Systematics of aleyrodine whiteflies (Hemiptera: Aleyrodidae), and their parasitoids belonging to the *inaron* and *luteola* groups of *Encarsia* (Hymenoptera: Aphelinidae)

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Aleyrodidae, Phylogeny, *Encarsia*,
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Abstract

Phylogenetic relationships of aleyrodine whiteflies based on a cladistic analysis of morphological characters derived from the pupal case are presented. This is the first attempt to construct a phylogenetic classification at genus level on a world basis for the subfamily Aleyrodinae. The current tribal classification is reassessed, and co-phylogeney of aleyrodines with their host plants is discussed in relation to the trees obtained. One new genus, seven new combinations, and three new generic synonyms are proposed.

Some taxonomic problems concerning their aphelinid parasitoids belonging to the *Encarsia inaron* and *E. luteola* species-groups are addressed. For the *inaron* group, objective views of species boundaries are presented based on principal component analysis and canonical discriminant analysis. D2-28S rDNA sequence data are used to evaluate the findings and explore the support for some postulated species-groups within *Encarsia*. The applicability of the morphological diagnosis of the group is also tested. For the *luteola* group, five closely-related species are analysed using the same techniques. Four of these belong to the *meritoria*-complex, and all species have a complex taxonomic history involving repeated misidentification and confusion. A combination of morphological and molecular study is shown largely to resolve the complex, and thus correct previous confusion surrounding this group of species. In total, for these two *Encarsia* species groups, three new species as well as one new specific synonym are proposed.

Finally, relationship between aleyrodine whiteflies and their parasitoids belonging to different *Encarsia* species-groups are investigated.

Dedicated to

The treasured memory of
My mother and father
Their spirit and memory will live on in my heart forever

To

My brothers,

My wife

And

My little daughter

Declaration

The work in this thesis is entirely my own, except for inputs from the following:

Chapter 3: Robert Belshaw contributed ideas to this chapter and assisted with the phylogenetic analysis.

Chapter 4: Andrew Polaszek contributed ideas to this chapter as well as measuring the antennal segments and providing the description/redescription of the *Encarsia* species.

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1

General introduction to whiteflies and their aphelinid parasitoids

1.1. Whiteflies

The family Aleyrodidae is composed of tiny insects (1-3 mm in body length), which are usually called whiteflies, although rather surprisingly, one of the most widespread pest species, *Aleurocanthus woglumi* Ashby, is called the citrus blackfly (Mound, 1973). The common name, "whiteflies", is derived from the white appearance of the powdery wax, which covers the body and wings of the adults of almost all species, and the family name, Aleyrodidae, is derived from the Greek word, *Aàleuron* (*Aleuron*), meaning flour or meal. Mound and Halsey (1978) catalogued the whiteflies of the world and listed 1156 species, which has now increased to approximately 1450 (Martin *et al.*, 2000). However the real number, i.e. including undescribed species, is certainly much higher.

Whiteflies are known from Afrotropical, Australian, Australo-oriental, Malagasy/Mascarene, Nearctic, Neotropical, Oriental, Pacific, and Palaearctic zoogeographical regions (Mound, 1984). Most species are tropical, and even in Europe, the number of species is closely related to latitude (Bink-Moenen & Mound, 1990). Three of the most speciose whitefly genera, *Aleuroplatus* Quaintance & Baker, *Aleurotrachelus* Quaintance & Baker and *Tetraleurodes* Cockerell, are known from many parts of the world but many others have more restricted distributions (Mound & Halsey, 1978).

Morphologically and biologically, adult whiteflies resemble Psylloidea, whereas the immature stages are more like those of Coccoidea (Carver *et al.*, 1991). Unusually amongst insects, the generic classification of whiteflies is largely based on one of the immature stages, the so-called, pupal case (= puparium = fourth instar = last nymphal stage = last larval stage), rather than on the adults (Gill, 1990). Quite often, third instar larvae have been used in species descriptions, having been mistaken for the so-called puparial stage (Martin, 1999). Unfortunately, whitefly puparia are notorious for displaying variation induced by environmental and physical factors such as

temperature and humidity (Mohanty & Basu, 1986), as well as by the type of leaf surface upon which they have developed (Russell, 1948; Mound, 1963: David & Ananthakrishnan, 1976; Neal & Bentz, 1999; Guershon & Gerling, 2001a). Aleyrodid systematists need to be alert to all of these problems.

The Aleyrodidae includes many species that attack cultivated plants, and several species, e.g. *Bemisia tabaci* (Gennadius), *Trialeurodes vaporariorum* (Westwood) and *Dialeurodes citri* (Ashmead), are economically important as pests of both crops and of ornamental plants. Further, the importance of whiteflies as economic pests seems to be increasing constantly. The amount of damage caused by whiteflies is considerable; for example in 1991 *B. tabaci* caused damage to U.S. agricultural production estimated at over 500 million dollars (Perring *et al.*, 1993). These hemipteran insects damage crops by direct feeding on large quantities of phloem sap, which can result in reduced crop yield and plant vigour. With high whitefly populations, plants may die. Furthermore, the honeydew excreted by these insects can serve as a medium for sooty mould fungi (e.g. *Capnodium* spp.) that undesirably affect photosynthesis, which may severely reduce the productivity the plant (Perkins, 1983, Byrne *et al.*, 1990a). In addition, sooty moulds may increase thermal absorption and raise leaf temperature, reducing leaf efficiency and possibly even causing premature death of tissue (Byrne *et al.*, 1990a). Finally, three species of whiteflies, *B. tabaci*, *T. vaporariorum* and *T. abutilonea* (Haldeman), can transmit viruses between plants and lead to virus disease epidemics and dramatic losses (Muniyappa, 1980; Byrne *et al.*, 1990a). *B. tabaci* is the vector of viruses in several groups, the largest of which are the geminiviruses, and it is known to transmit around 60 members of these (Markham *et al.*, 1994). Surprisingly, despite their known importance as virus vectors, the Aleyrodidae is a poorly studied family of insects (Bink-Moenen, 1983).

1.1.1. Host plants

Most whiteflies are known only from angiosperm hosts, primarily dicotyledons. However, some species feed on members of several families of monocotyledons, e.g. Poaceae, Arecaceae, and Smilacaceae. The only record of an aleyrodid species from a gymnosperm is *T. vaporariorum* on *Dioon spinulosum* Dyer (Zamiaceae) (Russell, 1963; Mound & Halsey, 1978). In addition to Spermatophyta (including gymnosperms and angiosperms), 20 described, and three or four undescribed, species

are known from fern hosts (Pteridophyta) (Mound & Halsey, 1978; Martin & Camus, 2001).

Host specificity does not seem to be highly developed in Aleyrodidae. World-wide, *Ficus* (Moraceae) is host to more than 80 species of whiteflies, and *Citrus* (Rutaceae) to more than 60 (Carver *et al.*, 1991). Well-known polyphagous species, *T. vaporariorum* and *B. tabaci* have been recorded from more than 80 and 60 plant families respectively (Mound & Halsey, 1978). Polyphagous species have a range of fitness on different hosts. For example, *T. vaporariorum* has a higher reproductive rate on tomato than on *Brassica* spp. (Iheagwam, 1980).

1.1.2. Biology and behaviour

Information on basic biology is scarce for most species, and mainly restricted to a few well-known pest species such as *B. tabaci* and *T. vaporariorum* (Byrne & Bellows, 1991). Whiteflies have six life stages, the egg, the crawler (1st nymphal instar or stadium), three sessile nymphal instars (2nd, 3rd and 4th instar nymphs, the latter being termed "pupa"), and the adult or imago (Gill, 1990).

The eggs are pedunculate like those of Psylloidea, usually elongate-oval in shape but occasionally reniform, and are either smooth or sculptured. The pedicel, a hollow extension of the chorion, is either inserted into a slit made by the ovipositor in the leaf surface, or into a stomatal opening (Quaintance & Baker, 1913; Gill, 1990; Carver *et al.*, 1991). Two main functions have been reported for the pedicel in addition to providing a means of attachment. According to Quaintance and Baker (1913), the pedicel seems to direct the spermatozoa at the time of fertilization, during which time it is filled with protoplasm. These authors also stated, "After fertilization, the protoplasm dries up and the pedicel becomes a hollow tube". Other authors have suggested that the pedicel is used as a means of absorbing water into the egg, which protects the egg from dehydration (Poinar, 1965; Paulson & Beardsley, 1985; Byrne *et al.*, 1990b). Based on a recent study (Buckner *et al.*, 2002) on *Bemisia argentifolii* Bellows & Perring (*B. tabaci*, biotype B) using scanning and transmission electron microscopy, the exterior of the distal portion of the pedicel consists of a tangled array of fibrous structures (0.2-0.3 mm in diameter) that constitutes about 20-25% of the outer diameter of the pedicel. The attachments of the fibres to the core of the pedicle suggest that the pedicel may function as a collector and conduit for water (vapour),

and perhaps solute movement into the egg (Buckner *et al.*, 2002). These authors also studied the effect of exposure of pedicels to different relative humidities and to radiolabelled materials, and demonstrated that whitefly egg hatch is dependent upon water uptake by the pedicel, and that the pedicel also has the ability to transport solutes into the developing egg.

The crawler has functional walking legs (apparently 3-segmented) and antennae (apparently 2-segmented). It is the only mobile immature stage. In most species the crawler probably settles within a few millimetres of the egg. Once crawlers find the phloem of a host plant, they remain immobile (with the exception of short periods during moults) until they become adults (Gill, 1990; Byrne & Bellows, 1991).

The second and third instar nymphs are intermediate feeding stages, and are usually oval or oval-elongate, and similar in general shape and colour to the pupal case. The two subfamilies of the Aleyrodidae (see section 1.1.4), Aleyrodinae and Aleurodicinae, differ morphologically in these stages. Legs and antennae appear to be reduced to one segment in the Aleyrodinae, but in the Aleurodicinae the legs are 3-segmented and the antennae are without distinct segmentation (Gill, 1990).

The fourth instar is not a true pupa, and based upon studies on *T. vaporariorum*, it has three morphologically distinct forms (Nechols & Tauber, 1977a, 1977b). The early fourth instar is flattened and translucent, but unlike the true pupa, it continues to feed. The next form, termed the transitional substage, is expanded and opaque-white with dorsal and lateral waxy, spine-like processes. Apolysis[1] takes place at this point. In the last form, the pharate adult with red eyes and yellow body pigment is present. At this point, apolysis is complete and the adult cuticle is laid down (Nechols & Tauber, 1977a, 1977b). Dividing the fourth instar into only three stages would prevent the detection of important physiological/biochemical changes that occur during the development of the 4th instar and the pharate adult (Gelman *et al.*, 2002), and these authors divided the 4th instar *T. vaporariorum* into nine stages: the last two of the above three forms were further subdivided and they provide additional detail of morphological changes of the eye and wing as well as changes in soluble protein content, and whole body ecdysteroid fluctuations.

Based on Eastop's (1969) observations on post-ecdysal setal development in *B. tabaci*, the pupal case is fixed to the leaf at its anterior end, but the abdomen is free.

[1] The separation of the old cuticle from the underlying epidermal cells in the moulting process.

The abdomen is raised to 90° and vigorously wriggled with the lingula protruding through the vasiform orifice during the first half hour after the moult. A fluid flows internally from the abdomen to the anterior part of the body, and the abdomen is then lowered, and after this, viscous globules appear on the pupal case in the position where the setae will appear. It is thought that the setae may be formed round a thread of wax extruded from the base of the microseta into the globule. If all the globules are removed from one side of the body, no setae are produced on that side. It is thought, however, that in some other genera, e.g. *Aleurocanthus* Quaintance & Baker and *Siphoninus* Silvestri, the setae are formed before the moult (Eastop, 1969). However, this seems somewhat dubious and further study is required.

Reproduction in whiteflies is usually sexual but occasionally it is parthenogenetic (Martin et *al.*, 2000). Unmated females, except in *Parabemisia myricae* (Kuwana), produce male offspring (XO) and mated females may produce both males and females (XO and XX) (Byrne & Bellows, 1991). Two races of *T. vaporariorum*, an American and an English one, show arrhenotokous and thelytokous parthenogenesis respectively (Schrader, 1920). According to Ahman and Ekbom (1981), however, virgin females did not give rise to females in any *T. vaporariorum* cultures studied by them. Females usually deposit their eggs on the lower surfaces of leaves, and the eggs of many species are laid in partial or complete circles by rotation of the female around her rostrum. Some species, particularly in the Aleurodicinae, oviposit on other surfaces such as fruits, and a few whitefly species habitually develop on the upper surfaces of leaves, whilst others readily develop on both surfaces (Martin et *al.*, 2000). In most species the adult emerges through a T-shaped split in the dorsal surface of the pupal case, but in a few species the apices of the T are connected by additional sutures, thus forming a 'trap-door' (Mound & Halsey, 1978) (fig. 2.6).

Adult males of a few whitefly species, especially *B. tabaci* and *T. vaporariorum*, have been observed to display courtship behaviour prior to mating, including abdominal oscillations that result in acoustic signals (substrate-borne vibrations) (Li *et al.*, 1989; Kanmiya, 1996; Kanmiya & Sonobe, 2002; Gullan & Martin, 2003). Females may produce sex pheromones to attract males (Li & Maschwitz, 1983). Adult whiteflies will fly short distances if disturbed from their host plant. They also undertake longer migratory flights, which are air-current dependent because whiteflies are weak fliers (Gullan & Martin, 2003). However, based upon

Byrne's (1999) study on *B. tabaci*, whitefly flight may not be characterized as weak. Whiteflies flew in a flight chamber against a strong air stream as well as dispersing in field experiments for a considerable distance. There is also information that whiteflies have a migratory form, as some strong flying insects, and their flight seems to meet many criteria associated with migration in insects (Byrne, 1999). Whiteflies have complex host-finding and host-orientation behaviour, involving at least attraction to particular colours, especially yellow or yellow-green (Gullan & Martin, 2003).

Parental care in whiteflies has been reported in *Aleyrodes singularis* Danzig (Guershon & Gerling, 1994, 2001b) and *Neomaskellia bergii* (Signoret) (Kurosu *et al.*, 1992). The findings of Guershon & Gerling's (2001b) study showed that specific behavioural displays, e.g. "bout flutter", "wing hit", "rodeo", performed by adults *A. singularis* under laboratory conditions, in the presence of their natural enemies, may cause the latter to depart from the patch, and so enhance the survival chances of the immature stages. Therefore, in *A. singularis*, parental care exists at a level considered to be beyond passive protection of eggs or even nymphs (Guershon & Gerling, 2001b).

Unlike some aphids that use major veins as feeding sites (Gibson, 1972), in at least some whiteflies, e.g. *B. argentifolii* (*B. tabaci*, biotype B), successful feeding always involves probing of minor veins that contain no more than three xylem elements (Cohen *et al.*, 1998). Therefore, whitefly feeding biology is complex and includes the location of appropriate sites to probe leaves so that minor veins can be located. There are distinct surface structures such as lamina trichomes and elongated epidermal cells that serve as guides for crawlers to begin probing at appropriate places. The nymphs use a specialised saliva to produce a sleeve-like structure named the "salivary sheath" that guides the stylets to the minor veins. The sheaths are often sinuous and may be branched, both in the mesophyll and at the veins (Cohen *et al.*, 1998).

Whiteflies as well as other insects that feed throughout their life cycles on nutritionally incomplete diets such as plant sap, blood and wood often harbour mutualistic intracellular prokaryotes that apparently are vital and provide specific nutritional needs for survival and reproduction of the hosts (Douglas, 1998; Spaulding & von Dohlen, 1998). Such endosymbionts live within specialized host cells called mycetocytes, or more appropriately, bacteriocytes (Spaulding & von Dohlen, 1998,

2001), which are organized into a large specialized organ-like structure called the mycetome or bacteriome (Campbell, 1993; Spaulding & von Dohlen, 1998). Some of the prokaryotic symbionts in whiteflies are transient or nonessential, that can either be beneficial or deleterious in the long-term (Zchori-Fein & Brown, 2002). The most distinctive groups of prokaryotic symbionts are 'primary' or 'secondary' symbionts (Moran & Baumann, 2000; Zchori-Fein & Brown, 2002). Primary symbionts are vertically transmitted, essential for the host's survival and reproduction, and confined to bacteriocytes (Fukatsu & Nikoh, 1998; Moran & Telang, 1998; Moran & Baumann, 2000). They are believed to represent an ancient mutualism (Spaulding & von Dohlen, 1998, 2001). In contrast, secondary symbionts are not necessarily incorporated into bacteriocytes nor are they essential to host survival (Chen & Purcell, 1997; Fukatsu & Nikoh, 1998; Fukatsu *et al.*, 2000). They are crucial perhaps for fitness, competition, and other more indirect aspects that also influence the evolution of their host (Zchori-Fein & Brown, 2002).

1.1.3. Waxes

All life stages of whiteflies, except the egg, secrete waxes that cover the body (Byrne & Bellows, 1991) and this is one of the distinguishing features of the family. According to Gill (1990), the ventral wax plates are unique in each subfamily. In the Aleyrodinae, there are two pairs of wax plates on the 2nd and 3rd abdominal segments of females, and four pairs on the 2nd to 5th abdominal segments of males. In the Aleurodicinae, there are four pairs in females on segments II-V, and three pairs in males on segments II-IV. However, the aleyrodine genus *Neomaskellia* Quaintance & Baker has two reduced wax plates in males (Bink-Moenen & Mound, 1990). In adult *B. tabaci* and *T. vaporariorum*, an individual wax plate consists of hundreds of templates, which appear as rows of modified microtrichia on the surface (fig. 1.1A,B). The wax material is produced by secretory vesicles that lie beneath the wax plate cuticle. Wax canals, which emerge from the vesicles and ultimately open at the tip of the template, direct the wax material toward the surface. The form of wax particles (fig. 1.1B; inset) is determined by the templates (modified microtrichia) from which they are extruded (Byrne & Hadley, 1988). Waxes can be secreted as both waxy particles and filaments. In adult females of the "giant whitefly", *Aleurodicus dugesii* Cockerell, the anterior abdominal wax plates produce the same waxy particles

characteristic of all whiteflies, as does the male. The posterior abdominal wax plates produce waxy filaments, up to 620 μm in length, which the female uses to make a spiral trail of waxy filaments on the underside of the leaf. Eggs are oviposited at intervals as the trail is being made. (Nelson *et al.*, 1999) (fig. 1.2A). The nymphs and pupae of *A. dugesii* secrete large quantities of lipids, as both waxy particles and filaments, which can attain lengths of 5-8 cm (Nelson *et al.*, 2000) (fig. 1.2B).

The external lipids of the adult whitefly can be differentiated into two categories: the wax particles, and the lipids of the cuticular surface (Nelson *et al.*, 1997). These authors' studies on selected species of whiteflies show that the wax particles are not a true wax but are composed of long-chain aldehydes and long-chain alcohols. However, the lipids of the cuticular surface are composed of true wax esters and small amounts of hydrocarbons (Nelson *et al.*, 1997).

The main function of cuticular lipids on terrestrial insects is to minimize loss of water across the integument. Other widely accepted functions include defence mechanisms against predators, chemical communication and camouflage. During growth and development, whitefly nymphs remain immobile and feed continually on plant phloem except during moulting activities between instars. Therefore, a need for cuticular lipids in reducing water loss could be a less important function than the role of cuticular lipids in protecting sessile nymphs against predators and providing camouflage. For whitefly nymphs, the waxy coating on the cuticular surfaces could also function to protect against honeydew, the sticky liquid excreted by phloem feeders (Buckner *et al.*, 1999).

1.1.4. Taxonomy

The taxonomy of the Aleyrodidae has long been problematic, partly because morphological traits of adults are currently poorly understood and so do not readily permit differentiation between genera or species (Frohlich *et al.*, 1999). Due to their secreted powdery wax, the adults resemble tiny moths with which they could, conceivably, be confused. In fact, early workers thought they were minute moths and *Aleyrodes proletella* (L.) was mistakenly classified in the Lepidoptera by Linnaeus (1758). Later, in 1795, Latreille correctly recognised their hemipterous nature and Westwood (1840) established the family name Aleyrodidae. The basis of the generic classification of the family was laid by Quaintance and Baker (1913, 1914).

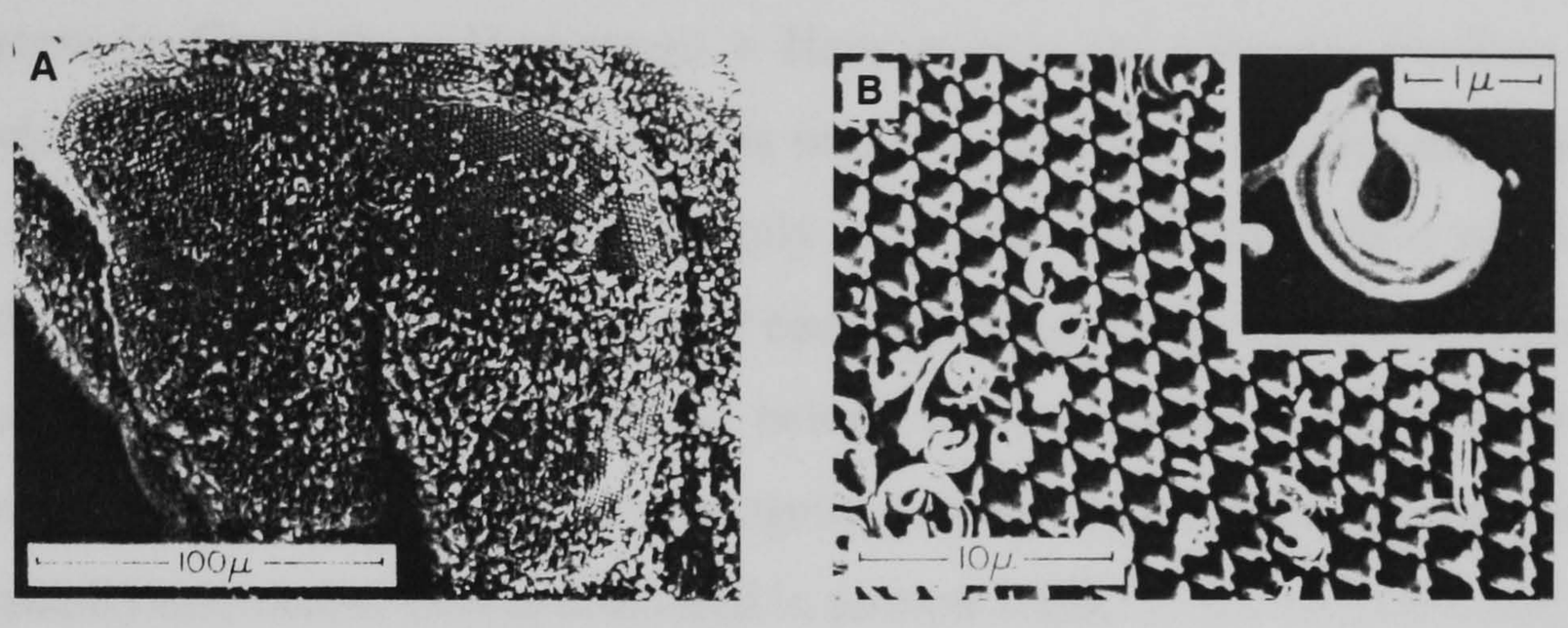

Fig. 1.1. A. Scanning electron micrograph of female *B. tabaci* abdominal wax plate. B. Idem, higher magnification (inset depicts individual wax particle); from Byrne & Hadley, 1988.

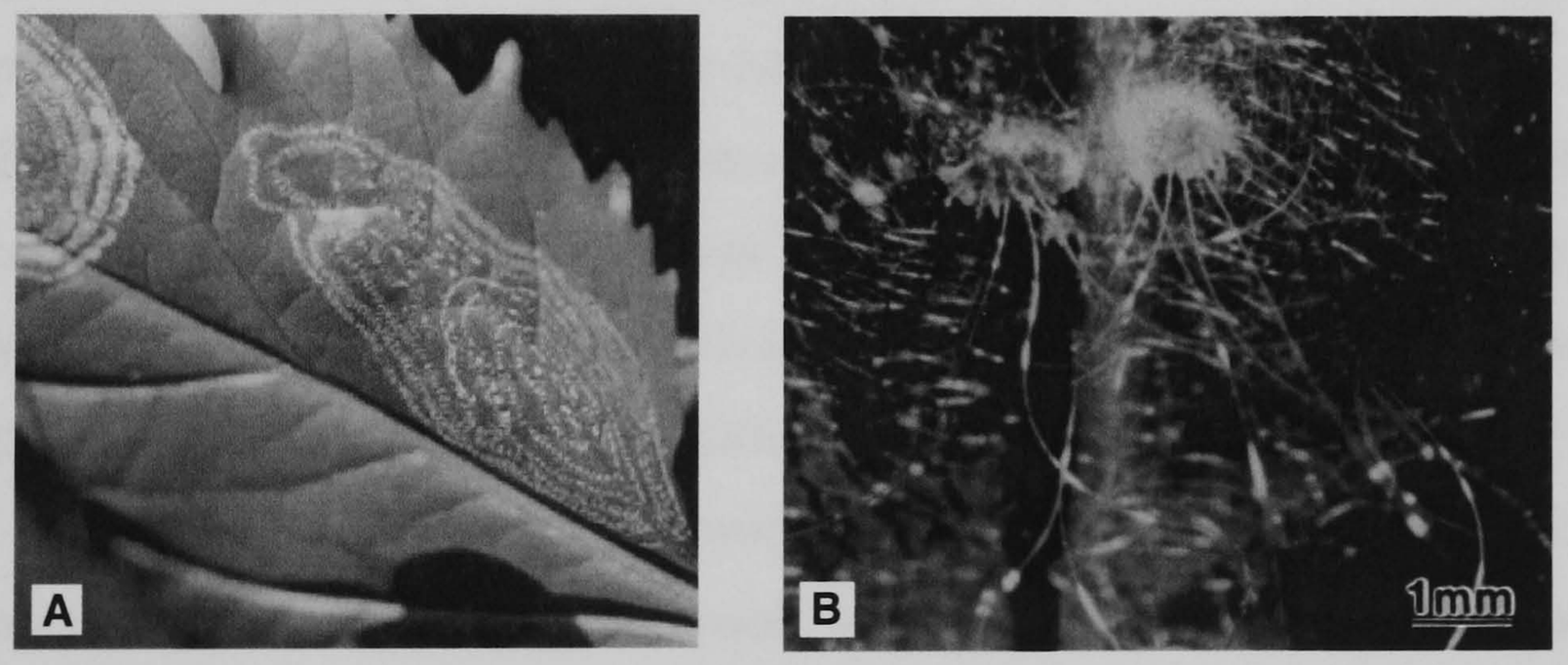

Fig. 1.2. A. Light microscope photograph of a spiral oviposition trail formed by the female *Aleurodicus dugesii* as she oviposites; from Nelson *et al.*, 1999. B. Microscopic view of external waxy filaments of fourth instar nymphs *A. dugesii* showing individual filaments; from Nelson *et al.*, 2000.

Whiteflies belong to the order Hemiptera, suborder Sternorrhyncha[1] and superfamily Aleyrodoidea (Martin *et al.*, 2000), however, there is little further agreement about their classification. For example, according to Borror *et al.* (1989), they belong to the order Homoptera; based on the recent classification proposed by Shcherbakov and Popov (2002), they belong to the superorder Cimicidea, order Hemiptera (= Cimicida = Homoptera + Heteroptera) and suborder Psyllina. In the latter classification, Sternorrhyncha splits into two suborders, Psyllina and Aphidina. These different classifications differ mainly in whether the Hemiptera is split into the suborders Homoptera and Heteroptera or each treated as a separate order. Aleyrodidae were almost universally considered to belong to Homoptera: Sternorrhyncha until relatively recently when molecular phylogeny showed "Homoptera" unequivocally to be a paraphyletic taxon. This is discussed in section 1.1.5.

The Aleyrodoidea includes the single family, Aleyrodidae, and is supported by the following synapomorphies: "fore wing with RS concave, M reduced, both CuA and 1A+2A simple; fore- and hind wing uncoupled in flight; metathorax enlarged; tibiae with setal rows used for wax distribution; abdomen petiolate, desclerotised, with spiracles reduced up to 2 pairs; ovipositor lacking sheath; anal tube transformed into operculum bearing lingula" (Shcherbakov & Popov, 2002).

Five extant subfamilies have been established at various times within the Aleyrodidae, of which only two are now considered valid: the Aleurodicinae, found mainly in Central and South America, and the Aleyrodinae, which are more widespread (Mound & Halsey, 1978; Gill, 1990). The latter has been divided into 13 tribes: Aleurocanthini Takahashi, Aleurochitonini Sampson, Aleurolobini Takahashi, Aleuroplatini David, Aleyrodini Sampson, Bemisini David, Dialeurodini Sampson, Lipaleyrodini David, Neomaskellini Sampson, Siphoninini Sampson, Tetraleurodini David, Trialeurodini Russell and Zaphanerini David (Sampson, 1943; Russell, 1947; Takahashi, 1954; David, 1990). A third subfamily, Udamoselinae, was suggested on the basis of a single specimen of a South American species, a male with a body length of 7 mm (Enderlein, 1909). Today the existence of the subfamily is thought to be dubious and the name is treated as *nomen dubium* (Mound & Halsey, 1978). However, Shcherbakov (2000) restored Udamoselinae in the broad sense (including

[1] The name "Sternorrhyncha" comes from the Greek *sternon* meaning chest or breast and *rhynchos* meaning nose, snout, or muzzle and refers to the ventral location of the mouthparts (between the bases of the front legs) of these insects.

Aleurodicinae). The type genera of the fourth and fifth subfamilies, Uraleyrodinae and Siphonaleyrodinae, i.e. *Uraleyrodes* Sampson & Drews and *Siphonaleyrodes* Takahashi, were synonymized with the aleyrodine genus *Aleurocerus* Bondar and the psyllid genus *Trioza* respectively (Mound & Halsey, 1978). These authors also synonymized Siphonaleyrodinae with Triozinae. Russell (2000) provides a more detailed account of the authorships of family group names in the Aleyrodidae, and on the validites of the names of the current subfamilies within the Aleyrodidae.

The basic morphological differences between pupae of the Aleyrodinae and Aleurodicinae are the frequent presence of compound/agglomerate pores on the dorsal disc, and the presence of a single claw at the apex of each leg in the Aleurodicinae. In the Aleyrodinae, the former character is absent and the legs end in a disc (adhesion pad) rather than a claw (Gill, 1990; Martin, 1999; Russell, 2000). Additionally, the number of lingular setae (usually four in the Aleurodicinae and two or none visible in the Aleyrodinae) has been used as a diagnostic character (Gill, 1990; Martin, 2000).

There are also major differences between the adults of the two subfamilies, in addition to the number of wax plates (which is an unreliable character) mentioned in section 1.1.3. In the Aleyrodinae, the tarsal "paronychium" - a process between the tarsal claw bases - is blade-like, whereas it is spine-like in the Aleurodicinae (Quaintance & Baker, 1913; Gill, 1990; Russell, 2000). It should be mentioned that the adults of the aleyrodine genus *Aleurocybotus* Quaintance & Baker have only one smooth, normal tarsal claw without a typical paronychium, and in place of a second claw there is a claw-shaped appendage which appears 'fleshy', has minute, scattered spinules, and a slender seta on its margin (Russell, 2000). If this structure represents the paronychium of other aleyrodids, it is remarkably modified from other known paronychia (Russell, 2000). Fore wing venation differences are presented in Table 1.1.

Table 1.1. Fore wing venation in the adult whiteflies of the Aleyrodinae and Aleurodicinae as proposed by different authors. C-Sc = Costa-Subcosta; Cu = Cubitus; M = Media; R_1 = Radius$_1$; R_S = Radial sector.

Reference	Subfamily	Fore wing veins				
		C-Sc	R_1	R_S	M	Cu
Gill, 1990:	Aleyrodinae	+	–/usually very short	+	–	occasionally present
	Aleurodicinae	+	+	+	+	usually present
Q. & B.*, 1913:	Aleyrodinae	+	–/+	+	–	+
	Aleurodicinae	+	–/+	+	+	–

* Quaintance & Baker

1.1.5. Origin

The paraphyletic nature of Homoptera (including Sternorrhyncha and Auchenorrhyncha) is now widely acknowledged (Wheeler *et al.*, 1993; Campbell *et al.*, 1994, 1995b; Sorensen *et al.*, 1995; von Dohlen & Moran, 1995). Efforts to determine the phylogenetic origin of whiteflies have been impeded by gaps in the fossil record of Hemiptera in general, and a paucity of fossil whiteflies in particular (Campbell *et al.*, 1994). Because of their size and fragility, adult aleyrodids would not be expected to be preserved as impression fossils often, and still less, their larvae (Evans, 1963). The additional possibility that they arose in tropical latitudes may also account for their absence in fossil deposits now located in northern latitudes, where fossils of aphids are found (Shcherbakov & Wegierek, 1991). The oldest known fossil whiteflies, *Juleyrodes gilli* Shcherbakov and *J. visnyai* Shcherbakov, belong to the extinct subfamily Bernaeinae, and are from the Late Jurassic or Early Cretaceous (more than 140 million years ago) (Shcherbakov, 2000).

Based on the phylogenetic analysis of 18S rDNA nucleotide sequences of hemipteran exemplars, the Sternorrhyncha appears to be a monophyletic clade, which forms a sister group to all other hemipterans (the Euhemiptera, including Auchenorrhyncha and Heteroptera) (Campbell *et al.*, 1994, 1995a, 1995b; von Dohlen & Moran, 1995). These molecular findings support several morphologically based cladistic inferences about paraphyly of Homoptera (e.g. Kristensen, 1975; Hennig, 1981; Popov, 1981; Wootton & Betts, 1986; Zrzavy, 1992). However, relationships within the Sternorrhyncha (which includes psyllids, whiteflies, aphids and scales) are controversial with molecular and morphological data supporting different scenarios. Based upon the same molecular evidence, whiteflies form a sister group to aphids and scales, while psyllids form a sister group to all other Sternorrhyncha (Campbell *et al.*, 1994, 1995a). However, some morphological evidence supports a sister-group relationship between whiteflies and psyllids (e.g. Quaintance & Baker, 1913; Goodchild, 1966; Szelegiewicz, 1971; Hennig, 1981; Carver *et al.*, 1991; Shcherbakov, 2000; Shcherbakov & Popov, 2002), though Evans' (1963) morphologically based conclusions are more in agreement with the available molecular studies. Furthermore, some molecular studies focused on the endosymbionts of sternorrhynchans, mainly concur with the morphological evidence. The analysis of 16S rDNA sequences of primary bacterial endosymbionts supports a

sister relationship between primary endosymbionts of psyllids and whiteflies (Spaulding & von Dohlen, 1998, 2001).

The molecular genetics of insect endosymbionts suggests that several independent lineages of intracellular bacteria have followed similar paths of evolution and for several insect taxa, there is a pattern of congruent host and primary bacterial endosymbiont phylogenies (Moran & Telang, 1998). These support the idea that extant associations arose from a single infection of the common host ancestor followed by vertical transmission of symbionts and parallel diversification of insect and bacterial lineages (Munson *et al.*, 1991; Moran *et al.*, 1993; Moran & Telang, 1998). In the same way, because most extant sternorrhynchans feed on phloem sap, it is plausible to hypothesize that their common ancestor was a phloem-feeder and had endosymbionts to supplement its diet (Spaulding & von Dohlen, 1998).

1.2. Whitefly parasitoids

Most of the natural enemies of the whiteflies are parasitoid wasps, whose taxonomy has not yet been adequately studied, i.e. it is often extremely difficult to identify them. The whiteflies' parasitoid complex is represented mainly by hymenopteran parasitoids of the Aphelinidae, Eulophidae, Platygasteridae and occasionally Encyrtidae, Pteromalidae and Signiphoridae, of which the Aphelinidae provides most of the biocontrol agents (Khan & Shafee, 1980a; Viggiani & Mazzone, 1982; Huldén, 1986; Hayat, 1989; Polaszek *et al.*, 1992, 1999; LaSalle & Schauff, 1994; LaSalle *et al.*, 1997; Evans & Polaszek, 1998; Huang & Polaszek, 1998; Bailey *et al.*, 2001; Hansson & LaSalle, 2003; Hernández-Suárez *et al.*, 2003).

1.2.1. Aphelinidae

Aphelinidae consists of about 1171 species in 33 genera (Noyes, 2001). The family is cosmopolitan and members are solitary or gregarious, endophagous or ectophagous koinobionts (Gibson *et al.*, 1999). Most genera are parasitoids or hyperparasitoids of immature and adult sternorrynchous Hemiptera (aphids, whiteflies and scale insects), but species of a few genera (e. g., *Ablerus* Howard, *Centrodora* Förster, *Encarsia* Förster) are known to parasitize the eggs or immature stages of Orthoptera, Coleoptera, Heteroptera, Diptera, Hymenoptera, and Lepidoptera (Yasnosh, 1979; Viggiani, 1984; Polaszek, 1991; Hunter *et al.*, 1996).

Aphelinidae are very unusual in that the males and females may have different ontogenies. Walter (1983) termed such divergent ontogeny, heteronomy, and also proposed a simplified classification of the different types of divergent male ontogenies found in the Aphelinidae. According to Walter's classification, the three principal types of heteronomous parasitoids are: (1) diphagous parasitoids, (2) heterotrophic parasitoids, and (3) heteronomous hyperparasitoids.

In diphagous parasitoids, females and males are both primary parasitoids of sternorrynchous Hemiptera, but the site of feeding differs; female larvae are endoparasitic whereas male larvae are ectoparasitic. Diphagous biologies appear to occur only in the genus *Coccophagus* Westwood (Hunter & Woolley, 2001), e.g. *C. bartletti* Annecke & Insley (Walter, 1986, 1993) and *C. hemera* (Walker) (Flanders, 1959).

In heterotrophic parasitoids, females develop as endoparasitoids of whiteflies and males develop as primary endoparasitoids in the eggs of Lepidoptera. This means that mated females may have to search for two completely different host types, which may occupy different (micro)habitats, though probably the Lepidoptera they attack are on the same host plant. To date, the heterotrophic biology is known only from two closely related species of *Encarsia*, i.e. *E. porteri* (Mercet) and in an undescribed North American species (Williams & Polaszek, 1996).

In heteronomous hyperparasitoids, females are primary endoparasitoids of hemipterous hosts but males develop hyperparasitically on other endoparasitoids, in particular, aphelinids, encyrtids, and eulophids larvae or pupae. Walter (1983) proposed that the group be divided into three subgroups: (i) obligate autoparasitoids, in which males always develop on conspecific individuals of either sex, (ii) facultative autoparasitoids, in which males develop on other species as well as conspecifics, and (iii) alloparasitoids, in which males always develop on non-conspecifics. The usefulness of these subdivisions was later questioned by Williams and Polaszek (1996) and these authors recommend heteronomous hyperparasitoids be viewed as a unified group defined by hyperparasitic male development. Hunter and Woolley (2001), however, retained the term "alloparasitoid" and proposed that the two subcategories, "obligate autoparasitoids" and "facultative autoparasitoids", be collapsed to one, viz. "autoparasitoids". Species from any of these subcategories may be either direct or indirect heteronomous hyperparasitoid (Walter, 1983). In direct

heteronomous hyperparasitoids, the male egg may be laid directly in or on the parasitoid host, but in indirect heteronomous hyperparasitoid the male egg is laid in a hemipteran host in anticipation of future parasitism by a suitable primary endoparasitoid (Williams & Polaszek, 1996; Hunter & Woolley, 2001). Direct heteronomous hyperparasitoids may be endophagous or ectophagous, whereas indirect heteronomous hyperparasitoids are ectophagous in their behaviour (Walter, 1983).

1.2.2. Classification of Aphelinidae

At least eleven different systems of aphelinid classification have been proposed (Ashmead, 1904a; De Santis, 1946; Erdös, 1964; Ferrière, 1965; Nikol'skaya & Yasnosh, 1966; Yasnosh, 1976; Shafee & Khan, 1978; Khan & Shafee, 1980b; Hayat, 1985, 1994, 1998; Shafee & Rizvi, 1990). In earlier classifications (e.g. Ashmead, 1904a; Howard, 1907), two basic groups, either as subfamilies, tribes or subtribes, were identified: the Aphelininae based on 5-segmented mesotarsi and the Pteroptricinae based on 4-segmented mesotarsi. This classification, however, is clearly artificial because even the same genus (e.g. *Encarsia*) can have members with four or five mesotarsal segments (Gibson *et al.*, 1999). Based upon the latest system proposed by Hayat (1998), the Aphelinidae consists of six subfamilies and eight tribes: 1. Aphelininae (I. Aphelinini, II. Aphytini, III. Eutrichosomellini, IV. Eretmocerini), 2. Eriaphytinae, 3. Azotinae, 4. Coccophaginae (I. Euxanthellini, II. Coccophagini, III. Pteroptricini, IV. Physcini), 5. Euryischiinae, and 6. Eriaporinae. The tribe Eretmocerini and subfamilies Euryischiinae and Eriaporinae were all considered as *incertae sedis*.

Various workers have suggested that Aphelinidae is paraphyletic with respect to either Signiphoridae or Trichogrammatidae (Gibson *et al.*, 1999). Based upon morphological phylogenetic analysis, Signiphoridae and Aphelinidae (excluding Eriaporinae) are sister groups, and the Eriaporinae is at most the sister group to Signiphoridae + Aphelinidae (Gibson, 1989). Furthermore, Yousuf & Shafee (1988) proposed affinities between *Eretmocerus* Haldeman (Eretmocerini; see above) and Trichogrammatidae, which was partly supported by Heraty *et al.*'s (1997) findings. According to the latter authors, *Cales* Howard[1], *Eretmocerus* and Trichogrammatidae

[1] *Cales* has most often been placed in Aphelinidae in the subfamily Calesinae (see above references). It is presently considered as *incertae sedis*.

have a similar mesofurca that is distinct from the other Chalcidoidea. Molecular evidence (28s rDNA sequences) supports the relationship of Trichogrammatidae with *Eretmocerus*, but not with *Cales* (Campbell *et al.*, 2000).

Amongst the genera of the family Aphelinidae, *Encarsia* is one of the most important biocontrol agents of whiteflies.

1.2.3. Genus *Encarsia*

Species of *Encarsia* are economically important for the biological control of whitefly and armoured scale pests (Hemiptera: Diaspididae). *Encarsia* is a diverse, cosmopolitan group of species and also a large genus in terms of the number of species, which currently contains about 280 described species (Polaszek *et al.*, 1999; Noyes, 2001). *Encarsia* species are being exploited in biological control programmes and several species, such as *E. perniciosi* (Tower), *E. formosa* Gahan and *E. inaron* (Walker), have demonstrated their importance for control of San Jose scale, *Quadraspidiotus perniciosus* (Comstock), greenhouse whitefly, *T. vaporariorum*, and ash whitefly, *Siphoninus phillyreae* (Haliday) respectively (Heraty, 2001).

According to Hayat's (1998) classification, *Encarsia* belongs to the subfamily Coccophaginae and the tribe Pteroptricini. The Coccophaginae (Coccophagini, Pteroptricini and *Euxanthellus* Silvestri) were regarded as monophyletic based on characters of the mesofurca (Heraty *et al.*, 1997).

Before the 1970's, many species now assigned to *Encarsia* were allocated to *Prospaltella* Ashmead, and *Aspidiotiphagus* Howard. *Encarsia* were considered to be whitefly parasites, whereas *Aspidiotiphagus* and *Prospaltella* were considered to be armoured scale parasites (Babcock *et al.*, 2001). Viggiani and Mazzone (1979) synonomized all of these genera under *Encarsia*. The synonymy of *Aspidiotiphagus* was disputed, and in addition to reinstating the genus, a new genus, *Aleurodiphilus* DeBach & Rose, was erected to accommodate similar species attacking whiteflies which shared a narrow fore wing with a distinct glabrous patch (DeBach & Rose, 1981). Hayat (1983) later synonymized these genera with *Encarsia*.

Species of *Encarsia* are endoparasites, with one potential case of ectoparasitism known for both sexes of *E. ectophaga* (Silvestri) on armoured scales (Hunter & Woolley, 2001; Heraty *et al.*, in press). Most *Encarsia* are autoparasitoids, with females eggs deposited on a primary host and male eggs deposited as parasites of the

same or other species of *Encarsia*. However, males and females of *E. inaron* and *E. longicornis* Mercet are both primary parasitoids of whiteflies, and in some species males develop as primary parasites of lepidopteran eggs (Walter, 1983; Viggiani, 1984; Polaszek, 1991; Williams & Polaszek, 1996; Hunter & Woolley, 2001; Heraty *et al.*, in press). It is interesting that all of the taxa known to have heteronomous biologies are members of the Coccophaginae and that, with few exceptions, all taxa of Coccophaginae for which both males and biologies are known are heteronomous (Hunter & Woolley, 2001). In general, *Encarsia* show a relatively high degree of host specificity. Of the species with known host associations, 119 have been reared from a single host and 72 from multiple hosts, and of these, 22 species have been reared from more than five host genera (Heraty *et al.*, in press).

Analysis of morphological characters has led to differing opinions concerning the relationships, composition and placement of species into species-groups (Hayat, 1998; Huang & Polaszek, 1998). Beyond morphology, molecular systematics offers a new character system and provides novel ways to separate closely related species. The analysis of nucleotide sequence data provides an opportunity to assess relationships and test the validity of morphological features currently used for placing species of *Encarsia* into groups. Preliminary results using molecular techniques to determine closely related species and phylogenetic relationships in *Encarsia* (Babcock & Heraty, 2000; Babcock *et al.*, 2001; Manzari *et al.*, 2002) have been very satisfactory.

In the present study, the current classification of the Aleyrodinae is evaluated with the benefit of modern phylogenetic approaches. The current tribal level classification proposed for this subfamily is reassessed, and co-phylogeny of aleyrodines with their host plants is discussed in relation to the phylogenetic trees obtained. Furthermore, some taxonomic problems in the parasitoids belonging to the *Encarsia inaron* and *E. luteola* species-groups are addressed using molecular and morphometric techniques, as well as the relationship between whiteflies and their parasitoids from different *Encarsia* species groups.

2

A cladistic analysis of the subfamily Aleyrodinae (Hemiptera: Sternorrhyncha: Aleyrodidae)*

2.1. Abstract

Phylogenetic relationships of the members of Aleyrodinae based on a cladistic analysis of 94 (70 binary and 24 multistate) morphological characters derived from the pupal case are presented. This is the first attempt to construct a phylogenetic classification at genus level on a world basis for the subfamily Aleyrodinae. More than 430 species, about one third of all described species, were examined. These belonged to 124 genera, of which 117 were aleyrodines (including two undescribed genera) and seven were out-groups from the subfamily Aleurodicinae (Hemiptera: Aleyrodidae). Maximum parsimony analysis yielded more than thirty thousand most-parsimonious trees (length = 2730, RI = 0.672, CI = 0.137). Based upon the strict consensus tree, only 33 of the currently accepted genera, for which I had multiple representatives, were found to be monophyletic (44 genera of the 117 examined genera were monobasic and/or only one species was available for study). Monophyly of some economically important genera, e.g. *Aleurolobus*, *Bemisia*, and *Dialeurodes*, as well as that of most previously proposed tribes, were not found to be supported. No parallel diversification of whiteflies with host plants was found, mostly because of within-species host switching. The problems in determining generic level characters and applicability of tribal classification for this subfamily are discussed. One new genus, *Pseudozaphanera* Manzari **gen. n.**, and seven new combinations, *Aleuroclava lanceolata* (Takahashi) **comb. n.**, *Crescentaleyrodes fumipennis* (Hempel) **comb. n.**, *Pseudozaphanera niger* (Maskell) **comb. n.**, *Pseudozaphanera papyrocarpae* (Martin) **comb. n.**, *Pseudozaphanera rhachisreticulata* (Martin) **comb. n.**, *Pseudozaphanera splendida* (Martin) **comb. n.**, *Pseudozaphanera wariensis* (Martin) **comb. n.**, are proposed as well as three new generic synonyms; *Taiwanaleyrodes* Takahashi is placed in synonymy with *Aleuroclava* Singh **syn. n.**, *Hempelia* Sampson

* Submitted to *Zoological Journal of the Linnean Society* as Manzari, S., Polaszek, A. & Quicke, D.L.J. (200*) A cladistic analysis of the subfamily Aleyrodinae (Hemiptera: Sternorrhyncha: Aleyrodidae). Reprinted here with minor alterations.

& Drews with *Aleurothrixus* Quaintance & Baker **syn. n.** and *Rositaleyrodes* Meganathan & David with *Aleurolobus* Quaintance & Baker **syn. n.**

2.2. Introduction

Many whiteflies are agricultural pests especially in the tropics and subtropics (Calvert *et al.*, 2001). Feeding activity damages their host plants and some species are known to transmit diseases, especially those caused by viruses (Gullan & Martin, 2003). In spite of this the family is poorly studied taxonomically, particularly in a phylogenetic context. Almost all publications dealing with whitefly taxonomy are restricted to alpha taxonomy. Major publications provide lists of species and descriptions of new species and/or the genera, mostly with a restricted geographical compass (e.g. Singh, 1931; Takahashi, 1932, 1933, 1934, 1935; Corbett, 1935; Russell, 1947, 1948; Mound, 1965, 1966; Cohic, 1966a, 1966b; David & Subramaniam, 1976; Bink-Moenen, 1983; Martin, 1985, 1988, 1999; Jesudasan & David, 1991). Apart from a few genealogical diagrams proposed (e.g. Quaintance & Baker (1913) (fig. 2.1); Bondar, 1923), the first attempt to construct a phylogenetic classification for whiteflies using morphological characters was made by Jensen (1999) for the species of *Dialeurodes* Cockerell. In Jensen's article, alternative generic names were not proposed despite the fact that his results showed the genus to be paraphyletic with respect to several others. Subsequently, Jensen (2001) proposed the use of three pre-existing generic names, *Dialeurodes*, *Massilieurodes* Goux and *Singhiella* Sampson, for many of the *Dialeurodes* of the world based on the placement of the type-species of these genera in the cladograms or based on the examination of original descriptions.

