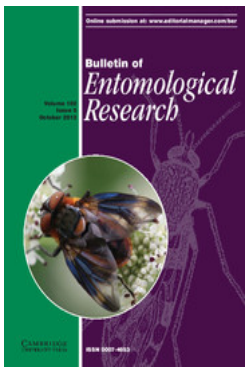

Encarsia species (Hymenoptera: Aphelinidae) of Australia and the Pacific Islands attacking *Bemisia tabaci* and *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) – a pictorial key and descriptions of four new species

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Encarsia species (Hymenoptera: Aphelinidae) of Australia and the Pacific Islands attacking *Bemisia tabaci* and *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) – a pictorial key and descriptions of four new species

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Abstract

After the recent introduction of the pest whitefly *Bemisia tabaci* (Gennadius) biotype B into Australia, research was undertaken to study the parasitoids of the long established native *B. tabaci* and *Trialeurodes vaporariorum* (Westwood). The genus *Encarsia* contains species which are important biological control agents of whiteflies and hard scales. The taxonomy of the *Encarsia* species attacking *B. tabaci* and *T. vaporariorum* in Australia and the Pacific Islands is revised. DNA sequencing of the 28S D2 ribosomal DNA was used to characterize species. Sixteen species are recognized, with 12 occurring in Australia, eight in the Pacific region, and four in both regions. All except one species (*E. formosa* Gahan) are new records for Australia. Four species are described as new from Australia: *E. accenta* Schmidt & Naumann **sp. n.**, *E. adusta* Schmidt & Naumann **sp. n.**, *E. oakeyensis* Schmidt & Naumann **sp. n.**, and *E. ustulata* Schmidt & Naumann **sp. n.** Diagnostic descriptions are given for all species and each species is illustrated. A pictorial key is provided to allow the identification of species by non-specialists.

Introduction

In Australia, the silverleaf whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) biotype B was first detected in Darwin, Northern Territory, in October 1994 (Gunning *et al.*, 1995). Subsequent surveys found the whitefly to be established in nurseries across northern New South Wales and Queensland (De Barro, 1995). The silverleaf whitefly is now well established in cropping areas along the Queensland coast from Cooktown to northern New South Wales with scattered populations in the Queensland cotton growing towns of Emerald, Biloela, Warra, St George, Dalby and Oakey. This pest is highly polyphagous and colonizes numerous hosts including cotton and ornamental, vegetable, and weed species. Damage is caused: (i) by direct feeding which may induce irreversible physiological disorders in certain plant species as well as yield decline; (ii) by contamination with honeydew and sooty mould; and (iii) by the vectoring of geminiviruses (see De Barro, 1995, for a review).

One of the key management challenges posed by the silverleaf whitefly is its ability to develop resistance against insecticides. This is further compounded by the shortage in Australia of effective insecticides and difficulties in obtaining minor use registration for new effective products. For this reason, reliance on insecticides as the sole means of managing infestations was considered at best a short term solution. It is generally considered that long term sustainable management of silverleaf whitefly requires an

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integrated approach in which a range of management strategies is combined to control the pest. One of the key components to achieving this elsewhere has been the use of natural enemies.

Australia has never before had a serious whitefly pest of outdoor crops. As a consequence, there was very little research experience present in Australia capable of dealing with the pest. It was therefore concluded that research into management of this pest should commence before problems occurred so as to build the necessary research capability. One of the key areas targeted was biological control. Research overseas indicated that parasitoids offered the best potential (Gerling, 1986; Osborne *et al*., 1990; Goolsby *et al*., 1996; Kirk & Lacy, 1996; Lacy *et al*., 1996; Legaspi *et al*., 1996; Nordlund & Legaspi, 1996; Goolsby *et al*., 1998; De Barro, 1995, for a review). Our knowledge of the parasitoid fauna in Australia that may contribute to the control of the silverleaf whitefly was virtually nil. There was, however, at least one indigenous biotype of *B. tabaci* which was widespread across the northern half of Australia (De Barro & Driver, 1997; De Barro *et al*., 1998) as well as several other related indigenous species of *Bemisia* (Martin, 1999). It was therefore concluded that agents capable of contributing significantly to the biological control of this pest may already be in Australia.

To determine the distribution and diversity of parasitoids attacking *B. tabaci* in Australia a series of surveys were planned. Both parasitoids of *B. tabaci* and *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae) were to be collected, as many parasitoids attack both species. However, while the surveys may find parasitoids, it was likely that their identification would not be possible, as keys to the parasitoid fauna of these whiteflies in Australia did not exist, and keys available elsewhere were either unreliable or did not include the fauna found in Australia. This paper describes the development of morphological taxonomic tools which enable researchers to separate species of one of the most promising genera, *Encarsia* Förster (Hymenoptera: Aphelinidae), in Australia.

Encarsia Förster, 1878, is a large genus of the chalcidoid family Aphelinidae, with currently about 280 described species (Polaszek *et al*., 1999). About 110 *Encarsia* species are known to parasitize whiteflies (Babcock & Heraty, 2000). Prior to this survey only a single species attacking *B. tabaci* and *T. vaporariorum*, *Encarsia formosa* Gahan, was known from Australia (Wilson, 1960). An illustrated key to the *Encarsia* species attacking *B. tabaci* and *T. vaporariorum* in Australia and the Pacific Islands is provided. Altogether 16 species are treated here, with 12 species from Australia, eight species from the Pacific Islands, and four species occurring in both regions (appendix 1).

Encarsia is a taxonomically difficult genus. To underpin the taxonomy based on morphological characters, the D2 expansion region of the 28S ribosomal DNA was sequenced to separate species at the molecular level. The D2 region provided genetic markers for most of the species with the only exceptions being those where there was insufficient material. These data, as well as a phylogenetic analysis, are presented in Babcock *et al*. (2001).

Materials and methods

The study was mainly based on material collected over a period of three years on the Pacific Islands (1996–1997) and in Australia (1996–1998). Most of the specimens were reared from either *B. tabaci* or *T. vaporariorum*, although some were obtained from related *Bemisia* spp. as well as species of *Lipaleyrodes* Takahashi and *Aleurocanthus* Quaintance & Baker. Each sample was given a unique code number and the host plant, host whitefly species, date, location and collector were noted. Nymphs of parasitized hosts were kept in emergence chambers and the parasitoids transferred to gelatine capsules or 94% ethanol, where they remained at room temperature until further examination or DNA analysis. Whiteflies were identified to species level using the fourth instar pupal case from which the parasitoid had emerged (Martin, 1987). *Bemisia tabaci* biotypes were identified using adults collected along with the parasitized nymphs according to the method described in De Barro & Driver (1997).

All specimens used in this study were slide mounted as described by Noyes (1982) with the following modifications: specimens were placed in 10% KOH for 5–8 min (depending on whether the specimen was dry or preserved in ethanol) and incubated at 97°C using a block heater. The terminology follows Heraty & Polaszek (2000). All measurements of antennae and legs refer to the maximal length of the morphological structure in lateral view. Lengths of antennal segments were taken excluding the intersegmental membranes because they can vary depending on how much the antenna was stretched during slide preparation. Fore wing length is the distance between its most apical point and the proximal end of the submarginal vein, excluding the tegula (FWL in fig. 2). Gaster refers to the metasoma without the petiole (metasomal tergite 1). The length of the ovipositor was measured as the distance between the proximal margin of the basal ring to the extreme apex (cf. fig. 5 in Huang & Polaszek, 1998: 1828, fig. 1B in Heraty & Polaszek, 2000: 145). This is different from Hayat (1998) who measured the ovipositor length as the combined lengths of second valvifer and third valvula (cf. fig. 8 in Hayat, 1998: 272). Care should be taken if specimens are distorted because this can affect measurements, in particular measurements of the ovipositor (Heraty & Polaszek, 2000). When taking measurements it is necessary that all reference points of the structure to be measured are equidistant from the objective of the microscope.

All specimens examined for this study were deposited in the Australian National Insect Collection (ANIC), Canberra, Australia, and in The Natural History Museum (BMNH), London, UK.

Males are often very difficult to identify without accompanying females. In several species males are not known. Therefore the pictorial key was designed only for females, but descriptions of males are provided where possible to aid identification of males in samples where males and females are present.

Measurements of quantitative characters given in the species descriptions are based on specimens which were available at the time this study was conducted. Additional material or abnormal specimens may reveal values which lie slightly outside the given ranges. This is particularly the case for species which were recorded by few specimens.

Depositories

ANIC	Australian National Insect Collection, Canberra, Australia.
BMNH	The Natural History Museum, London, UK.

BPBM	Bernice P. Bishop Museum, Honolulu, Hawaii, USA.
IEUN	Istituto de Entomologia Agraria, Universita degli Studi di Napoli, Portici, Italy.
NIAS	National Institute of Agroenvironmental Sciences, Tsukuba, Japan.
QMBA	Queensland Museum, Brisbane, Australia.
UNLP	Universidad Nacional de La Plata, Argentina.
USNM	United States National Museum of Natural History, Washington, D.C., USA.
ZDAMU	Zoology Department, Aligarh Muslim University, India.

Results

Of the 16 *Encarsia* species which were found parasitizing *B. tabaci* and *T. vaporariorum* in Australia and the Pacific, 11 parasitized both *B. tabaci* and *T. vaporariorum*, whereas four attacked only *B. tabaci* and one only *T. vaporariorum* (appendix 1).

Most *Encarsia* species can be assigned to one of the about two dozen species-groups that are currently recognized (Hayat, 1998; Huang & Polaszek, 1998; Babcock & Heraty, 2000). For some species-groups, morphological and molecular evidence suggest that they represent monophyletic groupings, for instance the *E. strenua* (Silvestri)-group and the *E. luteola* Howard-group (Babcock *et al*., 2001). In several cases, however, assignments of species to species-groups and the species-groups themselves are regarded as tentative (Hayat, 1998). For some species, the placement into a particular species-group is rather straightforward (*E. strenua*), for others the placement is problematic and in those cases opinions of different authors are mentioned.

A pictorial key to the *Encarsia* species found parasitizing *B. tabaci* and/or *T. vaporariorum* in Australia and the Pacific is given in plates 1–3. For accurate identification of most species it is necessary to use slide mounted specimens. The key is dichotomous and, starting leftmost in plate 1, at each step a decision has to be made based on the characters given in a particular column, proceeding from left to right. The habitus drawings are supposed to illustrate colour patterns and do not necessarily reflect exact body proportions. The key uses characters that can be readily seen using a standard compound microscope, although identification usually requires contrast enhancement techniques, e.g. phase contrast or differential interference contrast. A diagnostic description of each species is given below.

Genus *Encarsia* Förster

Encarsia Förster, 1878: 65. Type species: *Encarsia tricolor* Förster, designation by monotypy. = *Aspidiotiphagus* Howard, 1894a: 229, *Prospalta* Howard, 1894b: 6, *Prospaltella* Ashmead, 1904: 126. For a full list of generic synonyms see Huang & Polaszek, 2000: 1828–1829.

Revisionary studies of *Encarsia* for other geographical regions: China: Huang & Polaszek, 1999; Egypt: Polaszek *et al*., 1999; Europe: Ferrière, 1965; India: Hayat, 1998; Israel: Rivnay & Gerling, 1987; North America: Schauff *et al*., 1996; Russia and adjacent countries: Yasnosh, 1989, Trjapitzin *et al*., 1996. *Encarsia* parasitoids of *B. tabaci*: Polaszek *et al*., 1992.

Diagnosis. Colour variable from completely pale yellow to partly brown and (particularly males) completely brown or dark brown; pale colours in life often yellow, very pale yellow to dark yellow or orange. Head in frontal view usually wider than long. Mandibles normally with 3 teeth or 2 teeth and a truncation which may be separated by a distinct gap. Maxillary palp 1-, rarely 2-segmented. Labial palp 1-segmented. Female antenna (excluding radicle and anellus) with 8 segments, apical 2 or 3 segments often forming a distinct (apically rounded, not spindle-shaped) clava. Anellus small and often indistinct. Male antenna often 7-segmented. Pronotum medially with membranous incision. Mesoscutal midlobe with 0–20 setae, these often arranged in bilateral symmetry, in particular if midlobe with small or moderate number of setae. Each mesoscutal side lobe with 1–5, usually 2–3, setae. Axillae small, longer than wide, and separated medially by a distance greater than the maximal length of an axilla. Scutellum distinctly wider than long with anterior and posterior margins convex, with 2 pairs of setae and one pair of placoid sensilla. Fore wing with distinct marginal fringe of very variable length. Submarginal vein shorter than marginal vein, normally with 2 setae, rarely with only one or more (5–6) setae. Anterior margin of marginal vein with variable number of setae (often 6–8). Postmarginal vein absent. Fore wing disc sparsely to densely setose, in some species with bare area near anterior margin. Legs with tarsi of fore and hind legs 5-segmented tarsi; tarsi of middle leg 5- (most species) or 4-segmented. Metasoma with 8 tergites (T1–T8) including the petiole (T1), T7 with spiracles. T1–T2 usually without setae, T3–T7 with 1–5 setae laterally. T8 usually with 4 setae.

