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Aphelinid parasitoids (Hymenoptera; Aphelinidae) of whiteflies (Homoptera: Aleyrodidae) from India

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Abstract

Whiteflies are detrimental pests attacking a wide variety of agricultural crops and ornamental plants predominantly in the tropics and subtropics (Martin et al. 2000). They are primarily the pest of vegetables, cotton, citrus, sugarcane etc. Both nymphs and adults cause damage to plants by sucking their sap, adult flies are considered a vector of many plant viral diseases. Several methods have been used to control these damages such as chemical and biological methods. The family Aphelinidae, forming an important group of parasitic hymenoptera which are considered as one of the useful biocontrol agents of economically important pest species like coccoids, aphids and aleyrodids (whiteflies). In the present study, two aphelinid primary parasitoids (*Eretmocerus*, *Encarsia*) and one secondary parasitoid (*Ablerus*) have been mentioned which helps in the management of whiteflies population, among them genus *Encarsia* is extensively used in controlling many species of whiteflies. Keys are also provided for correct identification of the Indian genera of aphelinid parasitoids of aleyrodids. Hence, any success or failure in any biocontrol programme depends on the correct identification of the host and its parasitoid, incorrect identification leads to waste of years, labor and loss of money. Therefore, correct identification is essential to achieve successful control measures.

Keywords: Aphelinidae; whiteflies; parasitoids; India.

Introduction

Whiteflies are a great threat to agriculturists throughout the world. They are minute plant bugs, dull white in colour because the adults are small fly like, and was initially described as a moth by Linnaeus (1758) but later recognized as a bug by Latrielle (1975). They are primarily the pest of vegetables, crops, citrus, ornamental plants, grass, cotton, sugarcane, teak, sheesham, guava, papaya, banana etc. Both nymphs and adults cause damage to plants by sucking their sap, adult flies considered a vector of many plant viral diseases, and the "honey dew" of the nymphs is a good source for the development of sooty mould fungi, thus, whiteflies adversely affect the host by causing deformity of the leaves, excessive sap loss and interference of the sooty moulds with photosynthesis (Martin et al., 2001).

Many species of whiteflies infesting economically important crops, *Bemisia tabaci* on a wide range of host plants (Fig.1); *Aleurocanthus woglumi* on citrus (Fig.2); *Aleurolobus barodensis* on sugarcane, etc. Thus to control these damages, several methods have been used like chemical and biological methods.

In chemical method, various groups of insecticides have been used (synthetic pyrethroids) but whiteflies have developed resistance against them. Insecticides induced

resurgence and secondary outbreak of whiteflies has resulted in acute crop loss in the areas of Andhra Pradesh, Tamil Nadu and Karnataka (David et al., 1986). Now, the most preferred method is a biological control method by incorporating biocontrol agents such as parasitoids, predators, *Bacillus thuringiensis*, entomopathogenic fungi, etc. Nowadays, this method is considered the safest and nontoxic in controlling pest species. Several publications are of use in the identification of parasitoids of whiteflies (Evan and Bennett, 1996; Hayat, 1989, 1998).

In the present paper, two Aphelinid primary parasitoids have been mentioned and one secondary parasitoid (hyperparasitoid) namely *Eretmocerus*, *Encarsia* and *Ablerus* respectively, which helps in the management of whiteflies population, among them genus *Encarsia* extensively used in controlling many species of whiteflies in several countries. In this paper, a key to the genera of Aphelinid parasitoids/ hyperparasitoids of whiteflies is given with a species list of Aphelinid parasitoids, their hosts and distribution along with brief notes of each genus including the total number of species in the world and in India.