The application of molecular techniques such as DNA nucleotide sequencing for whitefly taxonomy has mainly been restricted to determining the biotypes of a few economically important species, especially *Bemisia tabaci* (Gennadius), and phylogenetic relationships among them rather than building a phylogenetic classification (e.g. Campbell *et al.*, 1993; Perring *et al.*, 1993; Wool *et al.*, 1994; Guirao *et al.*, 1997; Frohlich *et al.*, 1999; Brown *et al.*, 2000; Cervera *et al.*, 2000; De Barro *et al.*, 2000; Lima *et al.*, 2000; Viscarret *et al.*, 2003; Wu *et al.*, 2003). Campbell *et al.* (1995a) presented a cladogram based on 18S rDNA sequences for 11 whitefly species belonging to 7 genera, of which 10 species were from the subfamily

Aleyrodinae and the last one from the Aleurodicinae. In this cladogram, the aleurodicine was sister to all aleyrodines, and among aleyrodines, members of the genus *Bemisia* Quaintance & Baker formed a sister clade to all other species.

The subfamily Aleyrodinae consists of more than 140 described genera, but their relationships are equivocal. At least half of these genera have not been placed in any tribe and there is also no consensus about the composition of tribes that have been proposed. For example, the well-known genus *Bemisia* has been placed in three different tribes, viz. Dialeurodini, Aleurolobini and Bemisini by Sampson (1943), Takahashi (1954) and David (1990) respectively (Appendix 1). Characters used previously to identify the tribes are shown in Appendix 2.

The present study is the first attempt to construct a phylogenetic classification at genus level for the Aleyrodinae on a world basis as well as testing the applicability of its tribe level classification. In order to avoid considering current described genera as monophyletic units, multiple representative species of each genera were selected where possible (obviously excepting monobasic genera) so as to represent a wide range of the morphological variation present, and these were treated separately in the analyses; making it possible to test the monophyly of genera and to evaluate the current whitefly classification.

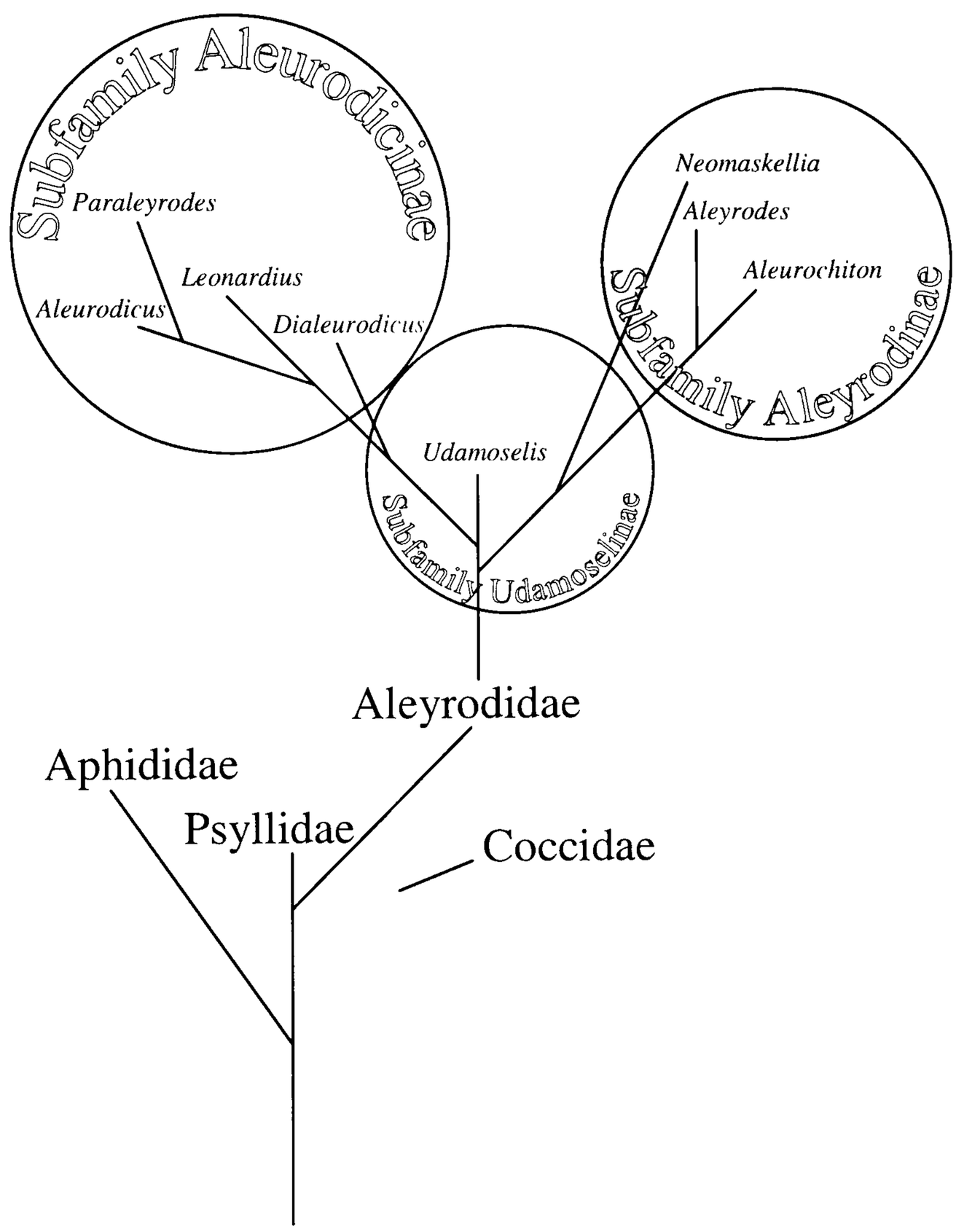

Fig. 2.1. Genealogical diagram of the Aleyrodidae; after Quaintance & Baker, 1913.

2.3. Materials and methods

In total, 439 whitefly species, about one third of all described species so far, were examined and used to define character systems. These comprised 124 genera, of which 117 were aleyrodines (including two undescribed genera mentioned as New genus 1 and New genus 2) and 7 were aleurodicines which were used as out-groups. All examined species were slide-mounted specimens and in most cases several specimens were studied for each species. Ninety-four morphological characters, 70 binary and 24 multistate, all of which were derived from the pupal case, were scored.

Choice of species examined was largely dictated by the material in the collection of The Natural History Museum, London (BMNH), which houses one the world's largest collections of whiteflies, and includes almost all described genera. Additional material was borrowed from the United States Department of Agriculture, Beltsville, Maryland, USA (Sternorrhyncha collections of the United States National Museum of Natural History, Washington DC) (USNM).

No specimens were available for the following 25 small genera (nearly all of which are monobasic): *Aleuroporosus* Corbett, *Anomaleyrodes* Takahashi & Mamet, *Axacalia* Danzig, *Dialeurotrachelus* Takahashi, *Dothioia* Dumbleton[1], *Hesperaleyrodes* Sampson, *Hindaleyrodes* Meganathan & David, *Juglasaleyrodes* Cohic, *Keralaleyrodes* Meganathan & David, *Lankaleurodes* David, *Luederwaldtiana* Hempel, *Metaleyrodes* Sampson, *Mexicaleyrodes* Sampson & Drews, *Mohanasundaramiella* David, *Nealeyrodes* Hempel, *Neoaleurodes* Bondar[2], *Neoaleurolobus* Takahashi, *Plataleyrodes* Takahashi & Mamet, *Pseudaleurolobus* Hempel, *Pseudaleyrodes* Hempel, *Rosanovia* Danzig, *Shanthiniae* David, *Trichoaleyrodes* Takahashi & Mamet, *Vasantharajiella* David, and *Xenobemisia* Takahashi. The monobasic genus *Laingiella* Corbett was erected by Corbett (1926) to accommodate specimens collected on bamboo. The syntype specimens of *L. bambusae* Corbett have been deposited in the USNM and BMNH (Mound & Halsey, 1978). Those in the USNM were not examined but all syntypes in the BMNH were third instar larvae and agreed with its original description (one syntype lacked its ventral surface, so there was no way to determine whether it was a third instar larva or a pupal case). Most probably therefore, the genus was described based on the

[1] The paratype puparium in the BMNH was entirely black (i.e. unbleached) and no characters recognisable.
[2] All five specimens on the *Neoaleurodes* slide from USNM were constricted and not cleared.

characters of third instar larvae and for this reason it was omitted from the analysis. The genera and species included in the cladistic analysis are given in Appendix 3.

The characters scored include nearly all those used to describe new genera/species in the literature. Different minor ornamentations of pupal cases of some species, which were almost impossible to code consistently for all taxa, were not included. Although some character states are somewhat subjective, I have attempted to make them as objective as possible in order to minimise miscoding of the characters used in this study.

Basic morphological terminology follows that of Russell (1943, 1947, 1948, 1965, 1986), Bink-Moenen (1983), Martin (1987) and Gill (1990). Figure 2.2 shows the stylized pupal case with major characters.

2.3.1. Characters and character coding using in the analysis

Pupal case

[1] Pupal case margin: (0) smooth (fig. 2.3A); (1) undulate and/or indistinctly indentate (fig. 2.3B); (2) distinctly toothed (figs 2.3C-L). Comments: in all cases, the word 'margin' is used to mean the real margin rather than the apparent margin, which may be submarginal in the case of marginal recurvature (see character 3). In other words, the real margin was used as a criterion to score the relevant characters.

[2] If pupal case margin distinctly toothed: (0) crenate (fig. 2.3C); (1) dentate (fig. 2.3D); (2) lobulate (fig. 2.3E); (3) truncate-lobulate (figs 2.3F,G); (4) serrate (fig. 2.3H); (5) each tooth with apical notch, which gives the teeth the appearance of being twinned and sometimes being triangular (figs 2.3I-K); (6) close-set lanceolate processes, each arising from a blunt marginal tooth (fig. 2.3L).

[3] Recurvature of margin: (0) margin not recurved; (1) margin partially recurved ventrally; (2) margin completely recurved ventrally. Comments: when the ventral surface of pupal case is much smaller than the dorsal surface the margin is evenly reflexed, a part of the submargin is recurved or the whole submargin is recurved. In some species the margin may easily be recurved by the mounting process and can cause misinterpretation when the character is coded.

Setae - spines

[4] Anterior marginal setae: (0) absent; (1) present (fig. 2.2).

[5] Posterior marginal setae: (0) absent; (1) present (fig. 2.2). Comments: although Bink-Moenen (1983) states they are probably always present, careful examination here at × 1000 shows they are completely absent in some cases.

[6] Cephalic setae: (0) absent; (1) present.

[7] Position of cephalic setae: (0) nearly above, lateral or anterior to mouthparts; (1) far removed from mouthparts toward the front, margin, or both.

[8] Mesothoracic setae: (0) absent; (1) present.

[9] Metathoracic setae: (0) absent; (1) present.

[10] First abdominal setae: (0) absent; (1) present.

[11] Position of first abdominal setae: (0) nearly above, lateral or anterior to hind legs; (1) distinctly mediad of hind legs. Comments: the presence of the first abdominal setae can be of taxonomic value at genus level but in some genera there is interspecific variation (Bink-Moenen 1983). In the literature, the term 1st abdominal "pseudosetae" is sometimes used for 1st abdominal setae when they are thickened, their bases submedial and often close-set (e.g. Martin, 1999 for the genus *Aleuroduplidens* Martin). Their function then seems to be to keep the third-instar exuviae attached to the pupal case. Such setae are not always considered as 1st abdominal setae, e.g. for *Aleurocanthus* Quaintance & Baker, Bink-Moenen (1983) stated that "1st abdominal setae absent" but Martin (1999) stated "1st abdominal setae present but usually thickened, sometimes similar to glandular spines". In this study these setae were accepted as 1st abdominal setae and mostly separated from the normal ones based on their position on the 1st abdominal segment.

[12] Eighth abdominal setae: (0) absent; (1) present.

[13] Position of eighth abdominal setae: (0) at the base of anterior margin and/or lateral to vasiform orifice (fig. 2.4A); (1) anterolateral to vasiform orifice (fig. 2.4B); (2) anterior to vasiform orifice (fig. 2.4C).

[14] Caudal setae: (0) absent; (1) present.

[15] Position of caudal setae: (0) close to margin; (1) on about half way from the posterior end of vasiform orifice to margin; (2) close to vasiform orifice.

[16] Length of caudal setae: (0) distinctly shorter than vasiform orifice; (1) approximately as long as vasiform orifice; (2) distinctly longer than vasiform orifice. Comments: the length of caudal setae shows both interspecific and intraspecific variation in relation to the vasiform orifice, but appears to be fixed for the species of some genera.

[17] Submarginal setae (excluding those in character 14): (0) absent; (1) present.

[18] Submarginal setae (excluding those in character 14): (0) hair-like, short or long (fig. 2.5A); (1) stout, apical acute and/or rounded, short or long (fig. 2.5B); (2) somewhat swollen at base and pointed apically (lanceolate) (fig. 2.5C); (3) capitate (fig. 2.5D); (4) apical bended (fig. 2.5E); (5) laciniate (fig. 2.5F); (6) almost T-shaped (fig. 2.5H); (7) almost arrow-shaped (fig. 2.5I). Comments: see the comments for character 20.

[19] Setae of dorsal disc area (except those in characters 6, 8, 9, 10 and 12): (0) absent; (1) present.

[20] Setae of dorsal disc area (except those in characters 6, 8, 9, 10 and 12): (0) hair-like, short or long (fig. 2.5A); (1) stout, apical acute and/or rounded, short or long (fig. 2.5B); (2) somewhat swollen at base and pointed apically (lanceolate) (fig. 2.5C); (3) capitate (fig. 2.5D); (4) apical bended (fig. 2.5E); (5) laciniate (fig. 2.5F); (6) very stout, apical truncate-capitate (fig. 2.5G); (7) almost T-shaped (fig. 2.5H); (8) almost arrow-shaped (fig. 2.5I). Comments: the length and position of setae as well as their number is variable within some species, e.g. *Aleurolobus gruveli* Cohic (Bink-Moenen, 1983). Except for a few genera, for which the position and number of setae are characteristic, e.g. *Corbettia* Dozier, their number and position have not usually been used as diagnostic characters at genus level (unlike for the aleurodicine genera). This is most probably due to variability so that even for a given number of setae for a species, it seems they are submarginal when small, but are located more subdorsally when they are enlarged. Therefore, the number of setae and their positions (except being on submargin or dorsal disc area) were not coded as separate characters. In the case of lack of submarginal line (see character 28), it is sometimes very difficult to assign setae as being submarginal or subdorsal when they are located far from the margin. In such cases, other features such as submarginal ridges radiating from the margin, colour differences or different ornamentations depending on

the examined taxa were used to help define the submarginal limit. It is worth mentioning that according to Bink-Moenen (1983), the division of the dorsal surface into submargin, subdorsum, submedian and median areas (the three latter areas all together is called dorsal disc area) is artificial, as can be seen from the variable position of some setae in many species. Even when the submargin is separated by a furrow the same setae may occur as often on the submargin as on the subdorsum.

[21] Submarginal spines: (0) absent; (1) present. Comments: there is almost no distinct boundary between setae and spines in some cases in the literature and the same feature has been defined as a seta and/or a spine by different authors. In general, if there is no circle at the base of this character indicating a socket, it is considered as a spine. The length, position and number of spines are variable as mentioned above for the setae.

[22] Submarginal spines: (0) stout and acute (fig. 2.5L); (1) stout and laciniate (fig. 2.5N); (2) tubiform (siphon-like) (fig. 2.5O).

[23] Spines of dorsal disc area: (0) absent; (1) present.

[24] Spines of dorsal disc area: (0) spines reduced to capitate seta-like structures (fig. 2.5K); (1) stout and acute (fig. 2.5L); (2) stout spines with a seta acutely pointed at the tip (fig. 2.5M); (3) stout and laciniate (fig. 2.5N); (4) tubiform (siphon-like) (fig. 2.5O).

Moulting sutures - major dorsal marking

[25] Transverse moulting suture: (0) not reaching margin of pupal case; (1) reaching margin of pupal case.

[26] Shape of transverse moulting suture: (0) like fig. 2.6A; (1) not bent near 90° in middle of each side (fig. 2.6B); (2) curves anteriorly at the junction of longitudinal moulting suture and posteriorly at the middle of each side (fig. 2.6C); (3) like fig. 2.6D; (4) each side curves anteriorly (fig. 2.6E); (5) like fig. 2.6F; (6) like fig. 2.6G; (7) each side bends to anterior and meets in the midline (fig. 2.6H); (8) each side curves anteriorly in the form of a pear together with a pair of membranous furrows (fig. 2.6I); (9) each sides curves anteriorly in the form of an almost triangular together with a pair of membranous furrows (fig. 2.6J). Comments: the shape of transverse moulting suture is quite variable and

the 10 shapes chosen above were almost the main shapes and other intermediate states were assignable to one the main ones.

[27] Longitudinal moulting suture: (0) not reaching margin of pupal case; (1) reaching margin of pupal case. Comments: only in one species studied, *Viennotaleyrodes curvisetosus* Martin, the longitudinal moulting suture was absent. For this species the character was coded as a question mark similar to those few species that the distal extremity of the suture was not clearly discernible due to slide quality.

[28] Submarginal line or fold, which separates submargin from the dorsal disc area: (0) absent; (1) present.

[29] If submarginal line or fold present: (0) parallel and longitudinal or almost bracket-shaped, not meeting at both anterior and posterior; (1) not parallel and longitudinal, meeting at both anterior and posterior, concentric with margin or nearly so; (2) like state 1, but with breaks at eyespot regions; (3) like state 1, but interrupted at caudal area; (4) like state 1, but with breaks at eyespot regions and interrupted at caudal area. Comments: in the literature, the shape of submarginal line or fold has sometimes been cited but almost never with clear diagnostic states separated or compared between taxa.

[30] Extra submarginal lines encircling the pupal case: (0) absent; (1) present.

[31] Longitudinal subdorsal furrow: (0) absent; (1) present.

[32] Subdorsal line, which separates subdorsal area from submedian area: (0) absent; (1) present.

[33] Cephalothoracic fold: (0) absent; (1) present. Comments: in some species, e.g. *Cockerelliella psidii* (Corbett), the cephalothoracic fold joins to the distal extremities of the transverse and longitudinal moulting sutures and forms a "trapdoor". This feature is similar to character 26, state 7 but in the latter, each side of the transverse moulting suture curves anteriorly and is connected with the longitudinal moulting suture.

Vasiform orifice

[34] Vasiform orifice shape: (0) semicircular; (1) nearly circular (fig. 2.7A); (2) nearly triangular (figs 2.7E-J); (3) nearly tetrahedral (figs 2.7K-M); (4) oval, truncate at the top (scutellate) (fig. 2.7B); (5) subcordate (fig. 2.7C); (6)

transversely elliptical (fig. 2.7D). Comments: Maskell (1895) was the first to describe and name the vasiform orifice and its components the lingula, operculum and lingular setae. The shape of vasiform orifice is very variable and the same feature has been defined using different terms and/or short sentences by different authors. The shapes chosen in the characters 34-36 were the main shapes and other intermediate states were assignable to one of these states. The shape of vasiform orifice, at least in some cases, may be subjective but it has been used in many generic and species descriptions and so it has been included here and I have been as objective as possible in differentiating the states.

[35] If vasiform orifice nearly triangular: (0) triangular, straight-sided (fig. 2.7E); (1) cordate (fig. 2.7F); (2) triangular, not very elongate, emarginate-sided (fig. 2.7G); (3) elongate-triangular, straight-sided (fig. 2.7H); (4) elongate-cordate (fig. 2.7I); (5) elongate-triangular, sinuous-sided (fig. 2.7J).

[36] If vasiform orifice nearly tetrahedral: (0) squarish (fig. 2.7K); (1) rectangular (fig. 2.7L); (2) nearly trapezoidal (fig. 2.7M).

[37] Vasiform orifice: (0) not elevated; (1) elevated. Comments: although in some genera e.g. *Aleurocanthus* this character is easily recognisable, but it is sometimes less obvious. For example, for the genus *Siphoninus* Silvestri, Martin (1999) stated that "vasiform orifice not elevated", which is the opposite of what Bink-Moenen (1983) stated, i.e. "vasiform orifice elevated". The latter author defined two major types of vasiform orifice: "open" vasiform orifice and "elevated" vasiform orifice. To recognize the latter type she stated that "the elevated vasiform orifice is situated on an elevation; its margin is often surrounded by a sclerotized ring; caudal furrow and ridges are absent". In this study, it has been found that the absence of caudal furrow and ridges is not always true and in some species for example, in *Dialeurolonga elongata* Dozier and *Zaphanera papyrocarpae* Martin, the vasiform orifice is elevated and the caudal furrow and ridges are present. Elevation of the vasiform orifice is probably not generically important but is important at the species level (J.H. Martin, BMNH, personal communication).

[38] Vasiform orifice inner margin teeth (carinae): (0) absent; (1) present.

[39] Vasiform orifice posterior notch: (0) absent; (1) present. Comments: although the shape of notch also shows variation, this variation appears to be continuous

rather than discrete. As far it is known from the literature, with the exception of Jensen's articles (1999, 2001), the shape of vasiform orifice notch has never been used as a diagnostic character, at least at genus level.

[40] Position of vasiform orifice: (0) inset from posterior margin of pupal case by less than its own length; (1) inset from posterior margin of pupal case by about its own length; (2) inset from posterior margin of pupal case by distinctly more than its own length (sometimes two or more times).

[41] Operculum size: (0) occupying about 0.25 of orifice; (1) occupying about 0.5 of orifice; (2) occupying about 0.75 of orifice; (3) occupying about whole of orifice. Comments: there are two types of vasiform orifice: the orifice is nearly or completely filled by the operculum and the lingula is normally not visible in dorsal view, and in the other type, the operculum dose not fill the posterior part of the orifice and the lingula is usually visible (Gill, 1990). Here these two main states were divided into four states so as to cover all those used by various authors in generic and/or species descriptions to date.

[42] Operculum shape: (0) transversely elliptical (fig. 2.8A); (1) nearly trapezoidal, rounded at angles (fig. 2.8B); (2) nearly rectangular, wide about twice as long as length, posterior angles toothed and/or slightly indentate (fig. 2.8C); (3) subcordate (fig. 2.8D); (4) semicircular (fig. 2.8E); (5) rectangular, convex-sided, hind margin straight and/or slightly curving anteriorly (fig. 2.8F); (6) rectangular, convex-sided, hind margin with a wide projection (fig. 2.8G); (7) cordate or slightly elongate-cordate (fig. 2.8H); (8) rectangular shaped pushed inward at posterior margin (fig. 2.8I); (9) squarish, convex-sided, narrowed posteriorly (fig. 2.8J). Comments: as with the vasiform orifice, the shape of the operculum is also variable and the same feature has been defined using different terms and/or short sentences used by different authors (see comments for the character 34). This character has not been used as frequently as the shape of vasiform orifice in species or generic descriptions.

[43] Opercular setae: (0) absent at posterior margin of the operculum; (1) present at posterior margin of the operculum (two setae).

[44] Head of lingula: (0) completely obscured by opaque operculum, not visible; (1) completely obscured by transparent operculum, visible; (2) incompletely obscured by operculum, partly visible; (3) not obscured by operculum.

[45] Head of lingula: (0) elongate (figs 2.9H-J); (1) not elongate (figs 2.9A-G, K).

[46] If head of lingula elongate: (0) lanceolate (fig. 2.9H); (1) cylindrical, rounded posteriorly (fig. 2.9I); (2) large and almost conical (fig. 2.9J).

[47] If head of lingula not elongate: (0) blunt apex exposed; (1) expanded apically (fig. 2.9B); (2) spatulate, sometimes nearly triangular (fig. 2.9G); (3) forked-shaped (fig. 2.9D); (4) lobular (fig. 2.9E); (5) large and tongue-shaped (fig. 2.9K); (6) bilobate (fig. 2.9C); (7) knobbed (fig. 2.9A); (8) transversely elliptical (fig. 2.9F). Comments: the same as for the vasiform orifice and operculum but the character shows some discrete states (e.g. states 3 and 6).

[48] Lingula: (0) not extending beyond posterior margin of vasiform orifice; (1) extending beyond posterior margin of vasiform orifice. Comments: sometimes the lingula may be protruded by the mounting process and can cause misinterpretation this character. It should be noted that in some species the length of lingula is longer than vasiform orifice but it folds inside the orifice. In order to avoid any error in determining its true length in such species, the normal state of lingula was chosen, i.e. the character was coded as having the first state (not extending beyond posterior margin of vasiform orifice).

[49] Lingular setae: (0) absent or not apparent; (1) present.

[50] Number of lingular setae: (0) two (if two more setae are present, these are minute and often visible only at 1000 magnification of a light microscope); (1) four. Comments: the lingula is usually spinulose and the number of conspicuous setae generally varies from without any seta to having four setae. In the Aleurodicinae, some of whose members were used as out-groups, the lingula almost always has four conspicuous setae. In the Aleyrodinae only two apical setae have usually been mentioned in original descriptions. Russell (1947) was the first to report the presence of two more small lateral lingular setae (for some species of Trialeurodini that she described as a new tribe including three genera (see Appendix 1)). In this study, examination of thousands specimens belonging to about one third of all described whitefly species at 1000 magnification indicates that with the exception of lack of lingular setae in some species, these two small lateral setae are also present in other genera and quite visible when the lingula is in a right position. It seems that they have been neglected, even by Russell in her other publications, because they are small and difficult to see at

least at × 400. However, since these two small lingular setae somehow differ from those of the Aleurodicinae, the character was included here.

Tracheal pores - tracheal folds

[51] Thoracic tracheal pores: (0) no discernible pore; (1) not forming a distinct pore, margin slightly curved inwardly/outwardly or thickened (fig. 2.10A); (2) somewhat invaginated and with slightly thickened cuticle (fig. 2.10B); (3) crenulated to a lesser degree than the rest of margin (fig. 2.10C); (4) in the form of a comb of modified teeth, sometimes only two or three teeth (figs 2.10D-F); (5) C-shape pore without teeth (figs 2.10G,H); (6) C-shape with teeth (figs 2.10I,J); (7) deeply emarginate and covered by a smooth rounded lobe (fig. 2.10K); (8) gland spines forming a comb (fig. 2.10L). Comments: each state shows variations even within some species, so for such a large-scale study it was almost impossible to score all numerous visible states that did not seem to be generic and even sometimes species level characters. The eight states coded are as objective as possible.

[52] Thoracic tracheal folds: (0) absent; (1) present. Comments: in some species tracheal folds are finely stippled or defined by microtubercles.

[53] Caudal tracheal fold: (0) absent; (1) present. Comments: the same as for the character 52.

[54] Secondary tracheal folds underline abdominal sutures III/IV: (0) absent; (1) present. Comments: this character was only observed in one monobasic genus, *Gagudjuia* Martin. In the future the character may be seen in other species, so it was added to the character system to help for further studies, though in this study it is parsimony-uninformative.

[55] Caudal furrow: (0) absent; (1) present.

[56] Caudal furrow: (0) narrow, half-width or less than half-width of vasiform orifice, sometimes suture-like; (1) wide at base (near vasiform orifice), the rest part narrow; (2) wide, more than half-width of vasiform orifice; (3) narrow at base, the rest part wide.

[57] Caudal ridges: (0) absent; (1) present.

Abdominal segments

[58] Lengths of seventh abdominal segment: (0) length of abdominal segment VII not significantly (half-length or less than half-length of segment VI) reduced medially; (1) length of abdominal segment VII significantly reduced medially. Comments: the length of abdominal segment VII, comparing to abdominal segment VI, is quite variable but the reduction of its length medially has been used as a diagnostic character for some genera, e.g. *Bemisia* and *Pealius* Quaintance & Baker, without clearly defining that how much reduction is significant. In order to make it clear and practical to score the character and subsequently to justify its validity as being a specific character, the above-mentioned criterion was used.

[59] Submedian abdominal depressions: (0) absent; (1) present.

[60] Median abdominal tubercles: (0) absent; (1) present; (2) tubercle-like markings.

[61] Abdominal rhachis: (0) absent; (1) present.

[62] Lateral arms arising from abdominal rhachis: (0) absent; (1) present.

[63] Eighth abdominal bifid process: (0) absent; (1) present (fig. 2.11A).

[64] Segmentation between the abdominal segments: (0) normal; (1) first three abdominal segments joined together, apparently forming a single structure.

Papillae - tubercles - glands - pores

[65] Submarginal papillae: (0) absent; (1) present (fig. 2.11B). Comments: there is no clear distinction between papillae and tubercles in most cases in the literature. Their presence, size and structure are very variable even within a species. Therefore only the presence and absence of these characters on the submargin (this character and character 66) or on the dorsal disc area (characters 74 and 75) was scored. Compared with papillae, tubercles are more shapeless, usually irregularly distributed and have no associated pore. According to J.H. Martin (BMNH, personal communication), tubercles are often environmentally induced characters.

[66] Submarginal tubercles (excluding the tubercle between caudal setae, when is present, and those at the bases of the larger setae): (0) absent; (1) present. Comments: see character 65.

[67] Submarginal glands: (0) absent; (1) present (figs 2.11C,D). Comments: these structures were named by Russell (1958), thought they have also been called papillae, pores, or tubercles by other writers.

[68] Shape of submarginal glands: (0) tips of glands smooth (fig. 2.11C); (1) tips of glands dentate (fig. 2.11D). Comments: the tips of the glands in the ten species described/redescribed by Russell (1958) were dentate. Later, Bink-Moenen (1983) described such glands for the monobasic genus, *Arachnaleyrodes* Bink-Moenen, but in that case their tips were smooth, and was used as one of the diagnostic character for the genus. Glands with smooth tip were only observed in one taxon, so this parsimony-uninformative character was automatically ignored by the analyses.

[69] Submarginal simple pores: (0) absent; (1) present.

[70] Submarginal geminate pore/porettes: (0) absent; (1) present (fig. 2.11E). Comments: these structures are also called combined pores and sometimes pores and porettes are widely spaced from each other. According to Russell (1948) and Bink-Moenen (1983), their distribution is of some value at the species level.

[71] Simple pores of dorsal disc area: (0) absent; (1) present.

[72] Geminate pore/porettes of dorsal disc area: (0) absent; (1) present (fig. 2.11E). Comments: the same as for the character 70.

[73] Large subdorsal simple pores: (0) absent; (1) present (fig. 2.11F). Comments: these structures are usually a generic level diagnostic feature but at least in *Dialeuropora decempuncta* (Quaintance & Baker) these large simple pores are sometimes absent or much reduced in size. It is considered likely that this is a modification arising from environmental factors which remain obscure (Martin, 1999).

[74] Subdorsal papillae: (0) absent; (1) present. Comments: the same as for character 65.

[75] Tubercles of dorsal disc area (except the tubercles mentioned in the character 60): (0) absent; (1) present. Comments: the same as for character 65.

[76] Modified papillae of dorsal disc area, which are slightly elevated, nearly flat and plate-like: (0) absent; (1) present (fig. 2.11G).

[77] Eyespots: (0) absent; (1) present (fig. 2.11H). Comments: according to Bink-Moenen (1983), the presence of eyespots can be of taxonomic value at the

species level, but presence and expression are often variable interspecifically. Both states were scored for those species that at least some individuals with them.

[78] Dorsal glands: (0) absent; (1) present (fig. 2.11I). Comments: these glands are easily distinguished from those mentioned in the characters 67 and 68 (see figs 2.11C,D,I).

[79] Subdorsal compound wax pores and/or agglomerate pores: (0) absent; (1) present (figs 2.11J-L; 2.12A,B). Comments: only members of the subfamily Aleurodicinae that have been chosen as out-groups for this study, have compound wax pores and/or agglomerate pores. For this reason these characters were not treated separately.

[80] Glandular bases to marginal teeth: (0) absent; (1) present (fig. 2.12C). Comments: in the literature, this structure has sometimes been described as "a double row of teeth" or rarely "a translucent membranous area at the bases of the marginal teeth". According to Bink-Moenen (1983), these are probably wax-secreting pores or papillae.

[81] Trumpet-like wax-secreting setae: (0) absent; (1) present (fig. 2.5J). Comments: these setae were considered by Tremblay & Iaccarino (1978) as a generic character for the monobasic genus, *Aleurotuba* Tremblay & Iaccarino. Because they were observed only in this single taxon, it is parsimony-uninformative.

[82] Chain-like design along some abdominal and thoracic sutures: (0) absent; (1) present (fig. 2.12D).

[83] Submedian conspicuous invaginations; sometimes hemispherical: (0) absent; (1) present (figs 2.12E,F).

[84] Subdorsal plate with one or two conical pores connected with tracheal pore area: (0) absent; (1) present (fig. 2.12G).

[85] A row of scallop-shaped thickenings along the longitudinal subdorsal furrow: (0) absent; (1) present (fig. 2.12H).

[86] Prominent glandular areas with polygonal reticulate pattern, sometimes resembling compound eyes: (0) absent; (1) present (fig. 2.12I).

[87] Submarginal crescent-shaped pores: (0) absent; (1) present (fig. 2.12J).

[88] Submarginal wax-plat cluster: (0) absent; (1) present (fig. 2.12K).

Legs - antenna

[89] Apical adhesion pad of legs: (0) absent; (1) present.

[90] Tarsal claw: (0) absent; (1) present.

[91] Basal mid- and hind leg seta: (0) absent; (1) present. Comments: this character has sometimes been used in species and/or generic descriptions, especially whenever the seta(e) have been long enough to be easily recognisable. In some cases there is no clear distinction between setae and spines (character 92), and apparently the terms have been used synonymously by some authors. For example, for *Acaudaleyrodes africana* (Dozier), Mound (1965) stated "*A. africanus* can be distinguished from the other species in *Acaudaleyrodes* by the absence of setae from the base of legs, ...". Based on the criterion given in the comments for the character 21, what are absent from the base of legs in this species are spines not setae. Here, examination of thousands specimens at 1000 magnification, clearly showed that at least one microseta is always present at the base of each mid- and hind leg. Sometimes one or rarely two or more setae can be seen in some species but because of slide quality it was almost impossible to count them precisely for each species for such a large-scale study. It seems that, the existence of extra seta(e) at most can be important at species level, but it is sometimes variable even for the same species. This character was automatically ignored due to being always present, i.e. a constant character.

[92] Basal mid- and hind leg spine: (0) absent; (1) present (fig. 2.12L).

[93] Antenna length: (0) limited to front legs or slightly more; (1) reaching middle of mid legs or more. Comments: sexual dimorphism occurs in some genera and species as a difference in the length of the antenna. In this case the antennae of males are comparatively longer than the antennae of females. Such species were scored as polymorphic.

[94] Position of antenna relative to the prothoracic legs: (0) mesal to the prothoracic legs; (1) lateral to the prothoracic legs.

2.3.2. Phylogenetic analysis

The data matrix used is given in Appendix 4. Multistate characters were treated as unordered and without *a priori* weighting. Inapplicable characters and missing data were coded as question marks (Lee & Bryant, 1999; Strong & Lipscomb, 1999).

Characters which the "part" (e.g. seta) and "character-variable" (e.g. seta shape) could be coded as separate characters and/or fused into a single character, were coded as separate characters to avoid loss of phylogenetic information (Lee & Bryant, 1999). Multistate taxa were coded as polymorphisms. Maximum parsimony analysis (MP) was carried out using PAUP*, version 4.0b10 (Swofford, 1998). Heuristic searches were carried out with 1000 random additions followed by branch swapping using tree-bisection-reconnection (TBR) holding a single tree (NCHUCK = 1, CHUCKSCORE = 1) (Morris *et al.*, 1999; Sallum *et al.*, 2000; Hall & Harvey, 2001; Skevington & Yeates, 2001; Vardal *et al.*, 2002). The resulting tree(s) were used for a final round of branch swapping with maxtrees 30,000. The new strategy for estimating large phylogenies (changing the landscape) was employed to help find more parsimonious trees (Quicke *et al.*, 2001). The approach was used with maximum and minimum retention index (RI), and maximum and minimum consistency index (CI).

The bootstrap support for individual branches was estimated using 100 pseudoreplicates each of 100 random additions (Felsenstein, 1985), though this will be very conservative due to the difficult nature of this data set (e.g. Gauthier *et al.*, 2000). Parsimony Jackknifing with 36.79% deletion, i.e. resampling 63.21% of characters, proposed by Farris *et al.* (1996) was also carried out to find support for branches as well as finding Bremer support (Bremer, 1994) for some clades. In order to carry out Bremer support using PAUP*, a constraint tree description for the taxa of the clade in question was created and a search then performed by enforcing the topological constraint, but with the programme to only search for trees that were NOT compatible with that constraint. As a result, if the node in question is strongly supported, the best trees found that do not contain that node, i.e. are not compatible with the constraint, will be at least one step longer than the most parsimonious tree found from the initial unconstraint analysis. This discrepancy in tree length is the decay index or Bremer support value.

Additionally, successive approximation weighting (SAW) (Farris, 1969) was applied for unweighted analysis using each of the four above-mentioned indices to increase resolution. Analyses were performed constraining some traditional whitefly genera to be monophyletic, and the resulting trees compared with the initial unconstrained ones using the Templeton (Wilcoxon sined-ranks) test implemented in PAUP*. The same procedure was used to find most-parsimonious trees (MPTs) for

constraint analysis, i.e. heuristic searches with 1000 random additions, and employing the new strategy. Characters were traced on to cladograms using MacClade 4.0 (Maddison & Maddison, 2000) and were optimised using the accelerated transformation algorithm (AccTran). In all cases, the obtained trees were rooted using the out-group taxa.

2.4. Results

2.4.1. Parsimony analysis

Maximum parsimony holding a single tree yielded one MPT (length = 2759, RI = 0.668, CI = 0.136). This shortest tree was hit only once during the 1000 random additions, showing that this is a rather difficult data set to analyse. Branch swapping with maxtrees set at 30,000 using this tree as the starting tree gave 30,000 equally MPTs with a length of 2743 (RI = 0.671, CI = 0.137). Application of the new strategy (changing the landscape) for these trees using maximum RI to weight characters found 30,000 (limited by computer memory) equally MPTs with a length of 2730 (RI = 0.672, CI = 0.137) (employing the same strategy using maximum CI, minimum CI or minimum RI to weight characters found no shorter trees). The strict consensus tree of these is shown in fig. 2.13. Although the strict consensus tree contains several monophyletic clades, the relationships among most of these are unresolved. Ignoring 44 of the 117 examined genera that are monobasic and/or only one species were available for study, the following 33 genera[1] were found to be monophyletic: *Acanthaleyrodes*, *Acaudaleyrodes*, *Africaleurodes*, *Aleurocerus*, *Aleurocybotus*, *Aleuroduplidens*, *Aleuroglandulus*, *Aleuroparadoxus*, *Aleuropteridis*, *Bellitudo*, *Combesaleyrodes*, *Corbettia*, *Dialeuropora*, *Fascaleyrodes*, *Filicaleyrodes*, *Fippataleyrodes*, *Indoaleyrodes*, *Leucopogonella*, *Metabemisia*, *Minutaleyrodes*, *Neoaleurotrachelus*, *Neomaskellia*, New genus 1, New genus 2, *Orchamoplatus*, *Paulianaleyrodes*, *Pentaleyrodes*, *Pogonaleyrodes*, *Rusostigma*, *Siphoninus*, *Singhius*, *Viennotaleyrodes*, *Xenaleyrodes*. This means that 40 genera were not recovered to be monophyletic. However, some of these were rendered non-monophyletic by a single species or very small groups of aberrant ones, viz. *Aleurocanthus* excluding *A. ceracroceus* Martin, *Aleyrodes* excluding *A. elevatus* Silvestri, *Lipaleyrodes* excluding *L. atriplex* (Froggatt), *Massilieurodes* excluding *M. fici* (Takahashi), *Rhachisphora*

[1] The author's names of all genera are given in Appendix 3.

excluding *R. elongatus* Regu & David, *Rugaleyrodes* excluding *R. bidentata* Bink-Moenen, *Setaleyrodes* excluding *S. vigintiseta* Martin, and most of the species of the genus *Dialeurolonga* including the type-species as well as those species of *Crenidorsum* described by Russell (1945) including the type-species formed monophyletic clades. None of the mentioned excluded species are the type-species of their genera.

2.4.2. Successive approximation weighting

Applying SAW gave more resolution for unresolved nodes of the tree. More than 10% of the 30,000 MPTs obtained from the unweighted analysis (UW-MPTs) were selected so that to have at least 100 representatives from each 1000 MPTs. Then, the approach was used with four different indices, i.e. maximum RI, maximum CI, minimum RI, and minimum CI to weight characters, and four, eight, four, and eight cycles of reweighting were needed respectively before stability was reached. When all characters were set back to unit weight, the lengths of the trees were 2733, 2953, 2734, and 2927 respectively. Comparing these lengths with the length of UW-MPTs, i.e. 2730, indicates that the trees obtained from applying SAW using maximum and minimum RI (MPTs-SAW-MaxRI and MPTs-SAW-MinRI) are only three and four steps longer respectively, and here the strict consensus tree of these trees (MPTs-SAW-MaxRI) is presented (fig. 2.14) and discussed. It is worth mentioning that the topology of the strict consensus trees of MPTs-SAW-MaxRI and MPTs-SAW-MinRI was almost the same as each other, and both were more in agreement with the strict consensus tree of UW-MPTs (Table 2.1). The strict consensus trees obtained from applying SAW using maximum and minimum CI (MPTs-SAW-MaxCI and MPTs-SAW-MinCI) showed two different topologies and were somewhat less in agreement with the strict consensus tree of UW-MPTs (Table 2.1).

In the strict consensus tree of MPTs-SAW-MaxRI (fig. 2.14), of the 33 genera recovered as monophyletic in the initial analyses, two, viz. *Dialeuropora* and *Pogonaleyrodes*, were no longer recovered, but the former excluding *D. silvarum* (Corbett) (not the type-species) did form a monophyletic clade. However, *Pectinaleyrodes* was monophyletic in this tree whereas it was not in the initial tree. The monophyly of other mentioned genera were the same.

Table 2.1. Symmetric-difference distances between different trees obtained from unweighted analysis and from applying successive approximation weighting.

Between trees	Symmetric-difference distances
MPTs-SAW-MaxRI – MPTs-SAW-MinRI	42-50
MPTs-SAW-MaxRI – UW-MPTs	73-98
MPTs-SAW-MinRI – UW-MPTs	100-124
MPTs-SAW-MaxCI – MPTs-SAW-MinCI	437-444
MPTs-SAW-MaxCI – UW-MPTs	611-620
MPTs-SAW-MinCI – UW-MPTs	614-624

2.4.3. Monophyly of large genera

The evidence against monophyly of two economically important genera, *Bemisia* and *Trialeurodes*, as well as several large genera, i.e. *Aleuroplatus*, *Aleurotrachelus*, *Dialeurodes*, and *Tetraleurodes*, which were not recovered to be monophletic in either unweighted or SAW analyses was investigated. Separate analyses were performed constraining each of these to be monophyletic, and the resulted trees compared statistically with the initial unconstrained ones using the non-parametric ranked-sign test of Templeton.

Constraining *Bemisia* to be monphyletic resulted in one MPT (length = 2772) and using the new tree searching strategy yielded more than 1000 MPTs (length = 2756). The Templeton test showed that there were significantly longer than the best unconstrained ones (P = 0.0196-0.0419) (Table 2.2). Constraining *Dialeurodes* to be monophyletic yielded trees of length 2771 which were not different from unconstrained ones based on the Templeton test (P > 0.07).

In all constraint analyses, only one MPT found after performing a heuristic search with 1000 random additions, which were significantly different from the UW-MPTs except for *Bemisia* and *Trialeurodes*. The final results changed for some genera after finding shortest possible trees applying the new strategy (at least 500 trees were compared), which are shown in Table 2.2. Generally, the monophyly of *Aleurotrachelus* and *Bemisia* was statistically rejected, while that of *Aleuroplatus*, *Dialeurodes*, *Tetraleurodes*, and *Trialeurodes* was not (Table 2.2). These results will be discussed in detail in section 2.5.

The finding that statistical significance can increase when difference in tree length decreases (as a result of finding most parsimonious trees) indicates that it is important to reduce the variance, i.e. noise, in the estimate of numbers of character

steps, and the test is only meaningful if the shortest possible trees to be compared. If they are not the MPTs, there will be a degree of "randomness" in the character lengths and such random variation might occasionally be on the side of increasing significance, sometimes not.

Table 2.2. The results of the Templeton test obtained from comparing the shortest trees, found for those genera constrained to be monophletic, with the UW-MPTs.

Constrained genus	Constrained tree length	Tree length of UW-MPTs	Templeton test P values
Aleuroplatus	2757	2730	0.0513-0.2019
Aleurotrachelus	2780	2730	0.0085*-0.0186*
Bemisia	2756	2730	0.0196*-0.0419*
Dialeurodes	2771	2730	0.0785-0.1120
Tetraleurodes	2764	2730	0.0469*-0.0948
Trialeurodes	2741	2730	0.5590-0.7035

* Indicate significant difference at $P < 0.05$.

2.4.4. Evaluating the current tribe classification

As already mentioned in Chapter 1 (section 1.1.4), 13 tribes have been proposed so far within the Aleyrodinae. In addition to the problems posed by unplaced genera, there is little agreement about the composition of some proposed tribes (Sampson, 1943, 1947; Russell, 1947; Takahashi, 1954; David, 1990). Before starting to evaluate the current tribe classification, it should be mentioned that some of the genera in Appendix 1 have been synonymized and these will be indicated in the discussion of each tribe. Furthermore, except the tribe proposed by Russell (1947), Trialeurodini, the other tribes were only defined in identification keys by the authors, who erected them (see above). Tribal level characters used by these authors for each tribe are given in Appendix 2 in order to avoid repeating them when each tribe is discussed.

- Tribe Aleurocanthini Takahashi

Three genera, viz. *Aleurocanthus*, *Aleurotrachelus*, and *Pentaleyrodes*, were placed in the Aleurocanthini by Takahashi (1954), and only *Aleurocanthus* by David (1990) for the whiteflies of Japan and India respectively (Appendix 1). As mentioned before, the latter excluding *A. ceracroceus* was found to be monophyletic and the monophyly of *Aleurotrachelus* even statistically rejected (Table 2.2). However, the type-species of *Aleurotrachelus*, *A. tracheifer* (Quaintance), was never recovered in the same clade either with *Aleurocanthus* or *Pentaleyrodes* in the strict consensus tree

of UW-MPTs (fig. 2.13), whereas in the strict consensus tree of MPTs-SAW-MaxRI (fig. 2.14) it was found in a different clade from the *Aleurocanthus* clade within a big clade.

- Tribe Aleurochitonini Sampson

Sampson (1943) proposed this tribe on the basis of a single genus, *Aleurochiton* (Appendix 1). Two of the four studied species of this genus, *A. acerinus* Haupt and *A. aceris* (Modeer) (the type-species), were recovered as forming a monophyletic group in this study (figs 2.13 and 2.14). Although in the strict consensus trees of MPTs-SAW-MaxCI and MPTs-SAW-MinCI (trees not presented), *A. pseudoplatani* Visnya also came out with the former two species, *A. forbesii* (Ashmead) was not recovered with them in the same clade in any analysis. Interestingly, Samson (1943) erected a new subgenus, *Nealeurochiton*, to accommodate *A. forbesii*, but this was subsequently synonymized with *Aleurochiton* by Mound and Halsey (1978).

- Tribe Aleurilobini Takahashi

This tribe was proposed by Takahashi (1954), for five genera based on Japanese species (*Acanthobemisia*, *Aleurolobus*, *Apobemisia*, *Bemisia*, *Parabemisia*). All studied species of *Aleurolobus* including the type-species, *A. marlatti* (Quaintance), were recovered in the same clade but not as a monophyletic group. The only examined species of *Apobemisa*, *A. kuwanai* (Takahashi) (the type-species), was not found with *Aleurolobus* in the same clade, and the type-species of *Bemisia* (not recovered as a monophyletic genus), *B. tabaci*, was never recovered either with *Aleurolobus* or *Apobemisia*. The type-species of *Parabemisia* was not studied but the five examined species did not form a clade. *Acanthobemisia* and the four species of *Parabemisia* were only recovered in the same clade in the strict consensus tree of MPTs-SAW-MaxRI (fig. 2.14). David (1990) later transferred *Bemisia* to a separate tribe, Bemisini (see below), but Takahashi's Aleurolobini, even excluding *Bemisia*, was not supported in this study.

David (1990), and Regu and David (1993) classified six genera from India in this tribe (Appendix 1). Only the type-species of *Aleuropapillatus* and *Orientaleyrodes* were studied and these appeared in two distantly separated clades. *Africaleyrodes* was found as a monophyletic genus, but did not form a clade with the other five genera.

Two examined species of *Asterochiton* (but not the type-species) were recovered on two different branches. All species of *Aleurolobus* and *Crescentaleyrodes* were found in the same clade (figs 2.13 and 2.14), and the possible monophyly of the latter will be discussed later.

- Tribe Aleuroplatini David

David (1990) placed two genera in this tribe (Appendix 1), of which *Moundiella* David was later synonymized with *Viennotaleyrodes* (David *et al.*, 1994). Unlike the latter genus, *Aleuroplatus* was found to be non-monophyletic, though its monophyly was not rejected statistically using the Templeton test (Table 2.2) (see also section 2.5). The type-species of *Aleuroplatus*, *A. quercusaquaticae* (Quaintance), and *Viennotaleyrodes* gathered in two different clades within a relatively big monophyletic clade in the strict consensus tree of MPTs-SAW-MaxRI (fig 2.14).

