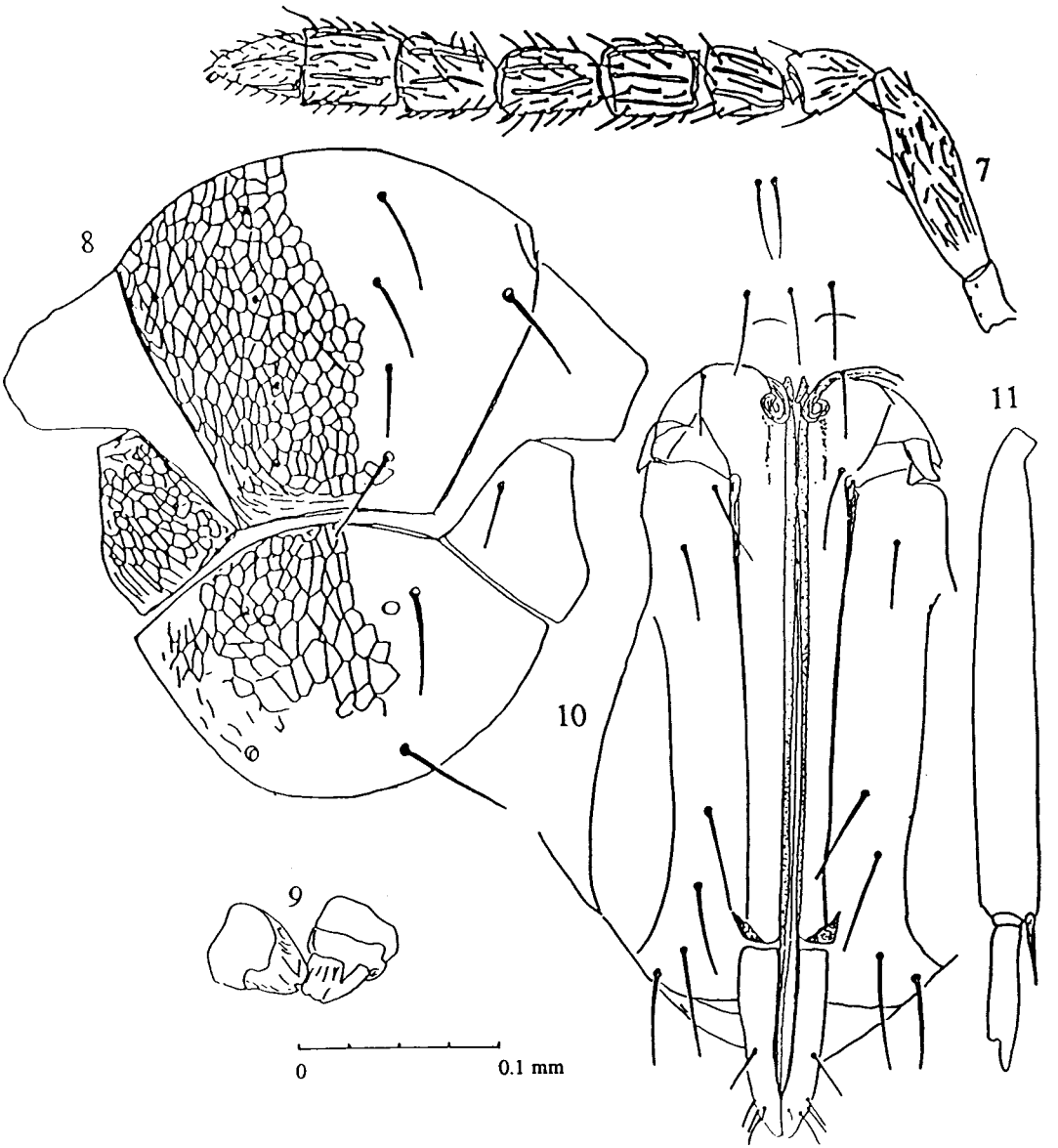
REINERT, J. A. & WOODIEL, M. L., 1974. Palm aphid control on 'Malayan Dwarf' coconut palms. Florida Entomol., 57: 411-413.

VIGGIANI, G. & LAUDONIA, S., 1988. Su alcuni complessi sensoriali delle antenne maschili di tre specie del genere *Encarsia* Foerster (Hymenoptera: Aphelinidae) e il loro rapporto con le fasi dell'accoppiamento. Boll. Lab. Entomol. Agraria "Filippo Silvestri" Portici, 45: 67-75.