Family Aphelinidae

The family Aphelinidae is a small group of Chalcidoidea, containing 32 genera and a thousand species and a major source of biocontrol agents of economically important pest species such as homopteran groups of coccoids, aphids and aleyrodids. The number of successes or near successes obtained (in terms of preventing economic losses) in the control of pests of agricultural and horticultural crops by the use of aphelinid parasitoids (Noyes, 1985). India has provided many parasitoids that were introduced into other countries, notably the United States (Woglum, 1913; Smith, 1950; Compere, 1961; Flanders, 1969; Rosen and DeBach, 1979), for biological control. Although no extensive work on the 'introduction' and release of foreign species in India was carried out, it is a well-known fact that success or failure in any biocontrol programme primarily depends on the correct identification of the host and its parasitoid(s). Aphelinidae is said to be cosmopolitan and its 10 genera recorded from the entire six zoogeographical regions; they are *Ablerus*, *Aphelinus*, *Aphytis*, *Centrodora*, *Coccobius*, *Coccophagus*, *Encarsia*, *Eretmocerus*, *Marietta* and *Pteroptrix*. The Aphelinid genera which are exclusively parasitic on whiteflies (aleyrodids) are *Eretmocerus* Haldeman and *Encarsia* Foerster having many species of them. The genus *Encarsia* Foerster with over 200 described species in the world contains most of the species that are considered as parasitoids of whiteflies.

Diagnosis of an Aphelinid

Female: Small to medium sized chalcids not exceeding 1.5 mm in length, antennae 3-9 segmented, excluding the radicle and anelli, mandible with 2 teeth and a truncation, mesoscutum with complete notaular line, fore wing with marginal vein long, stigmal vein usually short.

Male: Sexual dimorphism very little and largely confined to the antennal structure.

Key to Indian genera of Aphelinid parasitoids/hyperparasitoid of aleyrodids (females)

- 1. Tarsi 4-segmented (Fig.5), Antenna 5-segmented with funicle segments anelliform or very small and clava long (Fig.3); forewing with long stigmal vein and parastigma (Fig.4) Parasitoids of aleyrodids
..... *Eretmocerus* Haldeman

- Tarsi 5-segmented (Fig.12).....2
- 2. Antenna 7-segmented, 3rd funicle segment shorter than other segments (Fig.6); submarginal vein with one setae; Forewing usually with an infuscated pattern or with contrasting areas of pale and dark setae (Fig.7). Generally hyperparasitoid of aleyrodids *Ablerus* Howard
- Antenna 8 segmented (Fig.9); submarginal vein with 1-2 setae, costal cell distinctly shorter than marginal vein, parastigma short (Fig.11); maxillary palp usually unsegmented. Parasitoids of aleyrodids
..... *Encarsia* Foerster

Brief notes on the Indian genera of Aphelinid parasitoids/hyperparasitoids of whiteflies

- 1. Genus *Eretmocerus* Haldeman [key couplet: 1] (Figs. 3-5)

Eretmocerus Haldeman, 1850: 111. Type species *Eretmocerus corni* Haldeman, by monotypy

Ricinusa Risbec, 1951: 403. Type species *Ricinusa aleyrodiphaga* Risbec, by original designation. Synonymy by Ferriere, 1965: 170

Diagnosis

Female. Antenna with 5 segments, radicle long, scape cylindrical, usually unexpanded; the two funicle segments short to anelliform; clava large, either cylindrical or gradually widened distally and spatulate, or fusiform, with sparse sensilla. Mandible with two small teeth and a truncation, or with 3 small teeth; Forewing variable in dimensions and length of marginal fringe; marginal vein usually at most 2.Ox as long as stigmal vein, with 3-4 setae (rarely less or more); stigmal vein long, with 4 sensilla of which one distinctly separated from the other 3. Legs long and slender; tarsal formula 4-4-4. Gaster of variable length, but usually longer than head plus thorax.

Species and distribution

World species, 47; Oriental, 18; India, 15 species.

Hosts

Eretmocerus species are exclusively parasitoid of whiteflies. Host records other than aleyrodid are considered dubious.

2. Genus *Ablerus* Howard [key couplet: 2]
(Figs. 6-8)

Ablerus Howard, 1894b: 7. Type species *Centrodora clisiocampae* Ashmead, by original designation.