Encarsia accenta Schmidt & Naumann sp. n.
(figs 1–4)

Description. Female. Head yellow, with transverse brown band between eyes in frontal view, sometimes head largely brown with vertex and lower head lighter. Mesosoma light brown, scutellum lighter and propodeum darker than rest of mesosoma. Petiole brown. Gaster largely pale yellow to white, at base with sharply defined narrow dark brown band, fifth metasomal tergite laterally and sixth tergite with complete narrow dark brown band anteriorly (fig. 1). Antenna yellow with scape, pedicel and apical segments darkened. Fore wing hyaline. Legs yellow. Interocellar triangle with rugose-reticulate surface sculpture. Clava 2-segmented. Pedicel longer than F1 (1.26–1.30). F1 2.16–2.50 times as long as wide, slightly shorter than F2 (0.83–0.93) and F3 (0.82–0.88) (fig. 3). Flagellomers with the following numbers of sensilla: F1: 0, F2: 1, F3: 2, F4: 3, F5: 3, F6: 3. Mid lobe of mesoscutum with 8 setae arranged symmetrically, side lobes with 3 setae each. Mesoscutal midlobe, axillae, and scutellum with rather fine but distinctive reticulation, cells with distinct internal striations. Scutellar sensilla widely separated, approximately 7 times the width of a sensillum. Distance between anterior pair of scutellar setae larger than between posterior pair. Fore wing 2.4 times as long as wide. Marginal fringe 0.26–0.29 times as long as wing width. Submarginal vein with 2 setae, marginal vein anteriorly with 7–9 setae. Tarsus of middle leg 5-segmented. Apical spur of midtibia distinctly shorter than half the length of the corresponding basitarsus (0.27–0.36) (fig. 4). Tergites laterally with the following number of setae: T2: 2, T3: 2, T4: 2, T5: 2, T6: 3, T7: 3. T8 with 4 setae. Ovipositor subequal in length to middle tibia (0.99–1.04). Third valvula 0.32–0.34 times as long as the second valvifer.

Male. Overall colour of mesosoma brown. Mesoscutal midlobe, side lobes, and scutellum lighter. Metasoma predominantly brown. Legs yellow except coxae brown and hind femur slightly darkened. Antennae yellow with pedicel darkened. Head predominantly brown, top of head lighter. Apical two segments of antenna fused and sensilla partly overlapping.

Species-group placement. *Encarsia inaron* (Walker)-group.

Distribution. Australia: New South Wales and South Australia.

Host. An unidentified species of the *B. tabaci* complex.

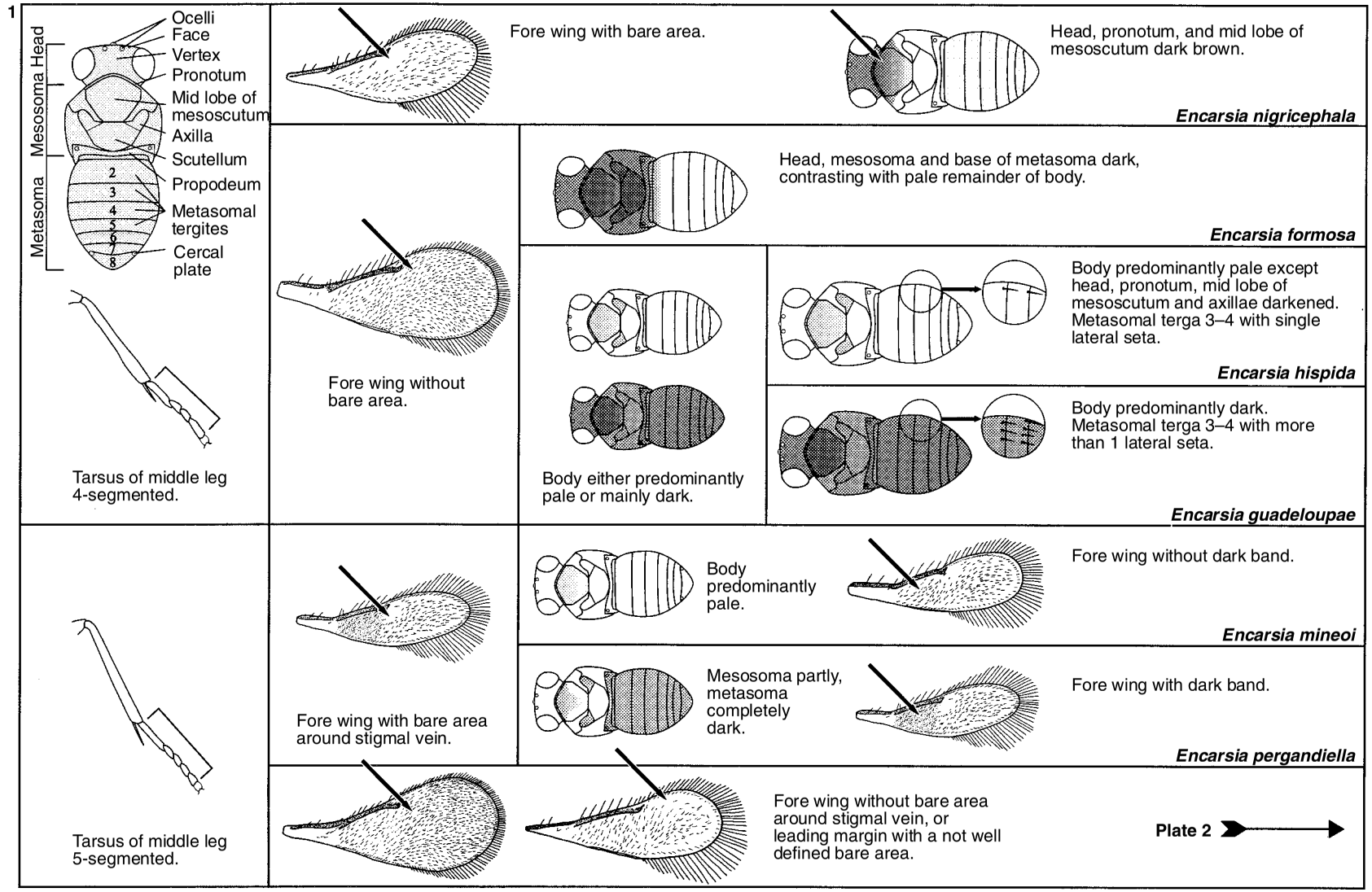
Material examined. Holotype ♀, SOUTH AUSTRALIA, Renmark, 4.i.1997 (P. De Barro) ex *Bemisia* sp. on *Atriplex rhagodioides* (Chenopodiaceae). Paratypes: 2♀, 1♂, same data as holotype. NEW SOUTH WALES, Barrington Tops, 1♀, nr Moppy Lookout, 11.ii.1984 (I.D. Naumann) (ANIC).

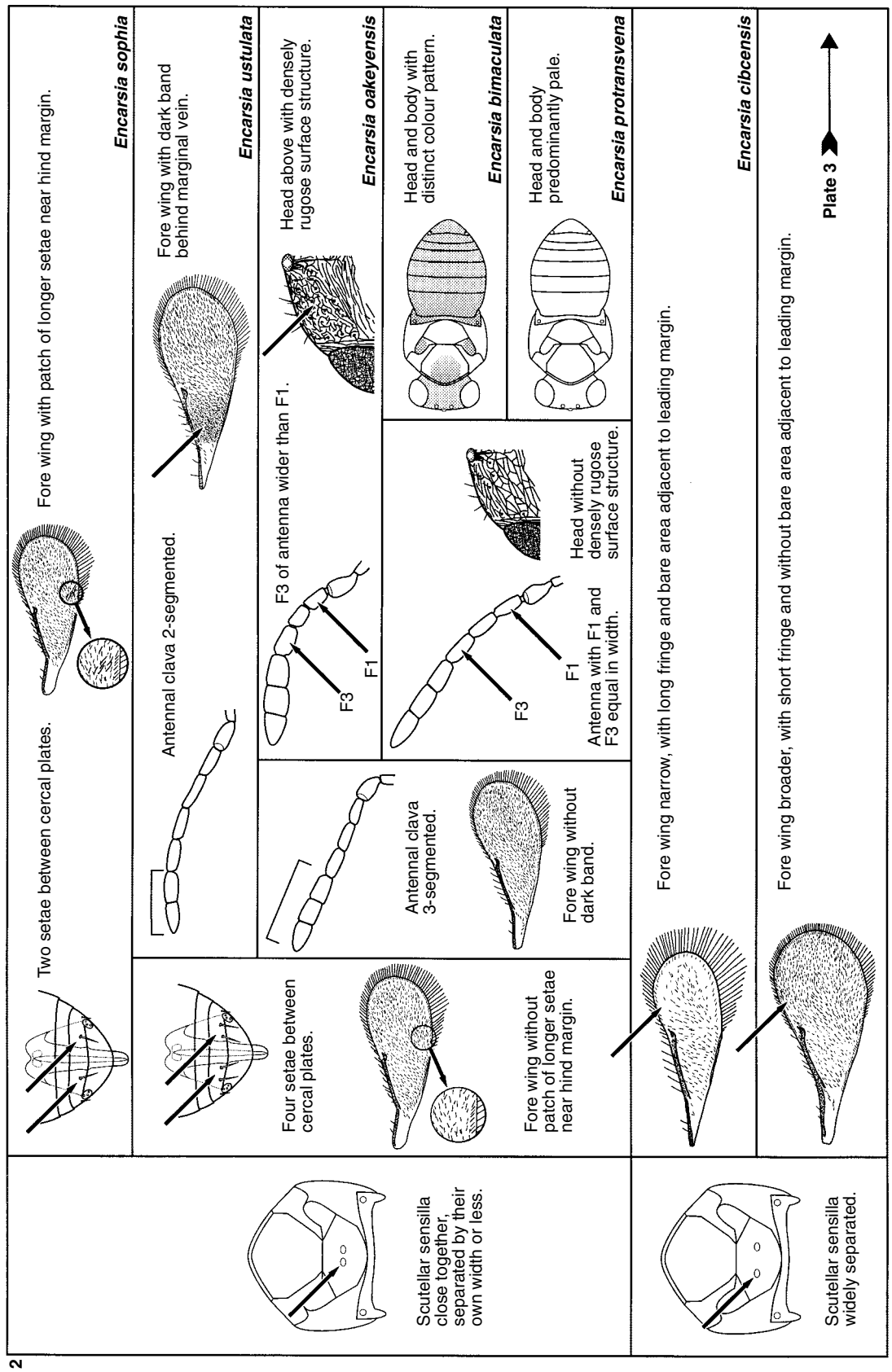
Comments. This species belongs together with *E. adusta* **sp. n.** and *E. azimi* Hayat to the *E. inaron* species-group. *Encarsia accenta* is characterized by the distinctive colour pattern of the metasoma. For differentiating *E. accenta* from the following two species see remarks under *E. adusta*. There are only slight genetic differences between this and the two related species *E. azimi Hayat* and *E. adusta*.

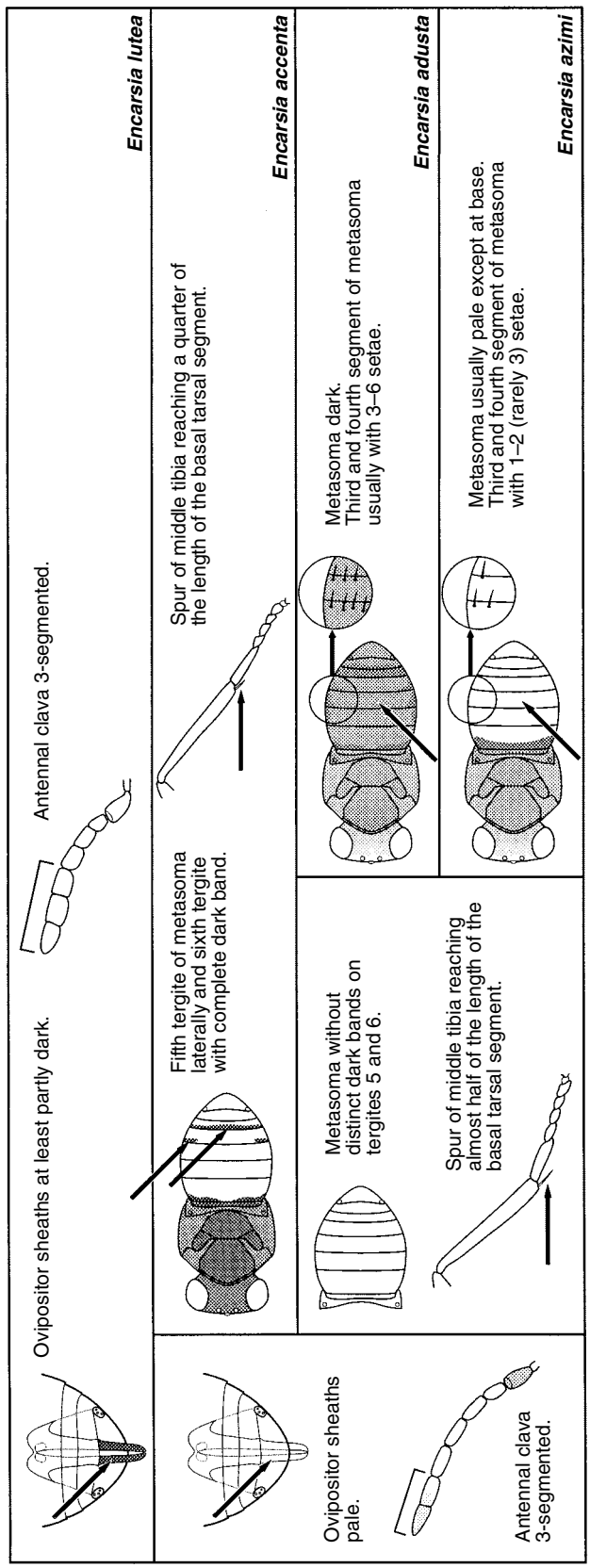
Encarsia adusta Schmidt & Naumann sp. n.
(figs 9–12)