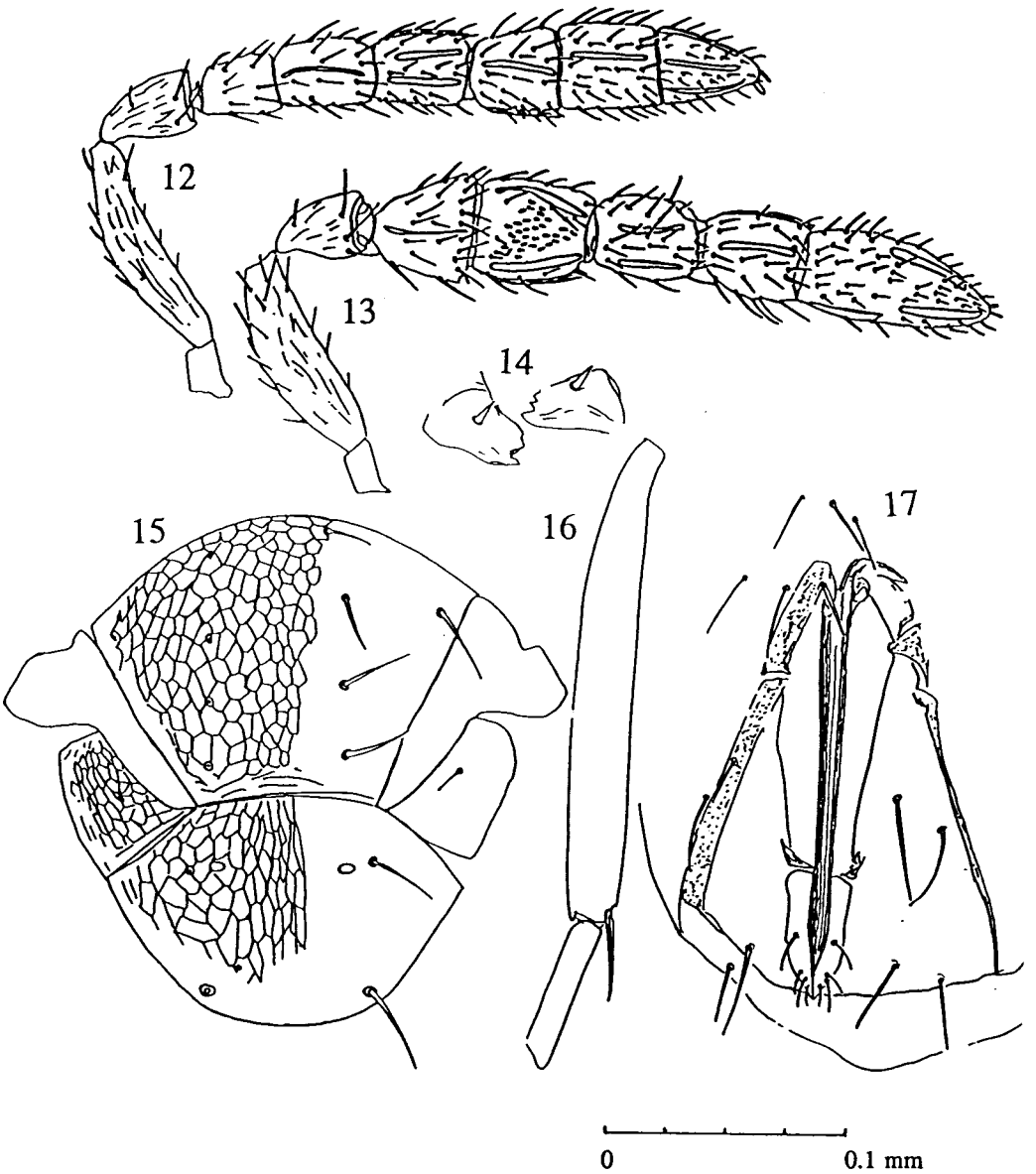
ZEHNTNER, L., 1900. De plantenluizen van het suikerriet op Java. X. *Ceratovacuna lanigera* Zehnt. (De "witte luis" der bladeren). Meded. van het Proefs. Suikerriet West Java te Kagok Tegal, 49: 1-32.