Azotus Howard, 1898: 138. Type species *Azotus marchali* Howard, by monotypy. Synonymy by Girault, 1913b: 189.

Myocnemella Girault, 1913b: 195. Type species *Myocnemella bifasciata* Girault, by original designation. Synonymy by Hayat, 1994a: 83.

Dimacrocerus Brethes, 1914: 4. Type species *Dimacrocerus platensis* Brethes, by original designation. Synonymy by Howard in Girault, 1917e: 8

Diagnosis

Female Antenna with 7 segments, with one or two anelli; F3 usually shorter than both F2 and F4. Mandible with two or three teeth and a truncation. Maxillary palp 2-segmented. Forewing either uniformly infusate behind venation or with infuscated bands of various shapes and bearing darker setae; marginal vein shorter than or subequal to costal cell; stigmalvein either with a thin or swollen stigma. Tarsal formula 5-5-5. Gaster generally longer than head plus thorax.

Species and distribution

World species, 86; Oriental, 17; India, 10 species.

Hosts

Hyperparasitoids of whiteflies. Some species are confirmed Oophagus.

3. Genus *Encarsia* Foerster [key couplet: 2]
(Figs. 9-12)

Encarsia Foerster, 1878 65 Type species *Encarsia tricolor* Foerster, by monotypy

Aspidiotiphagus Howard, 1894a 229 Type species *Coccophagus citnnus* Craw, by original designation Synonymy by Viggiani & Mazzone, 1979 44

Prospalta Howard, 1894b 6 Type species *Coccophagus aurantu* Howard, designated by the ICZN, Opinion 845 Preoccupied by *Prospalta* Walker, 1857, in Lepidoptera

Prospaltella Ashmead, 1904b 126 Replacement name for *Prospalta* Howard, not Walker Synonymy by Viggiani & Mazzone, 1979 44

Mimatomus Cockerell, 1911 464 Type species *Mimatomus peltatus* Cockerell, by monotypy as synonym of *Prospaltella* by Girault, 1917a 114

Doloresia Mercet, 1912b 294 Type species *Prospaltella filicormis* Mercet, by original designation Synonymy by Mercet, 1930a 191

Prospaltoides Brethes, 1914 12 Type species *Prospaltoides howardi* Brethes, by original designation Synonymy with *Aspidiotiphagus* through synonymy of the type species, by Brethes, 1916 429

Paraspidwtiphagus Alam, 1956 359 Type species *Aspidiotiphagus flavus* Compere, by original designation as subgenus of *Aspidiotiphagus*

Aleurodiphilus DeBach & Rose, 1981 659 Type species *Aleurodiphilus amencanus* DeBach & Rose, by original designation Synonymy by Hayat, 1983- 85

Diagnosis

Female Antenna with 8 segments; scape cylindrical or slightly flattened, but never expanded beneath; relative dimensions variable. Mandibles with two teeth and a truncation, teeth either sharp or blunt, or weakly developed, or rarely mandibles with a tooth and a truncation or edentate. Forewing shape and length of marginal fringe variable; costal cell at most as long as marginal vein, and usually with a line of minute setae on ventral surface; submarginal vein with 2 setae, rarely 1 or more than 2. Legs normal; tarsal formula 5-5-5, or 5-4-5. Gaster with 7 terga.

Species and distribution

World species, 222; Oriental, 86; India, 52 species. It is speciose and cosmopolitan genus.

Hosts

Endoparasitoids of whiteflies.

List of Aphelinid parasitoids, their hosts and distribution in India.