- Tribe Aleyrodini Sampson

The Aleyrodini originally comprised 24 genera (Sampson, 1943), and the author added another genus in 1947. Five more genera were added later (Drews & Sampson, 1956; Sampson & Drews, 1956) (Appendix 1). Of these *Aleuromigada* Singh is considered as *nomina nuda* and the name *Frauenfeldiella* Gomez-Menor is not available in Aleyrodidae as it is preoccupied in the *Cecidomyidae*; the genus is now known as *Aleurotuba* (Mound & Halsay, 1978; Tremblay & Iaccarino, 1978). There were no specimens available for *Hesperaleyrodes*, *Luederwaldtiana*, *Mexicaleyrodes*, *Nealeyrodes*, and *Neoaleurodes*, and *Laingiella* was also omitted from the analysis (see section 2.3). Furthermore, *Aleurocanthus*, *Aleurotrachelus*, and *Pentaleyrodes* were transferred to Aleurochantini (see above), but David (1990) later reassigned *Aleurotrachelus* to Aleyrodini. Russell (1947) transferred *Aleurotithius* to Trialeurodini, and David (1990) relocated *Acaudaleyrodes*, *Tetraleurodes*, and *Zaphanera* in Neomaskellini, Tetraleurodini, and Zaphanerini respectively (see below). Monophyly of Aleyrodini based on Sampson's classification even excluding *Acaudaleyrodes*, *Aleurocanthus*, *Aleurotithius*, *Aleurotrachelus*, *Pentaleyrodes*, *Tetraleurodes*, and *Zaphanera* was not supported in this study.

Takahashi (1954) placed only five genera from Japan in the Aleyrodini (Appendix 1), of which two genera are now considered as synonyms: *Odontaleyrodes*

Takahashi was synonymized with *Pealius* by Martin (1999). This tribal classification, too, failed to be monophyletic. Except *Aleyrodes*, David (1999) transferred all genera placed by Takahashi in Aleyrodini, to Bemisini and placed two more genera in the latter tribe (see Bemisini below).

David's (1999) classification of Aleyrodini with five genera from India viz. *Aleurocybotus*, *Aleuromarginatus*, *Aleurotrachelus*, *Aleurotulus*, and *Aleyrodes* was not supported by this study.

- Tribe Bemisini David

Four of the six genera placed in this tribe by David (1990) (Appendix 1) were briefly discussed above. The type-species of *Pealius* was not studied but the ten examined species did not form a monophyletic clade. *Setaleyrodes* including the type-species, *S. mirabilis* Takahashi, also appeared non-monophyletic, but they were recovered together with some species of *Pealius* in the same clade (figs 2.13 and 2.14). *Indoaleyrodes* (three species examined including the type-species, *I. laos* (Takahashi)) was recovered as monophyletic but in a separate clade. The type-species of *Neopealius* (the only examined species of this small genus) was on its own branch. As already mentioned, the monophyly of *Bemisia* was refuted statistically (Table 2.2) (see also section 2.5) and its type-species, *B. tabaci*, was on its own branch.

- Tribe Dialeurodini Sampson

Sampson (1943, 1947) placed 32 genera in the tribe Dialeurodini and 13 more genera were later added by Sampson and Drews in 1956 (Appendix 1). Of these, *Aleuroclava* and *Aleurotuberculatus* Takahashi are now treated under the former name (Martin, 1999) as well as *Corbettella* Sompson, *Neobemisia* Visnya, and *Roucasia* Goux which were synonymized with *Pealius*, *Asterobemisia* (Mound & Halsey, 1978) and *Bemisia* (Danzig, 1964) respectively. Also, *Nipaleyrodes* and *Stenaleyrodes* have since been classified as members of the Aleurodicinae (Mound & Halsey, 1978) (see also section 2.5 for *Stenaleyrodes*). For *Aleuroporosus*, *Anomaleyrodes*, *Dialeurotrachelus*, *Neoaleurolobus*, *Metaleyrodes*, *Plataleyrodes*, *Pseudaleurolobus*, *Pseudaleyrodes*, *Trichoaleyrodes* and *Xenobemisia* there were no specimens available for study. Although more than half of the 29 remaining genera were not found to be monophyletic, considering only their type-species, they never form a monophyletic

clade, and the picture is not improved by excluding those genera that were later transferred to other tribes, viz. *Acanthobemisia*, *Africaleurodes*, *Aleurolobus*, *Aleuroparadoxus*, *Aleuroplatus*, *Asterochiton*, *Bemisia*, *Parabemisia*, *Pealius*, *Setaleyrodes*, and *Trialeurodes* (Russell, 1947; Takahashi, 1954; David, 1990; Regu & David, 1993).

Takahashi (1954) placed only four genera from Japan in this tribe (Appendix 1), of which *Rhachisphora* was recovered in a separate clade from the other three genera in all analyses (figs 2.13 and 2.14) but not as a monophyletic genus. All examined species of *Taiwanaleyrodes* and *Aleuroclava* (=*Aleurotuberculatus*) (see above), and also a few species of *Dialeurodes* including the type-species, *D. citri* (Ashmead) were in the same clade together with some other genera in both strict consensus trees (figs 2.13, 2.14 and 2.17). *Aleuroclava* and *Taiwanaleyrodes* will be discussed in detail later (section 2.6).

David (1990) and David & Sundararaj (1993) classified 19 genera from India in the Dialeurodini (Appendix 1), of which three genera have now been synonymized (*Martiniella* Jesudasan & David and *Aleurotuberculatus* were synonymized with *Aleuroclava* by Martin (1999)). Also, the three subgenera of *Dialeurodes*, viz. *Dialeuronomada*, *Gigaleurodes*, and *Rabdostigma* of Quaintance & Baker, which were raised to the generic level by Indian authors (David & Sundararaj, 1993; Sundararaj & David, 1994), were here treated under *Dialeurodes* (the four examined species of the latter genus, viz. *D. cerifera* Quaintance & Baker, *D. cinnamomi* Takahashi *D. ixorae* Singh and *D. minahassai* Martin are assignable to *Gigaleurodes*, *Gigaleurodes, Dialeuronomada* and *Rabdostigma* respectively, but none of them is the type-species). *Kanakarajiella* (only the type-species examined), *Minutaleyrodes*, and *Singhius* gathered in the same clade with *Aleuroclava*, *Dialeurodes*, and *Taiwanaleyrodes* (fig. 2.17). The type-species of *Asialeyrodes* and *Cockerelliella* were not studied but one of the two examined species of the former and all examined species of the latter genus as well as six of the eight examined species of *Singiella* including the type-species, *S. bicolour* (Singh), were also recovered in this clade, while *Rusostigma* was only found in this clade in the MPTs-SAW-MaxRI (fig. 2.14). Furthermore, except *D. cinnamomi*, the other three species of *Dialeurodes*, all were found in this clade but only in the MPTs-SAW-MaxRI (*D. ixorae* was also found in the UW-MPTs), i.e. recovering the representatives of all three subgenera. The four

remaining genera, *Dialeurolonga*, *Dialeuropora*, *Fippataleyrodes*, and *Rhachisphora* also appeared in four different clades.

- Tribe Lipaleyrodini David

David (1990) included only *Lipaleyrodes* for this tribe (Appendix 1), and the genus excluding *L. atriplex* was recovered to be monophyletic (including the type-species, *L. phyllanthi* Takahashi). *L. atriplex* had originally been described in *Aleyrodes*, and was subsequently transferred to *Lipaleyrodes* by Martin (1999), though it did not group even with the species of *Aleyrodes* in this study.

- Tribe Neomaskellini Sampson

Sampson (1943) based the monotypic Neomaskellini on *Neomaskellia*, and later *Acaudaleyrodes* was added by David (1990) (Appendix 1). Both genera were recovered to be monophyletic but located in two distantly separated clades in all analyses (figs 2.13 and 2.14).

- Tribe Siphoninini Sampson

This tribe includes only the monophyletic genus *Siphoninus* (Sampson, 1943; David, 1990).

- Tribe Tetraleurodini David

The only included genus, *Tetraleurodes*, was not found to be monophyletic in any analyses, though its monophyly was not rejected statistically (Table 2.2) (see also section 2.5).

- Tribe Trialeurodini Russell

Russell (1947) erected this tribe and stated "only the known genera *Aleuroparadoxus* and *Aleurotithius* of Quaintance and Baker and *Trialeurodes* Cockerell appear to be assignable to this tribe". Subsequently, Russell (1967) added her new monobasic genus, *Venezaleurodes*. In the strict consensus tree of UW-MPTs (fig. 2.13), nine of the 11 examined species of *Trialeurodes* including the type-species, *T. pergandei* (Quaintance), as well as *Aleurotithius* (only the type-species studied), *Venezaleurodes* and several different genera formed a polytomy, and only two species

of *Trialeurodes* were recovered in the same clade. *Aleuroparadoxus* was found to be monophyletic and formed a separate clade with several different genera. In the MPTs-SAW-MaxRI (fig. 2.14), the nine species of *Trialeurodes*, and *Venezaleurodes* were recovered in the same clade, and *Aleurotithius* formed a separate small clade with the two other species of *Trialeurodes*.

- Tribe Zaphanerini David

This tribe was proposed by David (1990) for *Zaphanera*, (Appendix 1). Five species of this genus including the type-species, *Z. cyanotis* Corbett, were included in the present study. These formed two separate monophyletic clades which were supported by relatively high Jacknife values (fig. 2.13). The African and Oriental species (*Z. capparis* Bink-Moenen and *Z. cyanotis* respectively) were recovered in one, and the three Australian species in another (figs 2.13 and 2.14). Thus the Australian species (*Z. niger* (Maskell), *Z. papyrocarpae* Martin, and *Z. rhachisreticulata* Martin) do not appear to be congeneric with the type-species and a new genus needs to be erected for them (see section 2.6).

2.4.5. Whitefly-host plant relationships

Host plant information at family, order, and higher group levels for all whitefly species included in this study is given in Appendix 5. All botanical names follow the system of the Angiosperm Phylogeny Group (APG) (Bremer *et al.*, 1998; Soltis *et al.*, 2000; Bremer *et al.*, 2003). Whitefly host plant information was obtained from Mound and Halsey (1978), Bink-Moenen (1983), and Martin (1999) as well as from more recent original descriptions, and from unpublished information available on slides examined.

Except for the only gymnosperm host record, *Dioon spinulosum* (Zamiaceae) for *T. vaporariorum* (Westwood), and also those few species recorded from Pteridophyta (see below), whiteflies are found mainly on angiosperms. Furthermore, few whitefly species are known to be monophagous, most being oligo- or polypahgous. The number of host plant orders attacked by the species studied here varies from one to 31 (probably the true number is higher) (Appendix 5).

Twenty described, and three or four undescribed, species are reported from fern hosts (Pteridophyta) (Mound & Halsey, 1978; Martin & Camus, 2001), of which the

fern host record for *T. vaporariorum* (which is highly polyphagous on Angiospermae) is uncertain, and the identification of one of these species as *B. tabaci* (also highly polyphagous on Angiospermae) is not definitive (Martin & Camus, 2001). Here, 14 described species recorded from ferns (ignoring *B. tabaci* and *T. vaporariorum*) were scored. Of these, all described species of *Aleuropteridis* and *Filicaleyrodes*, were recovered as monophyletic, but they were distantly separated in trees from both analyses (figs 2.13 and 2.14). The results were the same for the two fern-feeding species of *Metabemisia* (*M. filicis* Mound and *M. palawana* Martin), as well as the two fern-feeding species of *Aleurotulus* (*A. nephrolepidis* (Quaintance) (the type-species) and *A. pteridophytae* Martin). Neither the type-species of *Metabemisia* (not examined) nor the other species of *Aleurotulus* have been recorded from ferns. The latter genus appears not to be monophyletic, and apparently its non-fern-feeding species are not congeneric with the type-species (it should be noted that one of its non-fern-feeding species, *A. arundinacea* Singh, is considered as species *incertae sedis* (Mound *et al.*, 1994)). For *Trialeurodes*, three of the 11 examined species, *T. bruneiensis* Martin, *T. dicksoniae* Martin, and *T. rex* Martin, colonise ferns, but they were not recovered in the same clade. The only studied species of *Mixaleyrodes* were not recovered as a sister group to any of the fern-feeding species. In general, the position of these 14 species on the both cladograms did not support a clear Pteridophyta-whitefly relationship for the all fern-feeding species, although separate correlations were found for some species at genus level.

Almost the same results were obtained after mapping angiosperm hosts on both strict consensus trees. In general, some small monophyletic clades appear to be specialized on particular host plant orders, but in most cases, there was little of any indication of correlation between the species of a particular clade and host plant order.

Three genera for which a clear relationship with host plant order was apparent were *Aleuromarginatus*, *Corbettia*, and *Viennotaleyrodes*. The last two appeared to be monophyletic, but *Aleuromarginatus* was not found to be so, though most of its examined species formed a monophyletic clade with *Corbettia* (fig. 2.15). Virtually all species of these three genera have been recorded from Fabaceae (the exception being *C. graminis* Mound on Poaceae, *V. bosciae* Bink-Moenen recorded from Brassicaceae, and *C. millettiacola* Dozier which has additionally been recorded from Apocynaceae) (there is no host record for *A. serdangensis* Takahashi but this species

most probably does not belong to *Aleuromarginatus*; see section 2.5) (Appendix 5). Further, the monobasic genus *Papillipes*, which is also recorded from Fabaceae, formed a sister group to *Viennotaleyrodes* (figs 2.13 and 2.14), but this clade did not form a sister group to *Aleuromarginatus* + *Corbettia*.

2.5. Discussion

The family Aleyrodidae is taxonomically difficult. The genera usually have no reliable suite of morphological characters to allow them to be recognised unambiguously, and this is obvious from many of the original descriptions. Many of the larger genera have some species included which differ in at least one of the characters given in the description of the genus (e.g. *Aleurotrachelus asparagi* (Lewis) and *A. tarennae* Bink-Moenen have a submarginal line or fold, whereas based on the original description of the genus, the submarginal area is not separated from the dorsal disc (Quaintance & Baker, 1914)) and sometimes, there is really no reason for a species to have been placed in its current genus at all (e.g. *Aleuromarginatus serdangensis*; see below).

These and other problems created some difficulties in choosing possible genus level characters for the cladistic analyses. I attempted to code all puparial characters used by authors in generic descriptions, although in most cases there are no distinct boundaries between genus level characters and those of species level. For example, Bink-Moenen (1983) while describing three new genera, *Arachnaleyrodes*, *Papillipes* and *Yleyrodes*, and comparing them with their morphologically closely related genera, i.e. *Orchamoplatus*, *Viennotaleyrodes* and *Africaleurodes* respectively, used the absence and/or presence of first abdominal setae as one of the diagnostic characters to separate the new genera from their allied genera. This character, however, has also been used to differentiate two species of a particular genus, e.g. *Dialeurolobus rhamni* Bink-Moenen and *D. pulcher* Danzig (Bink-Moenen & Gerling, 1990), and *Crenidorsum millennium* Martin and *C. celebes* Martin (Martin, 1999). As stated by Martin (2003), there is nothing inherently wrong with the use of immature stages taxonomically, but the problem is that, with our current poor understanding of the true significance of many puparial characters, we have yet to maximise their value. The lack of such information has impeded our understanding of relationships between aleyrodids, rather than any lack of characters for use (immature stages have been used

taxonomically in other insects such as Psylloidea (White & Hodkinson, 1982) and Lepidoptera (Kitching, 2002, 2003; Willmott, 2003)). For example, as mentioned in comments for character 80 (glandular bases to marginal teeth), this structure has sometimes been described as "a double row of teeth" or rarely "a translucent membranous area at the bases of the marginal teeth", and according to Bink-Moenen (1983), these are probably wax-secreting pores or papillae. In the latter case, characters 65 (submarginal papillae) and 80, apart from their shape differences, can be considered the same in a broad sense. Table 2.3 shows some examples regarding the opinions of different authors about the relationships between some genera. In fact, with whitefly puparial taxonomy lacking objective criteria (it seems to be partly a matter of guess-work at genus level), there is likely to be quite a lot of apparent homoplasy (in addition to some true homoplasy) because of misinterpreting similar character states during the coding stage.

Table 2.3. Relationships between whitefly genera proposed by various authors.

Genus	Allied genera	Reference
Aleuroduplidens	*Aleuroplatus, Zaphanera, Tetraleurodes*	Martin, 1999
Aleuroglandulus	*Aleyrodes*	Russell, 1944
Aleuropapillatus	*Aleurolobus, Crescentaleyrodes*	Regu & David, 1993
Aleuroparadoxus	*Trialeurodes*	Russell, 1947
Aleyrodiella	*Aleuroparadoxus, Aleurotithius, Trialeurodes*	Danzig, 1966
Asialeyrodes	*Africaleyrodes, Aleurolobus, Dialeurodes*	Corbett, 1935
Bellitudo	*Aleuroparadoxus, Pseudaleurolobus, Africaleyrodes, Aleurolobus, Paraleuroplobus*	Russell, 1943
Brazzaleyrodes	*Aleurolonga, Ramsesseus*	Bink-Moenen, 1983
Bulgarialeurodes	*Corbettia*	Corbett, 1936
Chitonaleyrodes	*Zaphanera, Gagudjuia*	Martin, 1999
Cockerelliella	*Asialeyrodes*	Sundararaj & David, 1992
Cockerelliella	*Asialeyrodes, Dialeurodes*	Martin, 1999
Crenidorsum	*Aleuroplatus, Aleurotrachelus, Aleurotulus, Aleuroputeus, Laingiella*	Russell, 1945
Crenidorsum	*Aleurotrachelus, Aleurotulus*	Martin *et al.*, 2001
Dumbletoniella	*Aleuroputeus, Aleuroclava*	Jesudasan & David, 1990
Dumbletoniella	*Aleuroclava, Aleuroplatus, Pseudaleuroplatus*	Martin, 1999
Extensaleyrodes	*Dialeurolonga, Aleuromarginatus*	Bink-Moenen, 1983
Fascaleyrodes	*Aleurocanthus*	Bink-Moenen, 1983
Filicaleyrodes	*Trialeurodes*	Takahashi, 1962; Mound, 1966
Gomenella	*Indoaleyrodes, Asialeyrodes*	Martin, 1999
Heterobemisia	*Bemisia*	Takahashi, 1957
Leucopogonella	*Aleurotrachelus*	Dumbleton, 1961
Malayaleyrodes	*Africaleyrodes, Asialeyrodes, Aleurolobus*	Corbett, 1935
Marginaleyrodes	*Aleurotrachelus*	Takahashi, 1961
Metabemisia	*Parabemisia, Apobemisia*	Takahashi, 1963
Mixaleyrodes	*Aleurotrachelus*	Takahashi, 1936a; Jesudasan & David, 1991
Neopealius	*Pealius, Bemisia*	Takahashi, 1954
Nigrasialeyrodes	*Asialeyrodes, Gomenella*	Martin, 1999

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Table 2.3. Continued.

Genus	Allied genera	Reference
Papillipes	*Viennotaleyrodes*	Bink-Moenen, 1983
Pseudaleuroplatus	*Aleuroduplidens*, *Aleuroplatus*, *Trialeurodes*, *Zaphanera*	Martin, 1999
Rositaleyrodes	*Aleurolobus*	Meganathan & David, 1994
Rugaleyrodes	*Neoaleurotrachelus*, *Cohicaleyrodes*	Bink-Moenen, 1983
Setaleyrodes	*Pealius*	Martin, 1999
Taiwanaleyrodes	*Aleurotuberculatus*, *Aleurocybotus*	Takahashi, 1932
Tetralicia	*Aleuropleurocelus*	Drews & Sampson, 1956; Mound, 1966
Tetralicia	*Aleuropleurocelus*, *Tetraleurodes*	Martin, 1999
Trialeurodes	*Aleuroparadoxus*, *Aleurotithius*	Russell, 1948
Trialeurodes	*Filicaleyrodes*	Mound, 1966
Trialeurodes	*Dialeurolonga*	Bink-Moenen, 1983
Venezaleurodes	*Trialeurodes*	Russell, 1967
Xenaleyrodes	*Aleuroplatus*	Takahashi, 1936b
Xenaleyrodes	*Aleurocanthus*	Martin, 1999
Yleyrodes	*Africaleurodes*	Bink-Moenen, 1983
Zaphanera	*Aleurotrachelus*	Corbett, 1926
Zaphanera	*Dialeurolobus*, *Tetraleurodes*	Martin, 1999

Owing to the high level of homoplasy in the data set, the maximum consistency index may be the best choice for reweighting characters for SAW, because it cannot weight characters as zero, so potentially useful characters would not be excluded from the analysis (Quicke *et al.*, 2001). It should be noted that when stability was reached in SAW analyses and all characters then set back to unit weight, the lengths of the MPTs-SAW-MaxCI and MPTs-SAW-MinCI were much higher (223 and 197 steps respectively) than that of UW-MPTs, while MPTs-SAW-MaxRI and MPTs-SAW-MinRI were only a few steps longer (see section 2.4.2).

Retention indices (ri) for each non-constant character were calculated to evaluate how much of the variation displayed by the characters could be attributed to true synapomorphy on trees, as well as calculating consistency indices (ci) to evaluate the amount of homoplasy of each character, and length. The results are shown in Table 2.4. In all UW-MPTs, the retention indices of characters 5, 14, and 86 were zero, i.e. contributing no synapomorphy to the cladograms. In contrast, retention index had the maximum value for the characters 22, 24, 30, 46 (only the best fit), 63, 64, 76, 78-79 (only the best fit), 82-84, 87-88, and 90, indicating the contribution of maximum synapomorphy to the cladograms (Table 2.4). Of these 15 characters, characters 79 (subdorsal compound wax pores and/or agglomerate pores) and 90 (tarsal claw) are restricted to the Aleurodicinae, although *Dialeurodicus* lacks character 79 and *Stenaleyrodes* lacks both characters.

Table 2.4. The range of retention indices, consistency indices, and lengths for each non-constant character calculated for the UW-MPTs. B = Best; Ch = Character; Ma = Maximum; Mi = Minimum; W = Worst. Characters 54, 68 and 81 are parsimony uninformative.

Ch	Retention index		Consistency index		Length		Ch	Retention index		Consistency index		Length	
	B	W	B	W	Mi	Ma		B	W	B	W	Mi	Ma
[1]	0.73	0.71	0.07	0.07	54	58	**[48]**	0.40	0.35	0.73	0.72	45	46
[2]	0.58	0.57	0.10	0.10	58	60	**[49]**	0.84	0.83	0.08	0.08	36	37
[3]	0.54	0.53	0.15	0.15	33	34	**[50]**	0.80	0.80	0.50	0.50	2	2
[4]	0.64	0.64	0.09	0.09	11	11	**[51]**	0.56	0.55	0.09	0.08	106	109
[5]	0.00	0.00	0.50	0.50	2	2	**[52]**	0.61	0.59	0.05	0.05	64	67
[6]	0.61	0.57	0.05	0.04	22	24	**[53]**	0.52	0.50	0.03	0.03	67	70
[7]	0.80	0.80	0.17	0.17	12	12	**[54]**	0/0	0/0	1.00	1.00	1	1
[8]	0.69	0.68	0.07	0.07	29	30	**[55]**	0.90	0.89	0.05	0.04	21	23
[9]	0.73	0.71	0.03	0.03	32	34	**[56]**	0.64	0.64	0.12	0.12	42	43
[10]	0.79	0.77	0.12	0.11	43	46	**[57]**	0.90	0.89	0.04	0.04	23	25
[11]	0.86	0.86	0.17	0.17	6	6	**[58]**	0.70	0.70	0.08	0.07	40	41
[12]	0.33	0.33	0.33	0.33	3	3	**[59]**	0.68	0.66	0.04	0.03	56	59
[13]	0.62	0.60	0.06	0.06	84	88	**[60]**	0.43	0.40	0.25	0.23	57	60
[14]	0.00	0.00	0.20	0.20	5	5	**[61]**	0.69	0.67	0.02	0.02	48	51
[15]	0.42	0.40	0.04	0.04	50	52	**[62]**	0.45	0.42	0.05	0.04	22	23
[16]	0.63	0.62	0.27	0.26	111	114	**[63]**	1.00	1.00	1.00	1.00	1	1
[17]	0.68	0.65	0.03	0.03	58	62	**[64]**	1.00	1.00	1.00	1.00	1	1
[18]	0.60	0.57	0.42	0.41	52	54	**[65]**	0.61	0.58	0.22	0.21	18	19
[19]	0.70	0.68	0.07	0.07	54	57	**[66]**	0.54	0.54	0.20	0.20	20	20
[20]	0.58	0.53	0.52	0.49	50	53	**[67]**	0.90	0.90	0.50	0.50	2	2
[21]	0.50	0.38	0.20	0.17	5	6	**[68]**	0/0	0/0	1.00	1.00	1	1
[22]	1.00	1.00	1.00	1.00	2	2	**[69]**	0.73	0.69	0.04	0.03	28	32
[23]	0.72	0.72	0.17	0.17	6	6	**[70]**	0.71	0.71	0.03	0.03	40	40
[24]	1.00	1.00	1.00	1.00	4	4	**[71]**	0.62	0.60	0.03	0.02	39	41
[25]	0.59	0.57	0.03	0.03	34	36	**[72]**	0.64	0.60	0.05	0.05	20	22
[26]	0.61	0.59	0.10	0.10	88	92	**[73]**	0.75	0.75	0.75	0.75	4	4
[27]	0.62	0.59	0.08	0.07	40	43	**[74]**	0.63	0.60	0.27	0.25	15	16
[28]	0.71	0.69	0.04	0.04	23	24	**[75]**	0.48	0.45	0.11	0.11	82	85
[29]	0.69	0.69	0.27	0.27	15	15	**[76]**	1.00	1.00	1.00	1.00	1	1
[30]	1.00	1.00	1.00	1.00	1	1	**[77]**	0.48	0.44	0.08	0.07	39	42
[31]	0.78	0.76	0.08	0.08	12	13	**[78]**	1.00	0.50	1.00	0.50	1	2
[32]	0.35	0.30	0.07	0.07	14	15	**[79]**	1.00	0.80	1.00	0.50	1	2
[33]	0.44	0.33	0.09	0.08	11	13	**[80]**	0.64	0.63	0.03	0.03	38	40
[34]	0.68	0.68	0.09	0.09	79	80	**[81]**	0/0	0/0	1.00	1.00	1	1
[35]	0.66	0.63	0.14	0.13	37	40	**[82]**	1.00	1.00	1.00	1.00	1	1
[36]	0.69	0.69	0.33	0.33	6	6	**[83]**	1.00	1.00	1.00	1.00	1	1
[37]	0.88	0.88	0.04	0.04	27	27	**[84]**	1.00	1.00	1.00	1.00	1	1
[38]	0.75	0.74	0.04	0.04	49	52	**[85]**	0.67	0.67	0.17	0.17	6	6
[39]	0.65	0.64	0.07	0.07	30	31	**[86]**	0.00	0.00	0.20	0.20	5	5
[40]	0.59	0.57	0.03	0.03	68	72	**[87]**	1.00	1.00	1.00	1.00	1	1
[41]	0.77	0.75	0.09	0.09	53	56	**[88]**	1.00	1.00	1.00	1.00	1	1
[42]	0.67	0.65	0.10	0.09	94	97	**[89]**	0.90	0.90	0.33	0.33	3	3
[43]	0.86	0.86	0.50	0.50	2	2	**[90]**	1.00	1.00	1.00	1.00	1	1
[44]	0.79	0.79	0.25	0.25	71	72	**[91]**	–	–	–	–	–	–
[45]	0.57	0.43	0.14	0.11	7	9	**[92]**	0.41	0.33	0.06	0.05	17	19
[46]	1.00	0.50	1.00	0.67	2	3	**[93]**	0.53	0.50	0.56	0.54	36	37
[47]	0.75	0.75	0.25	0.25	48	48	**[94]**	0.73	0.71	0.22	0.21	18	19

Character 91 is a constant character; see the comments of this character.

Excluding *Stenaleyrodes* from out-group taxa, puts it in the position of being a sister group to all in-group taxa. Although Takahashi (1938) gave no information about the subfamily placement in his description of the monobasic genus

Stenaleyrodes – as well as Mamet (1952) giving supplementary notes on the type-species, *S. vinsoni* Takahashi – but at the end of the description, the author stated "related to *Trialeurodes* Laing, but differs in the elongate vasiform orifice, ... Resembles *Bemisia* Quaint. et Baker in the characters of vasiform orifice, ..." (Takahashi, 1938). In other words, Takahashi was indicating similarities to two aleyrodine genera. As already mentioned, Sampson (1943, 1947) placed *Stenaleyrodes* in the Aleyrodinae, tribe Dialeurodini (Appendix 1). Mound and Halsey (1978) listed the genus under Aleurodicinae and synonymized *Dialeurodicus elongatus* Dumbleton, which had already been transferred to *Stenaleyrodes* by Cohic (1968), with *S. vinsoni*. The former authors also stated "the material in the BMNH from Tanzania listed here as *Stenaleyrodes* sp. indet. represents a distinct species, which as in the case of *vinsoni*, can only be distinguished from *Dialeurodicus* at present by the elongate shape of its pupal case". No syntype materials of *S. vinsoni* were examined, but a paratype of *D. elongatus* and another specimen of *S. vinsoni* collected from the type locality (Reunion Island) and from the host of *S. vinsoni* (palm) as well as Tanzanian samples were studied. These samples lacked both the tarsal claw and apical adhesion pad. The illustration of hind leg in the original description of *S. vinsoni* (fig. 5, Takahashi, 1938) is in agreement with this observation. It seems that Mound and Halsey (1978) did not notice the absence of the tarsal claw in *Stenaleyrodes* while comparing it with *Dialeurodicus*, in which the character is present, and only mentioned the elongation of pupal case to distinguish these genera from each other.

From a consideration of puparial characters, there is no reason for *Stenaleyrodes* to be in Aleurodicinae due to its lack of the tarsal claw and lack of compound wax pores and/or agglomerate pores, i.e. the two basic puparial characters of the Aleurodicinae, though the vasiform orifice and the general size are similar to those of aleurodicine members. However, the examination of recently collected material of an undescribed species of *Stenaleyrodes* in BMNH has revealed aleurodicine characters in adults. Therefore, it would seem expedient to retain *Stenaleyrodes* in Aleurodicinae.

All 13 remaining characters with maximum retention indices (ri = 1) (except characters 22, 24, and 46) are autapomorphic characters of certain genera, e.g. characters 63 (eighth abdominal bifid process) and 82 (chain-like design along some abdominal and thoracic sutures) support monophyly of *Aleurocerus* and *Bellitudo*

respectively. Thus, these characters did not provide any phylogenetic information about relationships between genera.

According to Bink-Moenen (1983), character 3 (recurvature of margin) is mostly of value at the genus level, although in my analyses it had an intermediate ri and pretty low ci. Furthermore, Mound (1961), who erected the genus *Aleuropteridis*, mentioned that "this genus is near *Tetralicia* and *Aleuropleurocelus* in that the true margin is deflexed ventrally, i.e. the dorsal disc is larger than the ventral surface". Although in these three genera the character is quite typical, it can also be seen in several species putatively belonging to other genera such as *Bemisia hirta* Bink-Moenen and *Tetraleurodes caulicola* Nakahara, which it is not a specific character of the latter genera. All examined species currently placed in *Tetralicia*, in spite of their sharing this character, were not found to be monophyletic. *Aleuropteridis* formed a sister group to *Xenaleyrodes* (also shows the character), and among the taxa gathered with *Aleuropteridis* in the same clade (fig. 2.16), two examined species of *Leucopogonella* lacked this character. In this clade, *Tetraleurodes selachidentata* Bink-Moenen was described as a species *incertae sedis* (Bink-Moenen, 1983). Incidentally, some examined species of *Corbettia* and *Viennotaleyrodes* (both genera were recovered as monophyletic) lacked the character. Thus, character 3 seems to be far less reliable than past authors have suggested.

Submarginal line or fold (character 28) has been thought to be an important character at genus level and has been used by authors both in generic descriptions and identification keys (e.g. Mound, 1965; Bink-Moenen, 1983; Jesudasan & David, 1991; Martin *et al.*, 2000). It separates the submargin from the dorsal disc area and can appear in different forms (see character 29). In general, this character could not gather the genera possessed it in a separate clade, at least those that it appears in an identical shape. It should be noted that *Aleurotuberculatus*, in spite of having the character, was synonymized with *Aleuroclava* (Martin, 1999). Although the 15 examined species (7 species had the character) of the latter large genus were not found to be monophyletic in this analysis (fig. 2.17), but *Aleuroclava* can be considered as a monophyletic genus if some new combinations and synonymy are accepted (see section 2.6).

Some binary characters, e.g. 7 (position of cephalic setae), 11 (position of first abdominal setae), 37 (elevation of vasiform orifice), 43 (opercular setae), 49 (lingular

setae), 50 (number of lingular setae), 55 (caudal furrow), 57 (caudal ridges), 67 (submarginal glands), and 89 (apical adhesion pad of legs), which have had little attention paid to some of them by aleyrodid systematists, had high retention indices (0.8 < ri < 1), of which the four characters, 37, 49 , 55, and 57 were important in supporting main clades in the strict consensus tree of UW-MPTs. The general topology of this tree is shown in figure 2.18. With a few exceptions all taxa included in clade B (fig. 2.18) have elevated vasiform orifice (character 37), and considering its presence in some other small clades in the remaining part of the tree, e.g. clades II and VI, it can be hypothesized that the character has independently evolved several times. The same hypothesis probably applies to characters 49, 55, and 57. Most taxa in the clade C (fig. 2.18) lack lingular setae (or the setae are not apparent) (character 49), and those in the clade A lack both caudal furrow (character 55) and caudal ridges (character 57), but as for character 37, some other small clades in the other part of the tree lack these characters too, e.g. clades III and V for character 49, and clades I and IV for both characters 55 and 57.

The applicability of any tribe level classification for the Aleyrodinae seems to be premature. Sampson (1943) was the first to classify aleyrodine genera to five tribes (Appendix.1). Whereas, in 1956, in their identification key for the genera of the subfamily, Sampson and Drews placed almost all described genera by that time in two tribes, Aleyrodini and Dialeurodini, and the other three tribes was each comprised of a single genus. The authors also did not include the sixth tribe proposed by Russell (1947) in the key because of difficulty of finding characters to separate it from the others, and nothing was mentioned about the two tribes proposed by Takahashi (1954). It seems that erecting more tribes, as done by David (1990), with our current poor understanding the significance of puparial characters will not help. For example, none of the genera placed in the Alyrodini by three different authors (Appendix 1) was recovered in the same clade as *Aleyrodes* in this study, and *Indoaleyrodes*, which was placed in the Bemisini by David (1990), formed a sister group to *Aleyrodes* (fig. 2.15). Bearing in mind that defining a reliable suite of morphological characters at genus level is still problematic and many genera lack objective definitive, it will obviously be difficult to find some synapomorphic characters to define different tribes confidently.

Unfortunately, some strikingly obvious structural apomorphies have probably been independently derived in a number of quite closely related species. Such characters can easily confuse attempts at phylogenetic reconstruction as they are difficult to differentiate from genuine synapomorphies. Often such striking characters are considered to be of 'generic worth' and in practice many species which show these kinds of characters are placed in separate monobasic or oligobasic genera (Gauld & Mound, 1982). It seems that the ability to develop apomorphies of this type independently in closely related taxa can be found in Aleyrodidae. The taxa of the clade shown in figure 2.19 may be good examples. In this clade, three genera, *Aleuroparadoxus*, *Bellitudo*, and *Crescentaleyrodes*, have obvious apomorphies, i.e. characters 76 (modified papillae of dorsal disc area, which are slightly elevated, nearly flat and plate-like), 82 (chain-like design along some abdominal and thoracic sutures), and 87 (submarginal crescent-shaped pores) respectively. Of these three genera, *Crescentaleyrodes* was not recovered as monophyletic and *Aleurotrachelus fumipennis* (Hempel) made it paraphyletic (fig. 2.19). David and Jesudasan (1987) proposed *Crescentaleyrodes* for *Tetraleurodes semilunaris* Corbett, which had already been transferred to *Aleurolobus* by Bink-Moenen (1983), as well as transferring two species of *Aleurolobus*, *A. monodi* Cohic and *A. paulianae* Cohic to *Crescentaleyrodes*. The main diagnostic character of *Crescentaleyrodes*, as the name implies, is the presence of crescent-shaped (semilunate) pores (fig. 2.12J) along the submargin. It should be noted that the syntype materials of *A. fumipennis* were not examined and its original description (Hempel, 1899) provides no illustration and is inadequate for the positive identification of the species. The examined specimens (from Brazil collected on grasses, the same locality and host plant as the syntypes) identified as *A. fumipennis* in BMNH had submarginal crescent-shape pores (character 87) and were in agreement with the redescription and illustration of *A. fumipennis* provided by Bondar (1923), i.e. belonging to *Crescentaleyrodes* (see also section 2.6). Furthermore, there are three monobasic genera, *Aleyrodiella*, *Harpaleyrodes*, and *Rositaleyrodes*, in this clade. The latter was proposed for *Aleurolobus oplismeni* Takahashi by Meganathan and David (1994), who erroneously proposed a new holotype and six paratypes from their samples collected for an extant species of another author. The authors stated "this genus resembles *Aleurolobus* Quaintance & Baker in all the characters, but it differs from it, by having the submargin entirely

demarcated from dorsum by a submarginal furrow and thoracic and caudal tracheal combs differentiated from margin by teeth and a pouch like structure". The entire submarginal furrow can be seen in other species of *Aleurolobus*, e.g. *A. hargreavesi* Dozier, and also the differentiation of tracheal area from the margin is variable in this genus. It seems that there is no reason for proposing a separate genus (see also section 2.6). Danzig (1966) erected *Aleyrodiella* and stated "an extremely distinctive genus whose taxonomic position is uncertain". The author then discussed its similarity to the three genera, *Aleuroparadoxus*, *Aleurotithius*, and *Trialeurodes* (Table 2.3), as well as its differences from them. These three genera are those that Russell (1947) placed in the Trialeurodini (Appendix 1) but only *Aleuroparadoxus* was recovered here in the same clade as *Aleyrodiella*. The latter two genera were found here to be more closely related to *Aleurolobus* than to *Trialeurodes* and/or *Aleurotithius* (Table 2.3). The third monobasic genus in this clade, *Harpaleyrodes*, was erected by Bink-Moenen (1983) and, as the author stated, it resembles *Aleurolobus*. One of its differences from *Aleurolobus* is its strongly recurved submargin (Bink-Moenen, 1983) (character 3), and as discussed above, this is variable in some genera. It is possible that *Harpaleyrodes* and *Aleurolobus* are congeneric, in spite of the alleged differences. It is also worth mentioning that according to Danzig (1964), *Dialeurolobus* (with two described species so far), which formed a sister group to all discussed taxa in this clade (fig. 2.19), is allied to *Aleurolobus* and differs from the latter in having no submarginal fold (character 28). The variability of this character has been discussed, above. *Dialeurodes erythrinae* Corbett has also much in common with the members of this clade (fig. 2.19) rather than with *Dialeurodes*, and its placement in *Dialeurodes* is doubtful (species *incertae sedis*).

As is common in phylogenetic analyses, the sister groups of some clearly monophyletic genera are often paraphyletic assemblages, e.g. *Aleurocerus* rendering *Aleurothrixus* paraphyletic (fig. 2.20). Seven of the 10 examined species, including the type-species, *Aleurothrixus floccosus* (Maslell), as well as *Hempelia* (see section 2.6 for proposed synonymy of *Hempelia* with *Aleurothrixus*) were recovered in the same clade as *Aleurocerus*. This clade was relatively highly supported in both bootstrap and parsimony Jackknifing analyses (fig. 2.20) (see section 2.6 for the discussion of the other three species of *Aleurothrixus*). A close relationship between *Aleurocerus* and *Aleurothrixus* was also postulated by Russell (1986) and the

presence of the eighth abdominal bifid process (character 63) (fig. 2.11A) in *Aleurocerus* its only diagnostic character.

The same was found for *Corbettia*, recovered as monophyletic here, but rendering *Aleuromarginatus* paraphyletic (fig. 2.15). Interestingly, *Aleuromarginatus* and *Corbettia* also colonize the same host plant family, Fabaceae (discussed in section 2.4.5). Seven of the 10 examined species, including the type-species, *A. tephrosiae* Corbett, were found in the same clade as *Corbettia*. The two other species scored, *A. marginiquus* Martin and *A. nemciae* Martin, are apparently not congeneric with the type-species and this uncertainty was alluded to by the author (Martin, 1999). Based on the results of this study, the placement of these species in *Aleuromarginatus* is uncertain (species *incertae sedis*). *A. serdangensis*, as already mentioned, seems to be a misplaced species differing in several characters (e.g. 4, 8, 9, 44, and 94) from the type and the other included species. *A. serdangensis* was recovered in a quite distantly separated clade that includes several diverse species putatively belonging to different genera (figs 2.13 and 2.14).

2.5.1. Monophyly of large genera

Aleuroplatus, *Aleurotrachelus*, and *Tetraleurodes* are genera with many included species and worldwide distribution (Mound & Halsey, 1978). Currently each includes many diverse species and lacks a suite of distinguishing characters. Therefore, there is no reason to assume that species currently classified in any of these, especially from different geographical regions, are related to one another. As expected these genera were not found to be monophyletic, but only for *Aleurotrachelus*, was monophyly rejected statistically. The reason for this may be the lack of distinct generic characters. In other words, the species of these genera just have combinations of characters shared with various other genera. Regarding *Aleurotrachelus*, it should be noted that the specimens checked as *A. fumipennis*, as discussed above, had the typical character of *Crescentaleyrodes* and in the constraint analysis it was not excluded from *Aleurotrachelus*. Thus, it is quite likely that this species contributed largely to the statistical rejection of monophyly of *Aleurotrachelus*. To test this, another constraint analysis was performed for this genus excluding *A. fumipennis*. The length of the MPTs was 2773 compared with 2730 for the UW-MPTs. The result of the Templeton test (500 trees were compared) showed

that the constrained trees were not consistently significantly longer with P values for the majority of the trees above 0.05 (P = 0.0390*-0.0793; see also Table 2.2). Such interpretation may also apply to *Dialeurodes*, which in spite of many of its some species having been transferred to *Massilieurodes* and *Singhiella* by Jensen (2001), it is still a large and heterogeneous genus.

In contrast, although monophyly of *Trialeurodes* was not also rejected statistically, the same interpretation does not seem to apply. *Trialeurodes* is quite well characterised and most of its species are certainly of New World origin (Mound, 1984). *T. vaporariorum*, which has long been known as a worldwide pest, almost certainly evolved in the south western part of North America (Russell, 1948). In the strict consensus tree of MPTs-SAW-MaxRI (fig. 2.14), nine of the 11 examined species including the type-species, *T. pergandei*, as well as the closely related monobasic genus *Venezaleurodes* (probably should be synonymized with *Trialeurodes*) were recovered as a monophyletic group. These species were unresolved in the strict consensus tree of UW-MPTs (fig. 2.13). The probabilities that this genus is monophyletic (Templeton test: P = 0.5590-0.7035) are much higher than for the other constrained genera (Table 2.2). The factors mentioned above for *Trialeurodes* may also be applicable to *Bemisia*. According to Mound (1984), it seems probable that the *Bemisia* group primarily originated in the Palaearctic, though it was previously suggested that *B. tabaci* was Indian region in origin (Mound, 1965). The main problem with this genus is that in spite of including the well-known pest, *B. tabaci*, it is not well defined. For this reason, it is expected that the genus includes at least several misplaced species which resulted its monophyly to be rejected statistically.

2.5.2. Host plant relationship

Relationships between whiteflies and their host plants are unclear. According to Mound & Halsey (1978), since the majority of aleyrodids are known only from the Angiosperms, it seems unlikely that this family evolved until after the radiation of the flowering plants. These authors compared the Cronquist's (1968) plant classification with the host plants of whiteflies and deduced that most whitefly species were recorded from plants belonging to four smaller, less highly evolved subclasses. The authors then stated "As the Asteridae and Rosidae are the most advanced groups of

higher plants, it may be that the aleyrodids did not evolve at the same rate but retained a relationship with the more primitive groups of plants. Alternatively the relationship may be a reflection of the geographical distributions of the organisms, the Asteridae and Rosidae being most common in temperate regions, whereas the Aleyrodidae are mainly a tropical group".

Based on the system of the Angiosperm Phylogeny Group (APG) (Bremer *et al.*, 2003), 328 of the 439 whitefly species examined in this study are known from the two advanced groups, i.e. asterids (including euasterids I and euasterids II) and rosids (including eurosids I and eurosids II). In this system, euasterids II and euasterids I are two of the most recently derived groups. More than 100 of the examined whitefly species are known from these groups (21 from euasterids II, 78 form euasterids I, and 17 from both) (Appendix 5). The positions of these species in the strict consensus tree of UW-MPTs as well in the MPTs-SAW-MaxRI show no pattern. Thus, parallel diversification with host plants and whiteflies is not apparent and it appears that widespread host switching has obscured any basic associations. Having said this, the evolution of aleyrodid host plant affiliations does not seem to be totally random as some groups have species feeding on related plants.

2.6. Nomenclatural changes

The results obtained from phylogenetic analyses presented above, indicate the great need for reclassification of the Aleyrodinae. It is quite possible that those species whose pupal cases differ considerably from each other nevertheless have adults showing apparently unique apomorphies and therefore they should be placed in the same genus (Bink-Moenen, 1992, discussing the genus *Aleuroviggianus*). On the other hand, adults can differ markedly despite of great similarities in their pupal cases, and so are placed in different genera (Russell, 2000, discussing the genera *Aleurocybotus* and *Vasdavidius*). Since adults for the majority of described species are unknown, it is not desirable to change the current genus concepts defined based on pupal case character only, unless the true significance of the latter is known. This will be the next necessary step in improving the taxonomy of whiteflies.

Checking such a large number of species, belonging to more than 100 genera, revealed the necessity for proposing some nomenclatural changes. These are only proposed for those taxa where the necessity of changing their current taxonomic

positions has been supported by the pylogenetic analysis, in addition to the convictions obtained during the visual examination of specimens. Those genera mentioned here as New genus 1 and New genus 2 will be described somewhere else.

ALEUROCLAVA Singh, 1931

Type-species: *Aleuroclava complex* Singh, 1931.

Aleurotuberculatus Takahashi, 1932. Type-species: *Aleurotuberculatus gordoniae* Takahashi, 1932 [synonymized by Martin, 1999].

Martiniella Jesudasan & David, 1990. Type-species: *Aleurotuberculatus canangae* Corbett, 1935 [synonymized by Martin, 1999].

Taiwanaleyrodes Takahashi, 1932. Type-species: *Taiwanaleyrodes meliosmae* Takahashi, 1932. **Syn. n.**

Comments: Takahashi (1932) erected *Aleurotuberculatus* mentioning that it was closely allied to *Aleuroclava* and may be a synonym of it. In the same article, he erected *Taiwanaleyrodes* and stated "allied to *Aleurotuberculatus* Takah., but differs from it in lacking dorsal tubercles and thoracic tracheal clefts, but in possessing a distinct marginal rim on the venter, and also distinguishable from ..." (Takahashi, 1932). Takahashi (1939) in the original description of *Taiwanaleyrodes carpini* Takahashi stated "cephalothorax with a pair of large rounded tubercle-like markings on the pronotum, and also on the mesonotum, and 2 pairs of similar ones on the metanotum, ..., thoracic tracheal folds very short, the clefts indistinct, very shallow, wide, without teeth". In this article, the author transferred *Aleurotuberculatus pyracanthae* Takahashi to *Taiwanaleyrodes* (apparently Mound and Halsey (1978) did not noticed this transformation and listed the latter species under *Aleurotuberculatus* and/or did not accept it, but mentioned nothing), although in the original description of *A. pyracanthae* stated "venter with no rim" (Takahashi, 1933). It is clear that the two species of *Taiwanaleyrodes*, which placed in this genus by the author of the genus, do not quite agree with the type-species, *T. meliosmae* Takahashi, in having the three diagnostic characters. Examination of many specimens of *Aleuroclava*, in addition to those included in this analysis, indicated that the dorsal tubercles and thoracic tracheal clefts definition is so variable and these characters should not be used for the separation of these genera. In the current study the type-

species of *Taiwanaleyrodes*, as well as its one other included species were recovered within *Aleuroclava* (fig. 2.17). *Taiwanaleyrodes* is therefore here regarded as a junior synonym of *Aleuroclava*.

Jesudasan and David (1990) proposed *Minutaleyrodes* for four species formerly included within *Aleurotuberculatus*. The genus was provisionally retained for its included species by Martin (1999), who synonymized *Aleurotuberculatus* and *Martiniella* with *Aleuroclava*. *Aleuroclava similis* (Takahashi) formed a sister group to *Minutaleyrodes* in this study (fig. 2.17). Of the characters specified for *Minutaleyrodes* by Jesudasan and David, demarcation of the submargin on the ventral surface, can be seen in some species of *Taiwanaleyrodes* (discussed above). The shape of transverse moulting suture is the same that of in *A. similis*, but the size of this species is not similar to *Minutaleyrodes* and submargin not ventrally demarcated in *A. similis*. Unlike *Aleuroclava*, the first abdominal setae in *Minutaleyrodes* are absent (not mentioned by the authors) but some species of the former genus, e.g. *A. similis* and *A. nigeriae* (Mound), also lack these setae. In the latter species, these setae are sometimes present (Bink-Moenen, 1983). Therefore, *Minutaleyrodes* seems to be congeneric with *Aleuroclava*, but because of the three species of *Dialeurodes* recovered between these two genera (see fig. 2.17), it is not synonymized. These three species currently accommodated in *Dialeurodes*, are not quite typical for their current genus nor for *Aleuroclava*, and it appears they have much in common with *Aleuroclava*, especially *D. mirabilis* Takahashi, rather than *Dialeurodes*.