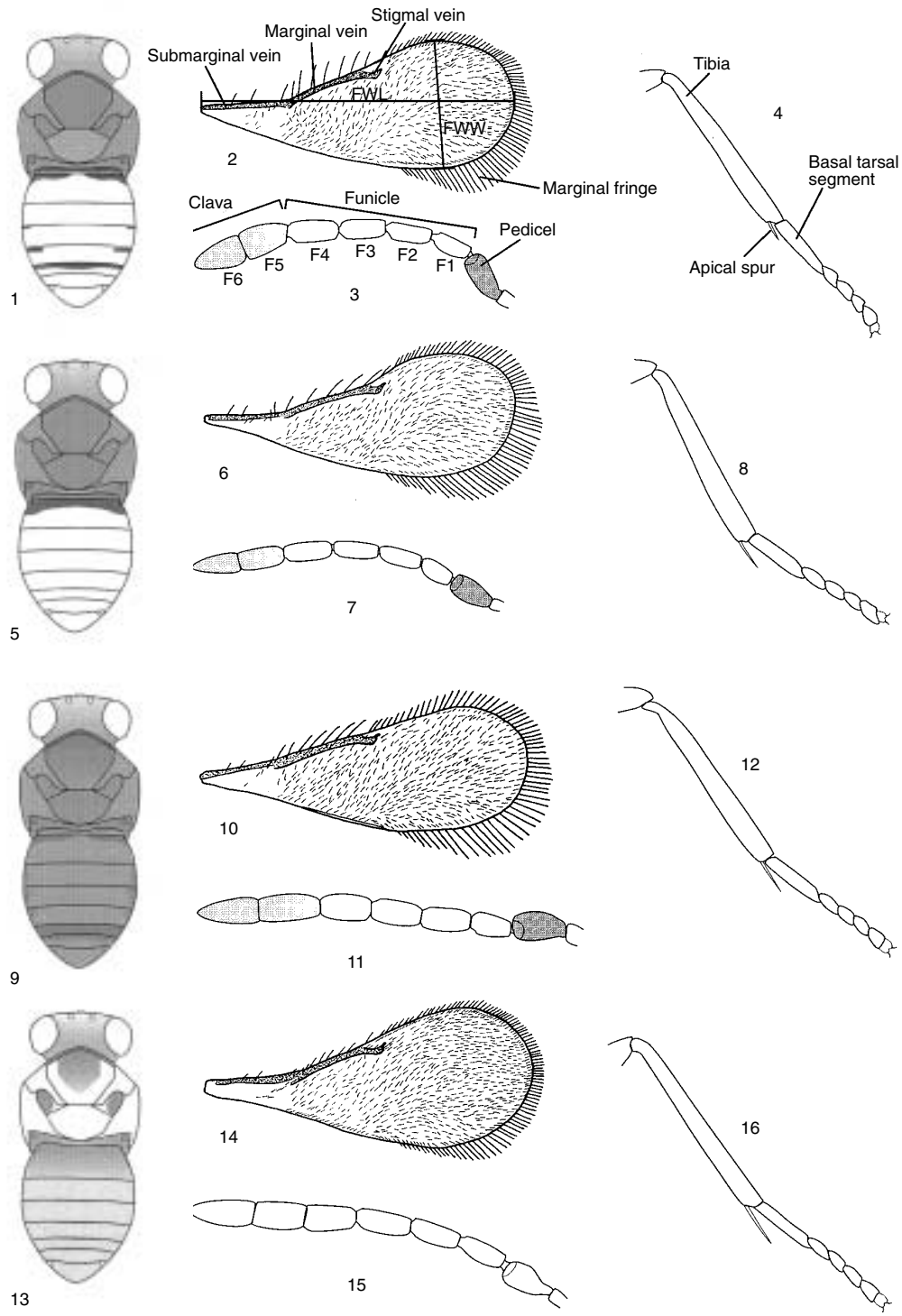
Description. Female. Head predominantly brown, upper head partly lighter. Overall coloration of mesosoma light brown, scutellum slightly

Plates 1–3. Pictorial key to *Encarsia* species of Australia and the Pacific Islands attacking *Bemisia tabaci* and *Trialeurodes vaporariorum* (females).




2
Two setae between cercal plates.
Fore wing with patch of longer setae near hind margin.
Encarsia sophia
Antennal clava 2-segmented.
Fore wing with dark band behind marginal vein.
Encarsia ustulata
F3 of antenna wider than F1.
F3
F1
Head above with densely rugose surface structure.
Encarsia oakeyensis
Four setae between cercal plates.
Antennal clava 3-segmented.
Head and body with distinct colour pattern.
Encarsia bimaculata
Fore wing without patch of longer setae near hind margin.
Fore wing without dark band.
F3
F1
Antenna with F1 and F3 equal in width.
Head without densely rugose surface structure.
Head and body predominantly pale.
Encarsia protransvena
Scutellar sensilla close together, separated by their own width or less.
Fore wing narrow, with long fringe and bare area adjacent to leading margin.
Encarsia cibcensis
Scutellar sensilla widely separated.
Fore wing broader, with short fringe and without bare area adjacent to leading margin.
Plate 3


3
Ovipositor sheaths at least partly dark.
Antennal clava 3-segmented.
Encarsia lutea
Fifth tergite of metasoma laterally and sixth tergite with complete dark band.
Spur of middle tibia reaching a quarter of the length of the basal tarsal segment.
Encarsia accenta
Ovipositor sheaths pale.
Metasoma without distinct dark bands on tergites 5 and 6.
Metasoma dark. Third and fourth segment of metasoma usually with 3–6 setae.
Encarsia adusta
Antennal clava 3-segmented.
Spur of middle tibia reaching almost half of the length of the basal tarsal segment.
Metasoma usually pale except at base. Third and fourth segment of metasoma with 1–2 (rarely 3) setae.
Encarsia azimi



Figs 1–16. Habitus, antenna, fore wing, and middle leg of *Encarsia accenta* (1–4), *E. azimi* (5–8), *E. adusta* (9–12), *E. bimaculata* (13–16). FWL, fore wing length; FWW, fore wing width. Note that habitus drawings illustrate colour patterns and may not reflect exact body proportions.

lighter and propodeum darker than rest of mesosoma. Gaster predominantly brown, petiole brown, gaster at base with sharply defined narrow dark brown band (fig. 9). Antenna yellow with scape, pedicel and apical segments darkened. Fore wing hyaline. Legs yellow except coxa basally brown and hind femur darkened. Head with rugose-reticulate surface sculpture. Clava 2-segmented. Pedicel longer than F1 (1.35–1.62). F1 1.44–1.80 times as long as wide, slightly shorter than F2 (0.72–0.85) and F3 (0.68–0.81) (fig. 11). Flagellomers with the following numbers of sensilla: F1: 0, F2: 2, F3: 2, F4: 3, F5: 3, F6: 3. Mid lobe of mesoscutum with 8(–9) setae arranged symmetrically, side lobes with 3 setae each. Mesoscutal midlobe, axillae, and scutellum with rather fine but distinctive reticulation, cells with distinct internal striations. Scutellar sensilla widely separated, approximately 5–6 times the width of a sensillum. Distance between anterior pair of scutellar setae larger than between posterior pair. Fore wing 2.6 times as long as wide. Marginal fringe 0.35–0.38 times as long as wing width. Submarginal vein with 2 setae, marginal vein anteriorly with 7 setae. Tarsus of middle leg 5-segmented. Apical spur of midtibia subequal to half the length of the corresponding basitarsus (0.44–0.55) (fig. 12). Tergites laterally with the following number of setae: T2: (2–)3–6(–8), T3: 3–6, T4: 3–6, T5: 4–6, T6: 4–6, T7: 3. T8 with 4 setae. Ovipositor slightly shorter than or subequal in length to middle tibia (0.90–1.03). Third valvula 0.44–0.46 times as long as second valvifer.

Male. Body predominantly brown with mesoscutal midlobe posteriorly and scutellum lighter. Legs light brown except coxae brown, femora, in particular hind femur, lighter brown and tibiae slightly darkened. Apical two segments of antenna fused and sensilla partly overlapping.

Species-group placement. *Encarsia inaron*-group.

Distribution. Australia: Northern Territory, Queensland, Western Australia.

Hosts. *Bemisia tabaci*, *Lipaleyrodes* sp., *T. vaporariorum*.

Material exmained. Holotype ♀, NORTHERN TERRITORY, Darwin, 27.ix.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus* (Asteraceae). Paratypes: 2♀, same data as holotype. QUEENSLAND, Mt Isa, 1♀, 3.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. WESTERN AUSTRALIA, Kununurra, 1♀, 1♂, 24.ix.1996 (P. De Barro) ex *Lipaleyrodes* sp. on *Euphorbia hirta* (Euphorbiaceae) (ANIC).

Comments. *Encarsia adusta*, together with *E. accenta* and *E. azimi*, belongs to the *E. inaron* species-group. *Encarsia azimi* is sometimes difficult to distinguish from *E. adusta* but has usually a pale yellow metasoma and only 1–2 (rarely 3) setae on each side of the third and fourth metasomal tergites (cf. plate 3). *Encarsia accenta* has a distinct colour pattern and differs morphologically by the short tibial spur of the middle leg, which is distinctly shorter than half the length of the corresponding basal tarsal segment (fig. 4). The 28S rDNA D2 gene region shows consistent differences and characterizes each species on a molecular level (Babcock *et al*., 2001).

Encarsia azimi Hayat
(figs 5–8)

Trichaporus indicus Azim & Shafee, 1980: 335. Holotype ♀, India, Tamil Nadu, Ootacamund, 24.vi.1968 (S.A. Shafee), ex aleyrodid on *Nerium* (Apocynaceae) (ZDAMU, not examined). Preoccupied by *Prospaltella indica* Shafee, 1973: 255.
Encarsia azimi Hayat, 1986: 160. Replacement name for *indicus* Azim & Shafee; Hayat, 1989: 62; Huang & Polaszek, 1998: 1845.
Encarsia adrianae Lopez-Avila, 1987: 425. Holotype ♀, Pakistan, Rawalpindi, iv.1985 ex *B. tabaci* on *Lantana camara* [ex culture UK, Ascot, Silwood Park, 26.viii.1986 (A. Lopez-Avila) ex *B. tabaci*] (BMNH, examined). Synonymy by Hayat, 1998: 202.
Encarsia adrianae Lopez-Avila: Polaszek *et al*., 1992: 381.

Diagnosis. Female. Mesosoma brown and gaster pale yellow to white except with sharply defined dark brown band at base (fig. 5), occasionally gaster more or less darkened. Antenna yellow with pedicel brown and apical segments slightly darkened. Pedicel longer than F1 (1.17–1.30). F1 distinctly shorter than F2 (0.75–0.88) and F3 (0.63–0.79), resp. (fig. 7). Antennal club 2-segmented. Scutellar sensilla widely separated, approximately 6–7 times the width of a sensillum. Mesoscutal midlobe, axillae, and scutellum with rather fine but distinctive reticulation, cells with distinct internal striations. Distance between anterior pair of scutellar setae larger than that between posterior pair. Fore wing 2.5–2.7 times as long as its maximal width. Marginal fringe 0.30–0.36 times as long as wing width. Apical spur of midtibia shorter than half the length of the basal tarsal segment (0.38–0.44) (fig. 8). Ovipositor slightly shorter than or subequal to middle tibia (0.91–1.00). Third valvula 0.36–0.46 times as long as second valvifer.

Male. Body brown with mesoscutal midlobe posteriorly and scutellum lighter. Legs brown, tibiae and tarsi light brown. Apical two segments of antenna fused and sensilla partly overlapping.

Species-group placement. *Encarsia inaron*-group.

Distribution. Australia: Queensland, New South Wales. Taiwan, India, Pakistan, Japan, Italy, Spain.

Hosts. *Bemisia tabaci*, *Lipaleyrodes* sp. The following additional hosts have been recorded (Chou *et al*., 1996; Huang & Polaszek, 1998): *Aleurolobus rhododendri* Takahashi, *Dialeurodes piperis*, Takahashi, *Odontaleyrodes rhododendri* (Takahashi), *Parabemisia myricae* (Kuwana), *Rhachisphora fici* (Takahashi) (recorded as *Dialeurodes citri*).