Aphelinid Parasitoids (genera and their species)	Hosts	Distribution
<i>Encarsia</i>		
<i>Encarsia acaudaleyrodids</i> Hayat	<i>Acaudaleyrodides rhachipora</i> on <i>Lawsonia ivermis</i>	Delhi, Rajasthan, Tamil Nadu
<i>Encarsia aseta</i> Hayat and Polaszek	<i>Dialeurolonga elongata</i> on citrus sp.	Maharashtra
<i>Encarsia albiscutellum longipalpa</i> Hayat	<i>Aleurolobus</i> sp. on <i>Eugenia jambolana</i>	Tamil Nadu, Uttar Pradesh
<i>Encarsia clypealis</i> (Silvestri)	<i>Aleurocanthus incertatus</i> , <i>Aleurocanthus woglumi</i> on Citrus ; <i>Aleyrodides</i> sp. on indet. aleyrodids on Citrus and <i>Murraya</i>	Andhra Pradesh, Assam, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh
<i>Encarsia opulenta</i> (Silvestri)	<i>Aleurocanthus woglumi</i> (type material reared from <i>Aleurocanthus incertatus</i>)	Between Delhi and Himalayan mountain, Uttar Pradesh
<i>Encarsia eurystoma</i> Hayat	Indet. aleyrodids on <i>Murraya roenigii</i>	Andhra Pradesh
<i>Encarsia longicauda</i> Hayat	Indet. aleyrodids on <i>Tephrosia purpurea</i> and indet. plants	Andhra Pradesh, Rajasthan, Tamil Nadu
<i>Encarsia terebrator</i> (Shafee)	Indet. aleyrodids	Andhra Pradesh
<i>Encarsia punicae</i> Hayat	Indet. aleyrodids on pomegranate, <i>Punica granatum</i>	Karnataka
<i>Encarsia inaron</i> (Walker)	Indet. aleyrodids; <i>Siphoninus phyllireae</i> on pomegranate <i>Punica granatum</i>	Assam, Karnataka, Maharashtra, Uttar Pradesh
<i>Encarsia gunturensis</i> (Azim and Shafee)	Indet. aleyrodids	Andhra Pradesh, Tamil Nadu, Uttar Pradesh
<i>Encarsia azimi</i> Hayat	Indet. aleyrodids on <i>Nerium</i> sp.	Karnataka, Tamil Nadu, Uttar Pradesh
<i>Encarsia brevivena</i> Hayat	<i>Bemisia tabaci</i> ; <i>Lipaleyrodides</i> sp. on <i>Vernonia</i> sp.	Maharashtra, Tamil Nadu
<i>Encarsia dialeurodis</i> Hayat	Indet. aleyrodid (presumably <i>Dialeurodes</i> sp) on <i>Ficus religiosa</i>	Uttar Pradesh
<i>Encarsia transvena</i> (Timberlake)	<i>Acaudaleyrodides rhachipora</i> on <i>Prosopis juliflora</i> ; <i>Aleurolobus</i> sp.; <i>Trialeurodes ricini</i> on <i>Phyllanthus acidus</i> ; indet. aleyrodids on <i>Ficus religiosa</i> ; indet. aleyrodids on <i>Gardinia</i> sp. "Tulsi"	Bihar, Delhi, Goa, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal
<i>Encarsia septentrionalis</i> Hayat	<i>Aleurolobus</i> sp on <i>Eugenia jambolana</i> ; <i>Dialeurdes</i> sp. on <i>Encarsia jambolana</i>	Bihar, Delhi, Uttar Pradesh
<i>Encarsia tristis</i> (Zehntner)	<i>Aleyrodides</i> sp. on grass	Bihar, Delhi, Karnataka, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh
<i>Encarsia merceti</i> Silvestri	<i>Aleurocanthus woglumi</i> ; indet. aleyrodids	Assam, Delhi to the Himalayan mountains
<i>Encarsia bennetti</i> Hayat	<i>Aleurocanthus woglumi</i>	Maharashtra, Uttar Pradesh
<i>Encarsia tinctoriae</i> Krishnan and David	<i>Aleurocanthus woglumi</i> on <i>Citrus</i> sp.; <i>Lipaleyrodides euphorbiae</i> on <i>Phyllanthus</i>	Tamil Nadu