Aleuroclava lanceolata (Takahashi) **comb. n.**

Dialeurodes lanceolata Takahashi, 1949. Holotype, Riouw (Riau) Islands (south of Singapore): Rempang [not examined].

Material examined: Singapore: Botanic Gardens, 15.ix.1980, (D.H. Murphy), ex: *Bhesa panicula*, (2 slides).

Comments: specimens checked were in agreement with the original description and illustration, and indicate that the inclusion of this species in *Aleuroclava* is appropriate. As stated by Takahashi (1949), this species is not a typical form of *Dialeurodes*. *A. lanceolata* is closely related to *A. filamentosa* (Corbett) (fig. 2.17).

ALEUROLOBUS Quaintance & Baker, 1914

Type-species: *Aleurodes marlatti* Quaintance, 1903.

Rositaleyrodes Meganathan & David, 1994. Type-species: *Aleurolobus oplismeni* Takahashi, 1931. **Syn. n.**

Comments: as discussed before, according to Meganathan and David (1994), *Rositaleyrodes* resembles *Aleurolobus* in all the characters, but it differs from it, by having the submargin entirely demarcated from dorsum by a submarginal furrow and thoracic and caudal tracheal combs differentiated from margin by teeth and a pouch like structure. The latter character is variable in *Aleurolobus* and the entire submarginal furrow can be seen in other species of this genus, e.g. *A. hargreavesi*. *Rositaleyrodes* is therefore here regarded as a junior synonym of *Aleurolobus*.

ALEUROTHRIXUS Quaintance & Baker, 1914

Type-species: *Aleyrodes howardi* Quaintance, 1907, a junior synonym of *Aleurodes floccosa* Maskell, 1895.

Hempelia Sampson & Drews, 1941. Type-species: *Hempelia chivelensis* Sampson & Drews, 1941. **Syn. n.**

Comments: as already discussed, seven of the 10 examined species of *Aleurothrixus* including the type-species, *A. floccosus* (Maslell), as well as *Hempelia* were recovered in a monophyletic clade with *Aleurocerus*. The syntype material of the type-species of monobasic genus *Hempelia* showed no clear differences from *Aleurothrixus* that appear to be of generic significance and here *Hempelia* is regarded as a junior synonym of *Aleurothrixus*.

Aleurothrixus antidesmae Takahashi and *A. smilaceti* Takahashi are closely related to each other and do not seem to be congeneric with the type-species. A different genus is needed for them; almost certainly a new one. The situation is the same for the American species, *A. interrogationis* (Bemis), but it differs from these two Asian species. It was recovered within some species of *Aleuroplatus* and its placement in *Aleurothrixus* is doubtful (species *incertae sedis*).

CRESCENTALEYRODES David & Jesudasan, 1987

Type-species: *Tetraleurodes semilunaris* Corbett, 1926.

Crescentaleyrodes fumipennis (Hempel) **comb. n.**

Aleurodes fumipennis Hempel, 1899. Syntypes, Brazil: São Paulo [not examined].

Aleurotrachelus fumipennis (Hempel) Quaintance & Baker, 1914.

Material examined: Brazil: Mato, Grosso, 25.iii.1968, (O.W. Richards), ex: undetermined grass, (2 slides).

Comments: as already mentioned in detail, the redescription and illustrations provided by Bondar (1923) as well as the specimens examined, clearly indicate the appropriate inclusion of this species in *Crescentaleyrodes*. This species is very close to *C. paulianae* (Cohic) and maybe they are synonym, but this need to check the type material of the latter species. The specimens of *C. paulianae* studied for this study were from the same locality and host plant of type materials and showed slightly differences from *C. fumipennis*.

PSEUDOZAPHANERA Manzari **gen. n.**

Type-species: *Aleurodes niger* Maskell, 1895.

Description. Pupal case. Cuticle black. Margin toothed, thoracic and caudal tracheal pore areas not differentiated from margin. Submargin not separated from dorsal disc area by a line or fold. Longitudinal moulting suture reaching margin, transverse moulting suture curving anteriorly and reaching margin. Abdomen with exaggerated intersegmental sutures extending into outer subdorsum. Abdominal rhachis present or absent. Dorsum usually punctuated by geminate pore/porettes. Vasiform orifice cordate or subcordate, often elevated. Operculum almost filling vasiform orifice. Caudal furrow absent or faintly indicated. Eyespots absent or present.

Chaetotaxy. Cephalic and first abdominal setae absent, eight abdominal and caudal setae present. A row of submarginal setae present but their total number as well as their number on abdomen and cephalothorax variable (6-11, usually 7-8 pairs

excluding the caudal setae), occasionally with a few pair subdorsal setae. All setae very small and often capitae.

Venter. Thoracic and caudal tracheal folds present. Antennae long, reaching middle of middle legs or more, male antennae much longer.

Distribution. Australia.

Hosts. Fabaceae.

Etymology. This genus is named to reflect its superficial similarity to *Zaphanera.*

Species included: *Pseudozaphanera niger* (Maskell) **comb. n.**; *Pseudozaphanera papyrocarpae* (Martin) **comb. n.**; *Pseudozaphanera rhachisreticulata* (Martin) **comb. n.**; *Pseudozaphanera splendida* (Martin) **comb. n.**; *Pseudozaphanera wariensis* (Martin) **comb. n.**

Comments: except the type-species, all above species included in this genus were originally described in *Zaphanera.* The type-species has already been transferred to *Aleurolobus*, *Tetraleurodes* and *Zaphanera* by Quaintance and Baker (1914), Dumbleton (1956) and Martin (1999) respectively. *Pseudozaphanera* differs from *Zaphanera* in the number of submarginal setae as well as their shape, absence of cephalic setae, position of eight abdominal setae, shape of transverse moulting suture, and length of antennae. In *Zaphanera* there are five pairs of setae (excluding the caudal setae), two pairs on the cephalothorax and three pairs on the abdomen, and these setae are not capitate. Antennae do not reach beyond front legs, and the eighth abdominal setae are located adjacent to postero-lateral margin of vasiform orifice. In three of the four described species (examined) retained in *Zaphanera*, including the type-species, *Z. cyanotis*, cephalic setae are present, and based on the redescription provided by David and Subramaniam (1976), they are not discernible in *Z. publicus* (Singh) (not examined). In *Zaphanera* abdominal segmentation is distinct only in the submedian area in contrast to *Pseudozaphanera* (see also section 2.4.4, tribe Zaphanerini).

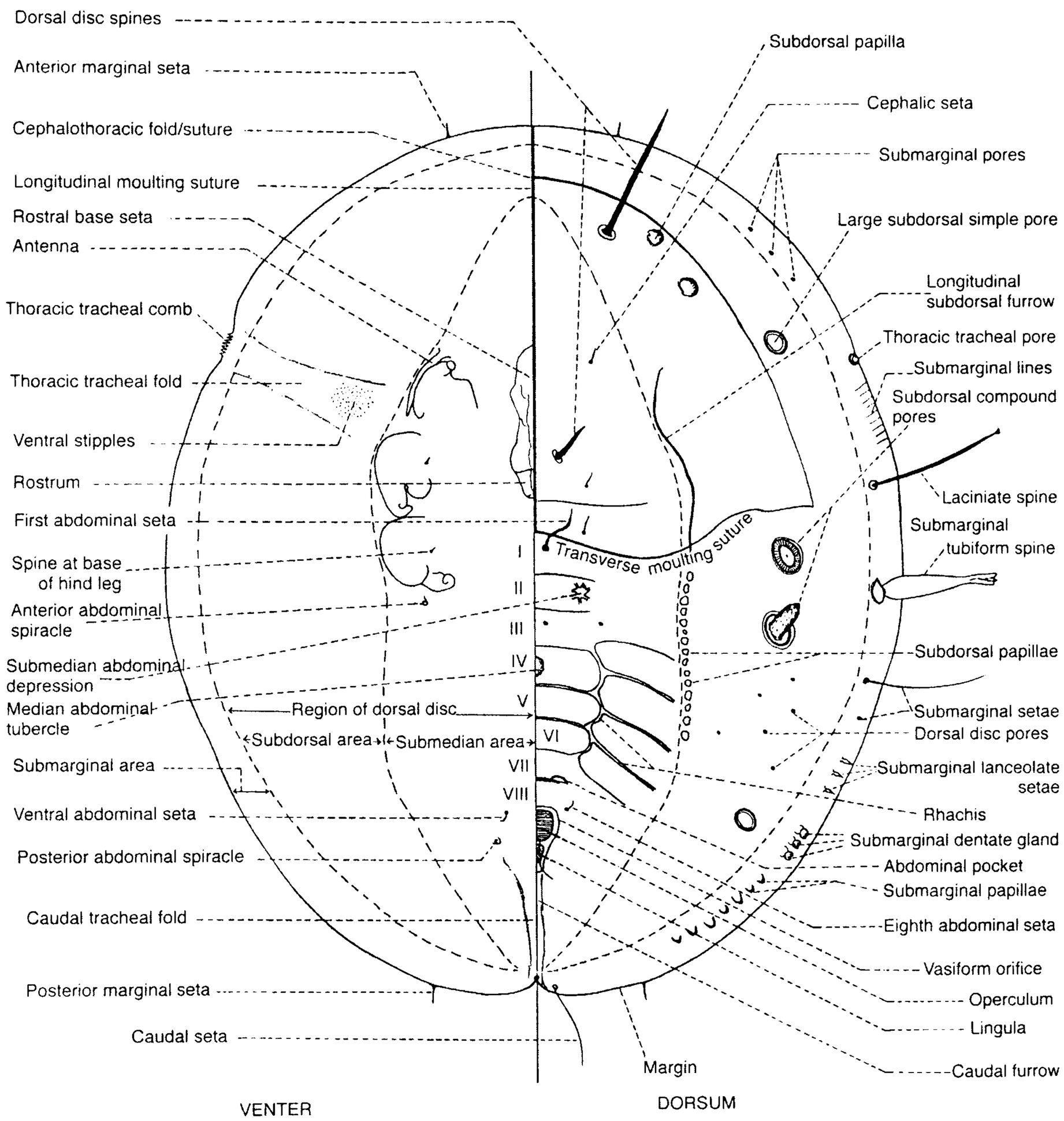


Fig. 2.2. Stylized whitefly puparium with major morphological features annotated (from Martin, 1987).

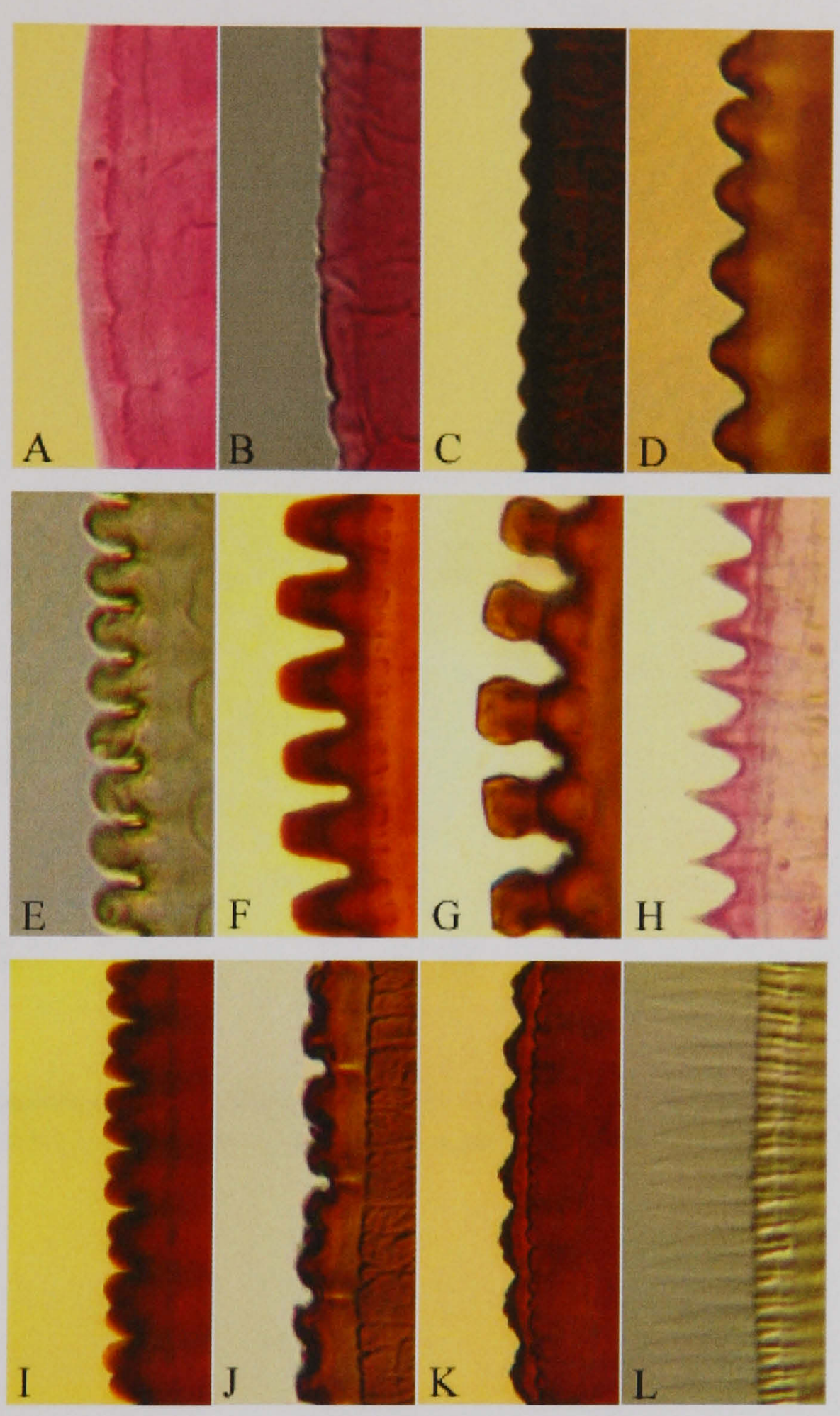


Fig. 2.3. Different shapes of margin. A. smooth line; B. undulate and/or indistinctly indentate; C. crenate; D. dentate; E. lobulate; F,G. truncate-lobulate; H. serrate; I-K. each tooth with apical notch, which gives the teeth the appearance of being twinned and sometimes being triangular; L. close-set lanceolate processes, each arising from a blunt marginal tooth.

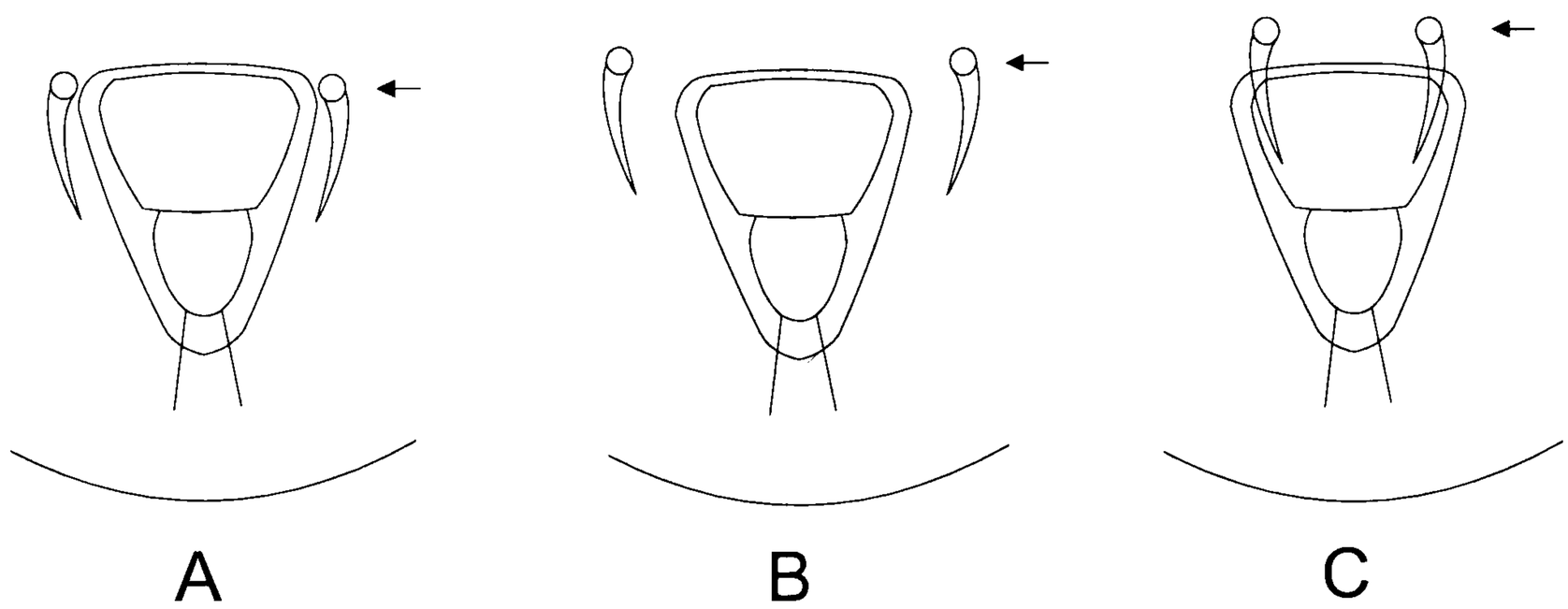


Fig. 2.4. Position of eighth abdominal setae (arrowed). A. at the base of anterior margin and/or lateral to vasiform orifice; B. anterolateral to vasiform orifice; C. anterior to vasiform orifice.

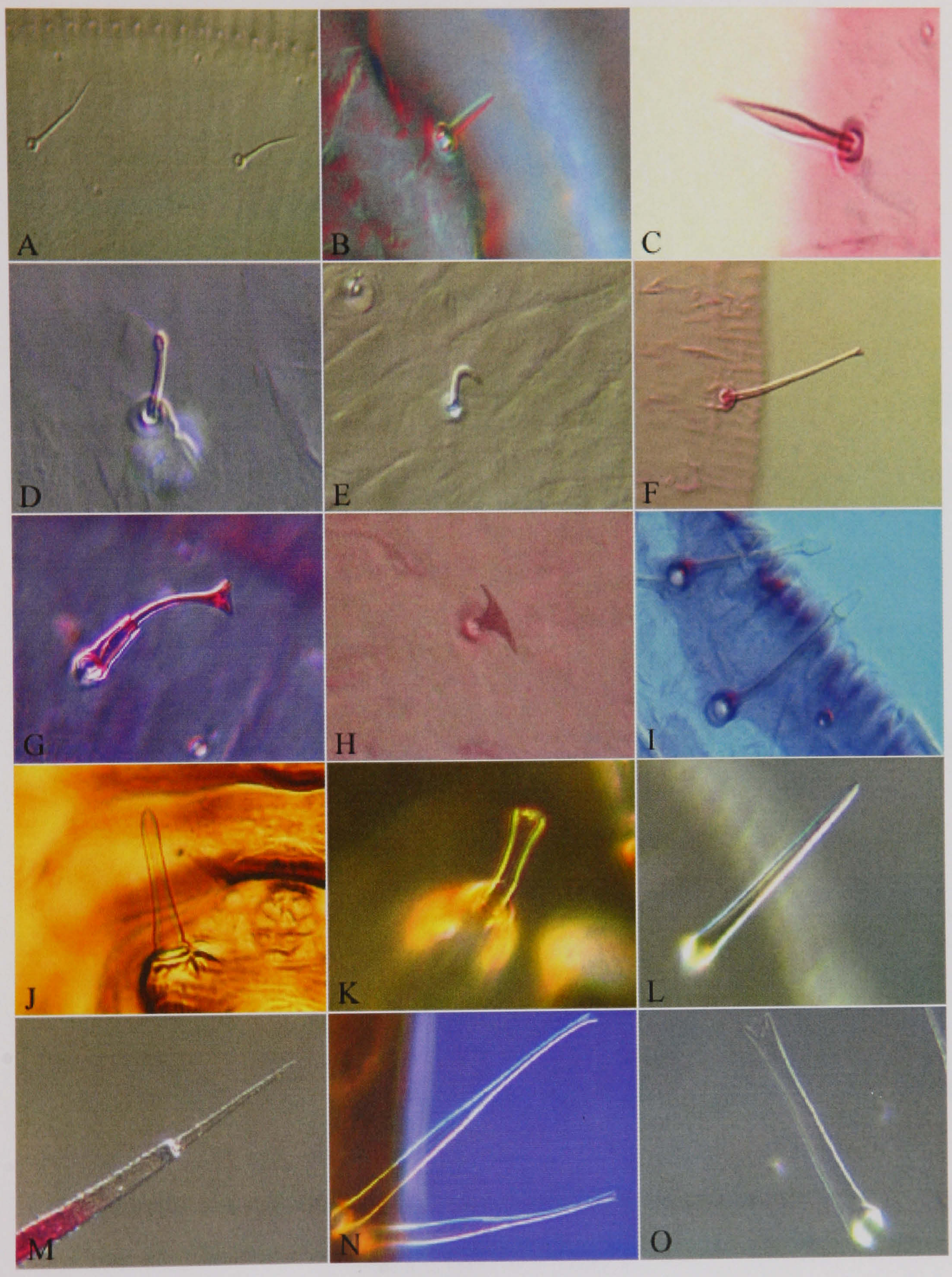


Fig. 2.5. Different shapes of setae (A-J) and spines (K-O). A. hair-like, short or long; B. stout, apical acute and/or rounded, short or long; C. somewhat swollen at base and pointed apically (lanceolate); D. capitate; E. apical bended; F. laciniate; G. very stout, apical truncate-capitate; H. almost T-shaped; I. almost arrow-shaped; J. trumpet-like wax-secreting setae; K. spines reduced to capitate seta-like structures; L. stout and acute; M. stout spines with a seta acutely pointed at the tip; N. stout and laciniate; O. tubiform (siphon-like).

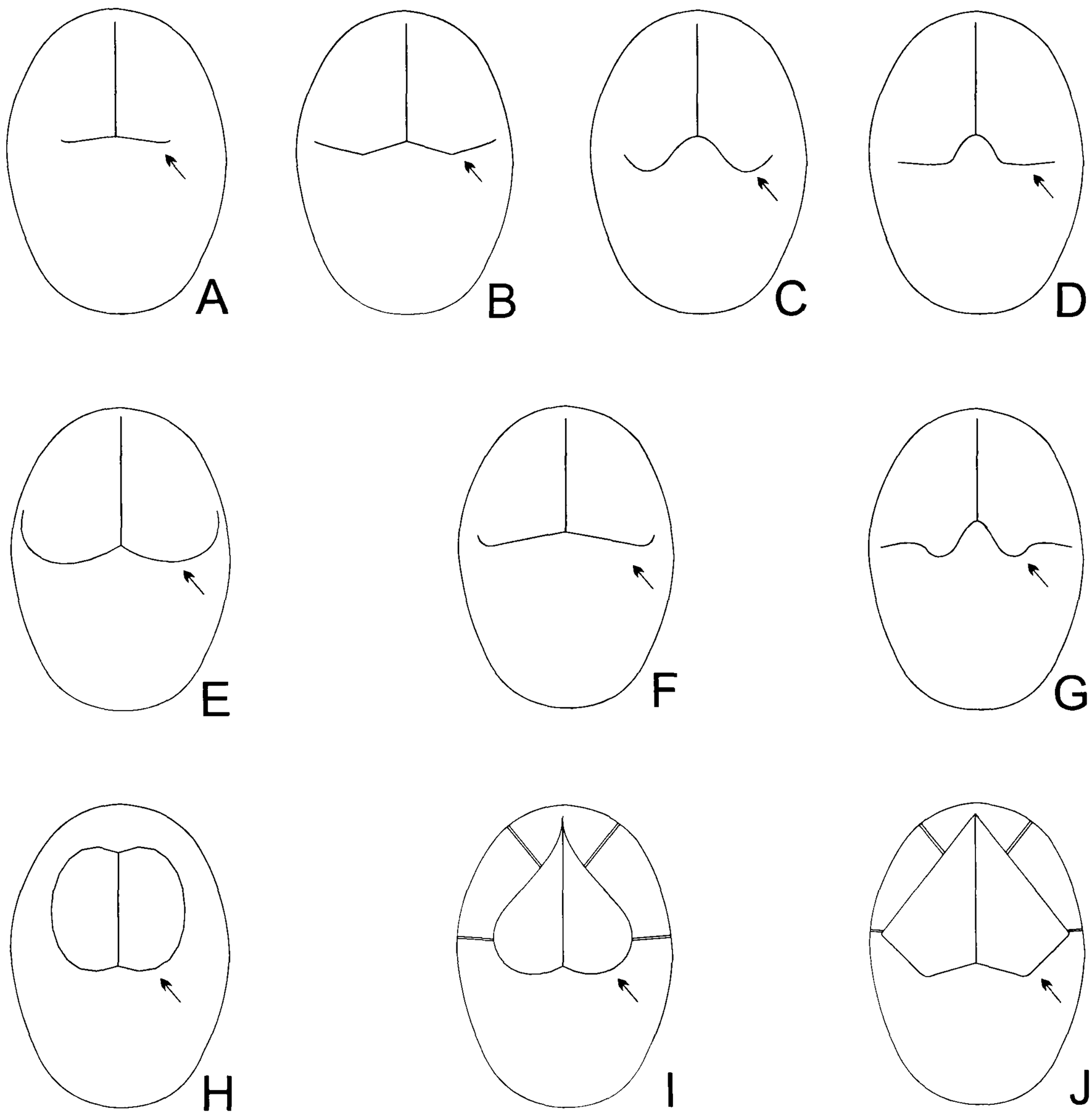


Fig. 2.6. Different shapes of transverse moulting suture (arrow shows transverse moulting suture).

Fig. 2.7. Vasiform orifice shape. A. nearly circular; B. oval, truncate at the top (scutellate); C. subcordate; D. transversely elliptical; E. triangular, straight-sided; F. cordate; G. triangular, not very elongate, emarginate-sided; H. elongate-triangular, straight-sided; I. elongate-cordate; J. elongate-triangular, sinuous-sided; K. squarish; L. rectangular; M. nearly trapezoidal.

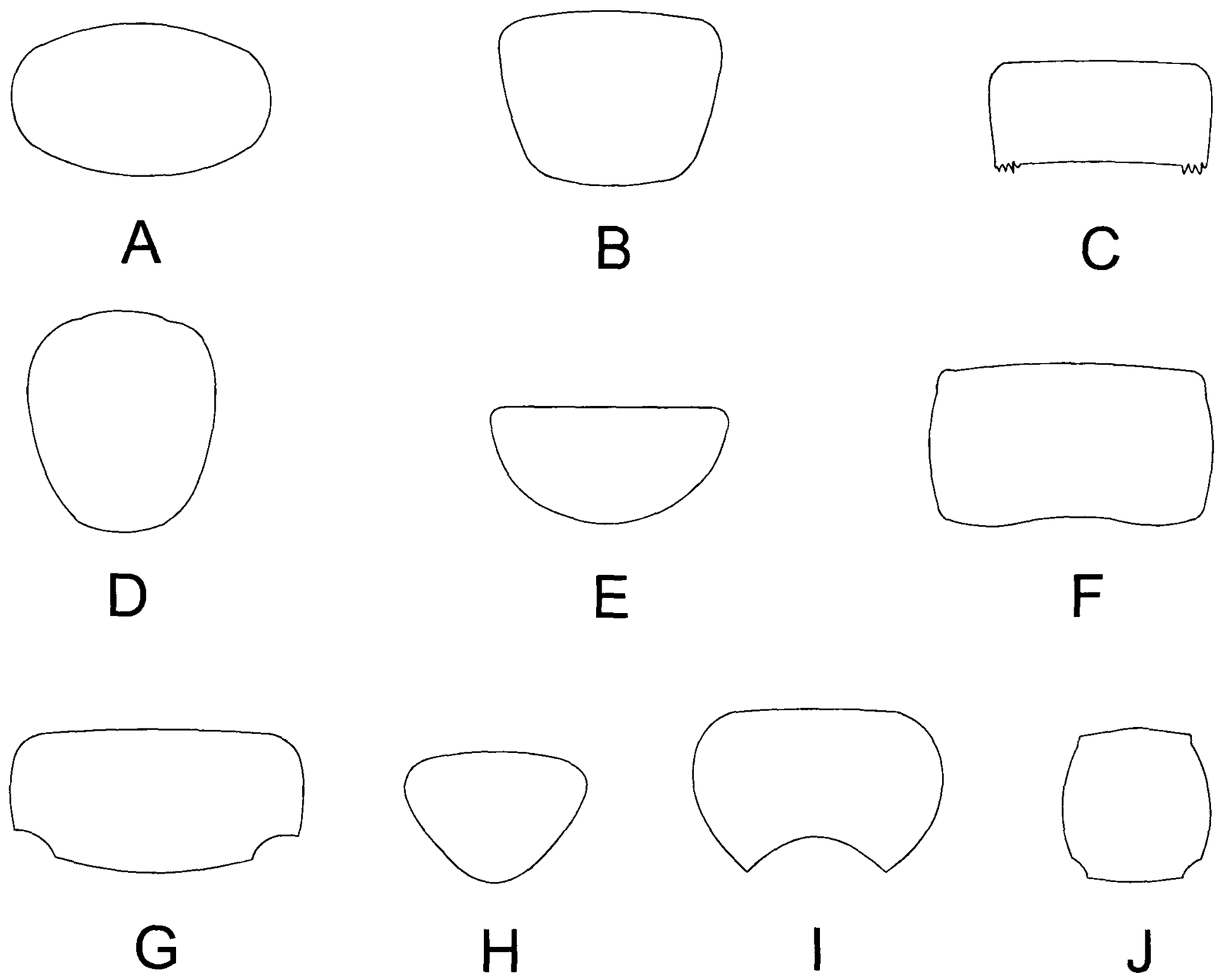


Fig. 2.8. Different shapes of the operculum. A. transversely elliptical; B. nearly trapezoidal, rounded at angles; C. nearly rectangular, wide about twice as long as length, posterior angles toothed and/or slightly indentate; D. subcordate; E. semicircular; F. rectangular, convex-sided, hind margin slightly curves anteriorly and/or straight; G. rectangular, convex-sided, hind margin with a wide projection; H. cordate or slightly elongate-cordate; I. rectangular shaped pushed inward at posterior margin; J. squarish, convex-sided, narrowed posteriorly.

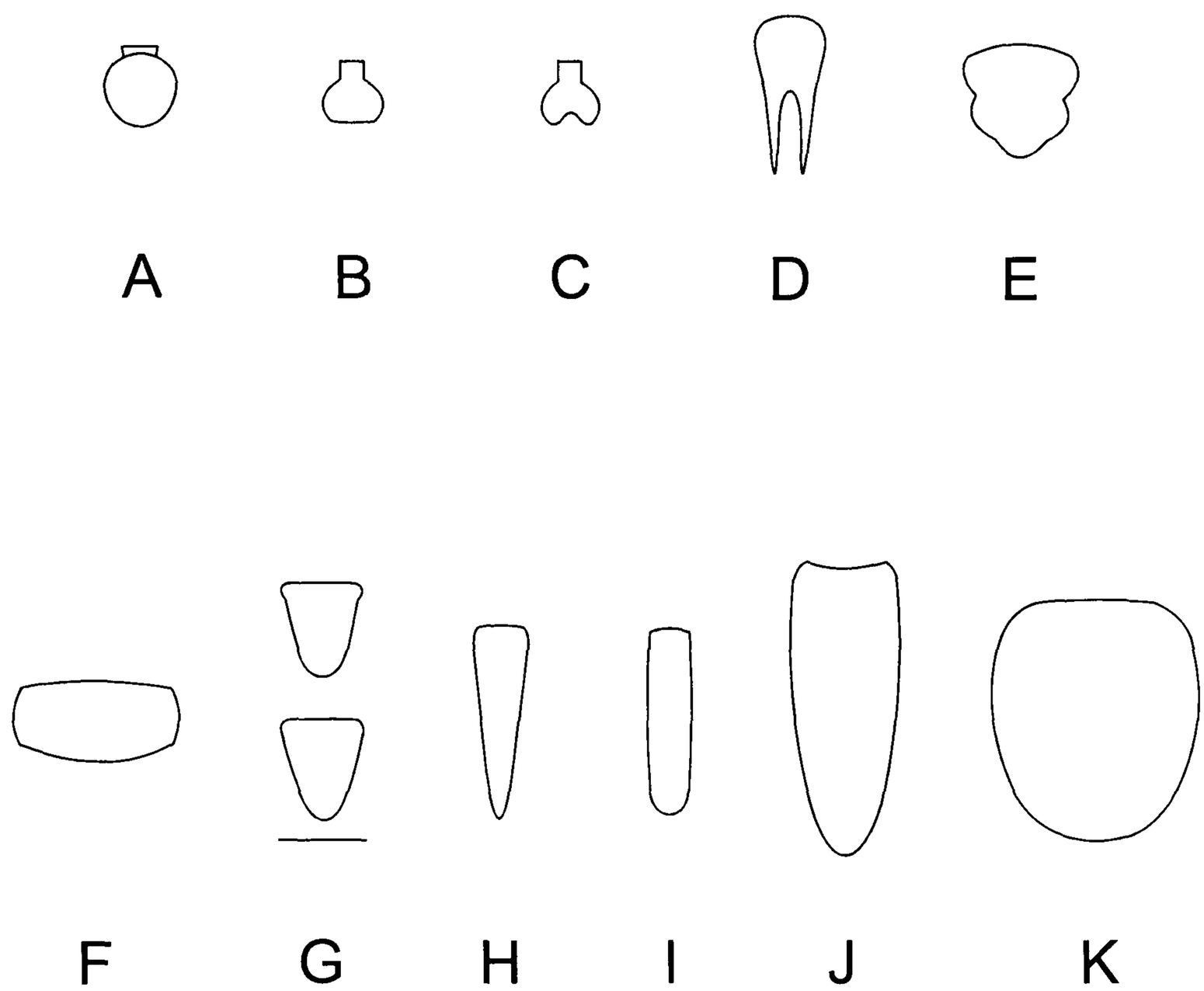


Fig. 2.9. Different shapes of lingula. A. knobbed; B. expanded apically; C. bilobate; D. forked-shaped; E. lobular; F. transversely elliptical; G. spatulate, sometimes nearly triangular; H. lanceolate; I. cylindrical, rounded posteriorly; J. large and almost conical; K. large and tongue-shaped.

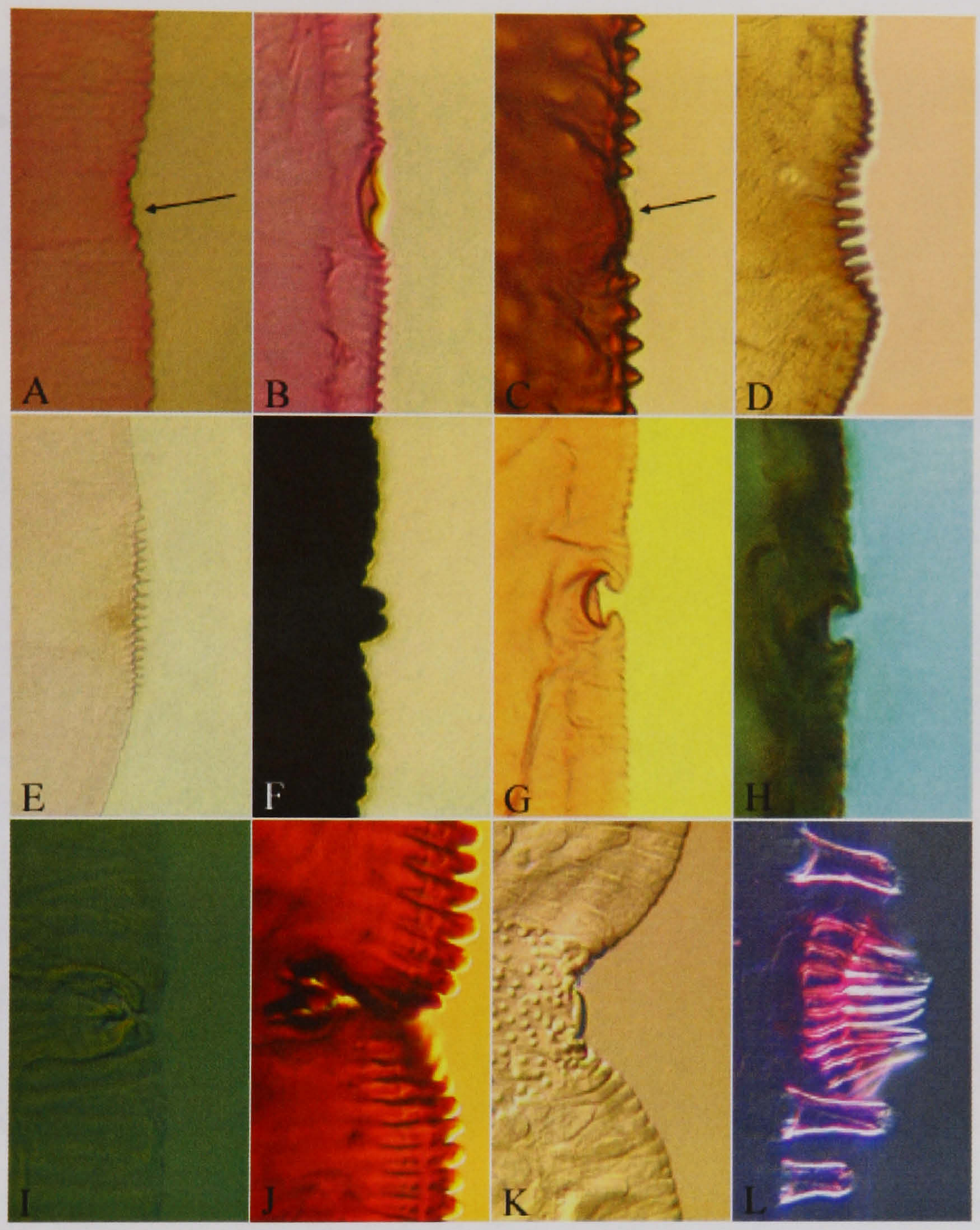


Fig. 2.10. Different forms of the tracheal pore. A. not forming a distinct pore, margin slightly curved inwardly/outwardly or thickened (arrowed); B. somewhat invaginated and with slightly thickened cuticle; C. crenulated to a lesser degree than the rest of margin (arrowed); D-F. a comb of modified teeth, sometimes only two or three teeth; G,H. C-shape pore without teeth; I,J. C-shape with teeth; K. deeply emarginate and covered by a smooth rounded lobe; L. gland spines forming a comb.

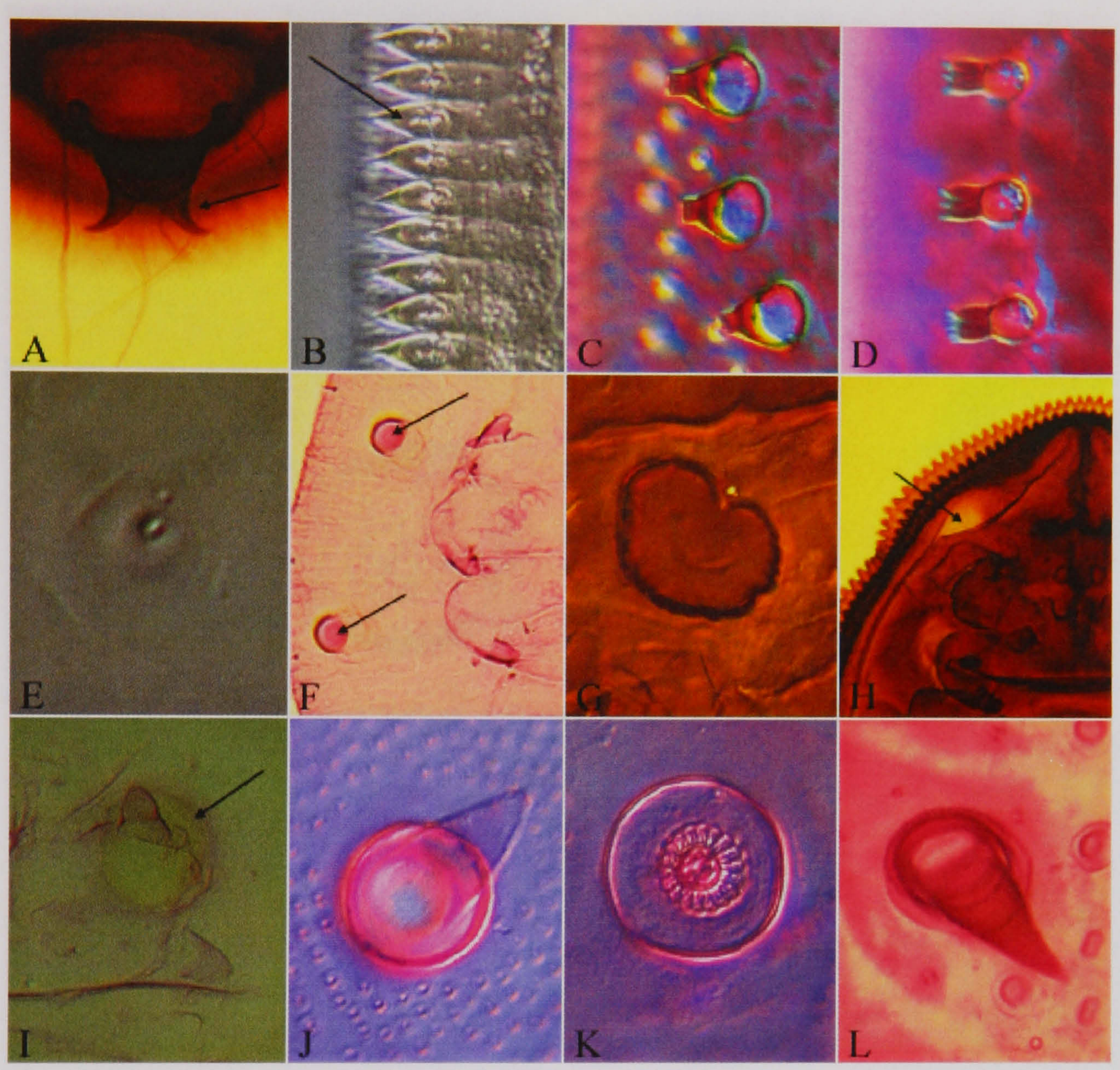


Fig. 2.11. Different characters of pupal cases. A. eighth abdominal segment showing bifid process (arrowed); B. submarginal papillae (arrowed); C. submarginal glands (tips of glands smooth); D. submarginal glands (tips of glands dentate); E. geminate pore/porettes; F. large subdorsal simple pores (arrowed); G. modified papillae of dorsal disc area, which are slightly elevated, nearly flat and plate-like; H. eyespot (arrowed); I. dorsal gland (arrowed); J-L. compound wax pores.

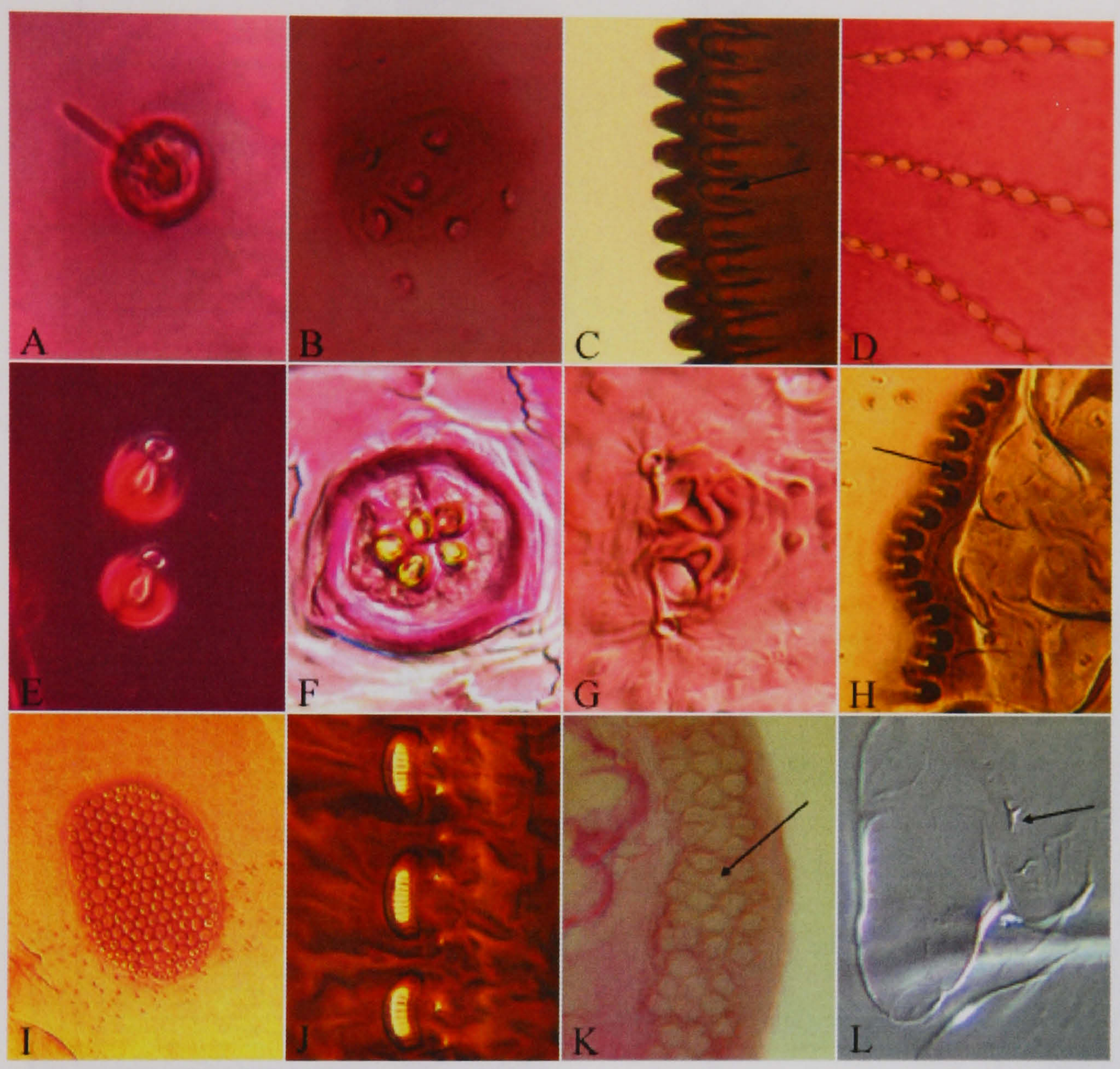


Fig. 2.12. Different characters of pupal cases. A,B. compound wax pores and/or agglomerate pores; C. glandular bases to marginal teeth (arrowed); D. chain-like design along some abdominal and thoracic sutures; E,F. submedian conspicuous invaginations; sometimes hemispherical; G. subdorsal plate with conical pores; H. a row of scallop-shaped thickenings along the longitudinal subdorsal furrow (arrowed); I. prominent glandular areas with polygonal reticulate pattern, sometimes resembling compound eyes; J. crescent-shaped pores; K. submarginal wax-plat cluster (arrowed); L. basal leg spine (arrowed).

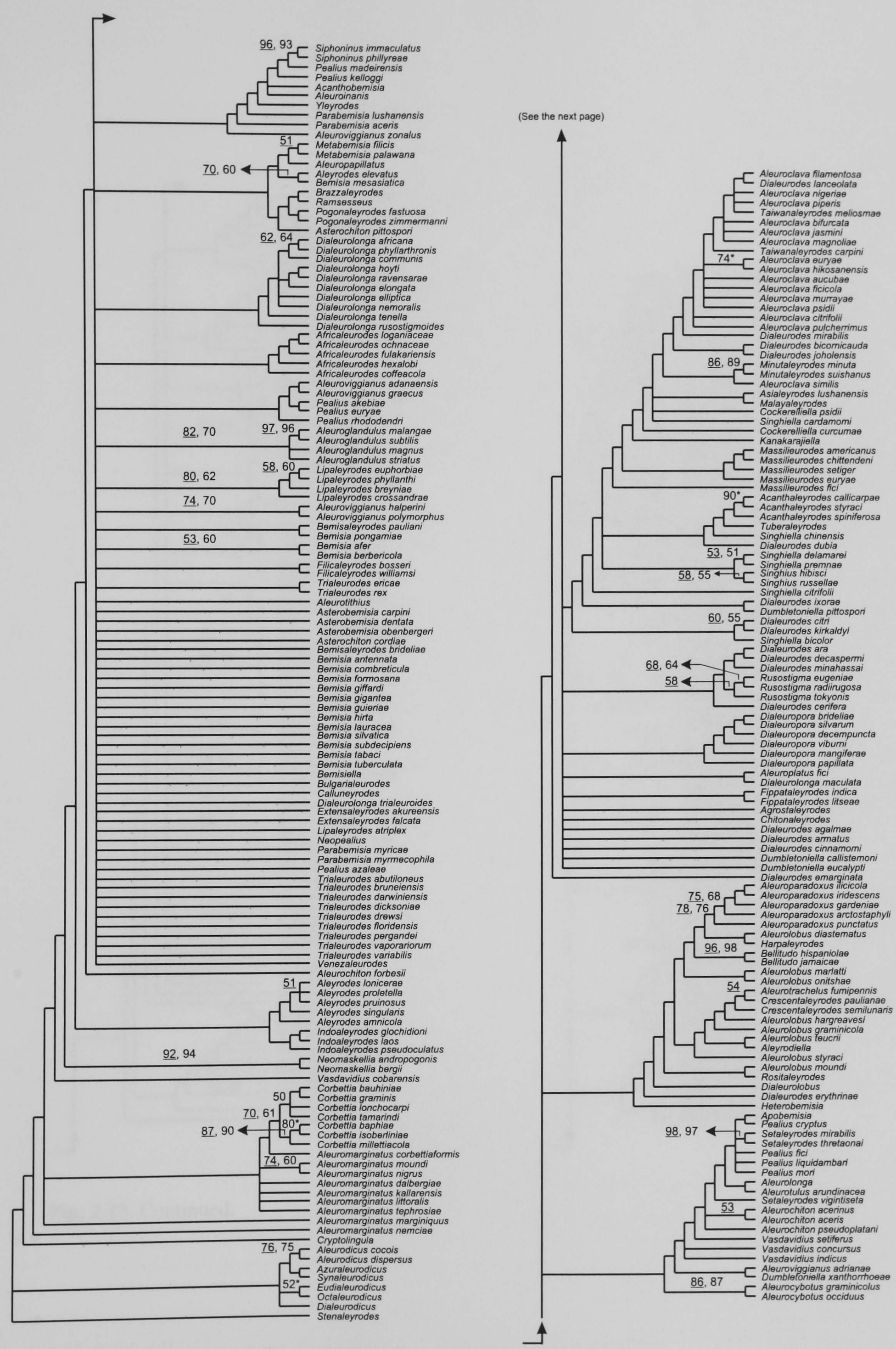


Fig. 2.13. Strict consensus tree of 30,000 UW-MPTs resulting from analyses of morphological data. Figures above branches show bootstrap and Jacknife (underlined figures) values. Figures with an asterisk indicate the same value for both bootstrap and Jacknife.