Material examined. NEW SOUTH WALES: Narrabri, Pikes Lane, 5♀, 2♂, 8.ii.1997 (P. De Barro) ex *Aleyrodes atriplex* on *Chenopodium trigonum* (Chenopodiaceae). QUEENSLAND: Ayr, 3♀, 1♂, 13.xi.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Dalby, 1♀, 17.iv.1997 (D.R. Lea) ex *B. tabaci* on *Gossypium hirsutum* (Malvaceae). Warra, 1♀, 25.vi.1997 (D.R. Lea) ex *T. vaporariorum* on *Anoda cristata*. Mt Isa, 3♀, 3.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Bundaberg, 3♀, 18.iii.1999 (G. Artlett) ex *Lipaleyrodes* sp. on *Convolvulus* sp. (Convolvulaceae). Redland Bay, 2♀, Dec. 1998 (J.R. Hargreaves), ex *B. tabaci* on *Lantana camara*..

Comments. Specimens from Narrabri, New South Wales, differ genetically from all other populations of *E. azimi*: sequence divergence (number of pairwise differences divided by the number of shared nucleotides) of the 28S D2 ribosomal DNA gene region between the Narrabri population and other populations is 3.1%, whereas there is no variation among non-Narrabri populations of *E. azimi*. This degree of genetical difference might indicate the existence of more than one species. However, no consistent morphological differences could be found and the species is currently being studied further.

Encarsia bimaculata Heraty & Polaszek
(figs 13–16)

Encarsia bimaculata Heraty & Polaszek, 2000: 155–157. Holotype ♀, India, Tabarbhani, 19.vii.1994 [ex culture Gainesville, Florida, R. Nguyen, autoparasitoid, M92018] (USNM, not examined).

Diagnosis. Female. Mainly yellow except pronotum, a large anteromedian patch on middle lobe of mesoscutum, axillae, propodeum and petiole brown (fig. 13). Head yellow with a transverse brown band. Metasoma mostly yellow except brown at base and occasionally with a faint brown patch on 5th and 6th tergites. Fore wing hyaline, slightly infuscate near base of marginal vein. Clava 3-segmented. Pedicel slightly longer than F1 (1.05–1.21). F1 shorter than or subequal to F2 (0.79–1.00) and shorter than F3 (0.75–0.95, fig. 15). Mid lobe of mesoscutum with 8 setae, arranged symmetrically. Scutellar sensilla close together, separated by a distance of about their width or less. Distance between anterior pair of scutellar setae distinctly smaller than between posterior pair. Fore wing 2.6–2.9 times as long as wide. Marginal fringe 0.35–0.42 times as long as wing width. Tarsus of middle leg 5-segmented. Apical spur of middle tibia longer than half the length of the basal tarsal segment (0.60–0.68) (fig. 16). Ovipositor 1.17–1.27 times the length of the middle tibia. Third valvula 0.32–0.36 times as long as second valvifer.

Male. Colour pattern similar to female but darker. Head with a transverse brown band. Apical two segments of flagellum fused.

Species-group placement. *Encarsia strenua*-group.

Distribution. Australia: Northern Territory, Queensland, Victoria. India, Philippines, Thailand, Indonesia, Papua New Guinea. USA (Florida, Texas?). Possibly Sudan, Israel and Mexico (possibly culture contaminations (Heraty & Polaszek, 2000)).

Hosts. *Bemisia tabaci*, *T. vaporariorum*.

Material examined. NORTHERN TERRITORY: Darwin, 6♀, 1♂, 27.ix.1996 (P. De Barro) ex *B. tabaci*. Darwin, 4♀, 25.x.1995 (P. De Barro) ex *B. tabaci* on poinsettia (Euphorbiaceae). QUEENSLAND: Cairns, 1♀, 30.ix.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Cairns, 1♀, April 1999 (P. Garland). Mt Isa, 1♀, 3.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Townsville, 1♀, 18.iii.1997 (B.A. Franzmann) ex *B. tabaci* on *Emilia sonchifolia* (Asteraceae). Townsville, 1♀, 4.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus* sp. (Malvaceae). Ayr, 2♀, March 1997 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Bundaberg, 2♀, ex *B. tabaci* on *Euphorbia cyathophora* (Euphorbiaceae) to laboratory culture. Mt Isa, 4♀, 3.x.1996 (P.

De Barro) ex *B. tabaci* on *Sonchus oleraceus*. VICTORIA: Red Cliffs, 1♀, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. INDONESIA: West Java, Karawang, 1♀, 14.ix.1999 (A. Rauf) ex *B. tabaci* on *Glycine max* (Fabaceae). PAPUA NEW GUINEA: Port Moresby, 1♀, 1♂, 27.iv.1997 (P. De Barro) ex *B. tabaci* on *Euphorbia heterophylla* (Euphorbiaceae).

Comments. *Encarsia bimaculata* has a distinctive colour pattern that is unique among the species of the *E. strenua* complex, in particular the dark mesosomal colour pattern, although this is occasionally very faint. The other species of the *E. strenua*-group present in Australia are almost completely yellow (*E. protransvena* Viggiani, *E. oakeyensis* **sp. n.**, *E. sophia* (Girault & Dodd)) or predominantly brown (*E. ustulata* **sp. n.**). Specimens from Bundaberg, Queensland, have a higher efficiency as control agents. They also differ genetically slightly from other populations of that species: sequence divergence (number of pairwise differences divided by the number of shared nucleotides) of the 28S D2 ribosomal DNA gene region between the Bundaberg population and other populations is 0.5%. This amount of sequence divergence is within the range of intraspecific variation found among allopatric populations of the same species (Babcock & Heraty, 2000; Babcock *et al*., 2001).

Encarsia cibcensis Lopez-Avila
(figs 17–20)

Encarsia cibcensis Lopez-Avila, 1987: 427. Holotype ♀ [ex culture UK, Ascot, Silwood Park] *B. tabaci* on beans, 26.viii.1986 (A. Lopez-Avila), origin: Pakistan, Rawalpindi, ex *B. tabaci* on *Lantana camara*, iv.1985 (A.I. Mohyuddin), (BMNH, examined).
Encarsia cibcensis: Polaszek *et al*., 1992: 381; Huang & Polaszek, 1998: 1856.

Diagnosis. Female. Head and body yellow (fig. 17), apical segments of antenna slightly darker. Fore wing hyaline with slightly darkened area near base of marginal vein and with sparse setation and poorly defined, bare area adjacent to leading edge (fig. 18). Clava 2-segmented and not very distinctly defined. Pedicel longer than F1 (1.43–1.48). F1 distinctly shorter than F2 (0.77–0.78) and F3 (0.59–0.61) (fig. 19). Mid lobe of mesoscutum with 4(–7) setae. Scutellar sensilla widely separated (approximately 4 times the width of a sensillum). Distance between anterior pair of scutellar setae smaller than between posterior pair. Fore wing 2.9–3.0 times as long as wide. Marginal fringe 0.60–0.61 times as long as wing width (fig. 18). Tarsus of middle leg 5-segmented. Apical spur of middle tibia subequal to half the length of the basal tarsal segment (0.56) (fig. 20). Ovipositor 1.25–1.32 times the length of the middle tibia. Third valvula 0.37–0.44 times as long as second valvifer.

Species-group placement. *Encarsia cibcensis* was erroneously placed in the *lutea*-group by Lopez-Avila (Polaszek *et al*., 1992) and later transferred to the *E. perflava* Hayat-group by Hayat (1989).

Distribution. Pacific Islands: Nauru, Cook Islands. India, Pakistan, Taiwan.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Huang & Polaszek. 1998): *Aleurotrachelus caerulescens* Singh, *Aleurotuberculatus ficicola* Takahashi, *Dialeurodes agalmae* Takahashi, *Pealius mori* (Takahashi), *Singhius hibisci* (Kotinsky), *Taiwanaleyrodes meliosmae* Takahashi.

Material examined. PACIFIC ISLANDS: Raratonga, Cook Islands, 2♀, 20.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Nauru, 1♀, 26.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus esculentus*.

Comments. *Encarsia cibcensis* is characterized by the distinct bare area near the leading edge of the fore wing distally from the stigmal vein and continuing along the margin towards the hind margin (fig. 18). *Encarsia cibcensis* was obtained from the Punjab, India, and released in Kiribati in 1990. It established and was subsequently recovered in 1992 (Sandhu, 1994). Whether it was effective is unknown.

Encarsia formosa Gahan
(figs 21–24)

Encarsia formosa Gahan, 1924: 14. Syntypes ♀. USA, Idaho, Twin Falls (USNM, not examined).
Encarsia formosa: Ferrière, 1965: 137; Nikol'skaya & Yasnosh, 1966: 266; Viggiani & Mazzone, 1979: 45; Huldén, 1986: 18; Rivnay & Gerling, 1987: 465; Viggiani, 1987b: 144; Liao *et al*., 1987: 151; Jiang & Petzold, 1988: 494; Yasnosh, 1989: 110; Polaszek *et al*., 1992: 382; Viggiani & Ren, 1993: 226; Liu & Stansly, 1996: 386; Huang & Polaszek, 1998: 1881; Polaszek *et al*., 1999: 146.

Diagnosis. Female. Head and mesosoma brown, contrasting with yellow remainder of body (fig. 21). Metasoma yellow except brown at base. Antenna yellow, petiole and antennal tip slightly darker. Legs yellow, coxae more or less brown at base. Wings hyaline. Clava 2-segmented. Pedicel longer than F1 (1.09–1.32). F1 distinctly shorter than F2 (0.69–0.86) and F3 (0.66–0.83) (fig. 23), F2 and F3 subequal in length or F2 slightly shorter than F3. Mid lobe of mesoscutum with 18–20 setae. Scutellar sensilla widely separated (approximately 7 times the width of a sensillum). Distance between anterior pair of scutellar setae subequal to distance between posterior pair. Fore wing about 2.4 times as long as wide. Marginal fringe 0.25–0.33 times as long as wing width (fig. 22). Tarsus of middle leg 4-segmented, apical spur shorter than half the length of the basal tarsal segment (0.30–0.40) (fig. 24). Ovipositor 0.88–1.00 times the length of the middle tibia. Third valvula 0.41–0.66 times as long as second valvifer.

Male. Body predominantly brown, legs lighter. Lower half of head, vertex partly and ocellar area brown.

Species-group placement. *Encarsia luteola*-group.

Distribution. Australia: Western Australia, Queensland, New South Wales, South Australia, Victoria. Pacific Islands: Tonga, Fiji, French Polynesia. Cosmopolitan.

Hosts. *Bemisia tabaci*, *T. vaporariorum*. The following additional hosts have been recorded (Huang & Polaszek, 1998): *Aleuroglandulus malangae* Russell, *Aleurotrachelus trachoides* (Back), *Aleyrodes lonicerae* Walker, *A. proletella* (Linnaeus), *A. spiraeoides* Quaintance, *Dialeurodes chittendeni* Laing, *D. citri* (Ashmead).