	<i>acidus</i>	
<i>Encarsia isaaci</i> Mani	<i>Aleurolobus barodensis</i> indet. aleyrodids on sugarcane, <i>Saccharum officinarum</i>	Andhra Pradesh, Orissa, Tamil Nadu, Uttar Pradesh
<i>Encarsia bifasciifacies</i> Hayat	<i>Aleurolobus</i> sp. near <i>niloticus</i> , on <i>Dalbergia sissoo</i>	Bihar, Delhi, Uttar Pradesh
<i>Encarsia occultans</i> Hayat	Indet. aleyrodid on <i>Terminalia arjuna</i>	Bihar, Orissa, Uttar Pradesh
<i>Encarsia narayanani</i> Agarwal	Indet. aleyrodid on <i>Terminalia arjuna</i>	Karnataka, Maharashtra, Orissa, Uttar Pradesh
<i>Encarsia ixorae</i> Krishnan and David	<i>Dialeurodes ixorae</i> on <i>Ixora</i> sp.	Tamil Nadu
<i>Encarsia divergens</i> Silvestri	<i>Aleurocanthus</i> spp. Including <i>Aleurocanthus woglumi</i>	Assam
<i>Encarsia smithi</i> (Silvestri)	<i>Aleurocanthus woglumi</i>	Bihar, Karnataka, Maharashtra, North India
<i>Encarsia trivittata</i> Hayat	<i>Aleurolobus</i> sp on <i>Eugenia jambolana</i>	Uttar Pradesh
<i>Encarsia udaipuriensis</i> (Shafee)	<i>Aleurolobus barodensis</i> and <i>Aleyrodes</i> sp. on <i>Saccharum officinarum</i>	Bihar, Orissa Rajasthan, Tamil Nadu, Uttar Pradesh
<i>Encarsia indica</i> (Shafee)	Indet. aleyrodid; <i>Bemisia</i> sp. on cotton	Pondicherry
<i>Encarsia lutea</i> Masi	Indet. aleyrodids on <i>Saccharum spontaneum</i> and "Tulsi"	Bihar, Uttar Pradesh
<i>Encarsia perflava</i> Hayat	Indet aleyrodid on <i>Dalbergia sissoo</i>	Uttar Pradesh
<i>Encarsia lipaleyrodids</i> Krishnan and David	<i>Lipaleyrodes euphorbiae</i> on <i>Phyllanthus acidus</i>	Tamil Nadu
<i>Encarsia lahorensis</i> (Howard)	<i>Dialeurodes citri</i> , <i>Aleurodes ricini</i>	North India, Bihar
<i>Encarsia macroptera</i> Viggiani	Indet. aleyrodids on <i>Saccharum officinarum</i>	Maharashtra, Punjab, Uttar Pradesh
<i>Encarsia confusa</i> Hayat	<i>Aleurolobus</i> sp. near <i>niloticus</i> , on <i>Dalbergia sissoo</i>	Bihar, Uttar Pradesh
Eretmocerus		
<i>Eretmocerus bisetae</i> Hayat	<i>Dialeurodis</i> sp. on <i>Ficus religiosa</i>	Uttar Pradesh
<i>Eretmocerus rajasthanicus</i> Hayat	<i>Acaudaleyrodes rhachipora</i> on <i>Prosopis juliflora</i>	Rajasthan
<i>Eretmocerus mundus</i> Mercet	Indet. aleyrodids including <i>Aleyrodes</i> spp. on grass, <i>Annona squamosa</i> ; <i>Bemisia tabaci</i> on <i>Gossypium</i> spp.; <i>Trialeurodes ricini</i> on <i>Phyllanthus acidus</i>	Andhra Pradesh, Bihar, Maharashtra, North India, Tamil Nadu, Uttar Pradesh
<i>Eretmocerus indicus</i> Hayat	<i>Aleurolobus</i> sp on <i>Eugenia jambolana</i> (Jamun)	Uttar Pradesh
<i>Eretmocerus gunturiensis</i> Hayat	Indet. aleyrodids on <i>Murraya koenigii</i> and <i>Annona squamosa</i>	Andhra Pradesh, Maharashtra
<i>Eretmocerus serius</i> Silvestri	<i>Aleurocanthus woglumi</i>	Andhra Pradesh, Vicinity of Assam, Karanataka, Uttar Pradesh
<i>Eretmocerus trialeurodis</i> Hayat	<i>Trialeurodes ricini</i> on <i>Ricinus communis</i>	Tamil Nadu
<i>Eretmocerus dialeurolongae</i> Krishnan and David	<i>Dialeurolonga fici</i> , <i>Dialeurolonga maculata</i> on <i>Ficus religiosa</i>	Tamil Nadu
<i>Eretmocerus flavus</i> Krishnan and David	<i>Lipaleyrodes euphorbiae</i> on <i>Phyllanthus acidus</i>	Tamil Nadu
<i>Eretmocerus longiscapus</i> Hayat	<i>Aleurolobus</i> sp. near <i>niloticus</i> , on <i>Dalbergia sissoo</i> ; indet aleyrodids on	Uttar Pradesh, Orissa