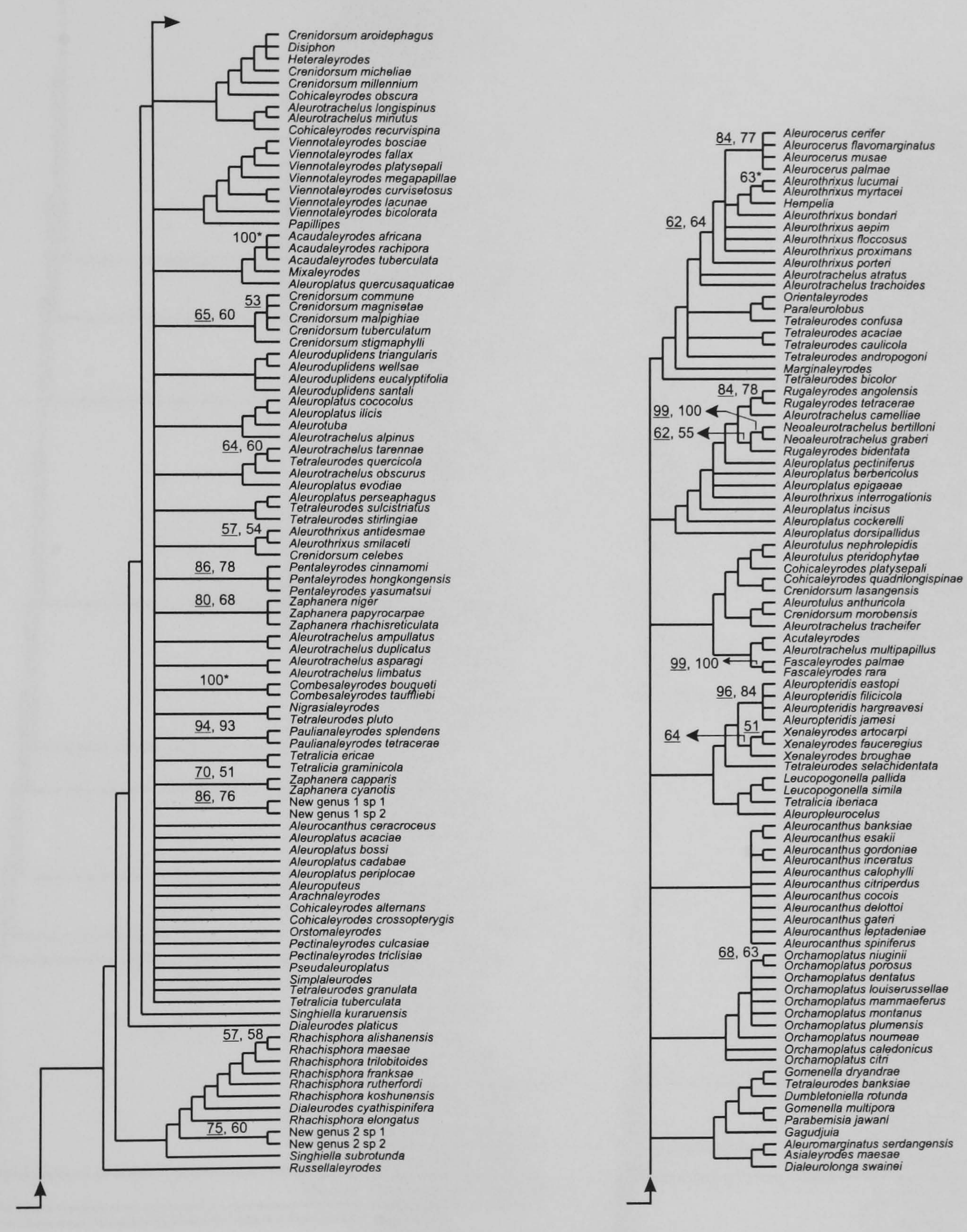


Fig. 2.13. Continued.

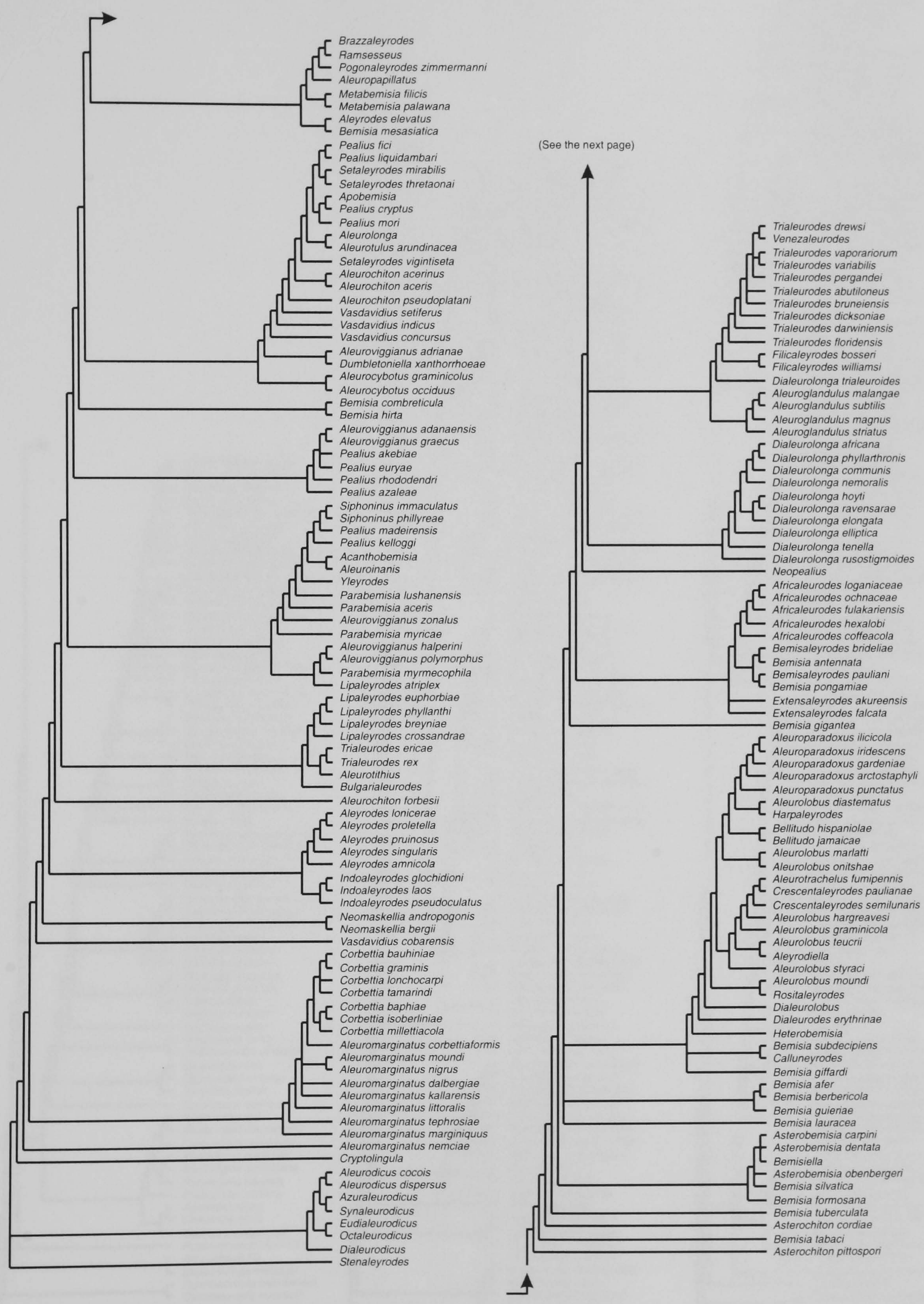


Fig. 2.14. Strict consensus tree of more than 10,000 MPTs-SAW-MaxRI.

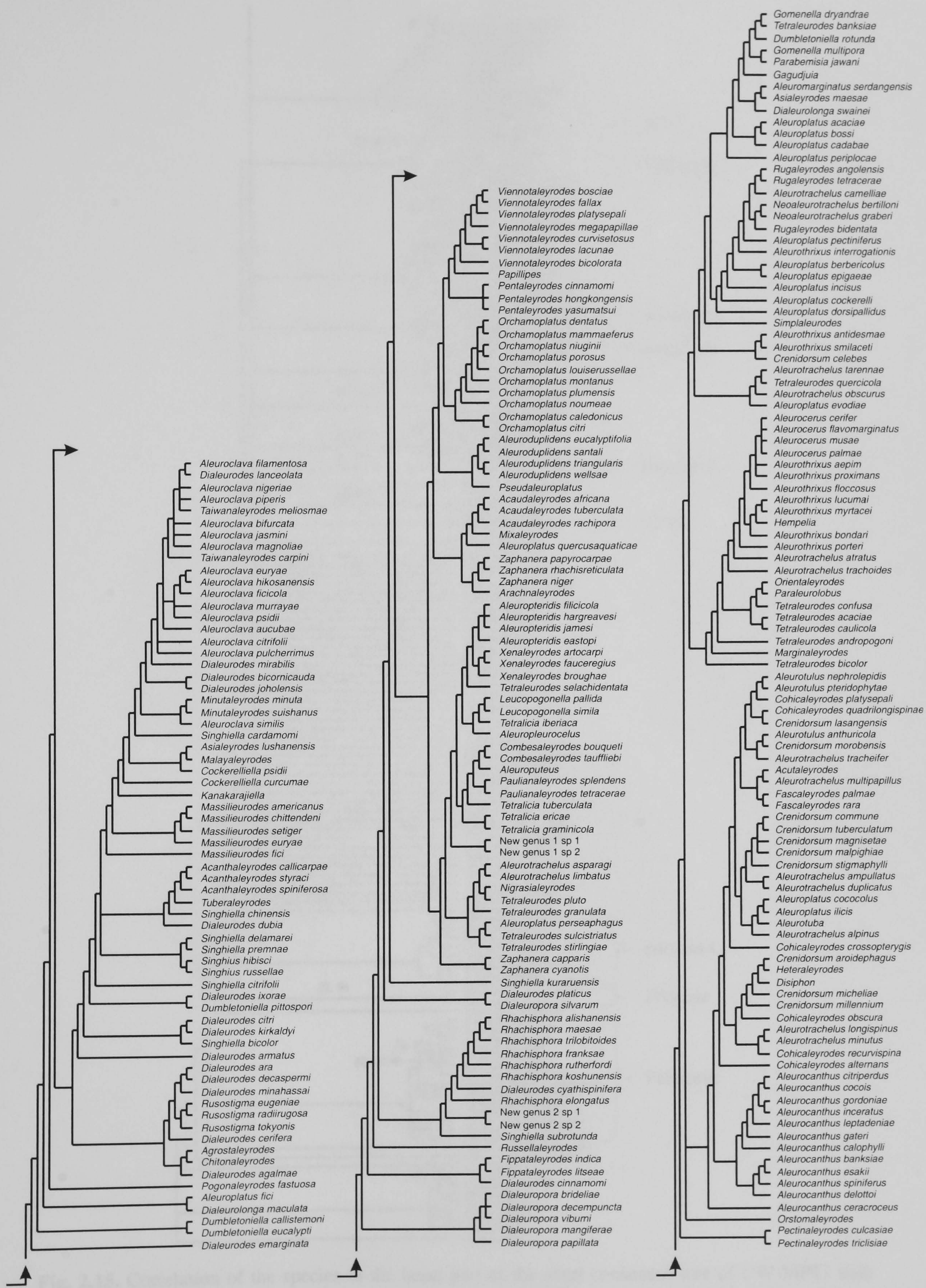


Fig. 2.14. Continued.

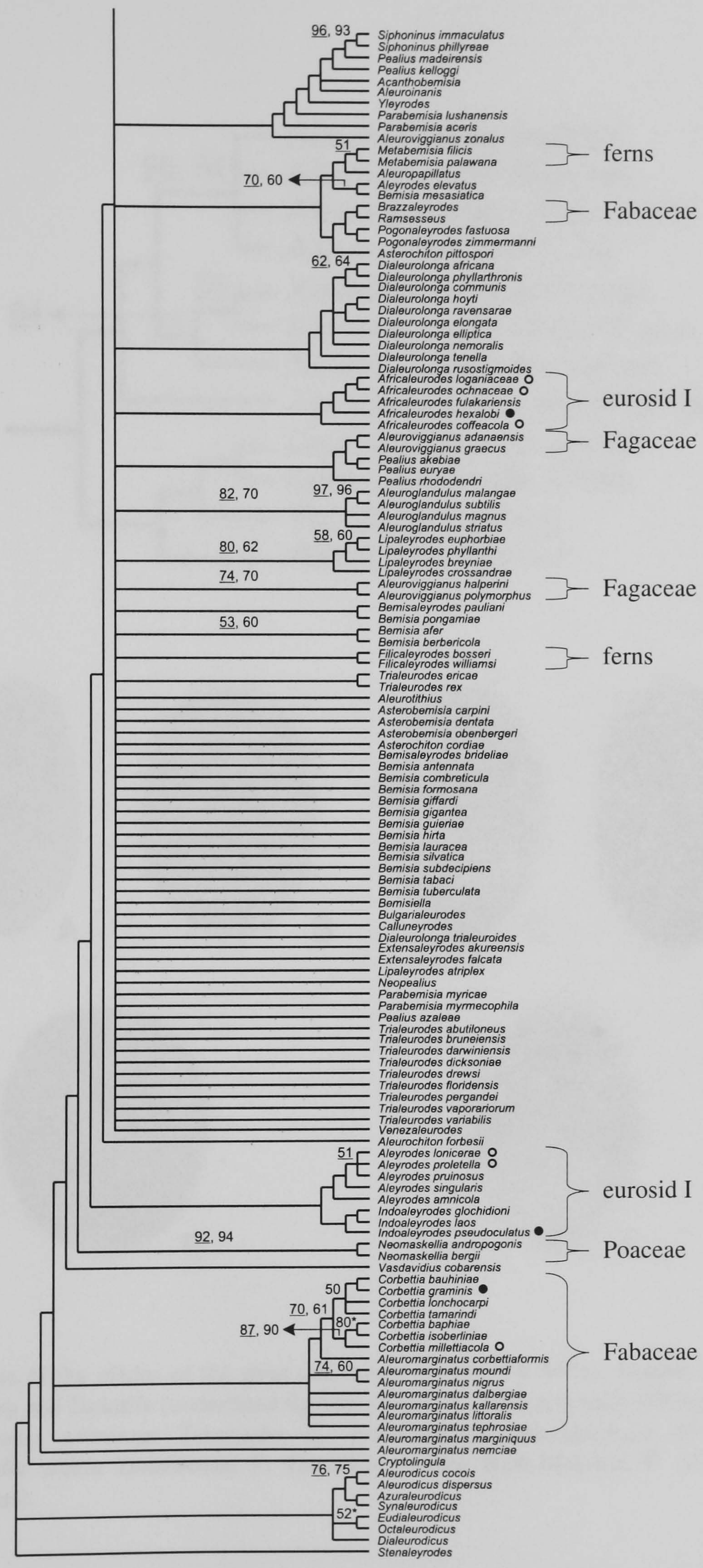
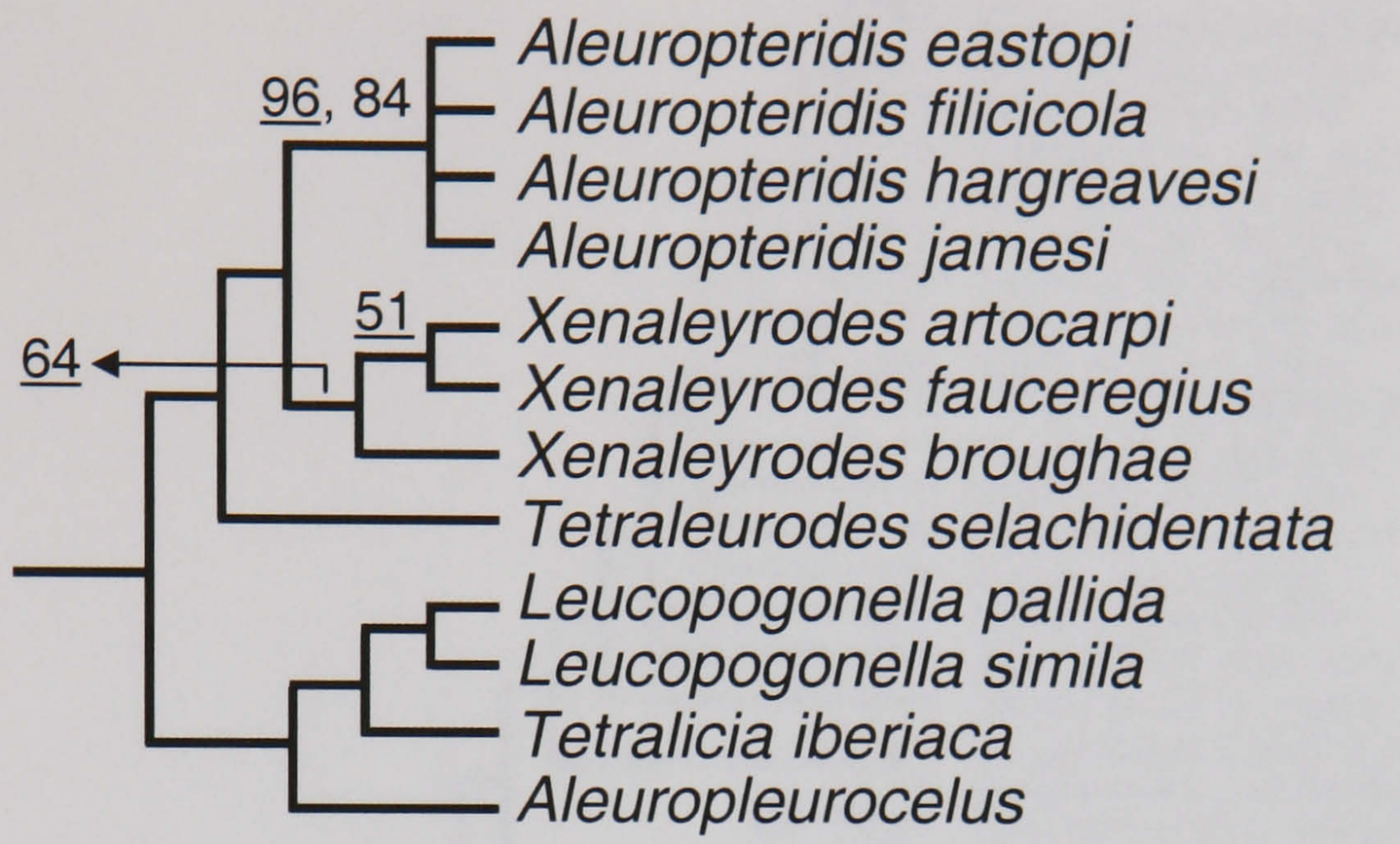


Fig. 2.15. Correlation of the species in the basal part of the strict consensus tree of UW-MPTs with host plants. Figures above branches show bootstrap and Jacknife (underlined figures) values. Figures with an asterisk indicate the same value for both bootstrap and Jacknife. A black circle indicates that the species was not recorded from the same host family/higher group in the relevant clade. An empty circle indicates additional host family/higher group record for the species in the relevant clade.



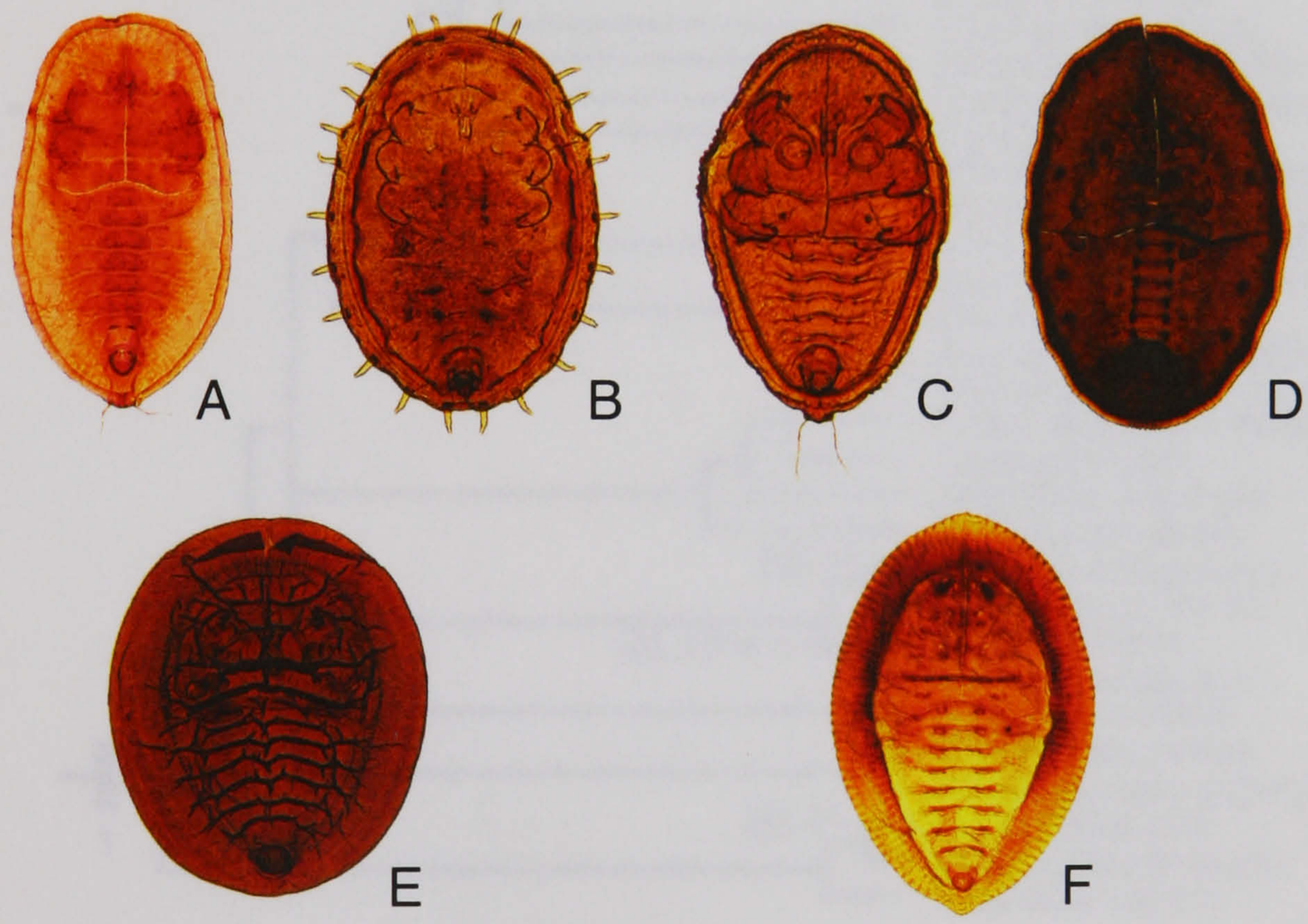


Fig. 2.16. One of the clades of the strict consensus tree of UW-MPTs. Figures above branches show bootstrap and Jacknife (underlined figures) values. A. *Aleuropteriddis filicicola* (Newstead); B. *Xenaleyrodes artocarpi* Takahashi; C. *Tetraleurodes selachidentata* Bink-Moenen; D. *Leucopogonella simila* Dumbleton; E. *Tetralicia iberica* Bink-Moenen; F. *Aleuropleurocelus nigrans* (Bemis).

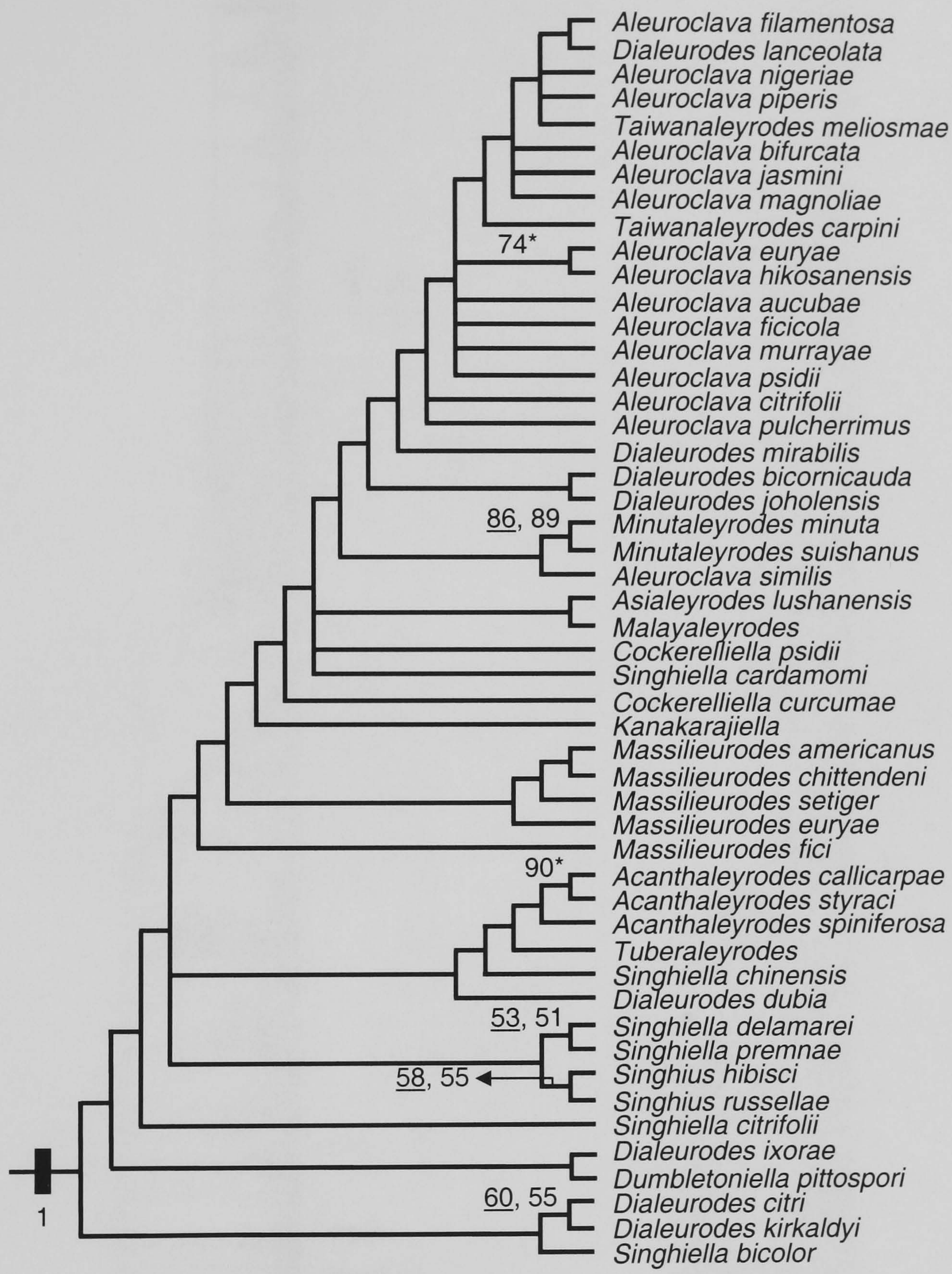


Fig. 2.17. One of the clades of the strict consensus tree of UW-MPTs. Figures above branches show bootstrap and Jacknife (underlined figures) values. Figures with an asterisk indicate the same value for both bootstrap and Jacknife. Black rectangular and the figure below indicate the Bremer support.

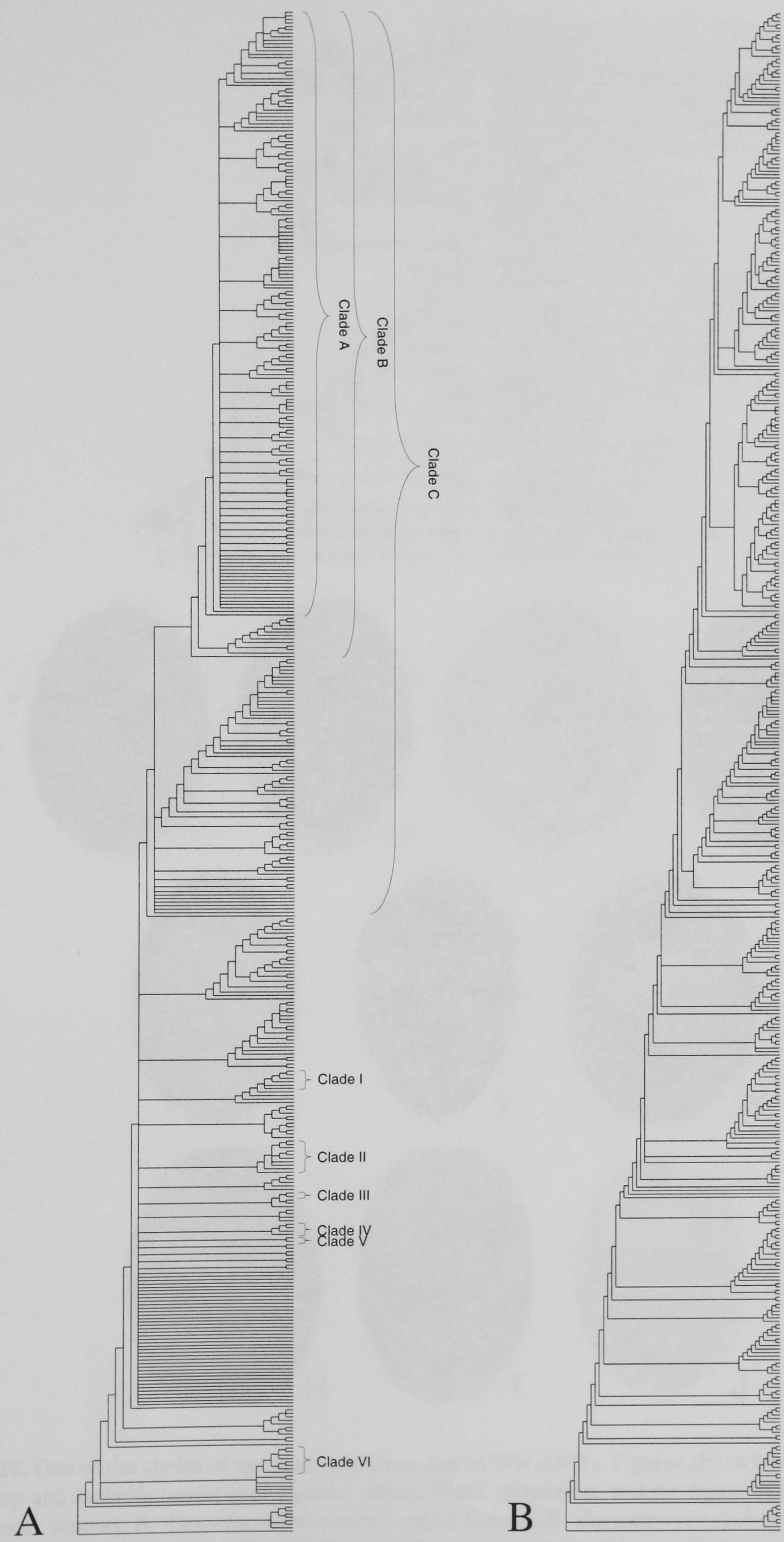


Fig. 2.18. The general topologies of the strict consensus trees of UW-MPTs (A) and MPTs-SAW-MaxRI (B). See text for the discussion of indicated clades.

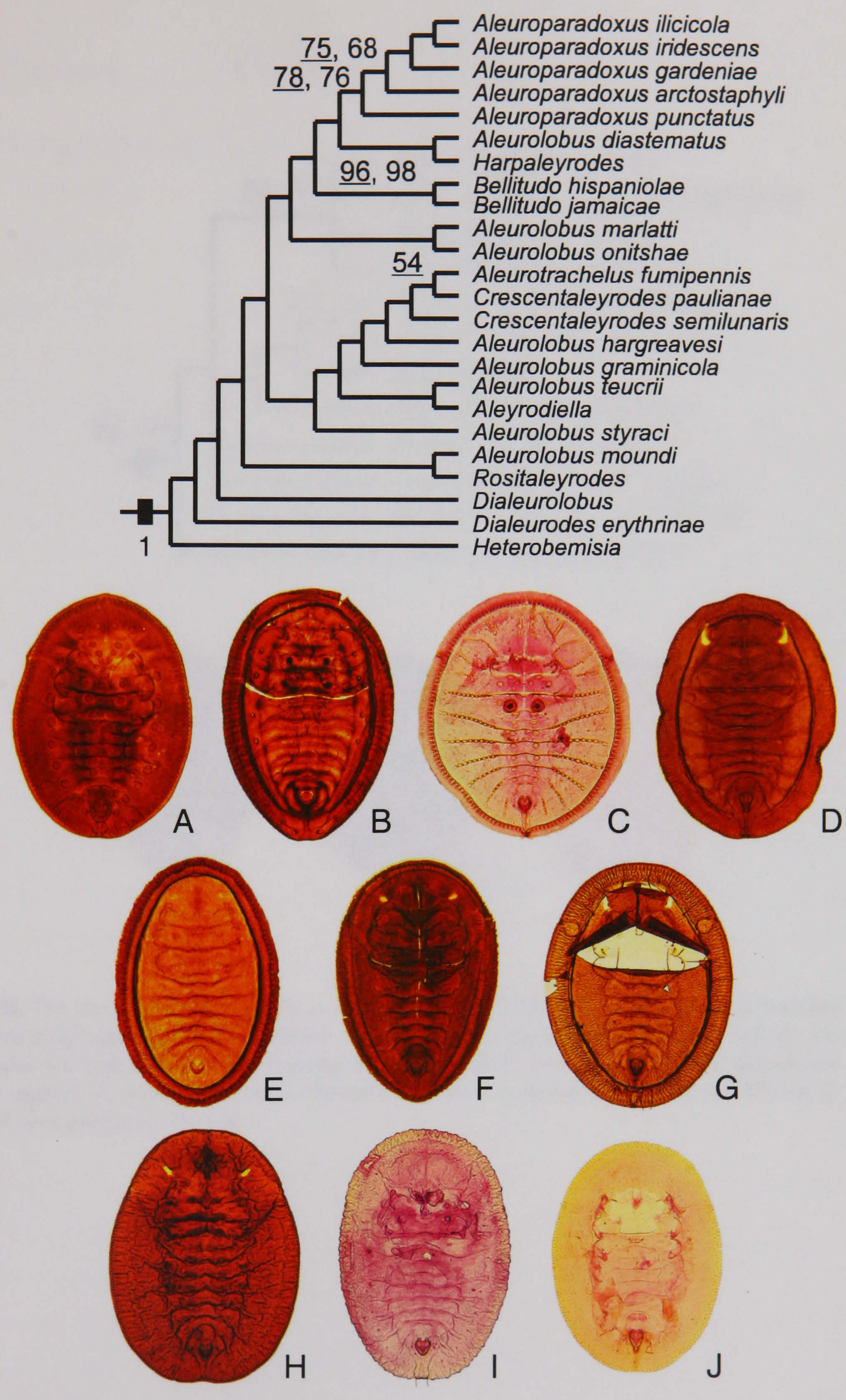


Fig. 2.19. One of the clades of the strict consensus tree of UW-MPTs. Figures above branches show bootstrap and Jacknife (underlined figures) values. Black rectangular and the figure below indicate the Bremer support. A. *Aleuroparadoxus arctostaphyli* Russell; B. *Harpaleyrodes tuberculata* Bink-Moenen; C. *Bellitudo jamaicae* Russell; D. *Aleurolobus marlatti* (Quaintance); E. *Crescentaleyrodes semilunaris* (Corbett); F. *Aleyrodiella lamellifera* Danzig; G. *Rositaleyrodes oplismeni* (Takahashi); H. *Dialeurolobus rhamni* Bink-Moenen; I. *Dialeurodes erythrinae* Corbett; J. *Heterobemisia alba* Takahashi.

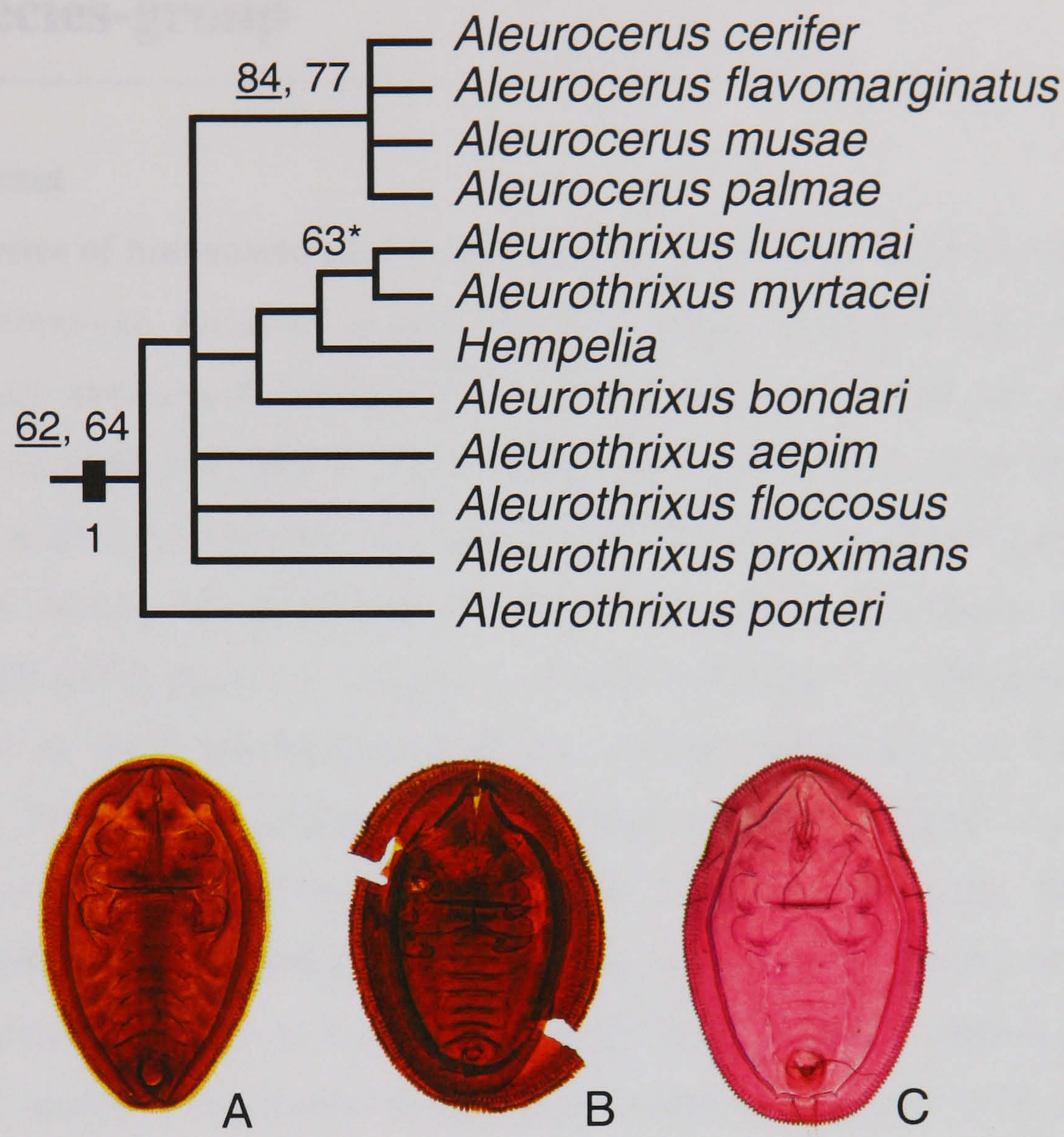


Fig. 2.20. The terminal clade of the strict consensus tree of UW-MPTs. Figures above branches show bootstrap and Jacknife (underlined figures) values. Figure with an asterisk indicate the same value for both bootstrap and Jacknife. Black rectangular and the figure below indicate the Bremer support. A. *Aleurocerus musae* Russell; B. *Hempelia chivelensis* Sampson & Drews; C. *Aleurothrixus proximans* Bondar.

3

Morphometric and molecular analysis of the *Encarsia inaron* species-group*

3.1. Abstract

Several series of host-reared specimens of an *Encarsia* species, initially thought to be the cosmopolitan *Encarsia inaron* (Walker), were collected in the Azores Islands (Portugal). Subsequent morphometric analysis supported the presence of two species: *E. inaron* and a new species, described herein as *Encarsia estrellae* Manzari & Polaszek **sp. n.** *Encarsia estrellae* was reared from *Aleyrodes singularis* Danzig, *A.* ?*singularis*, and *Bemisia* sp. *afer*-group on several host plants. In addition, the D2 region of the 28S rDNA gene was sequenced in eight individuals belonging to these species, as well as single representatives of two closely related and one distantly related species. Phylogenetic analysis of these DNA sequences, together with 23 additional *Encarsia* sequences retrieved from the European Molecular Biology Laboratory (EMBL) and GenBank databases, further supported the specific status of *E. estrellae*, and the placement of *E. dichroa* (Mercet) in the *E. inaron* species-group. Additionally, *E. inaron* is redescribed and some taxonomic problems in the *E. inaron* species-group are discussed.

3.2. Introduction

Encarsia Förster (Hymenoptera: Aphelinidae) is a taxonomically difficult genus, which currently contains about 280 described species (Polaszek *et al.*, 1999). *Encarsia* species are mostly primary parasitoids of whiteflies (Hemiptera: Aleyrodidae) and armoured scale insects (Hemiptera: Diaspididae) – on which they are important biological control agents – (Huang & Polaszek, 1998), but four species are parasitoids of aphids (Hemiptera: Aphididae: Hormaphidinae) (Evans *et al.*, 1995) and a few species parasitize the eggs of Lepidoptera (Polaszek, 1991).

* Published as Manzari, S., Polaszek, A., Belshaw, R. & Quicke, D.L.J. (2002) Morphometric and molecular analysis of the *Encarsia inaron* species-group (Hymenoptera: Aphelinidae), parasitoids of whiteflies (Hemiptera: Aleyrodidae). *Bulletin of Entomological Research* 92, 165-175. Reprinted here with minor alterations.

Although recent papers (Viggiani, 1985, 1987; Hayat, 1989, 1998; Polaszek *et al.*, 1992, 1999; Evans & Polaszek, 1998; Huang & Polaszek, 1998) have contributed to the identification of these parasitoids, reliable identification is still difficult for many species. This is for several reasons, e.g. their small size, diversity, and the existence of complexes of morphologically indistinguishable or hard to distinguish species (Polaszek *et al.*, 1999). The assignment of species-groups to *Encarsia* and the placement of the species within species-groups is also problematic, and a revision of the genus on a world basis is needed (Hayat, 1998). Approximately 29 species-groups are currently recognised within *Encarsia* but few of these groups can be recognised by discrete morphological characters. Indeed, for this reason, some species have been included in different groups by different authors (Viggiani & Mazzone, 1979; Heraty & Polaszek, 2000).

Several series of an *Encarsia* species were reared from several localities, and from different hosts and host plants, in the Azores Islands. After slide-mounting and examination with compound microscopy these were found to be morphologically extremely close to, if not the same as, the cosmopolitan *E. inaron* (Walker). Specimens were reared from *Aleyrodes singularis* Danzig, *A. ?singularis* (see note below under "hosts"), and *Bemisia* sp. *afer*-group whiteflies (Hemiptera: Aleyrodidae). In this study an attempt has been made to obtain objective views of species boundaries using principal component analysis (PCA) and canonical discriminant analysis (CDA) (Blackman & Paterson, 1986; Norusis, 1993; Chishti & Quicke, 1996; Añez *et al.*, 1997; Azidah *et al.*, 2000; Heraty & Polaszek, 2000). DNA sequence data were also used to test our findings and explore the support for existing species-groups. The D2 region of the rDNA gene was chosen for compatibility with the earlier study of Babcock *et al.* (2001). The *E. inaron* species-group currently contains 16 described species (http://cache.ucr.edu/~heraty/Encarsia.cat.pdf). In this catalogue Heraty & Woolley do not include *E. dichroa* (Mercet) in the *E. inaron* species-group, although Hayat (1998) does so. In the present study, the analysis of the *E. inaron* species-group also includes the first sequences for *E. dichroa* and *E.* sp. near *azimi* Hayat, from Cameroon. A morphological diagnosis of the group is provided by Hayat (1998), who, for Indian species, gives the following combination of characters: ovipositor shorter than mid tibia and basitarsus combined, mid tibial spur less than half-length of basitarsus, and clava 2-segmented. The applicability of

this diagnosis was therefore tested. Finally, the new material is described as *E. estrellae* Manzari & Polaszek **sp. n.** and *E. inaron* is redescribed.

3.3. Materials and methods

3.3.1. Morphometric analysis

One hundred specimens of *E. inaron*, 59 females and 41 males, including the holotype and paratypes of *E. borealis* Huldeń (synonymised by Huang & Polaszek, 1998), and 11 specimens of *E. estrellae* (5 females and 6 males) were each measured using slide-mounted preparations and an ocular graticule. Forty-six variables (25 continuous and 21 discrete) were recorded for females, and 37 variables (22 continuous and 15 discrete) were recorded for males. Morphological terminology follows that of Hayat (1989) except the use of "mesosoma" instead of "thorax". Material examined (Table 3.1) belongs to the following collections: The Natural History Museum, London, U.K. (BMNH); Museo Nacional de Ciencas Naturales, Madrid, Spain (MNCN); Zoological Museum of the University of Helsinki, Finland (MZH). Continuous and discrete variables were analysed both separately and in combination. Measurements (continuous variables) used for PCA and CDA are illustrated in figure 3.1 and listed in the legend. Appendix 6 shows the data set (measurements) used for the morphometric analysis.

Discrete variables were as follows: numbers of longitudinal sensilla (rhinaria) of the antennal flagellomeres (6 variables) (females only), numbers of setae on both left and right sides of mid lobe (2 variables) and side lobes (2 variables) of the mesoscutum, numbers of setae on both left and right sides of tergites 1-4 (8 variables) and all setae on tergites 5-7 (3 variables) (Appendix 7). Males and females were treated separately and the analyses were all carried out on untransformed data (Blackman & Spence, 1994; Quartau, 1982) based on correlation matrices using the statistical package SPSS (Norusis, 1993). Analyses of log-transformed data were also carried out and gave virtually the same results (not presented). Cases with missing values were treated in two different ways: replaced with the mean or excluded from the analysis. Since results of treating missing data in both ways were almost the same, only the latter are presented.

Table 3.1. Geographical and biological information of *Encarsia* specimens used in the morphometric analysis.