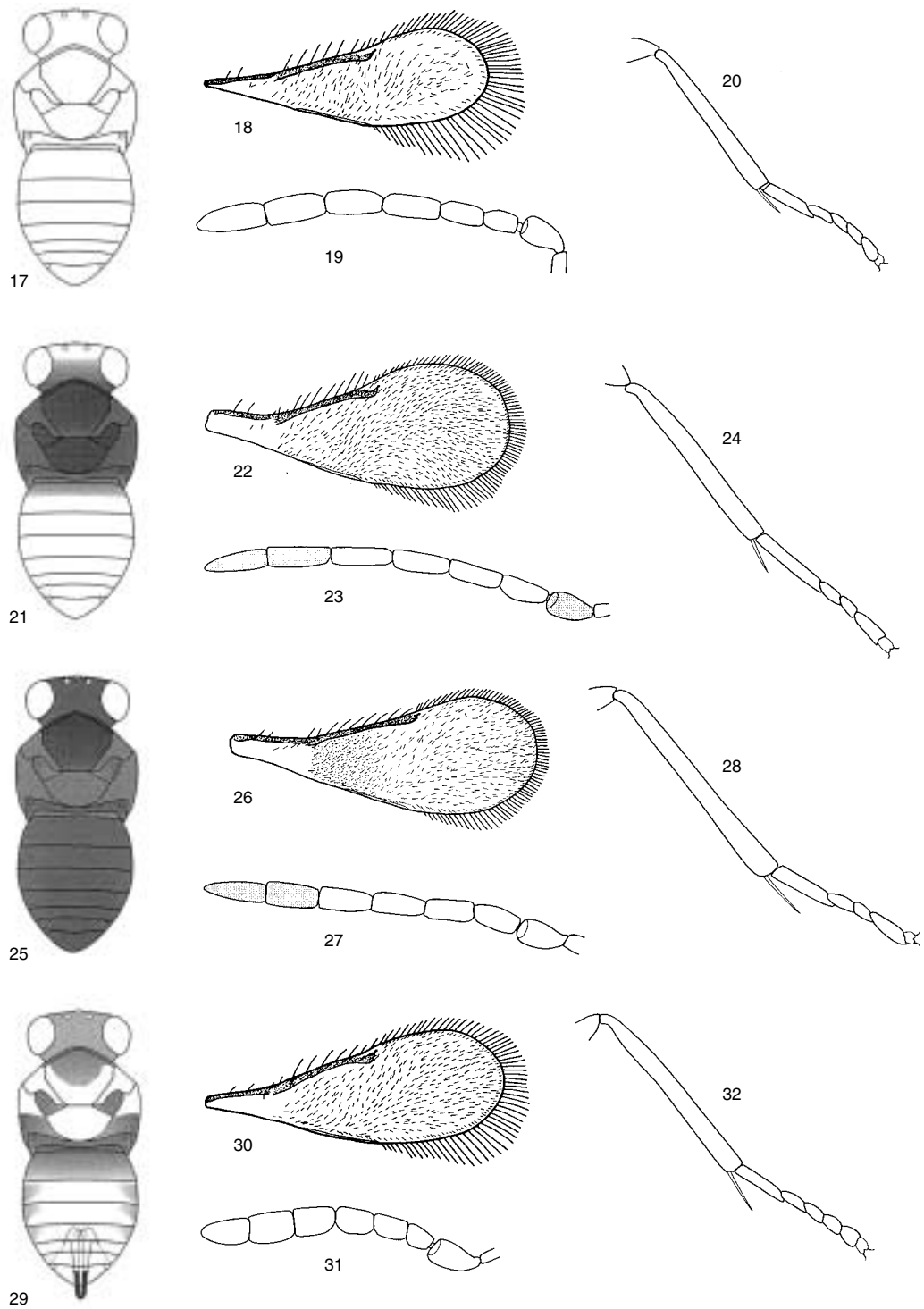
Material examined. NEW SOUTH WALES: Griffith, 1♀, 8.i.1997 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. Lake Tandou, 1♀, 6.i.1997 (P. De Barro) ex *T. vaporariorum* on *Xanthium occidentale* (Asteraceae). QUEENSLAND: Warra, 1♀ 25.vi.1997 (P. De Barro) ex *T. vaporariorum* on *Verbena bonariensis* (Verbenaceae). Dalby, 1♀, 3.v.1997 (P. De Barro) ex *B. tabaci* on *Gossypium hirsutum*. Dalby, 1♀, 17.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Sonchus oleraceus*. Oakey, 2♀, 3.iv.1997 (B.A. Franzmann) ex *B. tabaci* on *Sonchus oleraceus* and *Amaranthus spinosus* (Chenopodiaceae). Oakey, 1♀, 20.iii.1997 (B.A. Franzmann) ex *T. vaporariorum* on *Anoda cristata* (Malvaceae). Oakey, 2♀, 13.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Verbena bonariensis* and *Sonchus oleraceus*. Oakey, 4♀, 29.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Sonchus oleraceus*, *Malvastrum coromandelium* (Malvaceae), *Urtica* sp. (Urticaceae) and *Datura* sp. (Solanaceae) Oakey, 1♀, 1♂, 29.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Verbena bonariensis*. Oakey, 3♀, 25.vi.1997 (D.R. Lea) ex *T. vaporariorum* on *Sonchus oleraceus*, *Verbena bonariensis*, and *Urtica* sp. Highfields, 1♀, 1♂, 10.iii.1996 (B.A. Franzmann) ex *T. vaporariorum* on *Verbena* sp. SOUTH AUSTRALIA: McLaren Vale, 1♀, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on *Euphorbia peplus* (Euphorbiaceae). Cavan, 3♀, 1♂, 2.i.1997 (P. De Barro), ex *T. vaporariorum* on *Sonchus oleraceus*. VICTORIA: Red Cliffs, 1♀, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. Red Cliffs, 2♀, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on *Euphorbia peplus*. WESTERN AUSTRALIA: Wanneroo, Boogards Nursery, 3♀, 1♂, 1.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus* sp. PACIFIC ISLANDS: Tonga, Vaini Research Station, 1♀, 27.v.1997 (W. Liebregts) ex *T. vaporariorum* on *Emilia sonchifolia*. Fiji, Sigatoka Valley, 1♀, 1.xi.1996 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. Fiji, Nausori, 2♀, 31.x.1996 (P. De Barro) ex *T. vaporariorum* on *Cuphea carthaginensis* and *Lycopersicon esculentum* (Solanaceae).

Comments. *Encarsia formosa* was released into Australia between 1934 and 1936 as a biological control agent of the greenhouse whitefly, *T. vaporariorum* (Wilson, 1960).

Encarsia guadeloupae Viggiani
(figs 25–28)

Encarsia guadeloupae Viggiani, 1988 (1987a): 36–37. Holotype ♀, Guadeloupe (Wonche), 12.vi.1985 (J. Etienne), ex *Aleyrodes* sp. on *Persea americana*, (UNLP, not examined).
Encarsia guadeloupae: Viggiani, 1993: 123.

Diagnosis. Female. Head and body mostly brown (fig. 25). Antenna yellow, radicle and scape (except at apex) brownish. Fore wing hyaline with slightly infuscate band behind basal half of marginal vein. Legs yellow except hind coxa and femur brown. Clava 3-segmented. Pedicel slightly longer than F1 (1.07–1.19). F1 slightly shorter than F2 (0.84–0.94) and F3 (0.75–0.88) (fig. 27). F2 and F3 subequal in length. Mid lobe of mesoscutum with 16–20 setae. Scutellar sensilla widely separated (approximately 6 times the width of a sensillum). Distance between



Figs 17–32. Habitus, antenna, fore wing, and middle leg of *Encarsia cibcensis* (17–20), *E. formosa* (21–24), *E. guadeloupae* (25–28), *E. lutea* (29–32). Note that habitus drawings illustrate colour patterns and may not reflect exact body proportions.

anterior pair of scutellar setae subequal to distance between posterior pair. Fore wing 2.4–2.6 times as long as wide. Marginal fringe relatively short and only 0.19–0.22 times as long as wing width (fig. 26). Tarsus of middle leg 4-segmented. Apical spur of middle tibia longer than half the length of the basal tarsal segment (0.66–0.71) (fig. 28). Ovipositor 1.00–1.09 times the length of the middle tibia. Third valvula 0.61–0.65 times as long as second valvifer.

Species-group placement. Correctly placed in *E. luteola*-group by Viggiani (1993).

Distribution. Pacific Islands: Nauru, French Polynesia. Micronesia. Papua New Guinea, Guadeloupe, Thailand.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Viggiani, 1993): *Aleurodicus dispersus* Russell, *T. vaporariorum*.

Material examined. PACIFIC ISLANDS: Micronesia, Pohnpei, 1♀, 19.xi.1996 (W. Liebregts) ex *B. tabaci* on *Manihot utilissima* (Euphorbiaceae). Micronesia, Palau, Koror, 2♀, 3.xii.1996 (W. Liebregts) ex whitefly nymphs on *Solanum melongena* (Solanaceae). Nauru, 1♀, 26.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus esculentus*. French Polynesia, Taravao, 3♀, 16.x.1996 (P. De Barro) ex *Aleurodicus dispersus* on *Euphorbia pulcherrima*. PAPUA NEW GUINEA: Port Moresby, 1♀, 27.iv.1997 (P. De Barro), ex *B. tabaci* on *Euphorbia heterophylla*.

Comments: *Encarsia guadeloupae* is the only predominantly dark brown coloured species treated here with 4-segmented tarsi of the middle legs. It also has an infuscate band behind the marginal vein.

Encarsia hispida De Santis
(figs 37–40)

Encarsia hispida De Santis, 1948: 45. Holotype ♀, Brazil, Rosario, Santa Fe, ex aleyrodid on *Salvia splendens* (Polaszek *et al*., 1992: 383) (UNLP, not examined).
Encarsia hispida: Viggiani, 1989: 207, as synonym of *Encarsia meritoria* Gahan, 1927: 19. Holotype female, USA, Florida, Miami, ex *Trialeurodes floridensis* (Quaintance) (USNM, not examined).

Diagnosis. Female. Head and body yellow except pronotum and mesoscutum anteromedially light brown and axillae largely brown (fig. 37). Legs yellow. Antenna yellow, apical segments slightly darkened. Wings hyaline. Clava 2-segmented, not very distinctly defined. Pedicel longer than F1 (1.29). F1 shorter than F2 (0.87) and distinctly shorter than F3 (0.68) (fig. 39). Mid lobe of mesoscutum with 14 setae. Scutellar sensilla widely separated (approximately 6 times the width of a sensillum). Distance between anterior pair of scutellar setae subequal to distance between posterior pair. Fore wing about 2.6 times as long as wide. Marginal fringe 0.19–0.30 times as long as wing width (fig. 38). Tarsus of middle leg 4-segmented. Apical spur of middle tibia distinctly longer than half the length of the basal tarsal segment (0.79) (fig. 40). Ovipositor 1.09 times the length of the middle tibia. Third valvula 0.67 times as long as second valvifer.

Species-group placement. Correctly placed in *E. luteola*-group by Polaszek *et al*. (1992).

Distribution. Pacific Islands: French Polynesia. Brazil, Chile, Colombia, Dominican Republic, Guadeloupe, Honduras, Jamaica, Mexico, Puerto Rico and Vieques Island, Venezuela, ?Spain, ?Italy.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Polaszek *et al*., 1992): *Aleuroglandulus malangae*, *Aleurothrixus porteri* Quaintance, ?*Siphoninus phillyreae* (Haliday), ?*T. vaporariorum*.

Material examined. PACIFIC ISLANDS: French Polynesia, Taravao, 1♀, 16.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*.

Comments. *Encarsia hispida* is the only predominantly yellow coloured species treated here with 4-segmented tarsi of the middle legs. The other species with 4-segmented tarsi have either a dark brown mesosoma (*E. formosa*, *E. luteola* and *E. guadeloupae*) or the fore wing has a bare area near the leading edge (*E. nigricephala* Dozier, fig. 38). *Encarsia hispida* is similar to *E. meritoria* and is regarded as a synonym of the latter by some authors (Viggiani, 1989; Schauff *et al*., 1996). However, according to Polaszek *et al*. (1992) they are distinct species which can be separated by the following characters: in *E. hispida* the second flagellar segment (F2) of the female is smaller than the third one (F3) and intermediate in size between F1 and F3, whereas in *E. meritoria* F2 and F3 are equal in length. In male *hispida* F5 and F6 are separate, whereas in *E. meritoria* they are fused. Molecular evidence supports the view that *E. hispida* and *E. meritoria* are distinct species (Babcock *et al*., 2001).

Encarsia lutea (Masi)
(figs 29–32)

Prospaltella lutea Masi, 1909: 25. Syntypes ♀, Italy, Campania, Portici (IEUN, not examined).
Encarsia lutea: Ferrière, 1965: 132; Viggiani & Mazzone, 1979: 46; 1980: 51, Hayat, 1981: 466; 1986: 162; 1989: 48–50; Viggiani, 1987b: 155–156; Ren, 1988: 396; Polaszek *et al*., 1992: 384; 1999: 154–56; Viggiani & Ren, 1993: 223; Schauff *et al*., 1996: 21; Huang & Polaszek, 1998: 1912–1914.

Diagnosis. Female. Mesosoma yellow except pronotum, anteromedian patch on mesoscutum, axillae and propodeum largely brown and ovipositor dark brown at apex (fig. 29). Metasoma yellow except brown at base and laterally more or less darkened. Pedicel distinctly longer than and up to twice as long as F1 (1.53–2.05). Antenna relatively stout, F1 almost quadrate and shorter than F2 (0.65–0.86) and F3 (0.68–0.86) (fig. 31). Clava 3-segmented. Mid lobe of mesoscutum with (4–)6–8 setae. Scutellar sensilla widely separated, approximately 9 times the width of a sensillum. Distance between anterior pair of scutellar setae larger than distance between posterior pair. Fore wing 2.6–2.8 times as long as wide. Marginal fringe 0.37–0.47 times as long as wing width (fig. 30). Tarsus of middle tibia 5-segmented. Apical spur of middle tibia distinctly longer than half the length of the basal tarsal segment (0.73–0.87) (fig. 32). Ovipositor 0.80–0.84 times the length of the middle tibia and 0.92–1.25 times as long as clava. Third valvula 0.34–0.38 times as long as second valvifer.

Male. Body dark brown, mesoscutellar midlobe posteriorly, scutellum and legs lighter. Head brown except on top with pale areas. Antenna yellow, basal two flagellar segments with distinct sensorial complex, apical two segments fused.

Species-group placement. Placed in *E. lutea*-group by Hayat (1989).