	<i>Dalbergia sissoo, Terminalia arjuna</i>	
<i>Eretmocerus delhiensis</i> Mani	Indet. aleyrodids on grass	Bihar, Delhi, Rajasthan, Uttar Pradesh
<i>Eretmocerus adustiscutum</i> Krishnan and David	<i>Lipaleyrodes euphorbiae</i> on <i>Phyllanthus acidus</i> ; <i>Bemisia tabaci</i>	Karnataka, Kerala, Maharashtra, Tamil Nadu, Uttar Pradesh
<i>Eretmocerus hydrabadensis</i> Husain and Agarwal, <i>incertae sedis</i>	Indet. aleyrodids on <i>Nerium odorum</i>	Andhra Pradesh

Discussion

The Aphelinid parasitoids are important in controlling the pest of agriculture mainly the whiteflies (aleyrodids). Because of their parasitic habits, Aphelinids are extensively used in the biological control of homopteran and other pest species. Noyes (1985), in an analysis of the data given by Clausen (1978), has shown that Aphelinids ranked higher than encyrtids in the number of cases in which full economic control of the pests was achieved.

The taxonomic study of Aphelinid parasitoids of whiteflies (aleyrodids) is essential to provide correct identification, so that a successful control measures can be achieved. Although, India provided many parasitoids for biological control that were introduced into other countries, especially the United States (Woglum, 1913; Flander, 1969; Rosen De Bach, 1979) for biological control. The incorrect identification leads to waste of labor and loss of money.

The study provides a brief note of these parasitoids (*Eretmocerus* and *Encarsia*) in the form of their specific hosts (aleyrodids) and distribution in India as well as an identifying key to genera (females), *Alberus* Howard is not a primary parasitoid but a secondary parasitoid (hyperparasitoid) which itself is not considered very useful in controlling the pest species. In spite, the fact is that a taxonomic study is essential to warn biocontrol workers about its true nature.