Species	Locality	n	Host species	Host plant
E. inaron	Afghanistan	2	Unknown	*Rosa* sp.
	Austria	1	Unknown	Unknown
	Bulgaria	1	*Siphoninus phillyreae* (Haliday)	*Crataegus* sp.
	Egypt	4	*Trialeurodes vaporariorum* (Westwood)	*Ricinus communis*
	Egypt	3	*Siphoninus phillyreae* (Haliday)	*Punica granatum*
	Egypt	2	Unknown	Unknown
	England	6	*Aleyrodes proletella* L.	*Brassica oleracea*
	England	3	*Aleyrodes proletella* L.	*Urtica dioica*
	England	2	*Aleyrodes proletella* L.	Unknown
	England	1	*Aleyrodes proletella* L.	Crucifer
	England	3	*Tetraleurodes ?hederae* Goux	*Hedera helix*
	England	1	*Pulvinaria vitis* (?misidentification)	*Vitis* sp.
	England	1	*Trialeurodes vaporariorum* (Westwood)	*Solanum* sp.
	England	1	Unknown	Unknown
	Finland	2	*Pealius quercus* (Signoret)	Unknown
	France	1	*Aleyrodes lonicerae* Walker	*Thalictrum minus*
	France	1	*Aleyrodes proletella* L.	*Chelidonium majus*
	India	1	Unknown	Unknown
	India	1	*Siphoninus phillyreae* (Haliday)	Unknown
	Iran	6	Unknown	Unknown
	Iran	3	*Siphoninus phillyreae* (Haliday)	Unknown
	Israel	2	Unknown	Unknown
	Italy	7	*Siphoninus phillyreae* (Haliday)	*Fraxinus* sp.
	Italy	3	*Pealius azaleae* (Baker & Moles)	Unknown
	Italy	1	Unknown	*Robinia* sp.
	Jordan	5	*Aleyrodes singularis* Danzig	Unknown
	Jordan	1	Unknown	*Citrus* sp.
	New Zealand	2	Unknown	Unknown
	New Zealand	2	*Siphoninus phillyreae* (Haliday)	Unknown
	Pakistan	7	*Bemisia tabaci* (Gennadius)	*Gossypium hirsutum*
	Pakistan	1	Unknown	Unknown
	South Africa	2	Unknown	*Lycopersicon esculentum*
	South Africa	1	Unknown	Unknown
	Syria	1	Unknown	*P. granatum*
	Syria	4	*Aleyrodes singularis* Danzig	*Lactuca* sp.
	Thailand	1	Unknown	Unknown
	Turkey	4	*Siphoninus phillyreae* (Haliday)	*Pyrus communis*
	Turkey	4	*Aleyrodes proletella* L.	*B. oleracea*
	Turkey	3	*Aleyrodes* sp.	*Sonchus* sp.
	Turkey	1	*Aleurothrixus floccosus* (Maskell)	Unknown
	Venezuela	2	*Siphoninus phillyreae* (Haliday)	*P. granatum*
E. estrellae	Azores (Portugal)	1	*Bemisia* sp.	*Viburnum tinus subcordatum*
	Azores (Portugal)	2	*Bemisia* sp.	*H. helix canariensis*
	Azores (Portugal)	3	*Bemisia afer*-group	*Ilex perado azorica*
	Azores (Portugal)	2	*Aleyrodes ?singularis* Danzig	*Lysimachia nemorum*
	Azores (Portugal)	3	*Aleyrodes singularis* Danzig	*L. nemorum*

3.3.2. DNA extraction, amplification and sequencing

Adults were killed directly in 70-95% ethanol. DNA was extracted from single specimens using the DNeasy Tissue Kit (Qiagen, Crawley, U.K.) with elution into 30 µl distilled water. Standard 50 µl polymerase chain reaction (PCR) was then carried out in a GeneAmp 9600 thermal cycler containing 1.0 µl DNA extract, 5 µl *Taq* buffer (1.5 mM $MgCl_2$), 1.5 U *Taq* polymerase (Roche), 10 nmol dNTPs (Amersham

Pharmacia Biotech; APB, Amersham, U.K.) and 20 pmol of each primer. The D2 region of 28S rDNA was amplified using the following primers: forward 5'-GCG AAC AAG TAC CGT GAG GG-3'; reverse 5'-TAG TTC ACC ATC TTT CGG GTC-3' (note, this product includes the smaller D3 region, which was not used in the analyses). GFX gel band purification (APB) was used to clean all PCR products, which were then sequenced in both directions with the same primers using *Big Dye* terminators at half recommended volumes on an ABI Prism 3700 automated sequencer. PCR conditions were 35 cycles of 95°C denaturation (30 s), 45 °C annealing (30 s) and 72 °C extension (1 min) with an initial denaturation for 2 mins and a final extension for 4 mins. The 28S-D2 locus was sequenced for four individuals of *E. estrellae* from a total of three localities in the Azores Islands, and four individuals of *E. inaron* from UK, Japan (two individuals) and India. Single individuals of two other probable members of the *E. inaron* species-group, *E. dichroa* and *E.* sp. near *azimi* (Cameroon) were also sequenced, plus a third unrelated species (*E. tricolor* Förster). Sequences have been deposited in the European Molecular Biology Laboratory (EMBL) and GenBank databases under accession numbers AJ305294 - AJ305302 (Table 3.2).

Table 3.2. Specimens of *Encarsia* used in the molecular phylogenetic analysis and their geographical and biological information.

Taxa	Locality	Host	EMBL/GenBank accession number
E. sp. near *azimi* Hayat	Cameroon, Mbalmayo	Unknown	AJ305294
E. estrellae sp. n. (az2)	Azores Islands, São Miguel	*Bemisia* sp. on *Viburnum* sp.	AJ305297
E. estrellae sp. n. (az3a)	Azores Islands, Pico, Chão Vert	*Bemisia* sp. on *Rubia peregrina*	AJ305298
E. estrellae sp. n. (az3b)	Azores Islands, Pico, Lagoa do Caiado	*Bemisia* sp. on *R. peregrina*	AJ305299
E. estrellae sp. n. (az4)	Azores Islands, Pico, Lagoa do Caiado	*Bemisia* sp. on *Euphorbia stygiana*	AJ305300
E. dichroa (Mercet)	Granada	*Siphoninus* sp.	AJ305301
E. inaron (Walker)	England, London	*S. phillyreae* (Haliday)	AJ305295
E. inaron (Walker)*	Japan, Sanyocho	*S. phillyreae* (Haliday) on *Punica granatum*	–
E. inaron (Walker)*	Japan, Yamaguchi	*S. phillyreae* (Haliday) on *P. granatum*	–
E. inaron (Walker)	India, Tamil Nadu, Arrupukottai	Unknown	AJ305296
E. tricolor Förster	Azores Islands, São Miguel	Unknown	AJ305302

* These two sequences and the sequence of *E. inaron* from England are identical, so only the latter sequence was deposited in EMBL/GenBank databases.

3.3.3. Phylogenetic analysis

Amplified D2 regions were between 454 and 457 bp in length. The sequences obtained, together with 26 additional ones retrieved from EMBL/GenBank (from Babcock *et al.*, 2001) including representatives of three related genera, were aligned by eye and also using the Clustal X programme (Thompson *et al.*, 1997) with four sets of gap opening and gap extension penalties: 20:10, 15:6.66 (default), 10:5 and 5:1 (the default downweighting of transitions by 0.5 was used in all). Maximum parsimony analysis (MP) was then performed on the five multiple alignments using PAUP* (Swofford, 1998). Heuristic searches were carried out treating gaps as both missing data and informative with 1000 random additions followed by branch swapping using tree-bisection-reconnection (TBR) and unlimited maxtrees. In each alignment the bootstrap support for individual branches was found using 100 pseudoreplicates each of 100 random additions (Felsenstein, 1985).

3.4. Results

3.4.1. Principal component analysis

Five components were extracted based on continuous variables for each analysis and biplots of all pair-wise combinations of these examined. Eigenvalues and weights for first two principal components are presented in Table 3.3. Figure 3.2A,B show scatter diagrams of female and male *Encarsia* with respect to first and second principal components obtained using continuous variables. In both sexes, the specimens can be seen to fall into two groups, with no overlap. Females and males of the two *Encarsia* species were projected on the first two principal components (PC-I and PC-II), which together accounted for 74.5% and 77.8% of the overall variance respectively. Length of marginal fringe and distance between placoid sensilla had the lowest contributions, and length of meta tibia, length of scutellum and length of fore wing had the highest influences on PC-I for male *Encarsia* (see Table 3.3). Other variables had approximately equal contributions. For female *Encarsia*, length of third valvula, distance between placoid sensilla and length of marginal fringe had the lowest contributions, and length of funicle and length of flagellomeres 3 and 4 had the highest influences on PC-I (see Table 3.3). As with males, other variables had approximately equal contributions.

Table 3.3. Eigenvalues and weights for first two principal components extracted based on continuous variables for females and males.

Variable	Principal components			
	I	II	I	II
	Females		Males	
Eigenvalues	16.76	1.88	15.84	1.28
HDW	0.0453	0.1961	0.0477	-0.2162
RL	0.0369	0.2701	0.0411	-0.0933
SL	0.0533	0.0971	0.0578	-0.0669
PL	0.0492	0.1338	0.0484	0.0922
F1L	0.0544	0.0155	0.0585	0.1067
F2L	0.0544	-0.0350	0.0581	0.1343
F3L	0.0569	-0.0211	0.0592	0.0681
F4L	0.0569	-0.0694	0.0590	-0.0002
FUN (females only)	0.0580	-0.0265	–	–
F5L	0.0536	-0.1420	0.0583	-0.1059
F6L	0.0509	-0.1781	0.0542	-0.2255
CLV	0.0541	-0.1656	0.0581	-0.1681
FWL	0.0551	-0.0011	0.0596	0.1209
FWW	0.0492	0.0713	0.0574	-0.0081
MFL	0.0346	-0.3034	0.0292	0.6468
SCL	0.0530	0.0871	0.0597	-0.1009
SCW	0.0483	0.1128	0.0545	-0.0811
DPS	0.0313	-0.0828	0.0305	-0.2064
HFL	0.0480	0.0648	0.0544	-0.0149
HTL	0.0539	0.1145	0.0617	-0.0247
MBL	0.0501	-0.0401	0.0543	-0.0546
MTS	0.0415	-0.2065	0.0510	0.1162
SVL (females only)	0.0418	-0.1375	–	–
TVL (females only)	0.0295	0.3189	–	–
OVL (females only)	0.0451	-0.0005	–	–
GNL (males only)	–	–	0.0504	0.2805

See fig. 3.1 for abbreviations.

3.4.2. Canonical discriminant analysis

Separation between the putative species was more marked using canonical discriminant analysis of continuous variables, and combined continuous and discrete variables (Chishti & Quicke, 1996). Based on continuous variables, females and males were projected on the first and second canonical discriminant function (CD-I and CD-II), which together accounted for 73.4% and 72.6% of the original variance respectively (fig. 3.2C,D). Analysis based on combined continuous and discrete variables for both sexes gave no more separation than analysis based on continuous variables only (fig. 3.2E,F).

3.4.3. Phylogenetic relationships

Length of multiple alignments was 493-495, with 179-188 parsimony informative positions (gaps treated as informative). Maximum parsimony (MP) analyses of the 37 DNA sequences gave a total of 221 most-parsimonious trees (MPTs) from the five alignments and one of them is shown in figure 3.3. Those branches that are also recovered in all MPTs are shown by thick lines. Within the *inaron* species-group, despite the existence of clear morphological differences between *E. dichroa* and *E. estrellae*, these are found to be more closely related than *E. estrellae* is to *E. inaron*. This phylogenetic analysis confirms that *E. dichroa* and *E.* sp. near *azimi* (Cameroon) belong to the *E. inaron* species-group. Moreover, the sequence of *E.* sp. near *azimi* (Cameroon) differed from that of *E.* sp. nr *azimi* (Babcock *et al.* 2001) by 4.0-5.4% (depending upon different alignments; gaps treated as missing data), and from this it could be inferred that the specimens represent two different species.

Few sequence differences were found between individuals of *E. estrellae*: the average sequence distance based on different alignments was 0.54%, while the average sequence distance between *E. inaron* and *E. estrellae* was 3.6% (gaps treated as missing data).

The separation of *E. inaron* and *E. estrellae* was tested by constraining them in maximum parsimony analyses to form a clade (to the exclusion of *E. dichroa*). In this case, the shortest trees were between 6 and 20 steps longer than the unconstrained ones (gaps treated as informative), depending upon the alignment. In four of the five alignments, these constrained trees were significantly worse in Wilcoxon matched pairs sign tests implemented in PAUP* as the Templeton test (P = 0.003-0.0596 for all possible tree-to-tree comparisons; in the fifth alignment P = 0.1573-0.2888).

Within the genus *Encarsia*, overall relationships were similar to those found by Babcock *et al.* (2001), from whose study most of the sequences are derived. *E. tricolor* was recovered with *E. mineoi* Viggiani in all except one of the most parsimonious trees, despite these two species having been placed in different species-groups (*E. tricolor* and *E. parvella* species-groups, respectively) (Heraty & Woolley, http://cache.ucr.edu/~heraty/Encarsia.cat.pdf). Although the genus *Encarsia* is never recovered as monophyletic, constraining it to be so resulted in most parsimonious

trees that were significantly longer in only one of the five alignments (gaps treated as informative).

3.5. Discussion

Both the morphometric and molecular analysis indicate that the species from the Azores Islands is a new species, which is described below together with a redescription of *E. inaron* in the light of these analyses. The average sequence divergence within *E. estrellae* was typical of the values obtained by Babcock *et al.* (2001) for other *Encarsia* species, and the average sequence divergence between it and *E. inaron* was within the range of between-species values.

The first principal component in general is thought to be strongly influenced by overall size variation and possible allometric effects (Woolley & Browning, 1987). The host ranges for *E. inaron* and *E. estrellae* are variable (Table 3.1), although some populations of *E. inaron* were restricted to a single host. Apart from the possible effect of hosts on general size, the discrimination of species was not affected by size (considering the separation based on other components). A canonical discriminant function appears to be the best means of separating these species. No single measurement provided a definite separation of the two species. *E. inaron* was most variable for both size and host range and the complexity of the separation is reflected by this variability.

The relative length of the marginal fringe, although playing an important role in *Encarsia* taxonomy, had almost no contribution in either sex to PC-I. Heraty and Polaszek (2000) also found that this character had little effect on PC-I for the *E. strenua* group.

3.5.1. Separation of *E. estrellae* sp. n. and *E. inaron*

Encarsia estrellae is morphologically very close to *E. inaron*, especially with respect to females. For females the main difference between the two species is the ratio of the third valvula length to the clava length. In *E. estrellae* the third valvula is less than 0.5 times as long as the clava, while in *E. inaron* it is at least 0.5 times as long as the clava. Male specimens can be distinguished by comparing the clava: the two claval segments are partially fused in *E. estrellae* (fig. 3.4C) but are separate in *E. inaron*. The main differences between the two species are summarised in Table 3.4.

The *E. inaron* species-group, which was supported as a monophyletic group in this molecular analysis, has no defining suite of morphological characters. As already mentioned, this group has been characterised by having the ovipositor shorter than the mid tibia and basitarsus combined, a 2-segmented clava, and mid tibial spur less than 0.5 times basitarsus (Hayat, 1998). In this study, the latter character failed to place most *E. inaron* within the *E. inaron*-species group: in 59 female specimens, the mid tibial spur was on average 0.59 times as long as basitarsus. In addition, *E. dichroa*, which has a 3-segmented clava, was found to be a member of this group in the phylogenetic analysis.

Table 3.4. Summary of the main differences between *Encarsia estrellae* and *E. inaron*.

	E. estrellae	*E. inaron*
Female: third valvula length (TVL) / clava length (CLV)	TVL < 0.5 × CLV	TVL ≥ 0.5 × CLV
Male: fifth and sixth flagellar segments (F5 & F6)	Partially fused (fig. 3.4C)	Separate

All individual characters in DNA sequences, whether substitutions or insertion/deletion events, are prone to homoplasy, which means that single characters that define species-groups reliably are not available, however, two useful characters in the data can be emphasised. The following motif occurs 41 bases into the D2 region, and is found in all sequences of representatives of the *E. inaron* species-group (dashes represent gaps in the multiple alignment of all *Encarsia* species): AG(T/-)CCGCTTTGGCTTCCGTGTGAA-CGCG (fig. 3.5). In positions 23-26 of this motif the AA-C was found only in representatives of the *E. inaron* species-group, and the insertion of a T in position 3 of this motif occurred only in *E. estrellae* and *E. dichroa* (no unambiguously aligned single character distinguished *E. estrellae* from all other *Encarsia* species).

Encarsia estrellae Manzari & Polaszek **sp. n.**

(fig. 3.4A-D)

Description. Female. Head dark yellow; occiput, areas behind postocellar bar brown; clypeus, malar space brown to dark brown. Mesosoma brown but pronotum, axillae and propodeum dark brown; middle of scutellum dark yellow to brown.

Petiole brown, lateral parts dark brown. Gatser brown to dark brown. Third valvula yellow to dark yellow. Antenna dark yellow except scape, pedicel, anterior half of F5, F6 brown. Fore wings (fig. 3.4D) hyaline, slightly infuscate below marginal vein. Legs yellow except pretarsus brown. In one female (ex *Bemisia afer*-group on *Hedera helix*), the gaster is largely pale, having only a single dark band on T6. Morphometrically this female and a (presumably conspecific) male agree with the remaining *E. estrellae* specimens, although no individual from this population was sequenced. Colour variation is well-documented in the closely-related *E. inaron* as a response to temperature experienced during development (Laudonia & Viggiani, 1993), and therefore could also be affected by altitude. These individuals are provisionally assigned to *E. estrellae*, pending further studies.

Antennal formula 1-1-4-2 (fig. 3.4B). Pedicel shorter than F1-F6 individually. Flagellum with the following numbers of longitudinal sensilla: F1:2, F2:3, F3:3, F4:4, F5:4, F6:3. Mid lobe of mesoscutum, axillae and scutellum with distinctly reticulate sculpture, longitudinal on the central scutellum (fig. 3.4A).

Mid lobe of mesoscutum with 4+2+2 setae. Each side lobe of mesoscutum with 3 setae. Placoid sensillae on scutellum relatively distantly placed, distance between anterior pair of scutellar setae greater than that between posterior pair. Fore wing 2.41 times as long as wide (77:32). Marginal fringe of fore wing short. Tarsal formula 5-5-5. T1-T7 with 0+0, 1+1, 1+1, 1+1, 4, 4 and 5 setae, respectively. Ovipositor shorter than mid tibia and basitarsus combined (41:66), third valvula 0.36 times as long as second valvifer (11:30).

Male. Coloration similar to female. Structural details essentially as for female, except ovipositor, and antenna with abundant longitudinal sensilla on all flagellomeres. The last two flagellar segments partially fused (fig. 3.4C). Male genitalia approximately as long as hind tibia.

Species-group placement. *E. inaron*-group.

Distribution. Azores Islands: Pico, São Miguel.

Hosts. Aleyrodidae: *Aleyrodes singularis* Danzig, *A. ?singularis*, *Bemisia* sp. *afer*-group. *Aleyrodes singularis* specimens from *Lysimachia nemorum* (Primulaceae) were positively identified by Dr J.H. Martin (BMNH). Specimens from the Azorean endemic *Euphorbia stygiana* (Euphorbiaceae) differ in some respects from *A. singularis*, and may represent a distinct, and possibly undescribed, species. In the north Atlantic islands the *Bemisia afer* group appears to be either highly diverse in terms of species, or highly morphologically variable within species. For this reason it has not been possible to identify to species-level some of the hosts of *E. estrellae*. The group is currently being studied in greater detail (J.H. Martin, BMNH, personal communication).

Material examined. Holotype ♀ Azores, São Miguel, Lagoa Canarios, 715m, 27.ix.1998, (E. Hernandez & A. Polaszek), ex *Aleyrodes singularis* on *Lysimachia nemorum* (BMNH). Paratypes 2♂, same data as holotype (BMNH). 2♀, 1♂, Azores, São Miguel, Serra da Tronquiera, 26.ix.1998, (E. Hernandez & A. Polaszek), ex *Bemisia afer*-group on *Ilex perado azorica* (Aquifoliaceae) (BMNH). 1♀, 1♂, Azores, São Miguel, Sete Cidades, 27.ix.1998, (E. Hernandez & A. Polaszek), ex *Bemisia* sp. on *Hedera helix canariensis* (Araliaceae) (BMNH). 1♀, 1♂, Azores, São Miguel, Serra da Tronquiera, 26.ix.1998, (E. Hernandez & A. Polaszek), ex *Aleyrodes singularis* on *Lysimachia nemorum* (BMNH). 1♂, Azores, São Miguel, Serra da Tronquiera, 26.ix.1998, (E. Hernandez & A. Polaszek), ex *Bemisia* sp. on *Viburnum tinus subcordatum* (Caprifoliaceae) (BMNH). 2♀, 6♂, Azores, Pico, Lagoa do Caiado, 27.vi.2000, (A. Polaszek) *ex Aleyrodes ?singularis* on *Euphorbia stygiana* (BMNH) (not used in morphometric analysis).

Encarsia inaron (Walker)

Description. Female. Head, mesosoma and petiole brown to dark brown. Gaster variable, from largely pale to largely brown. Third valvula pale. Antenna brown. Fore wing hyaline except bases. Legs yellow except coxae. In dark specimens mid and hind femora brown. For variation see *E. estrellae* (above).

Antennal formula 1-1-4-2. Pedicel shorter than F1-F6 individually. Flagellum with the following numbers of longitudinal sensilla: F1:0-4, F2:1-4, F3:1-4, F4:2-5,

F5:2-5, F6:2-4. Mid lobe of mesoscutum, axillae and scutellum with distinctly reticulate sculpture, longitudinal on the central scutellum.

Mid lobe of mesoscutum with 8-12 setae. Each side lobe of mesoscutum with three setae. Placoid sensillae on scutellum distantly placed, distance between anterior pair of scutellar setae greater than that between posterior pair. Fore wing 2.09-2.50 times as long as wide (90:43-17.5:7). Marginal fringe of fore wing short. Tarsal formula 5-5-5. T1-T7 with 0-3+0-4, 0-3+1-4, 0-4+0-4, 0-5+0-4, 4-11, 3-8 and 3-4 setae, respectively. Ovipositor shorter than mid tibia and basitarsus combined, third valvula 0.39-0.77 times as long as second valvifer (27:69-17:22).

Male. Entirely brown. Gaster sometimes pale. Structural details essentially as for female, except ovipositor, and antenna with abundant longitudinal sensilla on all segments. Antennomeres all separated. Male genitalia approximately as long as hind tibia.

Species-group placement. *E. inaron*-group (=*E. partenopea*-group, *sensu* Viggiani & Mazzone, 1979).

Distribution. Europe, Africa, Asia, S. America. Introduced into North America (Huang & Polaszek, 1998).

Hosts. Aleyrodidae: *Acaudaleyrodes rachipora* (Singh), *Aleurothrixus floccosus* (Maskell), *Aleyrodes lonicerae* Walker, *A. proletella* L., *A. singularis*, *Asterobemisia carpini* (Koch), *A. paveli* (Zahradnik), *Bemisia tabaci* (Gennadius), *Bulgarialeurodes cotesii* (Maskell), *Pealius azaleae* (Baker & Moles), *P. quercus* (Signoret), *Siphoninus immaculatus* (Heeger), *S. phillyreae* (Haliday), *Trialeurodes vaporariorum* (Westwood).

Material examined. All specimens listed in Table 3.1.

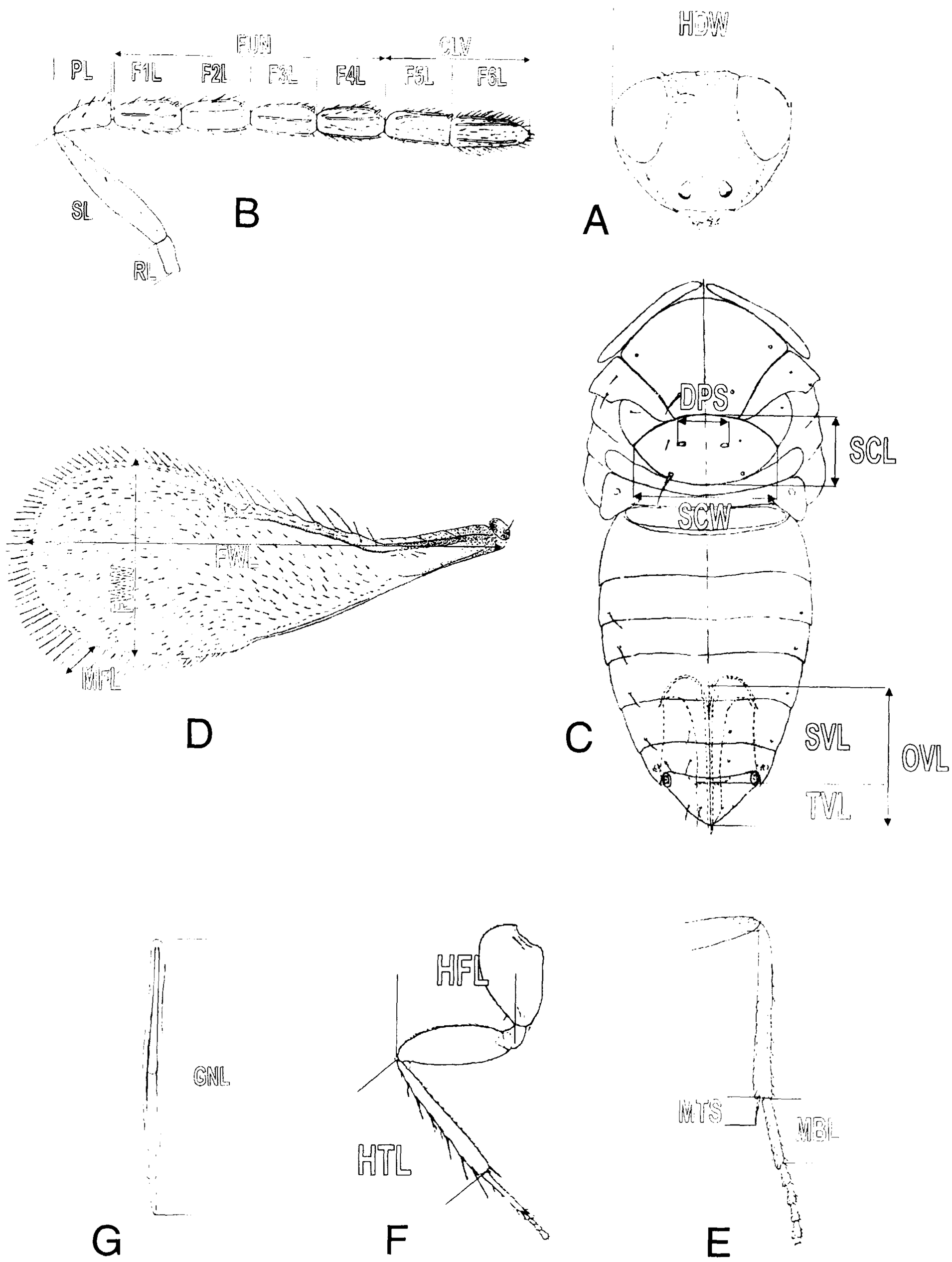


Fig. 3.1. Measurements (continuous variables) used for principal component analysis and canonical discriminant analysis. A. head; B. antenna; C. mesosoma and gaster; D. fore wing; E. mid leg; F. hind leg; G. male genitalia. CLV, clava length; DPS, distance between placoid sensilla; F1L, flagellomere 1 length; F2L, flagellomere 2 length; F3L, flagellomere 3 length; F4L, flagellomere 4 length; F5L, flagellomere 5 length; F6L, flagellomere 6 length; FUN, funicle length; FWL, fore wing length; FWW, fore wing width; GNL, male genitalia length; HDW, head width; HFL, hind femur length; HTL, hind tibia length; MBL, meso-basitarsus length; MFL, marginal fringe length; MTS, mesotibial spur length; OVL, ovipositor length; PL, pedicel length; RL, radicle length; SCL, scutellum length; SCW, scutellum width; SL, scape length; SVL, second valvifer length; TVL, third valvula length. A, F and G redrawn from Hayat (1998); B–E redrawn from Polaszek *et al.* (1999).

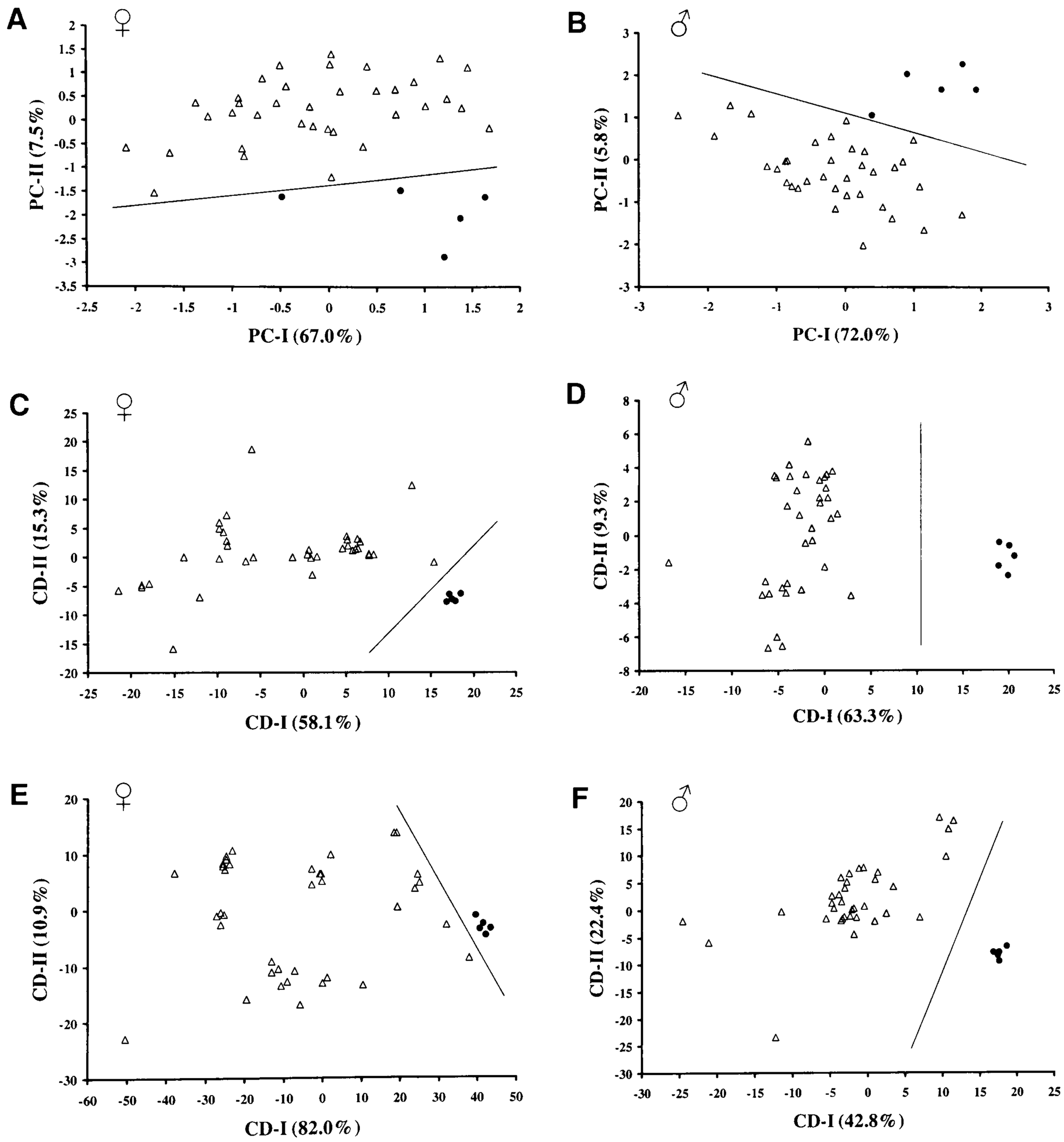


Fig. 3.2. Results of morphometric analysis. A-B. plots of first two principal components based on continuous data for *Encarsia* specimens (A, females; B, males); C-D. plots of first two canonical discriminant functions based on continuous data for *Encarsia* specimens (C, females; D, males); E-F. plots of first two canonical discriminant functions based on combined continuous and discrete data for *Encarsia* specimens (E, females; F, males). Δ *E. inaron*, • *E. estrellae*.

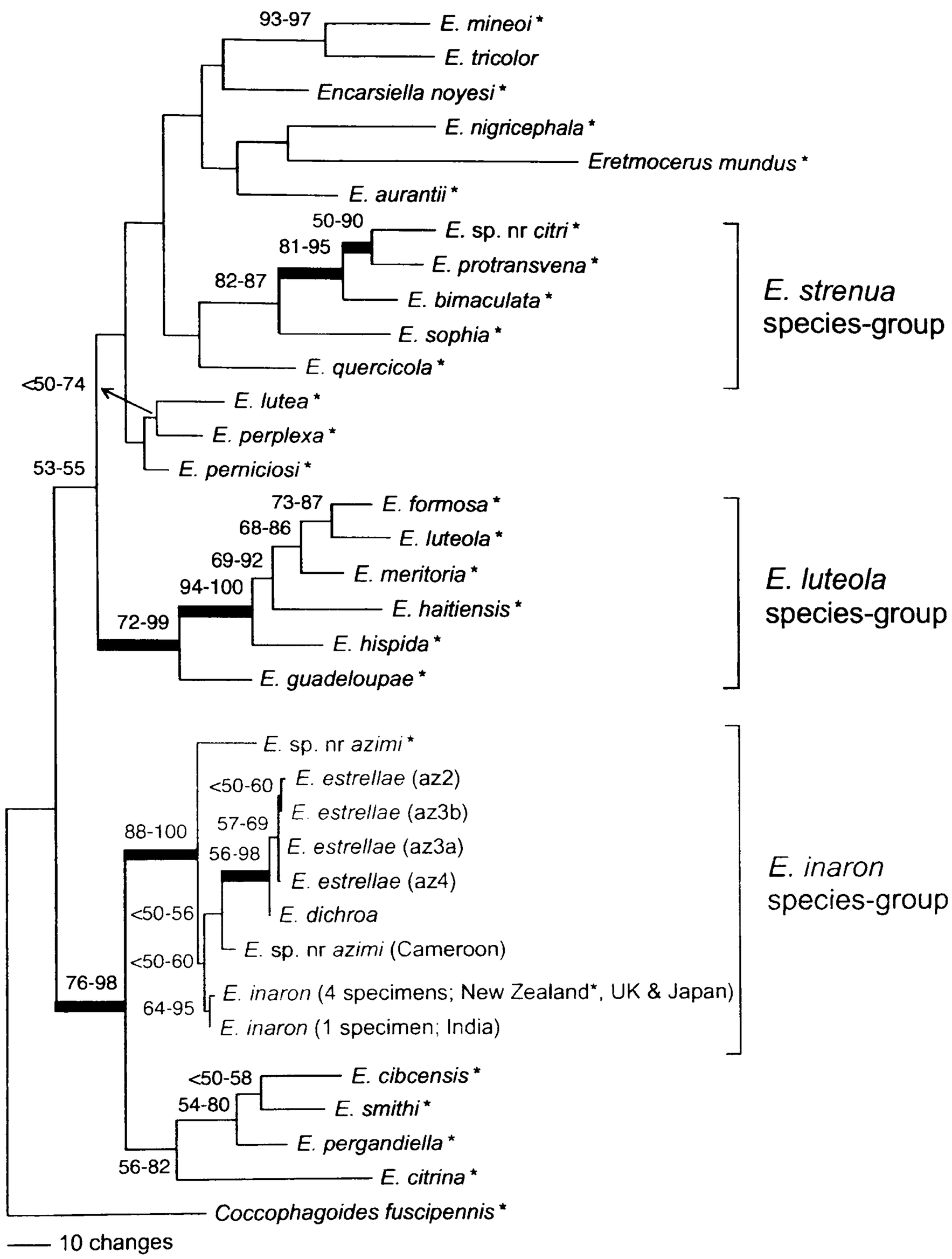


Fig. 3.3. One of 221 most parsimonious trees resulting from analyses of 28S-D2 rDNA sequence data (length = 866, R.I. = 0.641). Each sequence is from a single individual unless otherwise indicated. Branches are thickened when recovered in all MPTs from the five multiple alignments with gaps treated as both missing data and informative. Figures above branches show the range of bootstrap values (above 50%) for all analyses. An asterisk shows sequences from EMBL/GenBank databases (accession numbers: AF223366, AF223369-70, AF254192-94, AF254207, AF254211, AF254213, AF254221, AF254225-27, AF254230-32, AF254234-37, AF254242, AF254245-48, AF273667). See table 3.2 for accession numbers of new sequences (the inclusion of *Eretmocerus mundus* is here considerd to be an artefact).

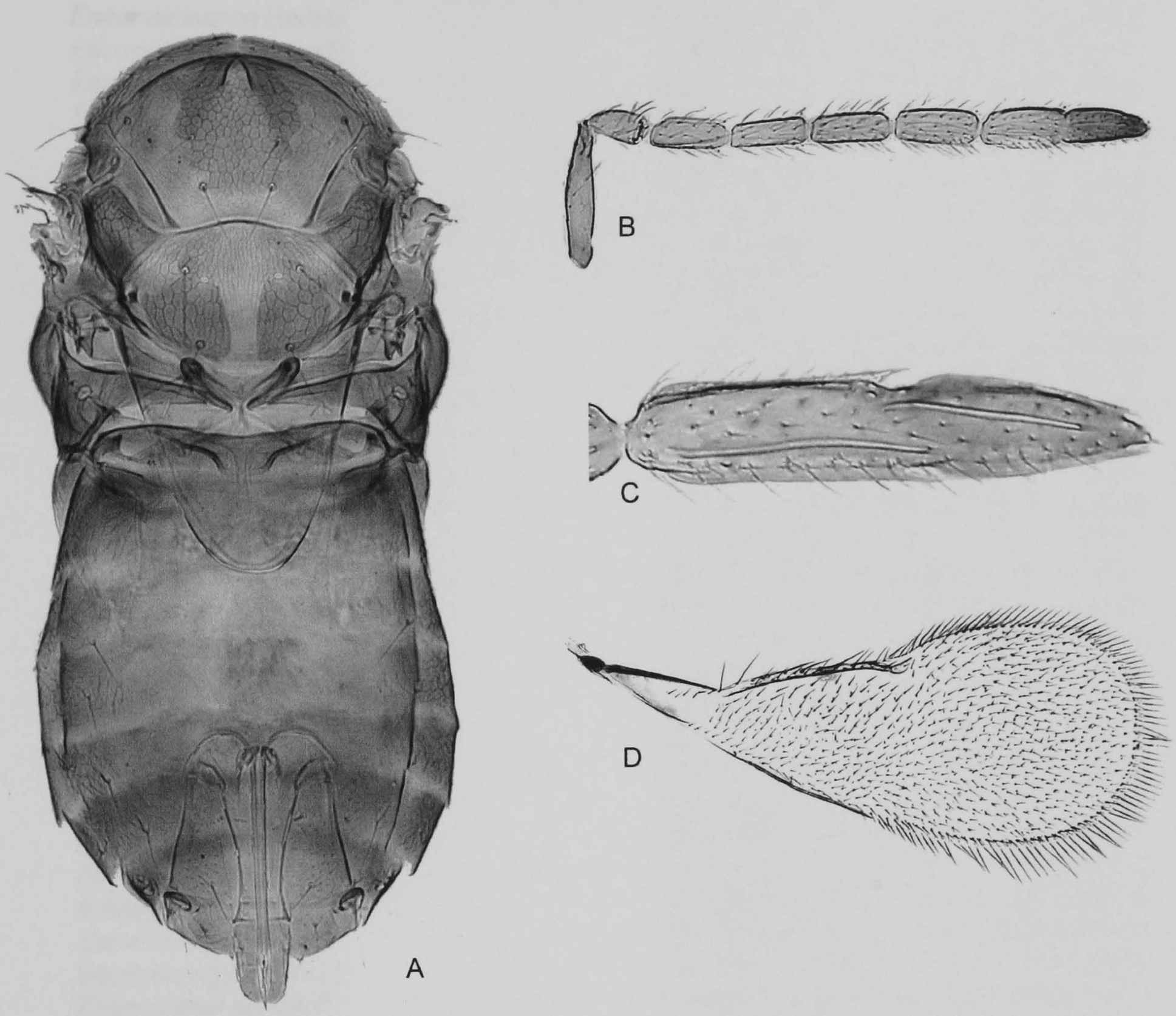


Fig. 3.4. *Encarsia estrellae* **sp. n.** A. mesosoma and gaster; B. antenna, female; C. F5+F6 of male antenna; D. fore wing.

Taxon	Sequence fragments
Encarsia inaron (New Zealand*; UK & Japan)	AG-CCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia inaron (India)	AG-CCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia estrellae (az2)	AGTCCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia estrellae (az3a)	AGTCCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia estrellae (az3b)	AGTCCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia estrellae (az4)	AGTCCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia dichroa	AGTCCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia sp. nr *azimi* (Cameroon)	AG-CCGCTTTGGCTTCCGTGTGAA-CGCG
Encarsia sp. nr *azimi**	AG-CCTCTTTGGCTTCCGTGTGAA-CGCG
*Encarsia lutea**	AG-CTGCTTTGGCTTCCGTGTGGTGCGCG
*Encarsia perplexa**	AG-CTTCTTTGGCTTCCGTGTGGTGCGCG
*Encarsia perniciosi**	AG-CTGCTTTGGCTTCCGTGTGGTGCGCG
*Encarsia bimaculata**	AG-CTGCTTTGGCTTACGTGCGGTGTGCG
*Encarsia sophia**	AG-CTACTTTGGCTTACGTGCGGTGCGCG
*Encarsia protransvena**	AG-CTGCTTTGGCTTACGTGCGGTGCGAG
Encarsia sp. nr *citri**	AG-CTGCTTTGGCTTACGTGCGGTGCGCG
*Encarsia quercicola**	AG-CTGCTTTGGCTTCCGTGTGG-GCGCG
*Encarsia formosa**	AA-CCTCTTTGGCTTACGTGTGG-GTGCG
*Encarsia meritoria**	AA-CCTCTTTGGCTTACGTGTGG-GCGCG
*Encarsia luteola**	AA-CCTCTTTGGCTTACGTGCGG-GTGCG
*Encarsia haitiensis**	AA-CCTCTTTGGCTTGCGTGTGG-GCGCG
*Encarsia hispida**	AA-CCTCTTTGGCTTACGTGTGG-ACGCG
*Encarsia guadeloupae**	GA-TCGCTCTGGCTTACGTGCGG-GCGCG
*Encarsia citrina**	AG-CCGGCTTGGCTTCCGTGCGGTTCGCG
*Encarsia pergandiella**	AG-CCGCTCTGGCTTCCGTGTGGTTCGCG
*Encarsia cibcensis**	AG-CCTCTTTGGCTTCCGTGTGGTTCGCG
*Encarsia smithi**	AA-CCTCTTTGGCTTCCGTGTGGTTCGCG
*Encarsia mineoi**	AG-CAGCTTTGGCTTACGTGTGGTTGGCG
Encarsia tricolor	AA-CAGCTTTGGCTTACGTGTGGTTTGCG
*Encarsia aurantii**	AG-CCGCTTTGGCTC-CGTGCGGAGTGCG
*Encarsia nigricephala**	AG-CCGCCTTGGCTTCCGTGCGG-GAGCG
*Eretmocerus mundus**	AG-CGCTGCTGGCTCGCGTGCGAACTGCG
*Encarsiella noyesi**	AG-CCGCTTTAGCTTCCGTGTGGTGTGCG
*Coccophagoides fuscipennis**	AG-CCGCTCTGGCTTCCGTGTGG-GTGCG

Fig. 3.5. Aligned part of D2 region corresponding to bases starting at position 41. An asterisk shows sequences from EMBL/GenBank databases (see the legend of fig. 3.3 for the accession numbers). See table 3.2 for accession numbers of new sequences.

4

Morphological and molecular taxonomic analysis of the *Encarsia meritoria* species-complex*

4.1. Abstract

Five closely-related species of *Encarsia*, belonging to the *luteola* species-group, are analysed using morphological and molecular techniques. Four of these belong to the *meritoria*-complex, and all species have a complicated taxonomic history of repeated misidentification and confusion. Morphological analysis is focussed on morphometric characters of the female antennae using principal component and canonical discriminant analysis. DNA sequence data for the D2 region of 28S nuclear ribosomal genes were obtained for 13 populations of the *luteola*-group, with a further five population sequences being obtained from GenBank. The combination of morphological and molecular study enables us to resolve the complex to a large extent, and to correct the previous confusion surrounding this group of species. Two species are described as new: *Encarsia californica* **sp. n.** and *Encarsia dispersa* **sp. n.** *Encarsia brasiliensis* Hempel is placed in synonymy with *Encarsia hispida* DeSantis **syn. n.** A lectotype is designated for *Encarsia haitiensis* Dozier. Diagnoses or descriptions, and illustrations, of all included species are provided to facilitate the identification of females belonging to this complex. All known data concerning hosts and geographical distribution are presented.

4.2. Introduction

The genus *Encarsia* currently contains 280 described species (Noyes, 2001) most of which are parasitoids either of Aleyrodidae (whiteflies) or Diaspididae (armoured scale insects). Several species are of major economic importance, either as biological control agents of pest species or as components of integrated pest management programmes (Heraty *et al.*, in press). Due to their small size and frequent

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morphological uniformity, the taxonomy and identification of many *Encarsia* species has often been problematic. Furthermore, in several species-groups, females belonging to different species are virtually identical, and males must be available for positive species identification. This is particularly true for the *perflava*-group (Huang & Polaszek, 1998) and for much of the *luteola*-group (Polaszek *et al.*, 1992; Babcock & Heraty, 2000). The availability of males, however, is subject to variation in several populations of what appear to be the same species. Uniparental, thelytokous populations exist in several species, including many of economic importance. Male production in these lineages has been affected either by infection with *Wolbachia* bacteria (Hunter, 1999) or in some cases by another agent known currently as *Encarsia* bacteria (M.S. Hunter, personal communication). In *Wolbachia*-infected populations, male production can often be induced by exposure to high temperature or treatment with antibiotics (Giorgini & Viggiani, 1996; Giorgini, 2001).

Some of the difficulties of identifying and distinguishing between morphologically close species have been alleviated recently by the successful application of DNA sequencing (Babcock & Heraty, 2000; Babcock *et al.*, 2001; Manzari *et al.*, 2002) and multivariate morphometrics (Heraty & Polaszek, 2000; Manzari *et al.*, 2002; Pedata & Polaszek, 2003). One target for the use of these techniques is the *Encarsia meritoria* species-complex, a subgroup of the *luteola*-group in which there is much taxonomic confusion. As currently understood, the subgroup consists of the following taxa: *Encarsia brasiliensis* (Hempel, 1904), *E. hispida* De Santis, 1948, *E. meritoria* Gahan, 1927, and the species widely reported as "*Encarsia* sp. near *haitiensis*" (Neuenschwander, 1994; Beevi *et al.*, 1999; Ramani, 2000), "*Encarsia ?haitiensis*" (Kumashiro *et al.*, 1983; D'Almeida *et al.*, 1998; Chien *et al.*, 2000) or even as *E. haitiensis* (Mani & Krishnamoorthy, 1999; Babcock *et al.*, 2001).

The presence of slide-mounted material in the USNM originally misidentified by H.L. Dozier (1932) as *Encarsia brasiliensis* prompted later confusion regarding this species, and the name became applied to what is clearly a member of the distantly related *Encarsia opulenta*-group. This has, unfortunately, resulted in the published use of the name *E. brasiliensis* when a completely different species was meant (Thompson, 1953; Peck, 1963; Herting, 1972; De Santis, 1979, 1980, 1989; Gordh, 1979; Grissell, 1979; Hamon, 1981). This *opulenta*-group species has recently been

described by Evans and Serra (2002) as *Encarsia dominicana* Evans. The original description of *E. brasiliensis*, although sketchy at best, at least allows the interpretation of *E. brasiliensis* as being closely related to *E. meritoria* and *E. hispida*.

Encarsia hispida was described from Argentina, reared from an unknown aleyrodid host on *Salvia splendens* (De Santis, 1948) and was known only from the Neotropics until 1988, when a thelytokous population from Spain was initially identified by Polaszek (*ex Trialeurodes vaporariorum* (Westwood) in a greenhouse) (unpublished). Later, wild populations from Southern Italy (Viggiani & Laudonia, 1991, as *E. meritoria*; Polaszek *et al.*, 1992) and France (Onillon *et al.*, 1994) were discovered. Male production has since been both induced in the laboratory (M.S. Hunter, personal communication; Giorgini, 2001) and observed in natural (but otherwise usually thelytokous) populations.

Encarsia meritoria was originally described from Florida (Gahan, 1927). Males and females were reared from *Trialeurodes floridensis* (Quaintance) by G.F. Moznette. Viggiani (1989) synonymised *E. hispida* with *E. meritoria*, but this action was not followed by other authors, and Polaszek *et al.* (1992) reinstated *E. hispida* as a valid species. Currently there is still a great deal of controversy over the status of these two species. Gerling (1967) referred to *E. meritoria* in an important paper dealing with whiteflies on cotton in California. It is certain that the species he called *meritoria* was something quite different (it is described below as *E. californica*). It would appear that many subsequent authors have followed this misidentification (Oatman, 1970; Gordh, 1979; Greathead & Bennett, 1981; Woolley & Vet, 1981). Within the *luteola*-group it actually lies outside the *meritoria*-complex, being much more closely related to *E. formosa* and *E. luteola*.

Finally, the species widely known as "*Encarsia* sp. near *haitiensis*" or "*Encarsia ?haitiensis*" or occasionally as "*Encarsia* sp. near *meritoria*" (see references above) has been both deliberately and fortuitously introduced around the world for the biological control of the spiralling whitefly, *Aleurodicus dispersus* Russell. Polaszek *et al.* (1992) regarded all three species as distinct, though very closely related. The global interest in these species as natural enemies of whiteflies, and in particular of *A. dispersus* and *Bemisia tabaci* (Gennadius), has until now been tempered by the taxonomic uncertainty and confusion surrounding the group. The advent of 28S D2 rDNA sequencing techniques has provided an extremely useful tool

for the resolution of several lineages in *Encarsia*. Combined with morphological characters that were previously considered rather weak (dimensions and form of antennal segments), it has now been possible to resolve this taxonomic confusion and provide a much-improved classification for this previously problematic species-complex.