Distribution. Australia: Queensland, Western Australia. Pacific Islands: Cook Islands, Nauru, Niue, Tonga. China, India, Pakistan, Italy, Russia.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Viggiani, 1987b; Ren, 1988; Hayat, 1989; Yasnosh, 1989; Chou *et al*., 1996; Huang & Polaszek, 1998): *Acaulaleyrodes citri* (Priesner & Hosny), *Aleurocanthus cinnamoni* Takahashi, *A. zizyphi* Priesner & Hosny, *Aleurolobus marlatti* (Quaintance), *A. niloticus* Priesner & Hosny, *A. rhododendri*, *A. setigerus* Quaintance & Baker, *A. wunni* (Ryberg), *Aleuroplatus pectiniferus* Quaintance & Baker, *Aleurotrachelus jelinekii* (Frauenfeld), *A. rubi* (Takahashi), *Aleurotuberculatus acubae* (Kuwana), *A. ficicola*, *A. gordoniae* Takahashi, *A. jasmini* Takahashi, *A. malloti* Takahashi, *A. mellastomae* Takahashi, *A. psidii* (Singh), *Aleyrodes lonicerae*, *A. proletella*, *Asterobemisia carpini* (Koch), *A. atraphaxinus* (Danzig), *Bemisia ovata* (Goux), *B. porteri* Corbett, *B. salicaria* Danzig, *Bulgarialeurodes cotesii* (Maskell), *Dialeurodes citri*, *D. formosoanensis* Takahashi, *D. kirkaldyi* (Kotinsky), *Pealius mori*, *P. setosus* Danzig, *Singhius hibisci*, *Siphoninus phillyreae* , *Taiwanaleyrodes meliosmae* , *Tetralicia* sp., *Trialeurodes abutiloneus* (Haldeman), *T. vaporariorum*.

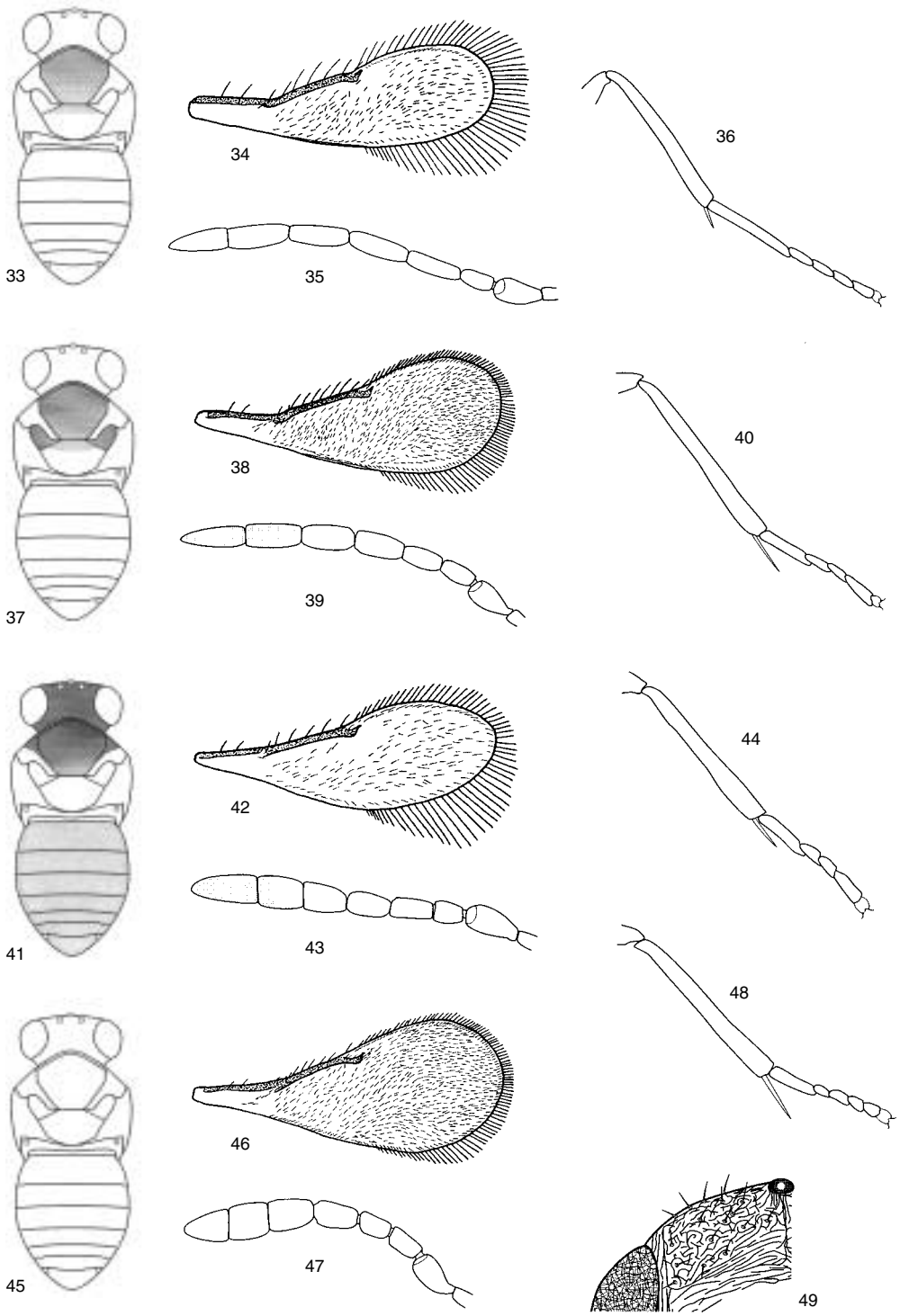
Material examined. QUEENSLAND: Ayr, 1♀, 13.ix.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Dalby, 1♀, 3.iv.1997 (B.A. Franzmann) ex *B. tabaci* on *Gossypium hirsutum*. WESTERN AUSTRALIA: Wanneroo, 2♀, 1.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus* sp. PACIFIC ISLANDS: Nauru, 3♀, 26.x.1996 (P. De Barro) ex *B. tabaci* on *Crotalaria* sp. (Fabaceae), *Phyllanthus amarus* (Euphorbiaceae) and *Cleome viscosa* (Capparidaceae). Cook Islands Raratonga, 1♀, 1♂, 20.x.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Cook Islands, Raratonga, 1♀, 21.x.1996 (P. De Barro) ex *B. tabaci* on *Euphorbia cyathophora*. Niue, Tama Kantonga, 1♀, 28.v.1997 (W. Liebregts) ex *B. tabaci* on *Euphorbia glomifera* (Euphorbiaceae). Tonga, Vaololoa, 1♀, 1.vi.1997 (W. Liebregts) ex *B. tabaci* on *Emilia* sp.

Comments. Although morphologically rather uniform in the Australian and Pacific regions, *E. lutea* exhibits large colour variation in other regions (Viggiani & Ren, 1993; Huang & Polaszek, 1998) and this species-group is currently being studied (A. Polaszek, personal communication). *Encarsia lutea* populations from Australia and the Pacific Islands differ from each other by a single point mutation in the D2 expansion region of the 28S ribosomal DNA gene region (Babcock *et al*., 2001).

Encarsia mineoi Viggiani
(figs 33–36)

Encarsia mineoi Viggiani, 1982: 27. Holotype ♀, Libya, Sidi Mesri, 10.vi.1969 (G. Mineo) ex *B. tabaci*. (IEUN, not examined); Polaszek *et al*., 1992: 386; 1999: 156.

Diagnosis. Female. Head and body yellow except clypeus margin brownish, pronotum and mid lobe of mesoscutum anteriorly slightly



Figs 33–49. Habitus, antenna, fore wing, and middle leg of *Encarsia mineoi* (33–36), *E. hispida* (37–40), *E. nigricephala* (41–44), *E. oakeyensis* (45–48). fig. 49: Vertex of *E. oakeyensis*. Note that habitus drawings illustrate colour patterns and may not reflect exact body proportions.

darker (fig. 33). Antenna yellow. Fore wing with bare area near leading edge (fig. 34). Clava 2-segmented. Pedicel longer than F1 (1.45). F1 shorter than F2 (0.61) and F3 (0.55) (fig. 35). Mid lobe of mesoscutum with 4 setae. Scutellar sensilla widely separated (approximately 5–6 times the width of a sensillum). Distance between anterior pair of scutellar setae larger than between posterior pair. Fore wing about 3.2 times as long as wide. Marginal fringe about 0.6 times as long as wing width. Tarsus of middle leg 5-segmented. Apical spur of middle tibia very short and its length distinctly less than half the length of the very slender basal tarsal segment (0.27) (fig. 36). Ovipositor shorter than middle tibia (0.88). Third valvula about 0.57 times as long as second valvifer.

Species-group placement. Placed in *E. parvella*-group *sensu* Hayat, 1989, 1998 (= *parvella* + *pergandiella*-groups *sensu* Viggiani & Mazzone, 1979; = *Aleurodiphilus* DeBach & Rose, 1981).

Distribution. Australia: Queensland. Egypt, Israel, Libya, Spain, Sudan.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Polaszek *et al*., 1999): *Acaulaleyrodes citri*, *Siphoninus phillyreae*. Males probably hyperparasitoids of *T. vaporariorum*.

Material examined. QUEENSLAND: Redland Bay, 1♀, Dec. 1998 (J.R. Hargreaves) ex *B. tabaci* on *Lantana camara*.

Comments. *Encarsia mineoi* is morphologically very similar to *E. acaulaleyrodes* Hayat and perhaps these species are conspecific (Polaszek *et al*., 1999). The most reliable difference is the ovipositor length, which is, in *E. mineoi*, shorter than, or up to 1.1 times the length of the middle tibia, and in *E. acaulaleyrodes* 1.2 times as long as the middle tibia (Polaszek *et al*., 1999). The species has been recorded so far only from southern Europe and the Middle East and the record from Australia indicates a recent introduction into the country.

Encarsia nigricephala Dozier
(figs 41–44)

Encarsia nigricephala Dozier, 1937: 129. Holotype ♀, Puerto Rico, Mayaguez, 12.ii.1936 (H.L. Dozier), ex *Bemisia euphorbiae (?tabaci)* on low backyard plant (USNM, type no 51607, not examined).
Encarsia nigricephala: Polaszek *et al*., 1992: 386.

Diagnosis. Female. Mostly yellow, head, pronotum and mesoscutal midlobe (except posteriorly) dark brown (fig. 41). Remainder of mesosoma yellow, metasoma slightly darkened. Fore wing hyaline with bare area near leading edge (fig. 42). Antenna yellow, apical segments darkened. Clava 3-segmented. Pedicel distinctly longer than F1 (1.64–1.92). F1 shorter than F2 (0.63–0.82) and F3 (0.70–0.78) (fig. 43). Mid lobe of mesoscutum with 4 setae. Scutellar sensilla widely separated (approximately 6 times the width of a sensillum). Distance between anterior pair of scutellar setae larger than between posterior pair. Fore wing 2.8–2.9 times as long as wide. Marginal fringe 0.49–0.57 times as long as wing width (fig. 42). Tarsus of middle leg 4-segmented. Apical spur of middle tibia slightly longer than half the length of the basal tarsal segment (0.63–0.65) (fig. 44). Ovipositor slightly shorter than or equal to middle tibia (0.85–1.00) and 1.03–1.07 times the length of the clava. Third valvula 0.67–0.68 times as long as second valvifer.

Species-group placement. Placed in *E. cubensis*-group by Polaszek *et al*. (1992).

Distribution. Pacific Islands: French Polynesia, Nauru, Mariana Islands. USA: Florida. Mexico, Brazil, Barbados, Colombia, Guadeloupe, Grenada, Guatemala, Honduras, Jamaica, Puerto Rico and Vieques Island, Réunion, Venezuela.

Hosts. *Bemisia tabaci*. The following additional hosts have been recorded (Polaszek *et al*., 1999; Schauff *et al*., 1996): *Trialeurodes abutiloneus*, *T. floridensis* (Quaintance), *T. vaporariorum*.

Material examined. PACIFIC ISLANDS: Nauru, 2♀, 26.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus esculentus*. French Polynesia, Punaaula, 2♀, 16.x.1996 (P. De Barro) ex *B. tabaci* on *Lycopersicon esculentum* + *Euphorbia hirta*. French Polynesia, Paea, Orofero Valley, 4♀, 16.x.1996 (P. De Barro) ex *B. tabaci* on *Lycopersicon esculentum* + *Euphorbia hirta*. French Polynesia, Paea, Orofero Valley, 3♀, 16.x.1996 (P. De Barro) ex *B. tabaci* on *Cucumis sativus* (Cucurbitaceae). French Polynesia, Papara, Taharun Valley, 1♀, 16.x.1996 (P. De Barro) ex *T. vaporariorum* on *Lantana camara*. Micronesia, Pohnpei, 1♀, 19.xi.1999 (W. Liebregts) ex *B. tabaci* on *Colocasia esculenta* (Araceae). Northern Mariana Islands, Saipan, 1♀, 7.vii.1997 (A. Moore) ex *B. ?tabaci* on cucumber.

Comments. The dark brown head and mesoscutum in combination with the bare area of the fore wing characterize this species and make it distinguishable from the other *Encarsia* species treated here.