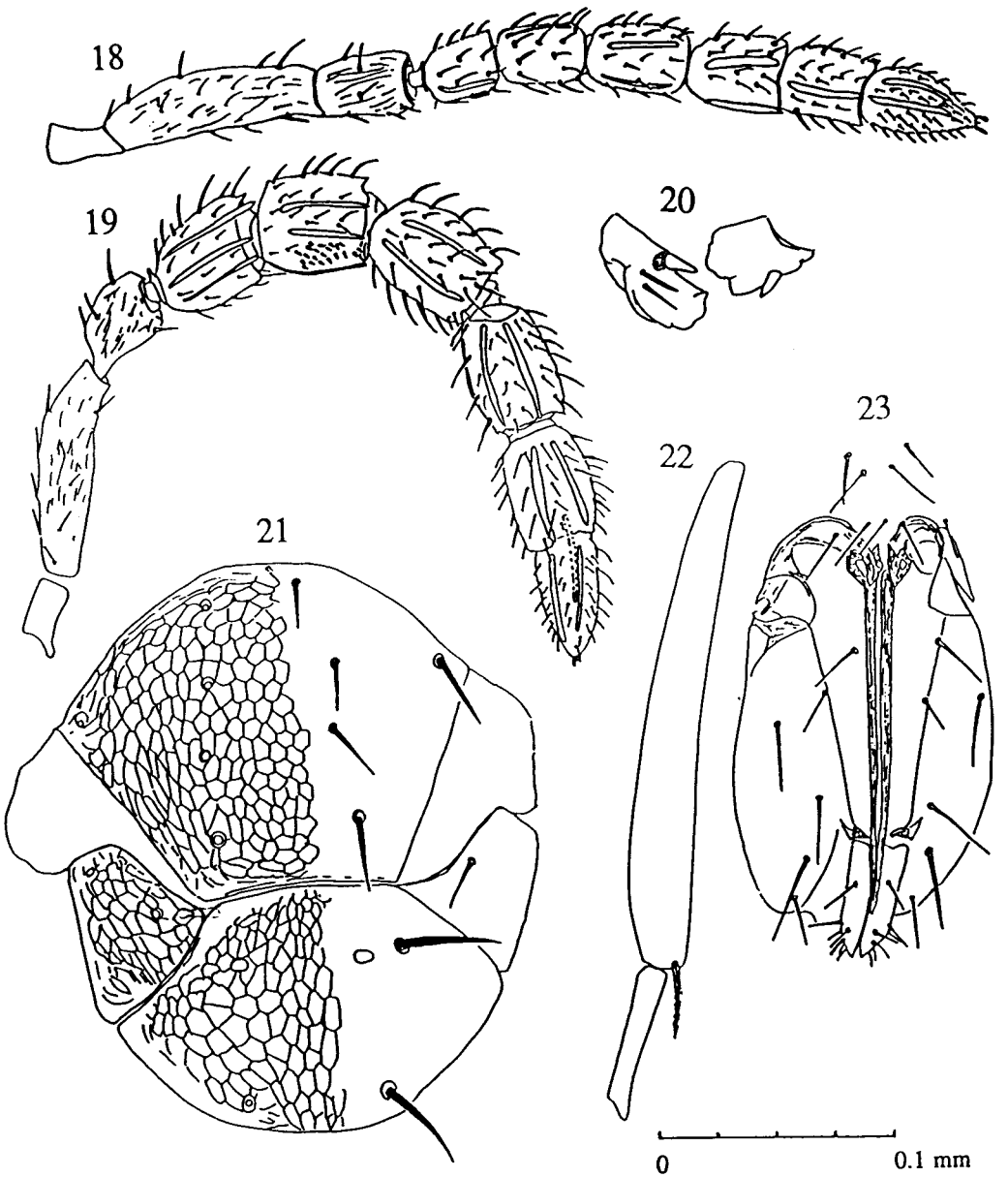
Figs. 1-6. *Encarsia flavoscutellum:* 1, female antenna; 2, male antenna; 3, female mandibles; 4, female thorax; 5, female hind tibia; 6. ovipositor.