4.3. Materials and methods

4.3.1. Morphological analysis

Populations of *Encarsia* approximating to the *meritoria*-complex were studied from all over the world. Host-reared material was accumulated from Argentina, Barbados, Belize, Benin, Brazil, Chile, Colombia, Cuba, El Salvador, Fiji, Guadeloupe, Guam, Guatemala, Haiti, Hawaii, Honduras, India, Italy, Kiribati, Madeira, Maldives, Malaysia, Mexico, Peru, Philippines, Puerto Rico, South Africa, Spain, Tenerife, Trinidad, USA and Venezuela. Female specimens mounted on microscope slides were selected for morphometric analysis of antennal segments 3-8 (F_1-F_6). The length of each of these flagellar segments was measured, as well as the lateral area presented by F_1-F_3 (fig. 4.1). Initially, the total funicle (fig. 4.1, "7") and clava (fig. 4.1, "8") lengths were also included. However, inconsistencies in the method of slide-mounting led to distortion affecting particularly the inter-flagellomere lengths, this in turn having a large effect on total funicle and total clava lengths. These measurements were therefore subsequently left out of the analysis. Because of a great deal of size variation, some of it probably host-induced, measurements were transformed into the following length and area ratios (Appendix 8):

lengths: F_3/F_1; F_2/F_1; F_3/F_2; F_5/F_1; F_6/F_1; F_6/F_5; F_6/F_4

areas: F_3/F_1; F_2/F_1; F_3/F_2

In total, 145 females of five species of the *E. meritoria*-complex, *E. dispersa* **sp. n.** (n = 35), *E. californica* **sp. n.** (27), *E. hispida* (68), *E. meritoria* (3) and *E. haitiensis* (12), were measured. Principal components analysis (PCA) was carried out on the resulting data matrix, after log transformation, using the statistical package SPSS (Norusis, 1993). Because all variables were in the same unit (ratio), the covariance matrix was used to observe the distribution of observations without the *a priori* constraints of assigning them to a particular species. A PCA based on the correlation matrix gave virtually the same results and is therefore not presented.

Canonical discriminant analysis (CDA) was employed to evaluate variables for the discrimination of individuals using the five species as class variables in the analysis. This analysis was carried out on log-transformed data using the same package in two different ways: entering independent variables together and using a stepwise method. Homogeneity of variance-covariance matrices was accepted in both cases (P = 0.142 and P = 0.152 for simultaneous and stepwise methods respectively). Prior probabilities were set to be computed from group sizes because of differences in sample size. Analyses of untransformed data were also performed for both PCA and CDA, and gave virtually the same results (not presented).

In two cases (*E. dispersa* **sp. n.** and *E. haitiensis*), for a selected subsample of 12 females three linear measurements were taken of the ovipositor system (fig. 4.2): length of 3rd valvulae (fig. 4.2, "A"); length of 2nd valvifers (fig. 4.2, "B") and total ovipositor length (fig. 4.2, "C"). Ratios were calculated for A:B and C:B (Appendix 9). For two subsamples of *E. californica* **sp. n.** and *E. hispida* (12 females in each sample) measurements of the mid basitarsus and mid tibial spur were taken and ratios compared.

4.3.2. DNA extraction, amplification and sequencing

Adult *Encarsia* specimens were collected directly in 70-95% ethanol from Belize, Brazil, India, Mauritius, Netherlands, Tenerife (Canary Islands), Trinidad, and U.S.A. (Arizona, California). Genomic DNA was extracted from single specimens using the DNeasy Tissue Kit (Qiagen) by crushing and incubating at 55°C for 6-12 hours in Proteinase K, with elution into 30 µl distilled water. Standard 50 µl PCR reactions were then carried out in a GeneAmp 9600 thermal cycler using 1.0 µl DNA extract, 5 µl *Taq* buffer (1.5 mM $MgCl_2$), 1.5 U *Taq* polymerase (Roche), 10 nmol dNTPs (Amersham Pharmacia Biotech; APB) and 20 pmol of each primer. The D2 region of 28S rDNA was amplified using the following primers: forward 5'-GCG AAC AAG TAC CGT GAG GG-3'; reverse 5'-TAG TTC ACC ATC TTT CGG GTC-3' (note, this product includes the smaller D3 region, which was not used in the analyses). GFX gel band purification (APB) was used to clean all PCR products, which were then sequenced in both directions with the same primers using *Big Dye* terminators at half recommended volumes on an ABI Prism 3700 automated sequencer. PCR conditions were 35 cycles of 95°C denaturation (30 s), 45°C

annealing (30 s) and 72°C extension (1 min) with an initial denaturation for 2 mins and a final extension for 4 mins. The 28S-D2 locus was sequenced for two individuals of *E. californica* **sp. n.**, three individuals of *E. dispersa* **sp. n.**, and seven individuals of *E. hispida*. In addition, two individuals of *Encarsiella* sp. from Trinidad were sequenced and used as outgroups for the phylogenetic analysis.

Sequences have been deposited in the European Molecular Biology Laboratory (EMBL) and GenBank databases under accession numbers AJ547624-AJ547631 (Table 4.1).

Table 4.1. Species sequenced and used in the molecular phylogenetic analysis with their geographical and biological information.

Species	Strain identifier	Locality	Host	EMBL/GenBank accession number
E. californica **sp. n.**	A	U.S.A., Arizona	*Bemisia tabaci* (Genn.)	AJ547624
E. californica **sp. n.**	C	U.S.A., California	*B. tabaci*	AJ547625
E. dispersa **sp. n.**	B	Belize	*Aleurothrixus floccosus* (Maskell)	AJ547626
E. dispersa **sp. n.**	T	Trinidad	*Aleurodicus pulvinatus* (Maskell)	AJ547627
E. dispersa **sp. n.***	I	India	*Aleurodicus dispersus* Russell	–
E. hispida	T	Tenerife	*A. dispersus*	AJ547628
E. hispida	dm	Brazil	*B. tabaci*	AJ547629
E. hispida	pm	Brazil	*B. tabaci*	AJ547630
*E. hispida***	M	Mauritius	*A. dispersus*	–
*E. hispida***	N	Netherlands	Unknown	–
*E. hispida***	T1	Tenerife	Unknown	–
*E. hispida***	T2	Tenerife	Unknown	–
Encarsiella sp. MS-2002	D	Trinidad	*A. pulvinatus*	AJ547631
Encarsiella sp.***	D1	Trinidad	*A. pulvinatus*	–

* This sequence and the sequence of *E. dispersa* **sp. n.** strain T are identical, so only the latter sequence was deposited in EMBL/GenBank databases.
** These four sequences and the sequence of *E. hispida* strain T are identical, so only the latter sequence was deposited in EMBL/GenBank databases.
*** This sequence and the sequence of *Encarsiella* sp. strain D are identical, so only the latter sequence was deposited in EMBL/GenBank databases.

4.3.3. Phylogenetic analysis

Amplified D2 regions were between 455 and 459 base pairs in length. The sequences obtained, together with seven additional ones retrieved from EMBL/GenBank (from Babcock & Heraty, 2000; Babcock *et al.*, 2001; accession numbers AF223366, AF223369-70, AF254192-94, AF254247) were aligned by eye. Additional alignments were also performed using the Clustal X programme (Thompson *et al.*, 1997) with four sets of gap opening and gap extension penalties:

20:10, 15:6.66 (default), 10:5 and 5:1 (N.B. the default downweighting of transitions by 0.5 was used in all). Maximum parsimony analysis (MP) was then performed on the five multiple alignments using PAUP* version 4.0b10 (Swofford, 1998). Heuristic searches were carried out with 100,000 random additions followed by branch swapping using tree-bisection-reconnection (TBR) holding a single tree and unlimited maxtrees. Gaps were treated as both missing data and informative. The bootstrap support for each alignment was found using 100 pseudoreplicates each of 100 random additions (Felsenstein, 1985) holding only one tree. Pairwise distances within and between species were calculated for all five different alignments using PAUP* (gaps treated as missing data).

Abbreviations:

NHM: The Natural History Museum, London, U.K.

UCR: University of California, Riverside, U.S.A.

UNP: University of Naples, Portici, Italy.

USNM: United States National Museum, Smithsonian institution, Washington D.C., U.S.A.

4.4. Results

4.4.1. Principal component analysis

Five components were extracted based on the 10 variables for the analysis and biplots of all pair-wise combinations of these examined. The extracted communality values of variables (the proportion of variance that is accounted for by the factors for each variable) were high (0.856-1.000), i.e. the factor analysis was accounted for much of the variance associated with each variable which means that each variable had much proportion of variance in common with the other variables in the analysis. Table 4.2 presents eigenvalues, percentages of variance, and weights (component score coefficients) for first two principal components (PC-I and PC-II). F2/F1 (area), F3/F2 (area) and F2/F1 (length) had the highest contributions, and F6/F5 (length) and F6/F4 (length) had the lowest contributions to PC-I. Along PC-II, F6/F1 (length), F3/F2 (area) and F5/F1 (length) had the largest, and F2/F1 (area), F6/F5 (length) and F2/F1 (length) had the smallest influences (Table 4.2).

A scatter diagram of individuals with respect to first and second principal components is shown in figure 4.3A. Female *Encarsia* species were projected on the

first two principal components, which together accounted for 86.45% of the overall variance (raw solution) (Table 4.2). The specimens can be seen to fall into four main groups (fig. 4.3A, solid line elliptical), with some overlap. *E. dispersa* overlaps with *E. haitiensis* but not at all with any of the other three species. *E. hispida* overlaps with *E. californica*, *E. meritoria* and *E. haitiensis*. Three representatives of *E. meritoria* were not recovered together as a separate group (fig. 4.3A, dashed line triangle). Bearing in mind that there were no *a priori* suppositions of group membership, the clustering of points is considered as a strong indicator of their group membership.

Table 4.2. Eigenvalues, percent of variances, and weights for first two principal components.

Variable	Principal components	
	I	II
Eigenvalues (raw)	0.01959	0.01338
Eigenvalues (rescaled)	3.913	3.794
% of variance (raw)	51.366	35.084
% of variance (rescaled)	39.126	37.938
F3/F1 (length)	0.058	0.130
F2/F1 (length)	0.238	0.023
F3/F2 (length)	-0.124	0.136
F5/F1 (length)	0.086	0.236
F6/F1 (length)	0.063	0.309
F6/F5 (length)	-0.012	0.021
F6/F4 (length)	-0.018	0.049
F3/F1 (area)	0.071	0.202
F2/F1 (area)	0.375	-0.012
F3/F2 (area)	-0.250	0.275

4.4.2. Canonical discriminant analysis

Discrimination of the species was better using canonical discriminant analysis. Individual specimens were projected on the first and second canonical discriminant functions (CD-I and CD-II) using the "entering independent variables together" method, which accounted for 98.9% of the original variance (fig. 4.3B). In this method, all predictor variables are analyzed at once and given equal priority, i.e. no special relationship is predicted or assumed to exist with any one of the predictor variable(s) and group membership. Table 4.3 shows standardized canonical discriminant function coefficients and functions at group centroids (group means are centroids). The functions at group centroids indicate the average discriminant function

score for each group on each function, showing between which groups the respective functions discriminate. Based on this table, the first discriminant function is largely a measure of F2/F1 (length) and F6/F1 (length) that completely separate *E. hispida* from *E. dispersa* and *E. haitiensis*. Furthermore, F6/F1 (length) and F5/F1 (length) collectively completely separate *E. californica* from *E. haitiensis* and from most of *E. hispida* and *E. dispersa* (except one individual from each species) along CD-II. Both *E. hispida* and *E. californica* overlap with *E. meritoria*, and the three individuals of the latter species do not cluster as a small group (fig. 4.3B, dashed line triangle). As with the result of PCA, *E. dispersa* overlaps with *E. haitiensis*.

Table 4.3. Standardized canonical discriminant function coefficients and functions at group centroids (group means), calculated from the "entering independent variables together" method.

Variable	Standardized canonical coefficients	
	CD-I	CD-II
F3/F1 (length)	-0.436	-0.653
F2/F1 (length)	1.090	-0.217
F5/F1 (length)	0.506	0.739
F6/F1 (length)	-1.061	0.905
F6/F4 (length)	0.277	-0.316
F3/F1 (area)	-0.502	-0.019
F2/F1 (area)	0.634	0.376
Species	**Functions at group centroids**	
	CD-I	**CD-II**
E. dispersa	4.215	0.708
E. californica	0.123	-3.135
E. hispida	-2.478	0.695
E. meritoria	-0.163	-0.807
E. haitiensis	1.512	1.252

F3/F2 (length), F6/F5 (length) and F3/F2 (area) not used in the analysis.

Low values of Wilks' Lambda test (the smaller the lambda, the greater the difference) for the two first functions and also statistically significant Chi-square for these functions (Table 4.4) clearly show that only the first two functions are significant predictors. In total, 95.2% of original grouped cases were correctly classified.

Using the stepwise method for CDA gave almost the same results of the "entering independent variables together" method with the following differences: (1) the first two discriminant functions accounted for 99.4% of the original variance (fig.

4.3C), (2) F3/F2 (length) and F3/F1 (length) completely separated *E. hispida* from *E. dispersa* and *E. haitiensis* along CD-I, (3) F5/F1 (length) completely separated *E. californica* from *E. haitiensis*, *E. dispersa* and *E. hispida* along CD-II (Table 4.5, fig. 4.3C), and (4) in total, 92.4% of original grouped cases were correctly classified.

Table 4.4. The level of significance for each of the successive discriminant functions.

Test of functions	Wilks' Lambda	Chi-square	df	Sig.
1 through 4	0.031	480.717	28	0.000
2 through 4	0.265	183.407	18	0.000
3 through 4	0.901	14.349	10	0.158
4	0.973	3.772	4	0.438

Table 4.5. Standardized canonical discriminant function coefficients and functions at group centroids (group means), calculated from the stepwise method.

Variable	Standardized canonical coefficients	
	CD-I	CD-II
F3/F1 (length)	-0.600	-0.427
F3/F2 (length)	0.779	-0.006
F5/F1 (length)	0.290	1.336
F6/F5 (length)	0.403	0.279
F3/F2 (area)	0.388	-0.130
Species	**Functions at group centroids**	
	CD-I	**CD-II**
E. dispersa	-4.096	0.659
E. californica	-0.156	-2.946
E. hispida	2.418	0.638
E. meritoria	0.419	-0.544
E. haitiensis	-1.510	1.225

F2/F1 (length), F6/F1 (length), F6/F4 (length), F3/F1 (area) and F2/F1 (area) not used in the analysis.

4.4.3. Bivariate analysis

In addition to the separation of species based on PCA and CDA, *E. dispersa* and *E. haitiensis* clearly separated based on the bivariate analysis of the ratios of linear measurements taken of the ovipositor, i.e. "ovipositor length / 2nd valvifer length" and "3rd valvula length / 2nd valvifer length" (fig. 4.4). Furthermore, *E. californica* and *E. hispida* separated based on the bivariate analysis of mid basitarsus length vs. mid tibial spur length. The ratio of these two variables can be used to separate the two species (see species treatments, below).

4.4.4. Phylogenetic analysis of molecular data

The lengths of multiple alignments were 464-472, with 88-98 parsimony informative positions (gaps treated as informative). Maximum parsimony (MP) analyses of the 15 DNA sequences (identical sequences not included) gave a total of 48 most-parsimonious trees (MPTs) from the five alignments and one of them (length = 178, R.I. = 0.788, C.I. = 0.787) is shown in figure 4.5. Thick lines show those branches that are recovered in all MPTs.

4.4.5. Phylogenetic relationships

Phylogenetic relationships derived from the 28S-D2 data set (fig. 4.5) do not concur entirely with any of the molecular analyses of *Encarsia* species presented by Babcock *et al.* (2001), despite the fact that all the species used in the present analysis were included by them. When comparing results of Babcock *et al.*'s analysis with the present study, it must be borne in mind that their "*meritoria*" is the *E. californica* and their "*haitiensis*" is the *E. dispersa* of this study. The main result of the present analysis is that the Western US species commonly misidentified in the published literature as "*Encarsia meritoria*" is actually closely related to the *E. formosa/E. luteola* clade. The mean pairwise distances between *E. californica* - *E. formosa* and between *E. californica* - *E. luteola* were 4.4% and 5.2% respectively (Table 4.6). This relationship is also supported by morphological studies. *E. californica* shares with *E. formosa* and *E. luteola* a short mid tibial spur. *E. dispersa* and *E. hispida* show relatively large of variation in sequence data, i.e. the average sequence distance between these two species based on different alignments was 7.9% (Table 4.6). Although perhaps not surprisingly, the "vagrant" populations of *E. californica* and *E. hispida* (i.e. those that have been transported either accidentally or deliberately around the world) show very few base pair differences (mean pairwise distance of 0.6% and 1.3% respectively) (Table 4.6). Knowing that the founder population of *E. dispersa* ("*Encarsia* sp. near *haitiensis*") for most of these introductions was from Trinidad, as expected the Trinidad population sequenced during this study is identical to the Indian and Australian populations. Belizian populations show 7.0% average sequence divergence (Table 4.6), and this, coupled with slight differences in antennal

coloration, suggest that further study may confirm that they constitute different species.

Within the *E. hispida* clade still greater variation is found. At least three of the "vagrant" populations (Mauritius, Netherlands, Tenerife) were found to be identical, but perhaps surprisingly, the Italian population showed slight differences from these, grouping with the Californian *E. hispida*. Surprisingly, two individuals collected from the same locality, host and host plant species in Brazil differed from each other by the average sequence distance of 1.2% and from other *E. hispida* by 1.9% and 1.7% (Table 4.6).

Table 4.6. Mean sequence distances within and between species of *Encarsia* based on different alignments (gaps treated as missing data). d = dark morph; p = pale morph; S.D. = standard deviation.

Within/between species	Average sequence distance based on different alignments					Total mean ± S.D. & (range)
	By eye	By computer using four different sets				
		5:1	10:5	15:6.66	20:10	
E. E. hispida	0.011	0.014	0.014	0.014	0.013	0.013 ± 0.007 (0.002-0.024)
E. dispersa	0.070	0.068	0.071	0.071	0.068	0.070 ± 0.001 (0.068-0.071)
E. californica	0.006	0.006	0.004	0.006	0.006	0.006 ± 0.001 (0.004-0.007)
E. dispersa – E. hispida	0.065	0.078	0.084	0.083	0.083	0.079 ± 0.010 (0.056-0.099)
E. californica – E. formosa	0.043	0.044	0.044	0.047	0.044	0.044 ± 0.002 (0.042-0.048)
E. californica – E. luteola	0.052	0.052	0.054	0.052	0.052	0.052 ± 0.003 (0.048-0.055)
E. hispida (p) – *E. hispida* (d)	0.011	0.014	0.011	0.011	0.013	0.012 ± 0.001 (0.011-0.014)
E. hispida (p) – *E. hispida**	0.015	0.018	0.021	0.020	0.021	0.019 ± 0.004 (0.013-0.024)
E. hispida (d) – *E. hispida***	0.013	0.017	0.019	0.018	0.015	0.017 ± 0.003 (0.011-0.022)

* All populations of *E. hispida* excluding *E. hispida* (d).
** All populations of *E. hispida* excluding *E. hispida* (p).

4.5. Discussion

The application of morphometric and molecular analyses to a taxonomically difficult species complex has resulted in its almost complete resolution. The lack of material, for both morphological and molecular study, of what can unequivocally be considered to be *E. meritoria* has hindered our understanding of that species. The three individuals used in the present morphological study neither clustered together in

any analysis, nor clustered particularly with any of the other species analysed. Several attempts at obtaining "true" *E. meritoria* from the type locality and type host over the last 10 years have been unsuccessful, but with perseverance it may eventually be possible to evaluate the true taxonomic status of *E. meritoria*. Given the differences in antennal morphology between males of *E. meritoria* and the other species treated here (except *E. dispersa*), and the differences in antennal morphology between females of *E. meritoria* and *E. dispersa*, it seems best to regard it provisionally as a valid species. The present study has clearly demonstrated that the species widely referred to in the literature as *E. meritoria* is in fact the one least closely related to it (*E. californica*). This study has also provided molecular markers for tracking several of the species treated. In particular, the continuing spread of *E. dispersa* and *E. hispida* around the world, both deliberately and accidentally, can now be monitored with respect to particular populations using differences in the 28S D2 sequence. While all the species treated here are originally of New World origin (southern Nearctic, Neotropical), several have invaded Europe, Africa and elsewhere, and multiple introductions are also taking place, for example in Tenerife and Mauritius. We now have the tools at our disposal not only to distinguish between the species of this complex, but also to identify the origins of introduced populations of the species concerned.

Encarsia californica Polaszek **sp. n.**

(fig. 4.6A-C; fig. 4.11A)

Encarsia meritoria Gahan: *sensu* Gerling, 1966, 1967; Oatman, 1970 (misidentifications); Longo *et al.*, 1990; *nec* Avilla *et al.*, 1991; Viggiani & Laudonia, 1991 (= *E. hispida* DeSantis); Barbagallo *et al.*, 1992; Baldanza *et al.*, 1994; De Santis & Fidalgo, 1994; Baldanza, 1996; Serra *et al.*, 1996; Babcock *et al.*, 2001.

Holotype. ♀, U.S.A., California, Napa Co. Oakville, Mondavi Vineyard, col 26.ix.2001 em. 1-8.x.2001, (I.G. Varela), ex *Trialeurodes vittata* (Quaintance) on *Vitis vinifera* (NHM).

Paratypes. Same data as holotype, 5 ♀ 2 ♂ (UCR, USNM, UNP). The type series are vouchers for the partial 28S D2 sequence, GenBank Acc. No.: AJ547625.

Other material. 2 ♀ 1 ♂, California, Orange Co. Natl. For. Ortega Highway, 1 mile N. Lower San Juan Ranger Stn, 4.viii.1982, (Rose, Woolley) JBW 82/041, ex

Trialeurodes abutilonea (Haldeman) on *Heterotheca grandiflora* (J. LaSalle det.) (UCR); 1 ♀, Imperial Co. Hwy 86 at Legion Rd, 29.iii.99, (W.J. Roltsch), ex *Bemisia* sp. on collards D242 (voucher from Babcock & Heraty's 2000 study; GenBank Acc. No.: AF223367) (NHM); 1 ♀ 2 ♂, El Toro, 5.xii.67, (E. Oatman), ex *Aleyrodes spiraeoides* on strawberry (UCR); 1 ♀, same data but 18.x.1966 (NHM); 1 ♀, UCR campus, iv.1977, (M. Badgley), ex aleyrodid on *Sonchus oleraceus* (NHM); 1 ♀1 ♂, 29.ix.1978, (L. Vet), ex *T. vaporariorum* on *Nicotiana glauca* (NHM); 2 ♂, same data but 26.x.1978, *ex T. vaprorariorum* (UCR); 2 ♀, same data but El Toro, 6.xii.78 (UCR); 1 ♂, same data but 3.x.1978 (UCR); 1 ♂, same data but ex *Aleyrodes spiraeoides* Quaintance (UCR); 2 ♀ 1 ♂, same data but 4.i.1979 (NHM, UCR); 1 ♂, same data but 31.xii.1978 (UCR); 3 ♀ (dark morphs, see above), same data but 17.i.1979, ex *A. spiraeoides* or *T. vaporariorum* (NHM); 1 ♀, same data but 31.xii.1978 (NHM); 3 ♀, 25.iv.1911 "mountain laurel", (E.G. Branigan) (USNM); 1 ♀, San Gabriel, 25.vii.1911, ex *Trialeurodes packardi* (Morrill) (USNM); 5 ♀ 1 ♂, S. California, ex *T. abutilonea* (D. Gerling leg.; UNP); 2 ♀ 5 ♂, Arizona, Lake Field, 16.x.1955, (F.F. Bibby), ex *Trialeurodes* on *Ambrosia* (USNM); 1 ♀, Tucson, 9.vii.1962, (G.D. Butler) (NHM).

Diagnosis. E. californica is distinguished from the other species treated here (i.e. the *meritoria* complex) by the comparatively shorter mid tibial spur, being approximately half the length of the mid basitarsus (fig. 4.6B). Also, the pupal sheath of *E. californica* is not black, whereas those of at least *E. hispida* and *E. dispersa* are.

Description. Female. Head, meso- and metasoma largely yellow; occasionally occiput, anterior mesoscutum and a transverse postocellar bar on each side of vertex, brown. Legs pale yellow, wings hyaline, antennae clearly darker than the remainder of the body and appendages, uniformly brown, even in the palest individuals. Four individuals with much more extensive dark colour, otherwise morphologically very similar, if not identical, to the "normal" pale specimens (see "remarks" below).

Antenna (fig. 4.6C) with pedicel slightly longer than F1. F1 to F4 increasing only slightly in length, each one twice as long as wide. Flagellar segments with the following number of linear sensilla: F1: 0, F2: 0, F3: 1-2, F4: 1-2, F5: 2-3, F6: 2-3.

Mid lobe of mesoscutum with reticulate sculpture becoming longitudinal at sides; with 5-7 pairs of setae. Anterior scutellar setae slightly more widely spaced, and slightly shorter than posterior pair. Tibial spur of mid leg (fig. 4.6B) 0.4-0.6 × as long as corresponding basitarsus - noticeably shorter than in the other species treated here. Two setae on submarginal vein, 5-8 setae on marginal vein, 2-5 setae in basal cell. Ratios of ovipositor (fig. 4.6A): mid basitarsus: third valvula = 100: 31-37: 40-45.

Male. Colour typical of male *Encarsia*, largely dark with the scutellum pale and the mesoscutal pigmentation in the form of and inverted triangle, centrally. F5 and F6 separate (fig. 4.11A).

Distribution. U.S.A.: Arizona, California.

Hosts. *Aleyrodes spiraeoides*, *Bemisia tabaci*, *Trialeurodes abutilonea*, *T. packardi*, *T. vaporariorum*, *T. vittata*, *Trialeurodes* sp.

Remarks. *E. californica* **sp. n.** has been referred to as "*E. meritoria*" by various authors since Gerling (1966, and see above). In actual fact, although belonging to the luteola-group, together with *E. meritoria*, it is rather distantly related to that species. *E. californica* is actually more closely related to *E. formosa* and *E. luteola*, with which it shares a much shorter mid tibial spur than that found in the true *meritoria*-complex (cf. figs 4.6B, 4.7B, 4.8D, 4.9B, 4.10B), as well as much greater congruence in the 28S D2 sequence data (see fig. 4.5). Based on different alignments, the average sequence distance between *E. californica* - *E. formosa* and *E. californica* - *E. luteola* was 4.4% and 5.2% respectively (Table 4.6).

Encarsia dispersa Polaszek **sp. n.**

(fig. 4.7A-C; fig. 4.11B)

Encarsia ?haitiensis: Kumashiro *et al.*, 1983; Chien *et al.*, 2000; *Encarsia haitiensis* Mani & Krishnamoorthy, 2000 (misidentifications); Babcock *et al.*, 2001; *Encarsia* sp. nr *haitiensis* Ramani, 2000.

Holotype. ♀, Malaysia, Sabah, Tawau, 2.vii.88, ex *Psidium guajava* QH 397 CIE A20033 (NHM).

Paratypes. Same data as holotype, 11 ♀ (NHM; USNM; UCR; UNP).

Other material. 1 ♀, Benin, Cotonou, 1993, (J.A. Lys), ex *Aleurodicus dispersus* (NHM); 1 ♀ Brazil, near Campinas, (H.W. Browning), ex *Aleurothrixus floccosus* (Maskell) on *Citrus* sp. (USNM); 2 ♀, Fiji, Suva, ii.90, ex *Aleurodicus dispersus*, CIE A20932 (NHM); 10 ♀, Hawaii, Honolulu, 31.viii.1982 (HDA 801), ex *Aleurodicus dispersus* (NHM); 1 ♀, Hawaii, Oahu, Ala Wai, 3.x.1991, (P. Watanabe), ex *Aleurodicus dispersus* on *Coccinia* and beans (NHM); 4 ♀, India, Kerala, 16.i.1998, AICRP College, ex *Aleurodicus dispersus* (NHM); 3 ♀, Kiribati, Tarawa, xi.1989, (G.S. Sandhu), ex *Aleurodicus dispersus* CIE A20932 (NHM); 2 ♀ 1 ♂, Malaysia, Bukit Lawang, 2.viii.88, ex *Psidium guajava* KC 571 CIE A20226 (NHM); 1 ♀, Malaysia, West Malaysia, Kedah, Muda, 3.vii.91, (H. Kajita), ex *Aleurodicus dispersus* MARDI M 24629 IIE 21883 (NHM); 2 ♀, Mariana Is., Guam, Inarajan (AES), 29.ix.1983, (L. Kikuchi), ex *A. dispersus* E1465 (NHM); 1 ♂, Mariana Is., Guam, viii.1983, (J. Nechols), ex *Aleurodicus dispersus* E1463 (NHM); 3 ♀, Philippines, Luzon Is. Ilagen, 7.xii.85, (M.J.W. Cock), ex *Aleurodicus dispersus* on *Psidium guajava* (NHM); 3 ♀, Trinidad, San Juan, iii.1955, (F.D. Bennett T-76), ex whitefly on soursop (CABIC); 6 ♀, Trinidad, St Augustine, iv.1961, (F.D. Bennett), ex *Paraleyrodes urichii* Quaintance & Baker on *Casearia* (UNP); 1 ♀, Trinidad, x.1996, ex *Aleurothrixus floccosus* on pommecythere IIE 23542 (NHM); 1 ♀, same data except ex *Aleurodicus* sp. on guava & pigeon pea IIE 23542 (NHM); 1 ♀, Trinidad, St Helena, 16.x.1992, assoc. whiteflies on capsicum IIE 22597 (NHM); 1 ♀, Trinidad, St George, Curepe, xi.1976, (M.Yaseen), ex whitefly on *Cajanus cajan* (NHM); 4 ♀, Trinidad, Wallerfield, 5.ix.2001, (J. Irish, E. Holder), ex *Aleurodicus maritimus* Hempel on *Psidium guajava* (NHM); 1 ♀, Venezuela, Barqto. Lara., i.1995, (A. Chavez & F. Diaz), ex *Aleurodicus pulvinatus* (Maskell) on *H. crepitans* (NHM); 1 ♀, U.S.A., Florida, Broward Co. Plantation, 1979, (R. Dowell) 802, ex *Tetraleurodes* [as *Trialeurodes*] *acaciae* (Quaintance) (NHM).

Diagnosis. *E. dispersa* is distinguished from the other species treated here (except *E. haitiensis*) by having the F2 antennal segment at least as long as, and often

longer than, the F3 segment. It is easily distinguished from *E. haitiensis* by the relative proportions of the ovipositor, 2nd valvifers and 3rd valvulae (see fig. 4.4).

Description. Female. Head, meso- and metasoma and appendages largely pale yellow. Wings hyaline. Mesoscutal-scutellar (transverse) suture distinctly pigmented brown-black, very clear in life; less clear in slide-mounted specimens. Anterior mesoscutum, mesosomal setae, antennae (esp. F6) brown. A single female in the type series has some indication of brown infuscation on the central mesoscutum ("*dispersa* ♀slide no. 133"). This individual, aberrant also in its morphology, is discussed below under "remarks".

Antenna (Fig. 4.7C) with pedicel clearly longer than F1, the latter slightly longer than wide. F2 usually slightly longer than F3, the remaining segments approximately equal in length. Flagellar segments with the following number of linear sensilla: F1: 0, F2: 2-3, F3: 2-3, F4: 3-4, F5: 3-4, F6: 3-4.

Mid lobe of mesoscutum with 6 pairs of setae (occasionally 8). Anterior scutellar setae slightly shorter and finer than posterior pair. Tibial spur of mid leg 0.6-0.9 × as long as corresponding basitarsus. Two setae on submarginal vein, 7-9 setae on marginal vein, 3-6 setae in basal cell. Discal setae uniformly distributed. Ratio of ovipositor: mid basitarsus: third valvula = 100: 30-32: 40-43.

Male. Coloration typical of male *Encarsia*; largely dark with the scutellum pale. Morphological characters as for female, with the exception of the genitalia and antennae. The latter with F5 and F6 partially fused (fig. 4.11B).

Distribution. Neotropical: Belize, Brazil, Trinidad, Venezuela; Nearctic: U.S.A. (Florida); Oriental/Pacific: Fiji, Guam, Hawaii, India, Kiribati, Malaysia, Maldives, Philippines, Taiwan (introduced); Afrotropical: Benin.

Hosts. *Aleurodicus dispersus*, *A. maritimus*, *A. pulvinatus*, *Aleurodicus* sp., *Aleurothrixus floccosus*, *Paraleyrodes urichii*, *Tetraleurodes acaciae*.

Remarks. *E. dispersa* has become an extremely widespread species since its introduction from Trinidad into Hawaii in 1979 (Cock, 1985). The earliest references

to this species are as *Encarsia* near *haitiensis*, or *Encarsia* sp. poss. *haitiensis* (Cock, 1985), but more recent papers have referred to it simply as *Encarsia haitiensis* (Babcock *et al.*, 2001). Although no populations of the true *E. haitiensis* have been sequenced, there are enough very obvious morphological and colour differences between the specimens comprising the long type series of *E. haitiensis* and its closest relatives, including *E. dispersa*, to show convincingly that *E. dispersa* is clearly different, and an undescribed species. The elongate F2 of the female antenna, usually slightly longer than F3 (fig. 4.7C), coupled with the partially fused F5+F6 of the (albeit rare) males (fig. 4.11B) serve to distinguish it from the closely related *E. hispida*. A single female from the type series is unusual in having dark pigmentation on the mesoscutum and also the F2 much smaller than F3 (in all other specimens F2 is longer than F3). The causes for this variation in coloration and morphology, possible also found in *E. californica* (see above) are worthy of investigation.

The widely introduced populations of *E. dispersa* probably originate from a single, or a few, original populations brought from Trinidad to Hawaii and then spread further around the globe. The molecular analysis showed no differences between populations from Trinidad, Australia and India. However, the native (i.e. non-introduced) population from Belize showed the amount of 7.0% average sequence divergence. The widespread *E. dispersa* type generally has the antennal F6 noticeably darker than the remainder of the flagellum. In the Belizian individuals the entire flagellum is darkened. Further research may eventually reveal that they belong to a distinct species.

Encarsia haitiensis Dozier

(fig. 4.8A-D)

Encarsia haitiensis Dozier, 1932: 118.

Trichoporus haitiensis (Dozier): Dozier, 1933.

Encarsia haitiensis Dozier: Myartseva & Ruiz-Cancino, 2000; Evans & Serra, 2002.

Lectotype (here designated). ♀, Haiti, Damien, 13-16.xii.1930, (H. L. Dozier), ex *Aleurothrixus floccosus* on *Spondias mombin* type no. 44661 (USNM).

Paralectotypes. Same data as lectotype, 9 ♀ (NHM, USNM); 6 ♀, same data as lectotype, except *Spondias lutea* (USNM); 1 ♀, same data as lectotype, except 9.iii.1931, *ex Aleurothrixus haitiensis* on *Catalpa longissima* (USNM).

Diagnosis. Female. Head, meso- and metasoma and appendages largely pale yellow. The following areas pale brown (fig. 4.8A): post-ocellar bars, pronotum, anterior axillae, scutellum, propodeum and TI (petiole). Wings hyaline.

Antenna (fig. 4.8B) with pedicel clearly longer than F1, the latter slightly longer than wide. F2 equal in length to F3, the remaining segments approximately equal in length. Numbers of linear sensilla on the antennae unclear due to the method of preservation.

Setation of the mesosoma unclear. Tibial spur of mid leg 0.8-0.9 × as long as corresponding basitarsus. Two setae on submarginal vein, 7-9 setae on marginal vein, 3-6 setae in basal cell. Discal setae uniformly distributed.

The main morphological distinguishing character of *E. haitiensis* is the longer 3rd valvula which is 0.75-0.8 × the 2nd valvifer (0.55-0.65 in *E. dispersa* - see fig. 4.4).

Male. Unknown.

Distribution. Haiti.

Hosts. *Aleurothrixus flocossus*, "*A. haitiensis*" (see below).

Remarks. *E. haitiensis* is included in this account so that it can be distinguished from the other species treated here, and with which it has been confused in the past (particularly the species described above as *E. dispersa*). The specimens belonging to the type series are much darker than any specimen of *E. dispersa* examined. Dozier (1932) referred to additional specimens of *E. haitiensis*, which are even darker than the type series (one female examined, from *A. haitiensis*). Myartseva & Ruiz-Cancino (2000) recorded *E. haitiensis* from Mexico on the basis of previously published records. Although Dozier's original description clearly refers to a holotype female, there are two females on the type slide, neither of which was specifically mentioned

by Dozier as the holotype. Therefore the upper female specimen is designated as the lectotype (it has been marked clearly with an arrow on the slide).

The single female examined from *Catalpa longissima* is labelled by Dozier as ex *Aleurothrixus haitiensis*. In his paper (1932: 119) he refers to this host as "*Aleurothrixus* n. sp.". Presumably the species was never described.

Encarsia hispida De Santis

(fig. 4.9A-C; fig. 4.11C)

Encarsia hispida De Santis, 1948: 45.

Encarsia hispida De Santis: Viggiani, 1989: 207 as junior synonym of *Encarsia meritoria* Gahan.

Encarsia hispida De Santis: Polaszek *et al.*, 1992: 383 status reinstated.

Encarsia meritoria Gahan: *sensu* Giorgini & Viggiani, 1996 (misidentifications).

Prospalta brasiliensis Hempel, 1904: 20. **Syn. n.**

Prospaltella brasiliensis (Hempel): Ashmead, 1904b: 126; Dozier, 1932: 121; Grissell, 1979: 3.

Encarsia brasiliensis (Hempel): Viggiani and Mazzone, 1979: 44.

Material examined. Holotype ♀, Argentina, Santa Fe, Rosario, v.1947, (Hack), ex "s/aleirodoideo en coral rojo" [= *Salvia splendens*]. Mistakenly attributed to Brazil by Polaszek *et al.* (1992: 383) (UNLP - not examined - 2 ♀ paratypes examined). 1 ♀, Argentina, Tucuman, CIRPON, 23.iii.93, (Frias/Ovruski), (NHM); 1 ♀, Argentina, Mendoza City, 9.iv.1996, ex aleyrodid on *Fraxinus* (NHM); 1 ♀, Argentina, Luján de Cuyo Mendoza, 14.iv.1998, (M. Holgado), ex whitefly on ornamental (NHM); 1 ♀, Argentina, Santiago, (Lobos), *ex B. tabaci* (UNP); Barbados, Graeme Hall, Christchurch, 2.xi.88, (J. Jones), sp. 4-P with *Aleurotrachelus trachoides* (Back) CIEA21052 (NHM); 6 ♀, Brazil, Piracicaba, (F.D. Bennett), ex *B. tabaci* (NHM); 2 ♀, Brazil, Brasilia, EMBRAPA compound, vi.2001, (A. Polaszek), ex *B. tabaci* (vouchers for 28S D2 partial sequence GenBank Acc. No.: AJ547629 and AJ547630) (NHM); 3 ♀ 2 ♂, Brazil, Minas Gerais, Sete Lagoas, ii.1994, (M. Rose), ex *Bemisia* sp. (♂ obtained by "curing" infected, uniparental females - M.S. Hunter T94008) (NHM); 2 ♀, CHILE, [San Bernardo], ex *Aleurothrixus porteri* Quaintance & Baker [Stuardo col.] (MNCN); 1 ♀, Colombia, Dagua, 28.v.1991, (R. Caballero), ex

Aleuroglandulus malangae Russell on *Colocasia esculentum* (C102) (UFG); 1 ♀, Dominican Republic, x.1991, (P. Stansly), ex *B. tabaci* on *Manihot esculentum* (1057) (UFG); 2 ♀, Guadeloupe, Le Gosier, 8.xi.1990, ex *B. tabaci* on *Euphorbia heterophylla*, (593) (NHM); 1 ♀, Guatemala, La Garrucha, 25.vii.87, (M. Rose) (NHM); 6 ♀, Honduras, Cortes, San Pedro Sula, 17.ii.1990, ex *B. tabaci* on *Euphorbia heterophylla* (185) (UFG); 2 ♀, Italy, Latina, Parc Nac. del Cineo, col. 12.viii.90 em. 28.viii.90, (M. van der Kroon / A. Polaszek), ex *Siphoninus phillyreae* (Haliday) on *Crataegus* (NHM); 3 ♀ 2 ♂, Italy, Portici, ex *T. vaporariorum* (UNP); 3 ♀, Jamaica, Clarendon, 20.vii.1989, ex *B. tabaci* on *Chamaesyce* sp. (45) (UFG); 1 ♀, Madeira, Funchal, 08.vii.93, (A. Aguiar), ex *Aleurotrachelus rhamnicola* (Goux) (NHM); 1 ♀, Madeira, Lombo da Boa Vista, Funchal, 09.iv.95, (A. Aguiar), ex *Lipaleyrodes* sp. (NHM); 3 ♀, Mexico, Yucatan, Uxmal, 5.iv.1990, ex *B. tabaci* on *Chamaesyce hyssopifolia* (346) (UFG); 1♀, Netherlands, Drenthe, Emmen Zoo, xi.2001, (voucher for 28S D2 partial sequence, which is identical to that of GenBank Acc. No.: AJ547628) (NHM); 2 ♀ 4 ♂, Puerto Rico, Mayaquez, 1.vi.1990, ex *B. tabaci* on *Emilia* sp. (421) (UFG); 1 ♀, South Africa, Tvl. Pretoria, Rietondale Exp. Farm, 8.xii.97, ex whitefly on *Lantana camara*; 5 ♀, Spain, Barcelona, 1987, (R. Gabarra) ex *T. vaporariorum* on tomato CIE 18748 (NHM); 2 ♀ 5 ♂, Venezuela, El Playon, Portugesa, 1.v.1991, ex *B. tabaci* on *Hibiscus* sp. (F111) (NHM).

Diagnosis. Female. The female of *E. hispida* can be distinguished from other species in the *meritoria* complex by having the F2 antennal segment intermediate in size between F1 and F3; F6 elongate, 1.2 × as long as F5; scape less than 1.6 × as long as F6; pedicel elongate, 1.2-1.3 × as long as F1 (fig. 4.9C), and the tibial spur of middle leg 0.75-0.8 × as long as corresponding basitarsus (fig. 4.9B).

Male. F5 and F6 separate (fig. 4.11C).

Distribution. Neotropical: Argentina, Barbados, Brazil, Chile, Colombia, Dominican Republic, Guadaloupe, Guatemala, Honduras, Jamaica, Mexico, Peru, Puerto Rico, Venezuela; Nearctic: U.S.A.: Arizona, California, Florida; Palaearctic: Canary Islands, France, Italy, Madeira, Netherlands (indoors), Spain; Afrotropical: South Africa.

Hosts. *Aleurodicus dugesii* Cockerell, *Aleuroglandulus malangae*, *Aleurothrixus floccosus*, *A. porteri*, *Aleurotrachelus trachoides*, *A. rhamnicola*, *Aleyrodes spiraeoides*, *Dialeurodes* sp., *Lipaleyrodes* sp, *Metaleurodicus minimus* (Quaintance), *Parabemisia myricae* (Kuwana), *Siphoninus phillyreae*, *Tetraleurodes acaciae*, *Trialeurodes abutilonea*, *T. floridensis*, *T. vaporariorum*, *T. variabilis* (Quaintance).

Remarks. Viggiani's (1989) synonymy of *E. meritoria* with *E. hispida* was challenged by Polaszek *et al.* (1992) primarily on the basis of the partially fused F5 and F6 antennal segments in male *E. meritoria*, compared with separate segments in male *E. hispida* (fig. 4.11C). Otherwise the females of the two species are indeed very similar. However, it should be noted that material included under *E. meritoria* in that study (Viggiani, 1989: 210) has here been assigned to four different species: *E. californica*, *E. dispersa*, *E. hispida* and *E. meritoria*. Although males were not present in the type series of *E. hispida*, all collections since, that have associated males, have the males with F5 and F6 separate. Furthermore, on several occasions males have been induced from uniparental *E. hispida* populations either by temperature manipulation or feeding the females antibiotics. In all of these cases resulting males have the F5 and F6 separate. The situation becomes more complicated by the fact that female specimens of true *E. meritoria* appear not to have been found since the description of the type series in 1924. *E. meritoria* is known from two series, both collected at Miami Beach by G.F. Moznette, ex *Trialeurodes floridensis*. The series were collected in 1918 and 1924, the second series forming the basis for Gahan's (1927) description of the species. Both series contain males having a partially fused F5 and F6. A single male of what appears to be *E. meritoria* was collected in 1985 (see below). As stated before, if the structure of the male F5 and F6 is stable throughout the species, that on its own would be good grounds to maintain the species as separate. Differences in the form of F6 between the two species reinforce this (comparatively longer and narrower in *E. hispida*; cf. figs 4.9C and 4.10C). Given the degree of variation within *E. hispida* with respect to both colour pattern and D2 base pair sequence data, it is most likely that *E. hispida* remains an unresolved complex to which *E. meritoria* either belongs or to which *E. meritoria* is extremely closely related. Hopefully, specimens of *E. meritoria* will become available for sequencing.

Regarding *E. brasiliensis* (Hempel), the original description (Hempel, 1904) does not enable unequivocal identification of this species, and if there ever was any type material, it appears to have been lost without trace. What the description *does* tell us is that *E. brasiliensis* belongs to the group considered here, the *Encarsia meritoria*-complex, and that the F2 antennal segment is clearly intermediate between F1 and F3. This would narrow its identity down to *E. hispida* and *E. meritoria* (unless of course it is a valid species). Given the fact that *E. meritoria* is still known only from Florida and from *Trialeurodes floridensis*, while *E. hispida* is known from the type locality of *E. brasiliensis* (Campinas) and from the host of *E. brasiliensis* (*A. floccosus*) it would seem expedient to synonymize *E. brasiliensis* with *E. hispida*. Unfortunately, because of the rule of precedence under the International Code of Zoological Nomenclature (ICZN, 1999) a ruling for suppression of *E. brasiliensis* is required from the Commission. Such an application has been made for a ruling under the Commission's plenary powers for suppression of the name *E. brasiliensis* (Hempel). The reason for this application, rather than simply treating *brasiliensis* as the senior synonym, is as follows: the identity of *E. brasiliensis* has been misinterpreted consistently since Dozier's (1932) "redescription". Furthermore, the type material is lost. Among the *meritoria*-complex, only the name *hispida* has been used with consistent accuracy. The other names, *brasiliensis*, *haitiensis* and *meritoria* have consistently been misapplied to other species. To re-erect the name *brasiliensis* with the consequent submerging of *E. hispida* would therefore be counter-productive to our understanding of all the species concerned.

Encarsia meritoria Gahan

(fig. 4.10A-C; fig. 4.11D)

Encarsia meritoria Gahan, 1927: 19.

Material examined. Holotype ♀, U.S.A., Florida, Miami Beach, 12.v.1924, (G.F. Moznette), ex *Trialeurodes floridensis* on avocado type no. 29445 (USNM). Paratype ♂, same data as holotype (USNM); 1 ♀ 2 ♂, same data as holotype (USNM); 2 ♀ 5 ♂, same data as holotype except 23.iv.1918 (NHM, USNM); 1 ♂, Florida, Dade Co., Everglades National Park, Visitor Center, 12.xii.85, (H.W. Browning), ex whitefly on cocoa plum (*Chrysobalanus icaco*).

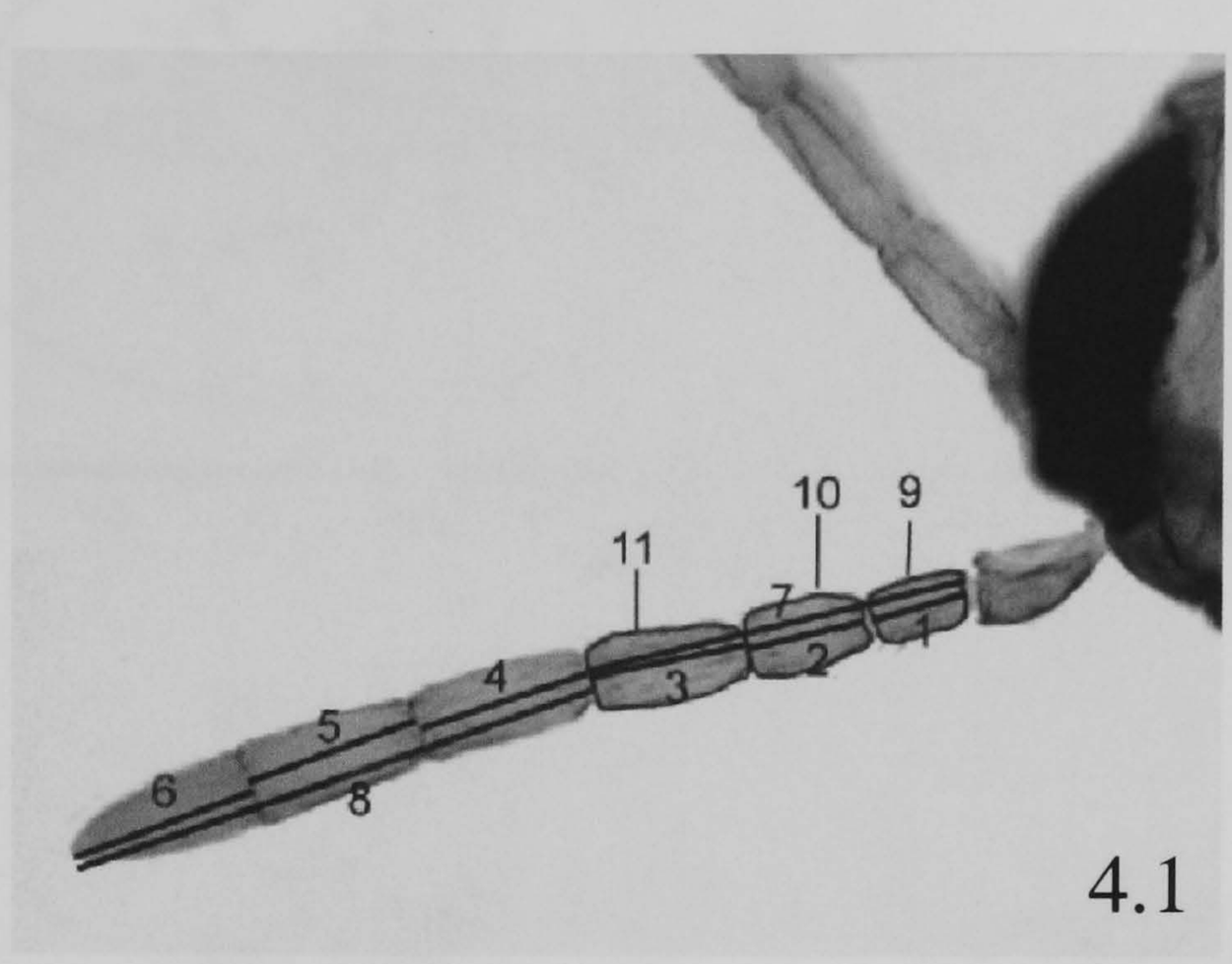
Diagnosis. Female. The female of *E. meritoria* can be distinguished from other species in this complex by having the F2 antennal segment intermediate in size between F1 and F3; F6 less elongate than in *E. hispida*, about as long as F5; scape more than 1.6 × as long as F6; pedicel elongate, 1.2-1.3 × as long as F1 (fig. 4.10C), and the tibial spur of middle leg 0.75-0.8 × as long as corresponding basitarsus (fig. 4.10B).