Encarsia oakeyensis Schmidt & Naumann sp. n.
(figs 45–49)

Description. Female. Colour. Head and body yellow except pronotum slightly darkened. Antenna and legs yellow. Fore wing hyaline. Vertex with densely rugose surface sculpture (fig. 49). Clava 3-segmented. Pedicel longer than F1 (1.25–1.41). F1 about twice as long as wide (2.00–2.12), subequal in length to F2 (0.94–1.07) and slightly shorter than F3 (0.81–0.89) (fig. 47). Flagellomers with the following numbers of sensilla: F1:0, F2:0–1, F3:1, F4:2–3, F5:2–3, F6:2. Mid lobe of mesoscutum with 13–14 setae arranged symmetrically, side lobes with 3 setae each. Scutellar sensilla close together, separated by a distance of about the width of a sensillum. Distance between anterior pair of scutellar setae smaller than between posterior pair. Fore wing 2.2–2.3 times as long as wide. Marginal fringe very short and only 0.16–0.20 times as long as wing width (fig. 46). Marginal vein anteriorly with 8–9 setae. Tarsus of middle leg 5-segmented. Apical spur of middle tibia subequal in length to basal tarsal segment (0.93–1.04) (fig. 48). Tergites laterally with the following numbers of setae: T2:0, T3:1, T4:1, T5:1, T6:2–3, T7:3. T8 with 4 setae. Tergite 7 with 4 setae between cercal plates. Ovipositor 1.16–1.24 times the length of the middle tibia and 2.11–2.12 times as long as clava. Third valvula 0.25–0.28 times as long as the ovipositor.

Species-group placement. *Encarsia strenua*-group.

Distribution. Australia: Queensland.

Hosts. *Bemisia tabaci*, *T. vaporariorum*.

Material examined. Holotype ♀, QUEENSLAND, Oakey, 25.vi.1997 (D.R. Lea) ex *T. vaporariorum* on *Lactuca serriola*. Paratypes: 1♀, 1♂, QUEENSLAND, Dalby, 17.iv.1997 (D.R. Lea) ex *B. tabaci* on *Sonchus oleraceus* (ANIC).

Comments. This species is distinguished from other yellow species of the *E. strenua*-group by the stout antennae, the short marginal fringe of the fore wing and the densely rugose surface sculpture of the vertex.

Encarsia pergandiella Howard
(figs 50–53)

Encarsia pergandiella Howard, 1907: 78. Holotype ♀, USA, Washington, D.C., 25.ix.1900 (T. Pergande), ex *'Aleyrodes'* [probably *Trialeurodes* sp.] on *Xanthium strumarium* (USNM, not examined).
Encarsia versicolor Girault, 1908: 53. Synonymy by Gahan (in Peck 1951): 438.
Aleurodiphilus pergandiellus (Howard): DeBach & Rose, 1981: 666.
Encarsia bemisiae De Santis, 1981: 37. Preoccupied by *bemisiae* Ishii 1938. Holotype ♀, Brazil, Sao Paolo, Campinas, *B. tabaci* (Lourençao), (UNLP, not examined). Synonymy by Polaszek *et al*., 1992: 387.
Encarsia tabacivora Viggiani, 1985a: 82. Replacement name for *bemisiae* De Santis. Synonymy by Polaszek *et al*., 1992: 387.

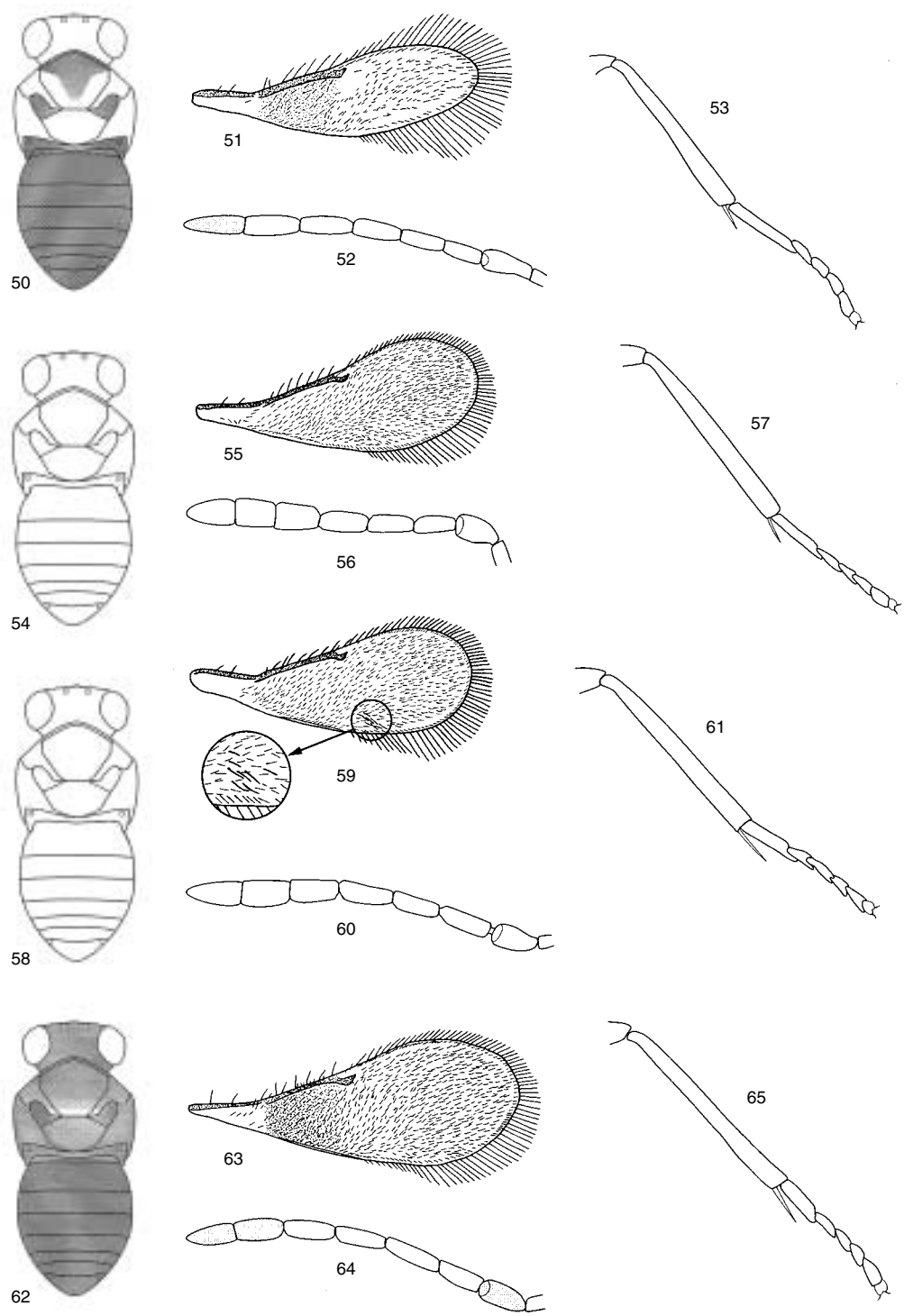
Diagnosis. Female. Head and mesosoma predominantly pale with pronotum, mesoscutellar midlobe and axillae largely brown (fig. 50). Antenna yellow, apex slightly darkened. Metasoma largely brown. Fore wing with infuscate band behind marginal vein and with bare area near leading edge (fig. 51). Antenna slender with 2-segmented clava (fig. 52). Pedicel longer than F1 (1.27–1.36). F1 subequal to or slightly shorter than F2 (0.90–1.00) and slightly shorter than F3 (0.77–0.85) (fig. 52). Scutellar sensilla widely separated (approximately 6 times the width of a sensillum). Distance between anterior pair of scutellar setae subequal to distance between posterior pair. Fore wing 3.4–3.6 times as long as wide. Marginal fringe of fore wing 0.68–0.75 times as long as wing width (fig. 51). Tarsus of middle leg 5-segmented. Apical spur of middle tibia shorter than half the length of the relatively long and slender basal tarsal segment (0.37–0.41) (fig. 53). Ovipositor almost as long as the length of the middle tibia (0.84–0.91). Third valvula 0.54–0.70 times as long as second valvifer.

Male. Head and body predominantly brown, mid lobe of mesoscutum, scutellum and legs lighter.

Species-group placement. Placed in *E. pergandiella*-group by Viggiani & Mazzone (1979) and Viggiani (1993), and in *E. parvella*-group by Hayat (1989, 1998) and Polaszek *et al*. (1992), which these authors consider encompasses the *E. pergandiella*-group.

Distribution. Australia: Queensland, South Australia, Victoria. USA, Mexico, Brazil, Colombia, Costa Rica, El Salvador, Grenada, Guadeloupe, Guatemala, Honduras, Mexico, Venezuela, Israel, Italy.

Hosts. *Bemisia tabaci*, *T. vaporariorum*. The following additional hosts have been recorded (Polaszek *et al*., 1992; Schauff *et al*., 1996): *Aleyrodes* sp.,



Figs 50–65. Habitus, antenna, fore wing, and middle leg of *Encarsia pergandiella* (50–53), *E. protransvena* (54–57), *E. sophia* (58–61), *E. ustulata* (62–65). Note that habitus drawings illustrate colour patterns and may not reflect exact body proportions.

Aleurodicus dispersus, *Aleuroglandulus malangae*, *Aleuroplatus coronata* (Back), *A. elemerae* Mound & Halsey, *Aleurothrixus floccosus* (Maskell), *Aleurotrachelus trachoides* (Quaintance), *Dialeurodes citri*, *D. kirkaldyi*, *Trialeurodes abutiloneus*, *T. floridensis*, *T. variabilis* (Quaintance).

Material examined. NEW SOUTH WALES: Griffith, 1♀, 8.i.1997 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. QUEENSLAND: Darling Downs, 2♀, 2♂, 1997 (D.R. Lea) ex *T. vaporariorum* on *Lactuca serriola* (Asteraceae). Dalby, 2♀, 7.+29.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Verbena bonariensis*. Dalby, 1♀, 24.vii.1997 (D.R. Lea) ex *T. vaporariorum* on *Verbena bonariensis*. Dalby, 1♀, 25.vi.1997 (D.R. Lea) ex *T. vaporariorum* on *Lantana* sp. Oakey, 1♀, 3.iv.1997 (B. Franzmann) ex *B. tabaci* on *Sonchus oleraceus*. Oakey, 1♀, 3♂, 25.vi.1997 (D.R. Lea) ex *B. tabaci* on *Sonchus oleraceus* and *T. vaporariorum* on *Sonchus oleraceus* and *Verbena bonariensis* and *Urtica* sp. Oakey, 1♀, 13.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Xanthium occidentale*. Oakey, 1♀, 24.vii.1997 (D.R. Lea) ex *T. vaporariorum* on *Urtica*. Oakey, 3♀, 29.v.1997 (D.R. Lea) ex *T. vaporariorum* on *Sonchus oleraceus*, *Xanthium occidentale*, and sunflower. SOUTH AUSTRALIA: 5♀, 2♂, McLaren Vale, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on holly-hock, *Euphorbia peplus*, *Salvia* sp., *Lycopersicon esculentum*, *Sonchus oleraceus*. 2♀, McLaren Vale, 2.i.1997 (P. De Barro) ex *T. vaporariorum* on *Hibiscus* sp. VICTORIA: 2♀, 1♂, Red Cliffs, 2.i.1999 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus* and *Euphorbia peplus*.

Comments. This species has, similar to *E. mineoi*, 5-segmented tarsi of the middle legs and a bare area near the leading edge of the fore wing, but unlike in *E. mineoi*, the metasoma is completely dark brown.

Encarsia protransvena Viggiani
(figs 54–57)

Encarsia protransvena Viggiani, 1985a: 89. Holotype female, USA, Florida, Broward C[ounty]. F[or]t. Lauderdale, ix.1984 (C.R.R. Thompson) ex *Dialeurodes kirkaldyi* (IEUN, not examined).
Encarsia protransvena: Nguyen & Hamon, 1989: 2, Polaszek *et al*., 1999: 158–160.
Encarsia strenua: Polaszek *et al*., 1992: 388 (misidentification, in part of *E. protransvena*), Schauff *et al*., 1996: 29 (misidentification of *E. protransvena*).

Diagnosis. Female. Head and body yellow (fig. 54). Fore wing hyaline. Antenna yellow. Head, including stemmaticum, with reticulate surface sculpture. Clava 3-segmented. Pedicel subequal in length to F1 (0.91–1.10). F1 shorter than or equal to F2 (0.85–1.00) and slightly shorter than F3 (0.80–0.90) (fig. 56). Mid lobe of mesoscutum with 8–10 setae. Scutellar sensilla close together, separated by a distance of about their own width or less. Tergite 7 with 4 setae between cercal plates (cf. plate 2). Distance between anterior pair of scutellar setae smaller than between posterior pair. Fore wing about 2.7 times as long as wide. Marginal fringe 0.28–0.37 times as long as wing width (fig. 55). Tarsus of middle leg 5-segmented (fig. 57). Apical spur of middle tibia longer than half the length of the basal tarsal segment (0.77–0.79) (fig. 61). Ovipositor 1.40–1.43 times the length of middle tibia and 2.19–2.33 times as long as clava. Third valvula 0.29–0.30 times as long as second valvifer.

Species-group placement. Placed in *E. strenua*-group by Hayat (1989).

Distribution. Australia: Western Australia. Pacific Islands: French Polynesia, Fiji. USA: California, Florida, Georgia, Hawaii (Nguyen & Hamon, 1989). China, Colombia, Cayman Islands, Honduras, Puerto Rico and Vieques Island, Spain.

Hosts. Aleyrodidae: *B. tabaci*, *T. vaporariorum*, *Aleurocanthus* sp., *Aleurolobus* sp. The following additional hosts have been recorded (Huang & Polaszek, 1998): *Dialeurodes citri*, *D. citrifolii* (Morgan), *D. kirkaldyi*, *Trialeurodes packardi* (Morill).