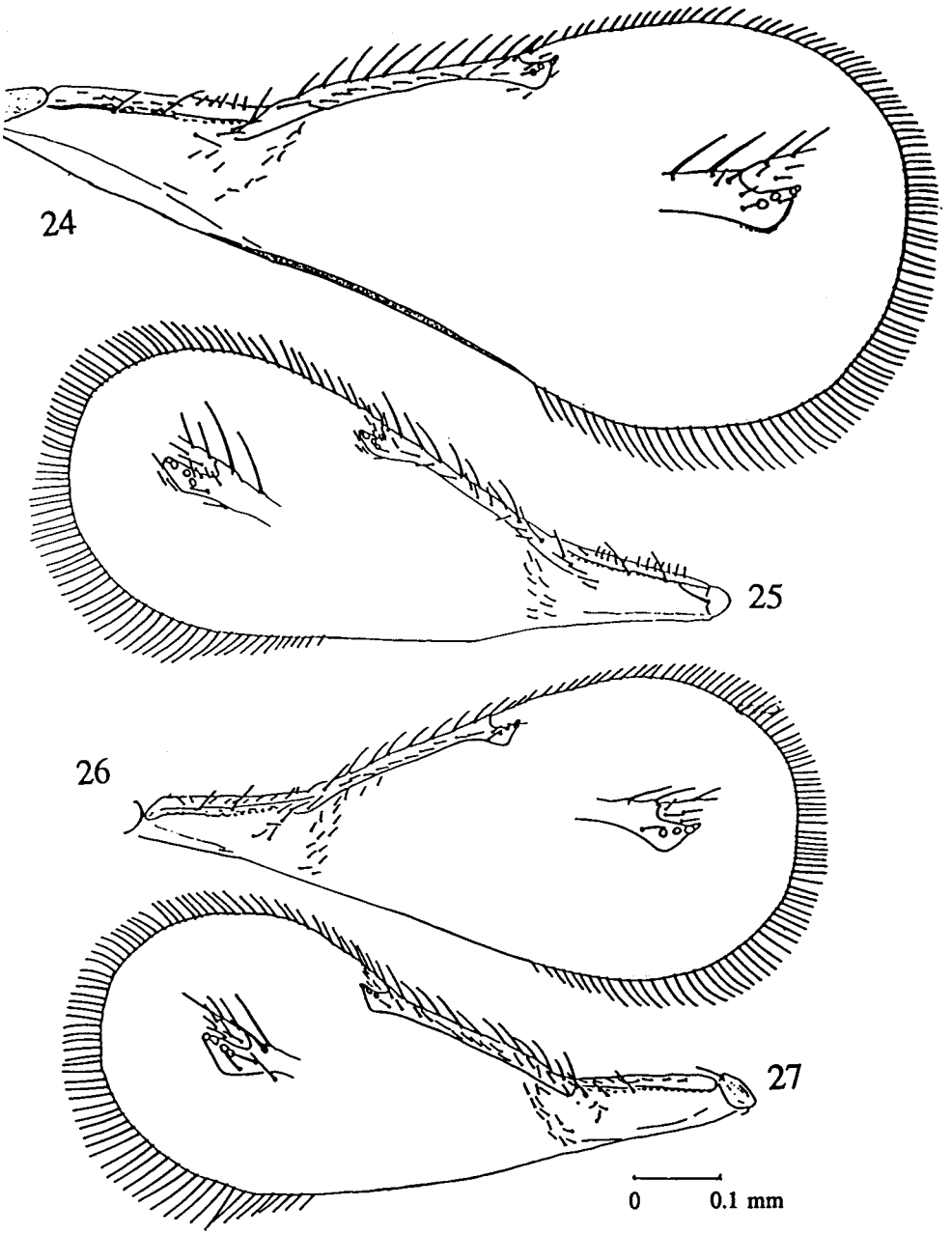
Figs. 7-11. *Encarsia thoracaphis* female: 7, antenna; 8, thorax; 9, mandibles; 10, ovipositor; 11, hind tibia.



Figs. 12-17. *Encarsia noordami:* 12, female antenna; 13, male antenna; 14 female mandibles; 15, female thorax; 16, female hind tibia; 17, ovipositor.



Figs. 18-23. *Encarsia cerataphivora:* 18, female antenna; 19 male antenna; 20, female mandibles; 21, female thorax; 22, female hind tibia; 23, ovipositor.



Figs. 24-27. Fore wings of female *Encarsia:* 24, *E. thoracaphis;* 25, *E. flavoscutellum;* 26, *E. noordami;* 27, *E. cerataphivora.*