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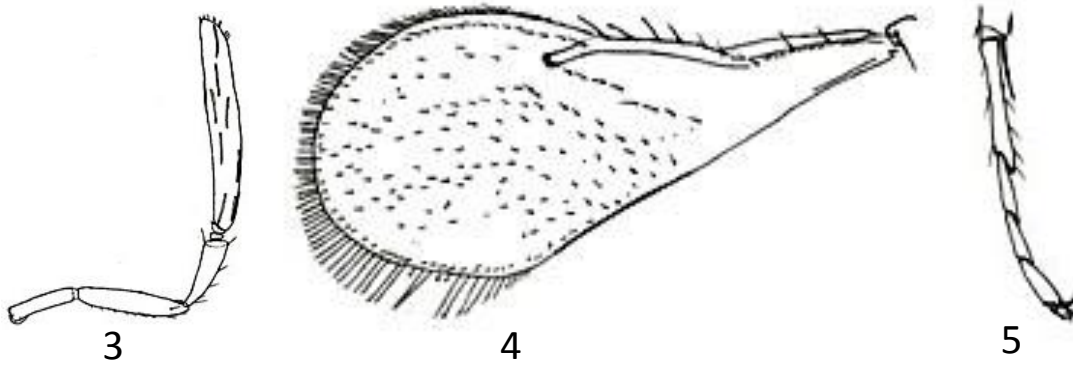
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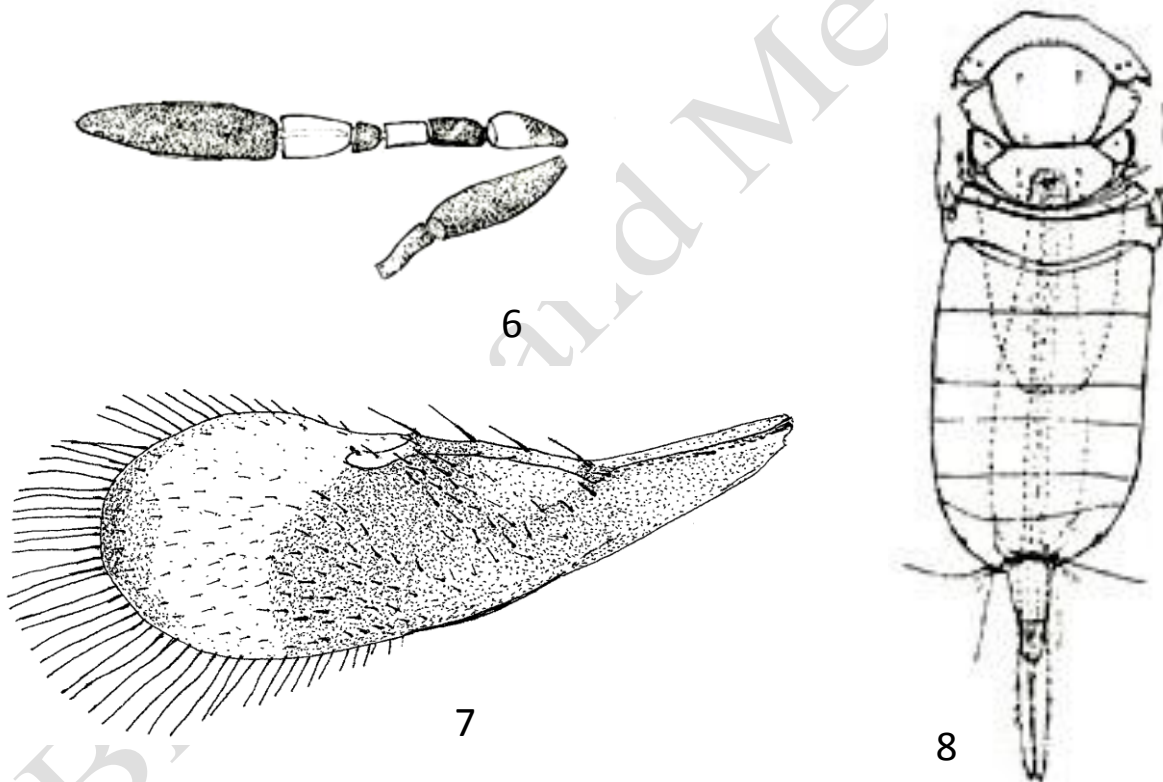
Figure 1. *Bemisia tabaci* (sugarcane whitefly).
(Courtesy: www.ecographica.blogspot.com/2009_01_01_archive.html)