Material examined. WESTERN AUSTRALIA: Barton Plain, 1♀, 18.vi.1997 (G. Bellis) ex *Aleurolobus* sp. on *Eucalyptus bigalerita*. PACIFIC ISLANDS: Fiji, Sigatoka Valley, 1♀, 1.xi.1996 (P. De Barro) ex *T. vaporariorum* on *Sonchus oleraceus*. French Polynesia, Paea, Orofero Valley, 1♀, 16.x.1996 (P. De Barro) ex *B. tabaci* on *Cucumis sativus*.

Comments. The identification of *E. protransvena* is difficult and the species has in the past been confused with *E. strenua* (Silvestri) and *E. citri* (Ishii) (Polaszek *et al*., 1992; Schauff *et al*., 1996). *Encarsia strenua* has not been found in the Australian region and can be separated by its longer ovipositor, which is more than 1.6 times the length of the middle tibia in *E. strenua* and 1.3–1.5 times in *E. protransvena* (with few exceptions, see Heraty & Polaszek, 2000). All these species belong to a group of cryptic species within the *E. strenua*-group (Huang & Polaszek, 1998; Heraty & Polaszek, 2000).

Encarsia sophia (Girault & Dodd)
(figs 58–61)

Coccophagus sophia Girault & Dodd, 1915: 49, 56. Syntypes ♀, Australia, Cairns (QM, Brisbane, type no. Hy. 2926, examined).
Prospaltella transvena Timberlake, 1926: 312–315. Holotype ♀, USA, Hawaii, Oahu, reared from *Trialeurodes* [as *Aleyrodes*] *vaporariorum* on tomato (BPBM, type no. 5690, not examined). Synonymy by Heraty & Polaszek, 2000: 163.
Prospaltella sophia: Compere 1931: 11. Change of combination.
Prospaltella sublutea Silvestri, 1931: 20–22. Syntypes ♀, Somalia, Duca [?], (IEUN, not examined). Synonymy by Gerling & Rivnay in Viggiani, 1985a: 90.
Prospaltella bemisiae Ishii, 1938: 30. Syntypes female, Japan, Ikawa-cho, Mei-Ken, 25.viii.1932 (Iino), ex *Parabemisia* [as *Bemisia*] *myricae* Kuwana (NIAT, not examined). Synonymy with *transvena* by Polaszek *et al*., 1992: 388–389.
Prospaltella flava Shafee, 1973: 254. Holotype ♀, India, Uttar Pradesh, Aligarh. Synonymy by Hayat, 1989: 72. Preoccupied by *flavus* Compere, 1936: 300. Synonymy questionable (Viggiani, 1985b) because type material reared from coccid.
Encarsia sophia: Viggiani, 1985b: 249. Change of combination.
Encarsia transvena: Gerling & Rivnay in Viggiani, 1985a: 90–92. Change of combination.
Encarsia shafeei Hayat, 1986: 163. Replacement name for *E. flava* (Shafee).
Encarsia transvena; Hayat, 1989: 71–73; 1998: 205–207; Polaszek *et al*., 1992: 388–389; Schauff *et al*., 1996: 31–33; Huang & Polaszek, 1998: 1954–1956.

Diagnosis. Female. Head and body yellow (fig. 58), pronotum and axillae anteriorly and metasoma occasionally slightly darkened. Tergite 7 with 2 setae between cercal plates (cf. plate 2). Fore wing with a patch of longer setae near hind margin (fig. 59). Head, including the area encompassed by the ocelli, with transversely strigose surface sculpture. Pedicel slightly longer than F1 (0.87–1.18). F1 about as long as F2 (0.86–1.07) and F3 (0.85–1.10) (fig. 60). Clava 3-segmented. Mid lobe of mesoscutum with 8–10 setae. Scutellar sensilla close together, separated by a distance of about their width or less. Distance between anterior pair of scutellar setae distinctly smaller than between posterior pair. Fore wing 2.6–2.7 times as long as wide. Marginal fringe 0.32–0.43 times as long as wing width (fig. 59). Tarsus of middle leg 5-segmented. Apical spur of middle tibia slightly longer than half the length of the basal tarsal segment (0.62– 0.66) (fig. 61). Ovipositor 1.13–1.23 times the length of the middle tibia and 1.56–2.08 times as long as clava. Third valvula 0.24–0.33 times as long as second valvifer.

Species-group placement. Placed in *E. strenua*-group by Polaszek *et al*. (1992).

Distribution. Australia: Western Australia, Queensland. Pacific Islands: French Polynesia. Cosmopolitan.

Hosts. *Bemisia tabaci*, *T. vaporariorum*. The following additional hosts have been recorded (Huang & Polaszek, 1998): *Aleurocybotus indicus* David & Subramaniam, *Aleurodicus dispersus*, *Dialeurodes citri*, *Parabemisia myricae* (Kuwana), *Pealius longispinus* Takahashi (with *Bemisia afer* (Priesner & Hosny)).

Material examined. QUEENSLAND: Dalby, 1♀, 17.iv.1997 (D.R. Lea) ex *T. vaporariorum* on *Xanthium occidentale*. Ayr, 2♀, 13.xi.1996 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. Ayr, 2♀, 21.iii.1997 (P. De Barro) ex *B. tabaci* on *Sonchus oleraceus*. WESTERN AUSTRALIA: Wanneroo, 2♀, 1.x.1996 (P. De Barro) ex *B. tabaci* on *Hibiscus* sp. PACIFIC ISLANDS: French Polynesia, Papara, Tararuu Valley, 1♀, 16.x.1996 (P. De Barro) ex *T. vaporariorum* on *Lantana comara*. French Polynesia, Paea, Orofero Valley, 1♀, (P. De Barro) ex *B. tabaci* on *Cucumis sativus*.

Comments. The species is characterized by the presence of two setae between the cercal plates on metasomal tergite 7, the patch of long setae near the hind margin of the wing, and by the transversely striate surface sculpture of the vertex, in particular the ocellar triangle. Heraty & Polaszek (2000) examined large series of this species and confirmed the importance of these characters for recognizing the species.

Encarsia ustulata Schmidt & Naumann sp. n.
(figs 62–65)

Description. Female. Head yellow with transverse brown band, or lower half of head brown. Mesosoma yellow except pronotum, mesoscutum

anteriorly and axillae partly brown (fig. 62). Metasoma predominantly brown. Antenna yellow with apex darkened (sometimes faint). Fore wing with brown band behind marginal vein (fig. 63). Legs yellow. Head with rugose surface sculpture. Clava 2-segmented. Pedicel subequal to F1 (1.00–1.11). F1 3.29–4.00 times as long as wide, shorter than F2 (0.77–0.85) and slightly shorter to or subequal to F3 (0.87–1.10) (fig. 66). Flagellomers with the following number of sensilla: F1: 0, F2: 1, F3: 1, F4: 2, F5: 3, F6: 3. Mid lobe of mesoscutum with 8 setae arranged symmetrically, side lobes with 3 setae each. Scutellar sensilla close together, separated by a distance of about the width of a sensillum. Distance between anterior pair of scutellar setae distinctly smaller than between posterior pair. Fore wing 2.6–2.7 times as long as wide. Marginal fringe 0.21–0.30 times as long as wing width. Submarginal vein with 2 setae, marginal vein anteriorly with 6–7 setae. Tarsus of middle leg 5-segmented. Apical spur of midtibia longer than half the length of the corresponding basitarsus (0.61–0.74) (fig. 65). Tergites laterally with the following number of setae: T2: 0, T3: 2, T4: 2, T5: 2, T6: 3, T7: 3. T8 with 4 setae. Ovipositor longer than middle tibia (1.11–1.20). Third valvula 0.29–0.30 times as long as second valvifer.

Species-group placement. *Encarsia strenua*-group.

Distribution. Australia: Western Australia, South Australia.

Hosts. *Trialevrodes vaporariorum*.

Material examined. Holotype ♀, SOUTH AUSTRALIA, Aldinga Scrub, 50 km S of Adelaide, xiii.1986 (John S. Noyes) (ANIC). Paratype: 1♀, WESTERN AUSTRALIA, Pemberton, 22.i.1997 (P. De Barro) ex *T. vaporariorum* on tamarillo (Solanaceae) (BMNH).

Comments. This species has been reared from tamarillo heavily infested with *T. vaporariorum* in Pemberton, Western Australia. The vast majority of these were parasitized by a *Eretmocerus warrae* Naumann & Schmidt (Hymenoptera: Aphelinidae). The lack of additional specimens suggests that *E. ustulata* may not normally parasitize *T. vaporariorum*. The species is similar to *E. whittieri* Girault (1915: 60), but can be separated by the ovipositor which is about 1.5 times the length of the middle tibia in *E. whittieri*, whereas it is 1.11–1.20 times in *E. ustulata*. Furthermore, in *E. whittieri* the metasomal tergites T4 and T5 have laterally only a single seta on each side, whereas there are 2 setae in *E. ustulata*. *Encarsia whittieri* is known only from the type specimen collected in New South Wales, Tweed Heads (Tweed River), by A.P. Dodd on 2 May 1914. The host of *E. whittieri* is not known.

Discussion

Our study revealed the existence of 12 *Encarsia* species in Australia attacking either *Bemisia tabaci* or *Trialeurodes vaporariorum*. Prior to this study only a single species, *E. formosa* Gahan, was known to occur in Australia as a parasitoid of these pest whiteflies (Wilson, 1960).

The identification of *Encarsia* species is often difficult because of their small size and the necessity to prepare slide mounts. New species are being continuously added to the approximately 280 described species and there is evidence for the presence of complexes of cryptic species within several of these described species (Polaszek *et al*., 1999). Many *Encarsia* species have a very wide or even cosmopolitan distribution, complicating taxonomic revisions on a local scale. Only four of the 16 species treated in this study seem to be restricted in their distribution to Australia, whereas at least seven species have either a wide geographical distribution embracing several major zoogeographical regions (*E. azimi*, *E. bimaculata* and *E. pergandiella*) or are cosmopolitan (*E. formosa*, *E. lutea*, *E. protransvena* and *E. sophia*) (Huang & Polaszek 1998; Heraty & Polaszek, 2000).

In addition to traditional morphological methods, molecular approaches are more and more used and provide an important tool to investigate the status of closely related species and to infer phylogenetic relationships (Babcock & Heraty, 2000; Babcock *et al*., 2001). The D2 expansion region of the 28S ribosomal DNA showed rates of sequence divergence, expressed as the number of pairwise differences divided by the number of shared nucleotides, of, on average, 10.8% between species and 2.4% within species and was found to be most suitable to characterize *Encarsia* species genetically and to develop molecular markers which allow rapid identification of species which are morphologically difficult to distinguish (Babcock & Heraty, 2000).

Despite considerable efforts, there are many geographical regions where the *Encarsia* fauna is still very poorly known. The results of this study and our current research efforts indicate that Australia has a high diversity of *Encarsia* species. This notion is supported by the high species richness of host taxa, in particular whiteflies (Martin, 1999, and personal communication), and the high number of Australian species described by early authors: between 1894 and 1939 about 50 *Encarsia* species have been described, the majority of them by A.A. Girault (Noyes, 1998). Most of these species are insufficiently described and they are usually only known from the type specimens which are often in very poor condition. The taxonomy of most of the early described species cannot be clarified until the Australian fauna is better known, and until redescriptions of freshly collected and slide mounted specimens have been made.

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Appendix 1

Encarsia species of Australia and the Pacific Islands attacking *Bemisia tabaci* (*B. t.*) and *Trialeurodes vaporariorum* (*T. v.*). Species-group placement, distribution, and host records.

Encarsia species	Species-group	Distribution in Australia and the Pacific Islands	*B. t.*	*T. v.*
E. accenta	*E. inaron*	South Australia, New South Wales.	●	
E. adusta	*E. inaron*	Northern Territory, Queensland, Western Australia.	●	●
E. azimi	*E. inaron*	New South Wales, Queensland.	●	
E. bimaculata	*E. strenua*	Northern Territory, Queensland, Victoria.	●	●
E. cibcensis	*E. perflava*	Cook Islands, Nauru.	●	
E. formosa	*E. luteola*	New South Wales, Queensland, South Australia, Victoria, Western Australia. Fiji, French Polynesia, Tonga.	●	●
E. guadeloupae	*E. luteola*	Micronesia, Nauru, Papua New Guinea.	●	
E. hispida	*E. luteola*	French Polynesia.	●	●
E. mineoi	*E. parvella*	Queensland.	●	●
E. lutea	*E. lutea*	Queensland. Cook Islands, Nauru, Niue, Tonga.	●	●
E. nigricephala	*E. cubensis*	French Polynesia, Nauru.	●	●
E. oakeyensis	*E. strenua*	Queensland.	●	●
E. pergandiella	*E. parvella*	Queensland, South Australia, Victoria.	●	●
E. protransvena	*E. strenua*	Western Australia. French Polynesia, Fiji, Hawaii.	●	●
E. sophia	*E. strenua*	Queensland, Western Australia. French Polynesia.	●	●
E. ustulata	*E. strenua*	South Australia, Western Australia.		●

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