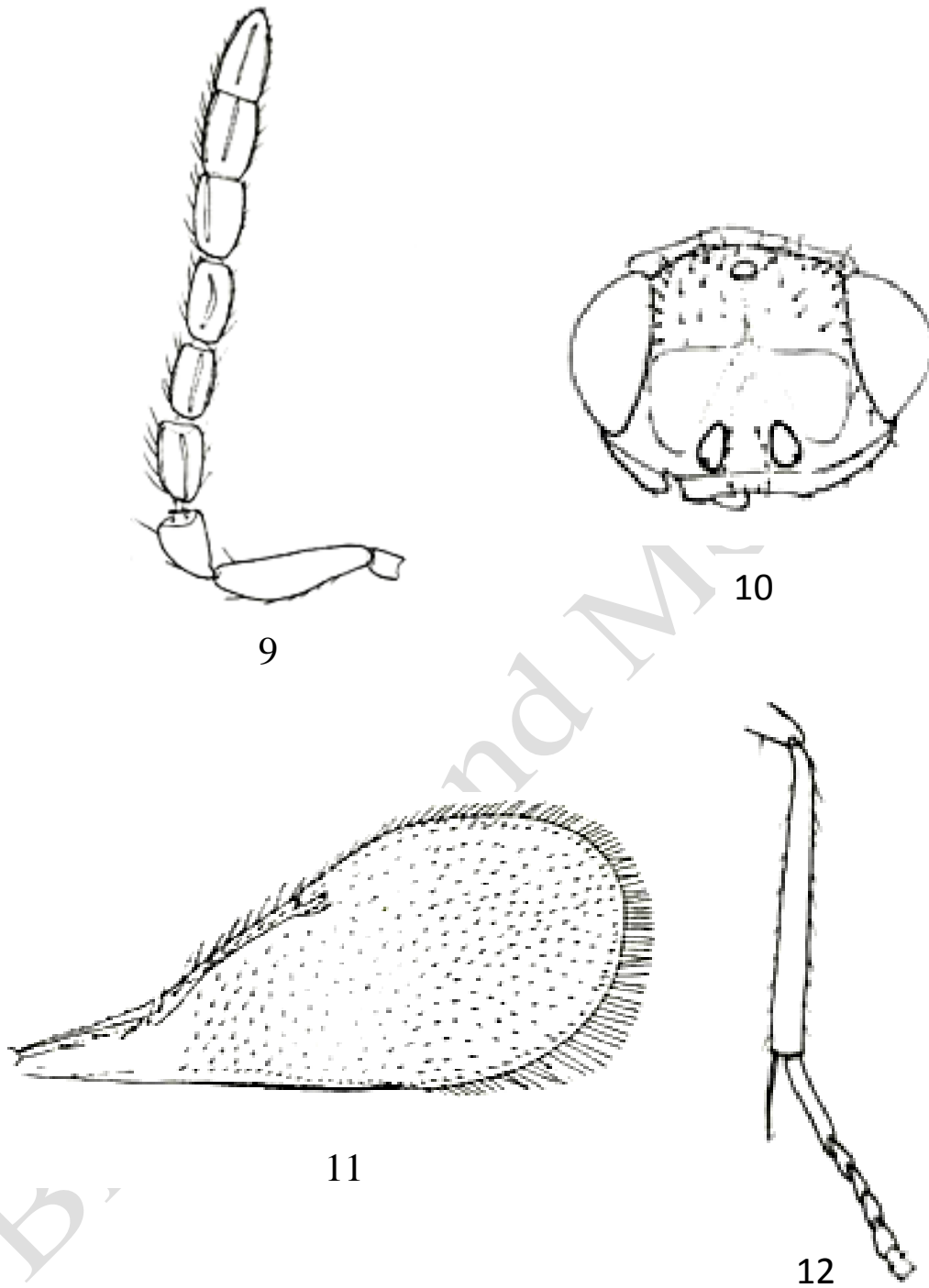
Figure 2. *Aleurocanthus woglumi* (citrus blackfly).
(Courtesy: www.invasive.org/images/768x512/0656100.jpg)



Figs. 3-5. *Eretmocerus indicus*: 3, Antenna; 4, Forewing; 5, Mid tarsus (4-segmented tarsi).



Figs. 6-8. *Ablerus* sp: 6, Antenna; 7, Forewing showing infuscation; 8, Thorax and gaster (dorsal).



Figs. 9-12. *Encarsia albiscutellum*: 9, Antenna; 10, Head (frontal); 11, Forewing; 12, Mid tibia and tarsus (5-segmented tarsi).