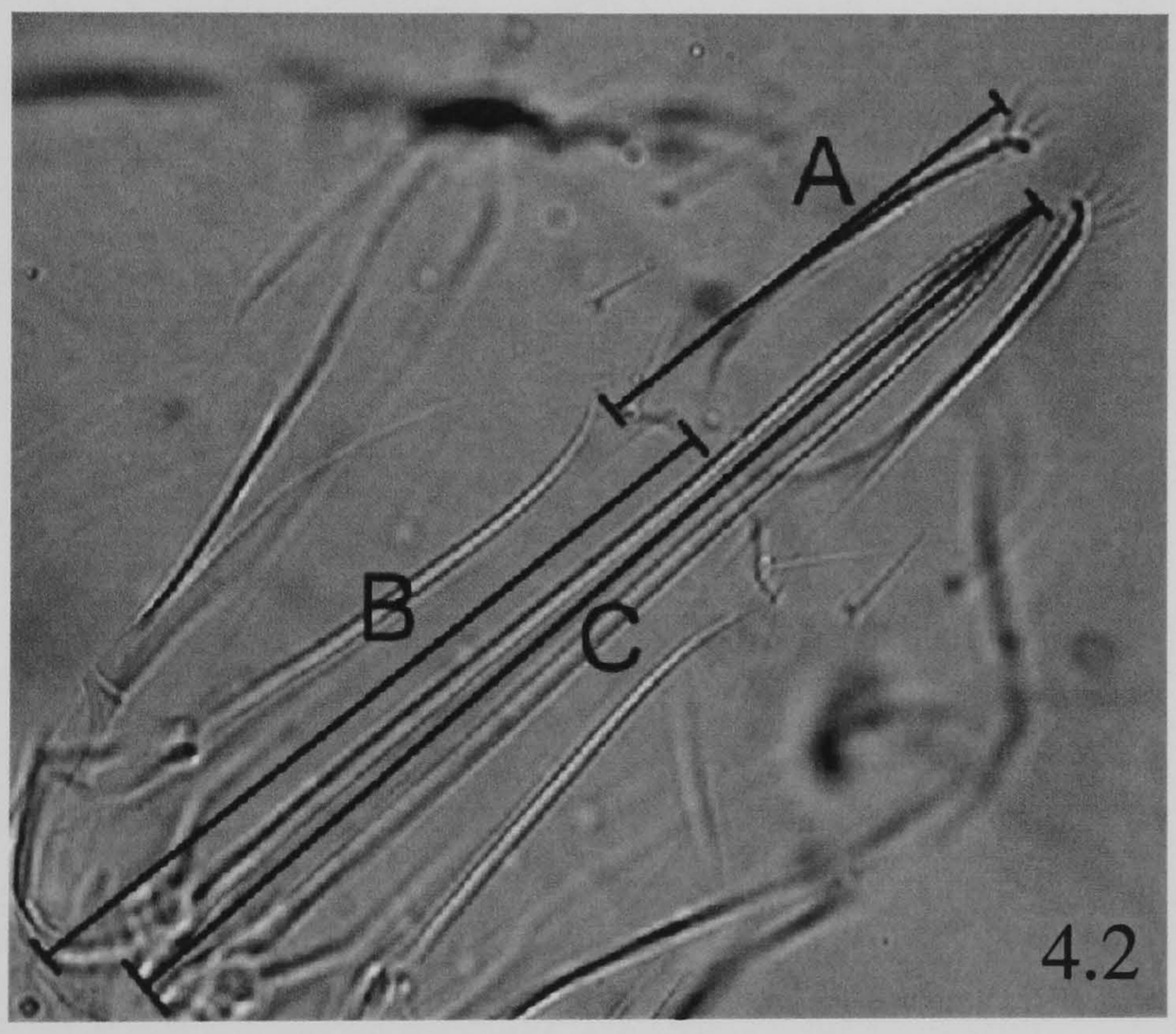
Male. F5 and F6 partially fused (fig. 4.11D).

Distrinution. U.S.A.: Florida.

Host. *Trialeurodes floridensis*.

Remarks. As stated above, although clearly very closely related to *E. hispida*, there appear to be good reasons for maintaining the two species as distinct pending DNA sequencing of populations of true *E. meritoria*, preferably from the type locality.





Figs 4.1-4.2. 4.1. Measurements of the female antenna used in morphometric analyses. 4.2. Measurements of the ovipositor used in morphometric analyses. See text for details.

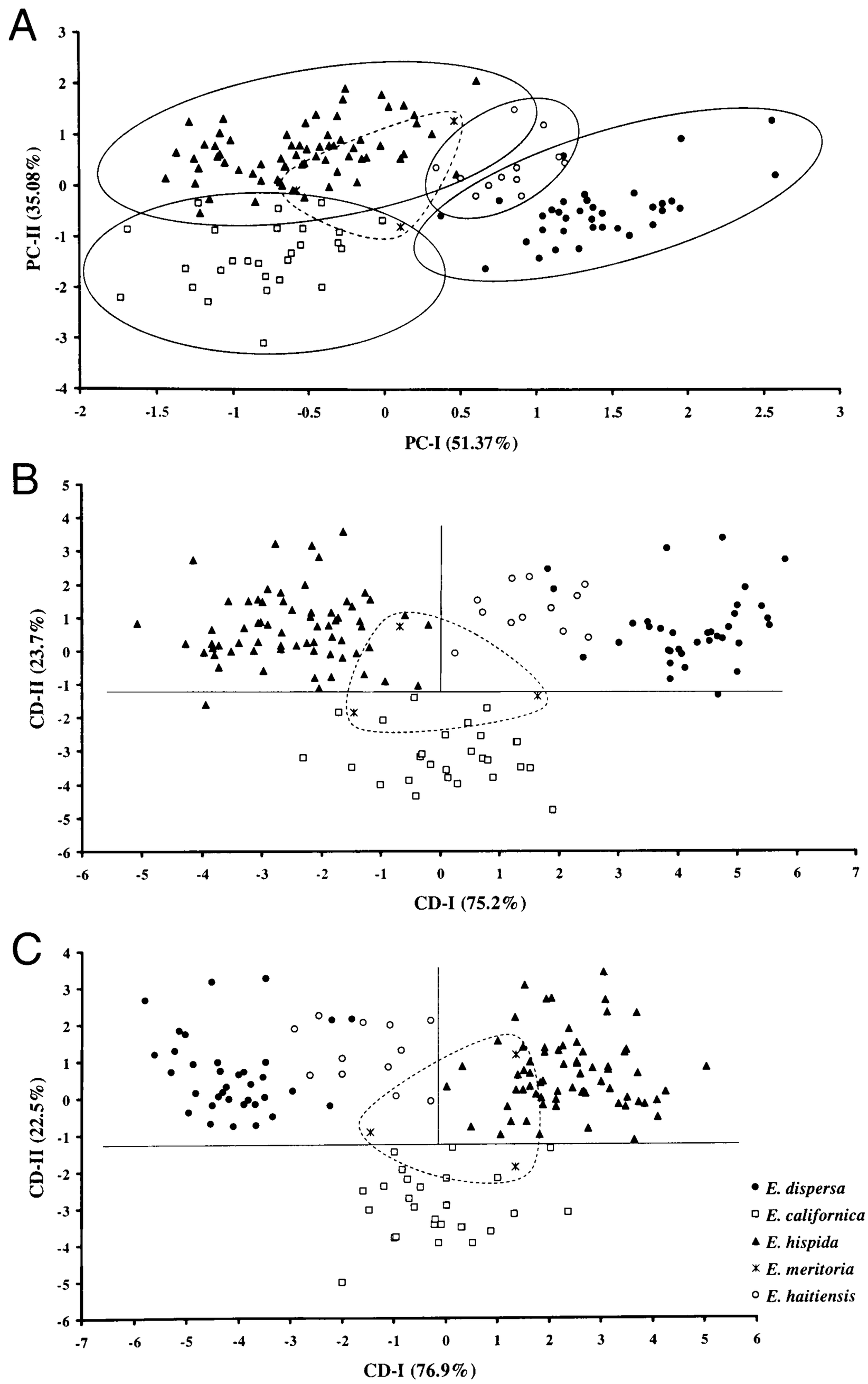


Fig. 4.3. Results of multivariate analysis. A. scatter plot of the first two principal components from the analysis of log-transformed data for *Encarsia* specimens; B. scatter plot of first two canonical discriminant function using the "entering independent variables together" method from the analysis of log-transformed data for *Encarsia* specimens; C. scatter plot of first two canonical discriminant function using the stepwise method from the analysis of log-transformed data for *Encarsia* specimens.

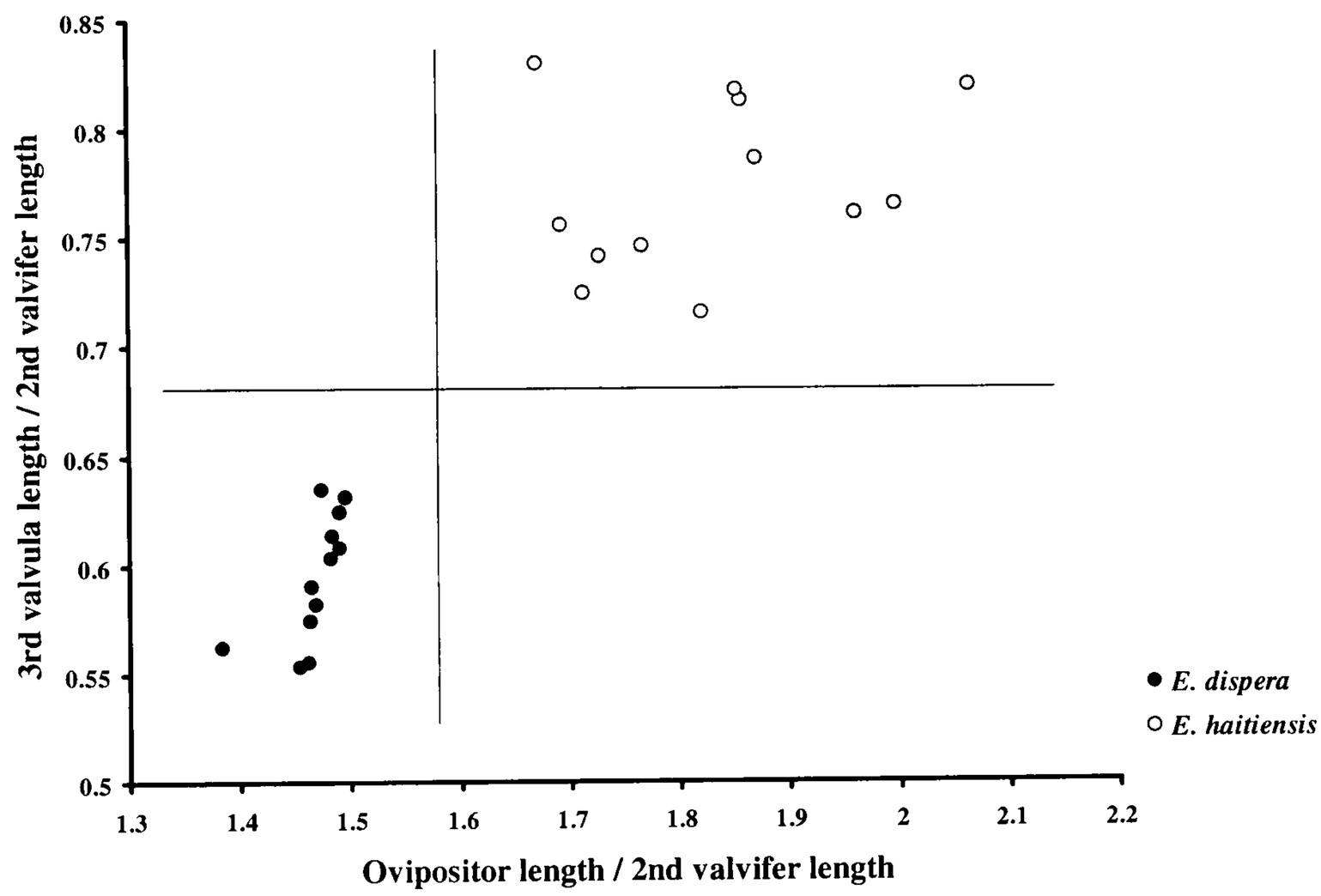


Fig. 4.4. Scatterplot of length ratios of "ovipositor / 2nd valvifer" and "3rd valvula / 2nd valvifer" for *E. haitiensis* and *E. dispersa*.

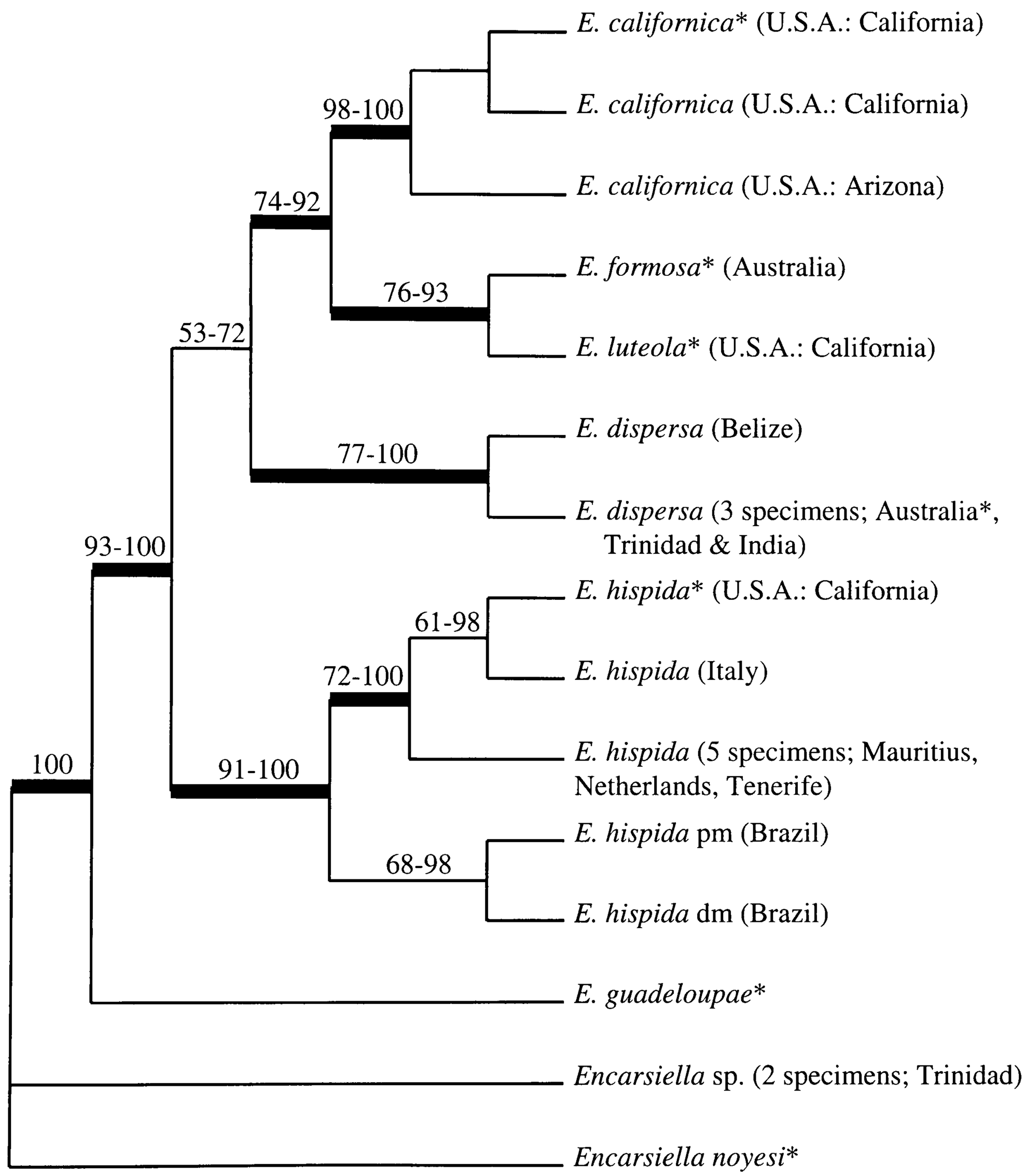
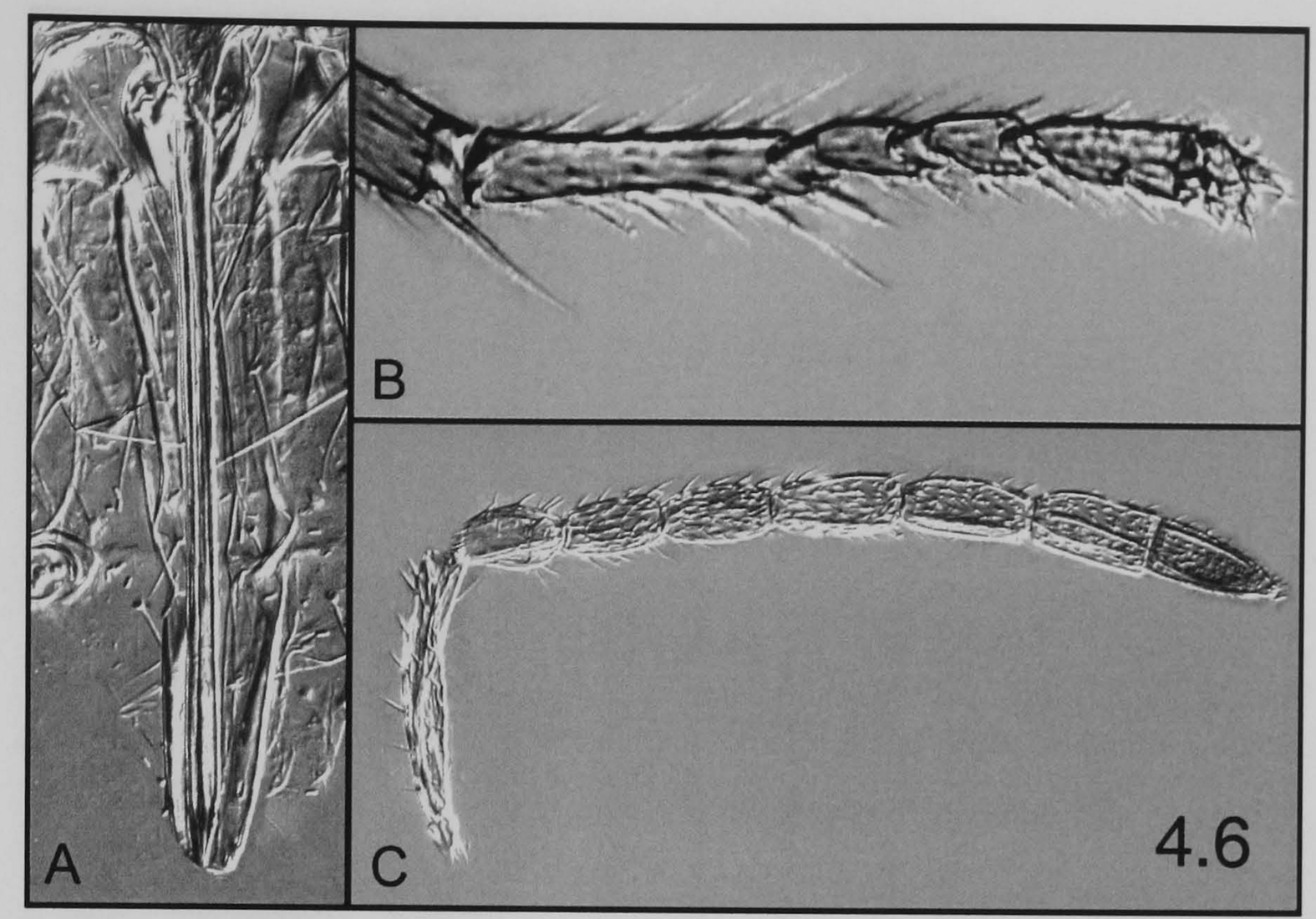
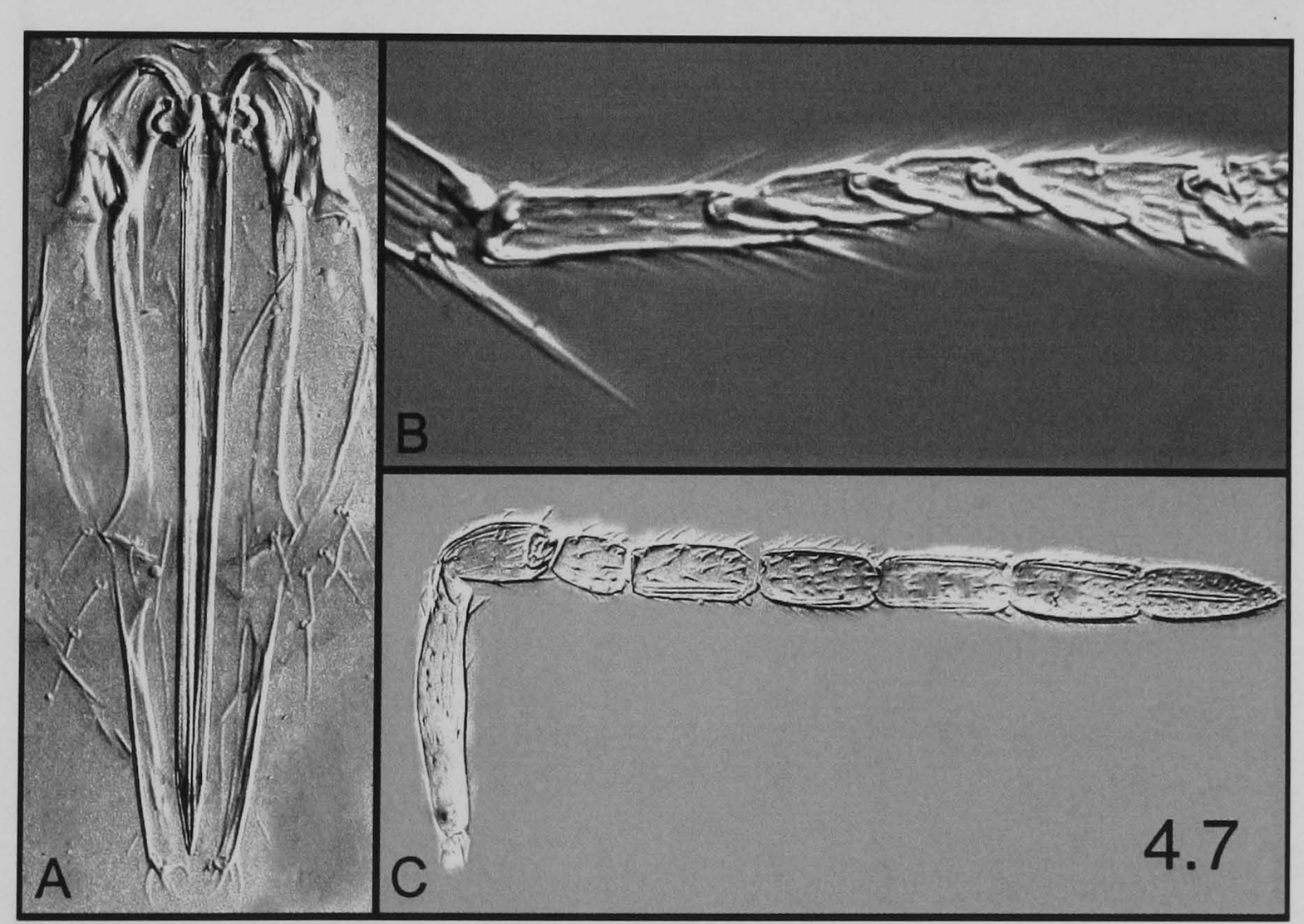
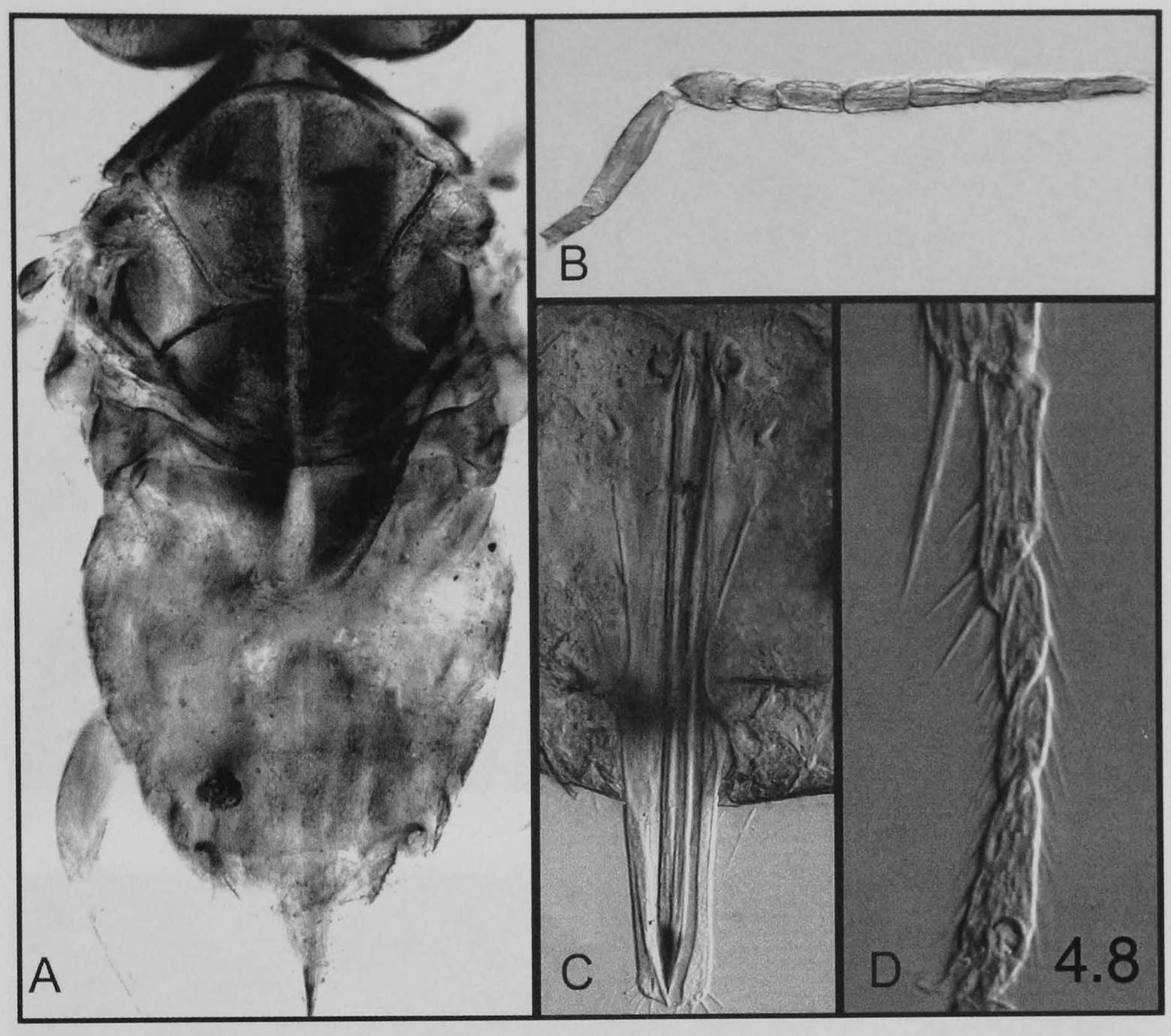


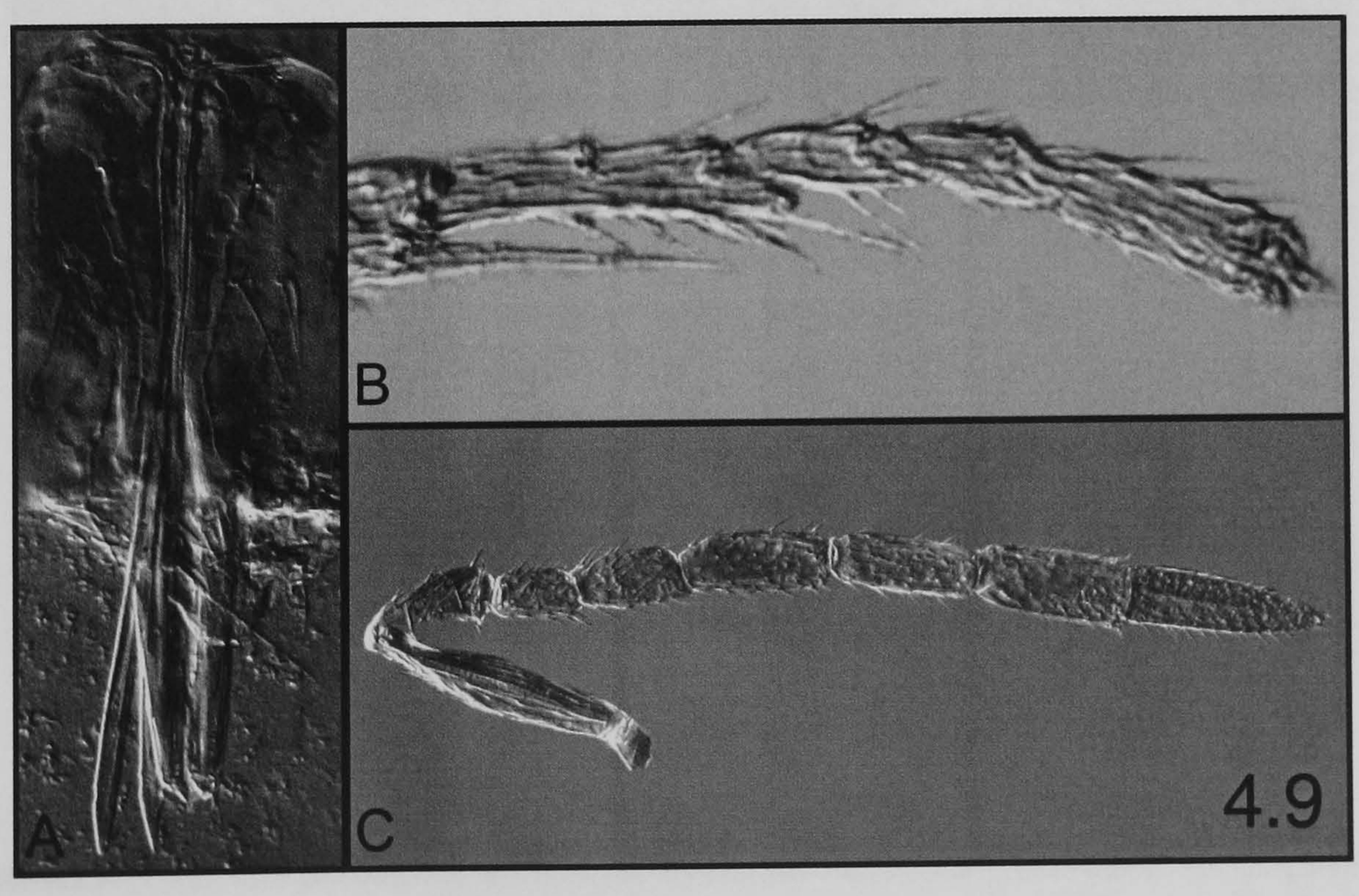
Fig. 4.5. One of 48 most parsimonious trees resulting from the analyses of 28S-D2 rDNA sequence data (length = 178, R.I. = 0.788, C.I. = 0.787). Each sequence is from a single individual unless otherwise indicated. Branches are thickened when recovered in all MPTs from the five multiple alignments with gaps treated as both missing data and informative. Figures above branches show the range of bootstrap values (above 50%) for all analyses. An asterisk shows sequences from EMBL/GenBank databases (see text for accession numbers). See table 4.1 for accession numbers of new sequences.



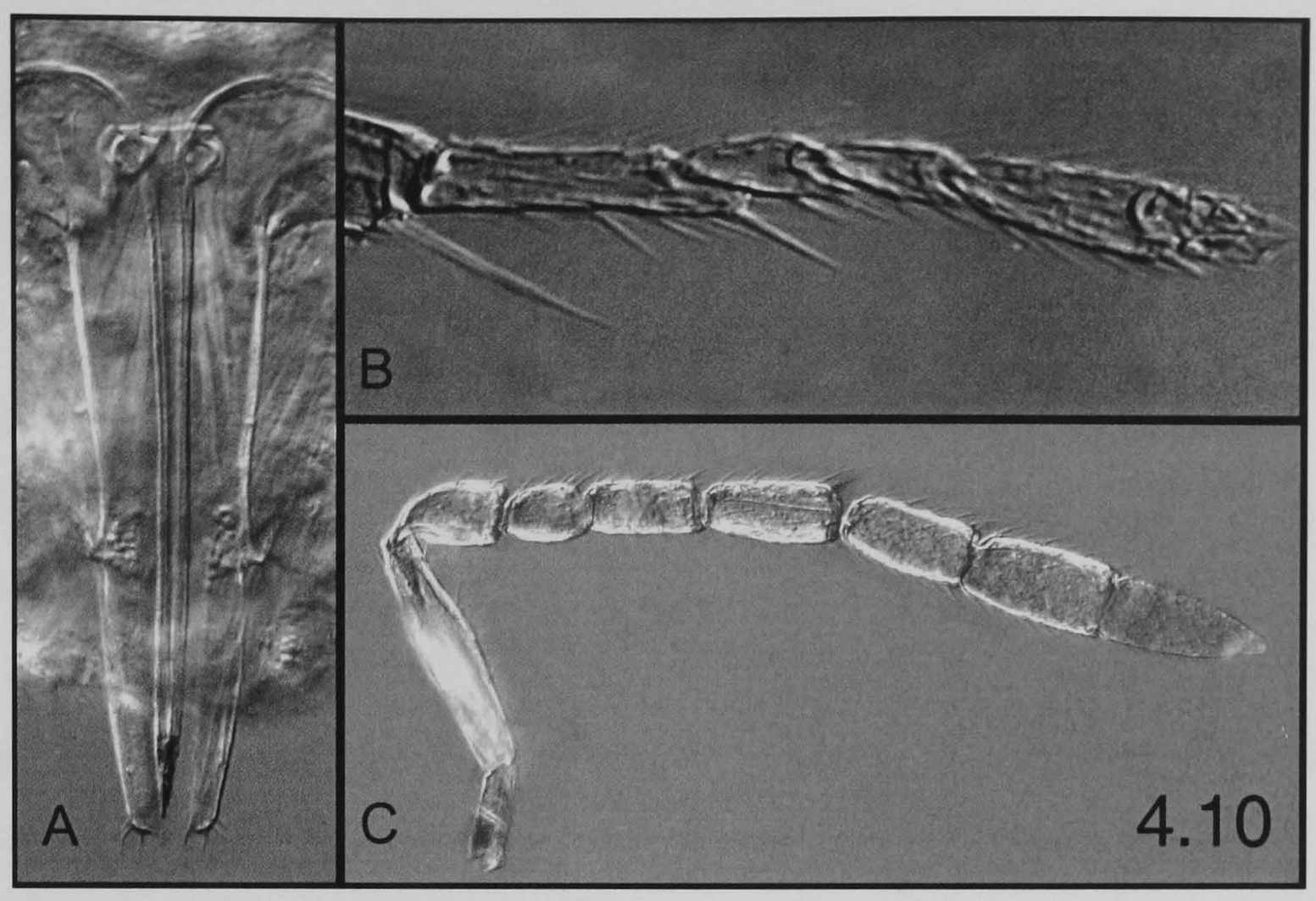


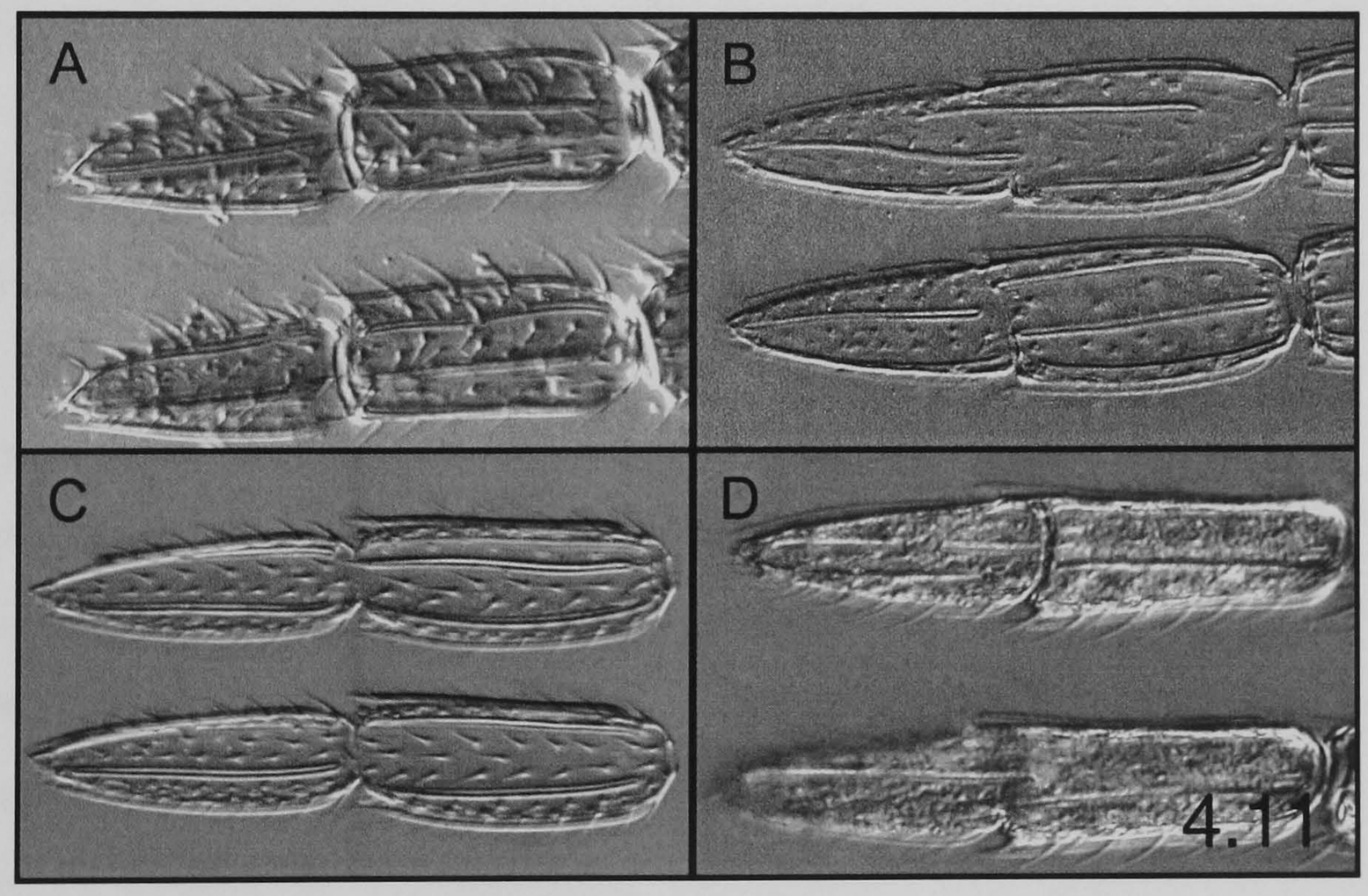
Figs 4.6-4.7. 4.6. Morphological details for *Encarsia californica.* A. ovipositor; B. mid tarsus; C. female antenna. 4.7. Morphological details for *Encarsia dispersa.* A. ovipositor; B. mid tarsus; C. female antenna.





Figs 4.8-4.9. 4.8. Morphological details for *Encarsia haitiensis* (lectotype). A. female habitus; B. female antenna; C. ovipositor; D. mid tarsus. 4.9. Morphological details for *Encarsia hispida*. A. ovipositor; B. mid tarsus; C. female antenna.





Figs 4.10-4.11. 4.10. Morphological details for *Encarsia meritoria* (holotype). A. ovipositor; B. mid tarsus; C. female antenna. 4.11. Male antennal F5 + F6. A. *Encarsia californica*; B. *E. dispersa*; C. *E. hispida*; D. *E. meritoria*.

5

The coevolution of whiteflies and their parasitoids - evidence from host relationships of different *Encarsia* species-groups*

5.1. Abstract

The relationship between whiteflies and different *Encarsia* species-groups was investigated. The observed number of steps required to fit the *Encarsia* species-group treated as a multistate character to the preferred whitefly phylogenetic tree was compared with a null distribution generated by randomly shuffling the states (each species-group) of the character between whitefly species. The fit of the character to the whitefly tree required significantly fewer steps than would occur by chance indicating some degree of phylogenetic association.

5.2. Introduction

Encarsia Förster (Aphelinidae) is one of many hymenopterous parasitoid genera, the species of which are associated to a greater or lesser extent with whiteflies (Hemiptera: Aleyrodidae). While the majority of *Encarsia* species for which the hosts are known attack whiteflies, many species are primary parasitoids of armoured scale insects (Diaspididae), and a few attack aphids (Williams & Polaszek, 1996). Other chalcidoid and platygastroid genera appear to be exclusively whitefly parasitoids (e.g. *Euderomphale* Girault (Eulophidae) and most (or all) other Euderomphalini; *Eretmocerus* Haldeman (Aphelinidae), and *Aleyroctonus* Masner & Huggert and *Amitus* Haldeman (Platygastridae). However, species diversity within *Encarsia*, despite species not being exclusively whitefly parasitoids, is extremely high among the species attacking whiteflies.

Within *Encarsia*, and concerning only the Aleyrodidae-attacking species, there are more than 10 morphologically distinct species-groups, though the definitions and delineations of these groups have been extremely variable (e.g. Viggiani & Mazzone,

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1979; Hayat, 1998; Huang & Polaszek, 1998). Using a combination of morphological and molecular characters applied to *Encarsia*, several authors have provided convincing evidence for the establishment of at least the *inaron*-, *longifasciata*-, *luteola*- and *strenua*-groups (Babcock *et al.*, 2001; Manzari *et al.*, 2002; Pedata & Polaszek, 2003). Many other *Encarsia* species-groups appear to be quite distinct (*citrella*-, *cubensis*-, *flavoscutellum*- and *parvella*-groups; Viggiani & Mazzone, 1979; Evans *et al.*, 1995; Evans & Polaszek, 1997, 1998) despite currently being based entirely on morphological characters.

Coevolutionary hypotheses testable with *Encarsia* species-groups concern primarily the number of occasions on which an *Encarsia*-aleyrodid host association might have evolved, and whether any correlation exists between putative *Encarsia* species-groups and their aleyrodid host-groups as phylogenetically defined in the present work. Given the morphological diversity of the aleyrodid-specific *Encarsia* species-groups, coupled with the biological diversity of *Encarsia* species, it would seem that *Encarsia* is a highly appropriate genus for testing evolutionary hypotheses of host acquisition.

5.3. Materials and methods

Parasitoid association of the whitefly species selected for the morphological phylogenetic study (Chapter 2) is given in Appendix 10. Whitefly parasitoid information was mainly obtained from Mound and Halsey (1978), Noyes (2001), Hernández-Suárez *et al.* (2003) and Heraty & Woolley's online *Encarsia* catalogue (http://cache.ucr.edu/~heraty/Encarsia.cat.pdf), and other references for non-aphelinid parasitoids (e.g. Polaszek, 1997; Evans & Castillo, 1998; Bailey *et al.*, 2001). As is apparent from Appendix 10, the majority of parasitoid species belong to the genus *Encarsia*. Two different species-group placements for these *Encarsia* species were prepared using published citations and Polaszek's unpublished observations (Table 5.1). Those whitefly species which had no *Encarsia* parasitoid records were deleted from the strict consensus tree obtained from the unweighted analysis (Chapter 2, fig. 2.13) using MacClade 4.0 (Maddison & Maddison, 2000), and the resulted pruned tree (figs 5.1 and 5.2) was in subsequent analyses of relationship between whiteflies and their parasitoids belonging to different *Encarsia* species-groups. Two different data sets with *Encarsia* species-groups treated as an unordered multistate character

were prepared. These differed in the formation sources used for the allocation of *Encarsia* species to the different species-groups, i.e. published literature (data set A) or Polaszek's unpublished data (data set B). The numbers of states for this character were 18 and 15 for data sets A and B respectively. To assess the statistical significance of the observed fit for each data set, the states of the respective character were randomly shuffled between taxa 200 times using MacClade 4.0 to generate the null distribution.

Table 5.1. The placement of *Encarsia* species recorded from the whiteflies selected for the morphological phylogenetic study within species-groups.

Based on	***Encarsia* Species-group**	***Encarsia* species**
The literature	*aurantii*	*E. aleurotubae, E. divergens, E. ixorae, E. obtusiclava, E. olivine, E. portoricensis, E. silvestrii, E. smithi*
	citrella	*E. citrella, E. paracitrella,* E. *pseudocitrella*
	cubensis	*E. aleurothrixi, E. cubensis, E. hamoni, E. nigricephala, E. quaintancei*
	duorunga	*E. duorunga, E. mohyuddini*
	elegans	*E. collecta, E. elegans*
	inaron	*E. adusta, E. azimi, E. coquilletti, E. coryli, E. dichroa, E. estrellae, E. galilea, E. inaron, E. levadicola, E. longicornis, E. lycopersici, E. margaritiventris, E. melanostoma, E. persequens, E. reticulata, E. siphonini*
	longifasciata	*E. longifasciata*
	lutea	*E. abatei, E. asterobemisiae, E. davidi, E. dialeuroporae, E. lutea*
	luteola	*E. californica*, E. desantisi, E. dispersa*, E. formosa, E. guadeloupae, E. haitiensis, E. hispida, E. luteola, E. meritoria, E. variegata*
	merceti	*E. merceti, E. tinctoriae*
	opulenta	*E. bellottii, E. clypealis, E. ishii, E. longicauda, E. opulenta, E. perplexa, E. punicae*
	parvella	*E. acaudaleyrodis, E. aleuroplati, E. americana, E. aseta, E. basicincta, E. citrofila, E. lanceolata, E. mineoi, E. nipponica, E. pergandiella, E. sueloderi*
	perflava	*E. aleurochitonis, E. ancistrocera, E. bothrocera, E. cibcensis, E. confusa, E. echinocera, E. lahorensis, E. lipaleyrodis, E. perflava, E. porteri, E. synaptocera*
	septentrionalis	*E. septentrionalis*
	strenua	*E. abundantia, E. bimaculata, E. brevivena, E. citri, E. dialeurodis, E. japonica, E. longivalvula, E. magnivena, E. neocala, E. oakeyensis, E. perstrenua, E. protransvena, E. ramsesi, E. sophia, E. strenua, E. ustulata*
	tremblayi	*E. tremblayi*
	tricolor	*E. aleuroilicis, E. gautieri, E. isaaci, E. tricolor*
	tristis	*E. tristis*
	Unplaced	*E. costaricensis, E. peltata, E. polaszeki*
A. Polaszek (unpublished opinion)	*citrella*	*E. citrella, E. paracitrella, E. pseudocitrella*
	cubensis	*E. aleurothrixi, E. cubensis, E. hamoni, E. nigricephala, E. quaintancei*
	elegans	*E. collecta, E. elegans, E. isaaci, E. olivina*
	inaron	*E. adusta, E. aleurochitonis, E. aleuroilicis?, E. azimi, E. coryli, E. coquilletti, E. dichroa, E. estrellae, E. galilea, E. inaron, E. levadicola, E. lipaleyrodis, E. longicornis, E. lycopersici, E. margaritiventris, E. melanostoma, E. persequens?, E. reticulata, E. septentrionalis?, E. silvestrii, E. siphonini*
	longifasciata	*E. aleuroplati, E. longifasciata*
	lutea	*E. abatei, E. asterobemisiae, E. davidi, E. dialeuroporae, E. lutea, E. obtusiclava, E. polaszeki?, E. tinctoriae*
	luteola	*E. californica*, E. desantisi, E. dispersa*, E. formosa, E. guadeloupae, E. haitiensis, E. hispida, E. luteola, E. meritoria, E. variegata*
	opulenta	*E. bellottii, E. clypealis, E. divergens, E. ishii, E. longicauda, E. merceti, E. opulenta, E. perplexa*

Table 5.1. Continued.

Based on	*Encarsia* Species-group	*Encarsia* species
	parvella	*E. acaudaleyrodis, E. americana, E. aseta, E. basicincta, E. citrofila, E. lanceolata, E. mineoi, E. nipponica, E. pergandiella, E. sueloderi*
	perflava	*E. ancistrocera, E. bothrocera, E. cibcensis, E. echinocera, E. lahorensis, E. perflava, E. synaptocera*
	porteri	*E. porteri*
	smithi	*E. smithi*
	strenua	*E. abundantia, E. bimaculata, E. brevivena, E. citri, E. costaricensis, E. dialeurodis, E. duorunga, E. japonica, E. longivalvula, E. magnivena, E. neocala, E. noahi, E. oakeyensis, E. perstrenua, E. protransvena, E. punicae, E. ramsesi, E. sophia, E. strenua, E. tremblayi, E. ustulata*
	tricolor	*E. gautieri, E. tricolor*
	tristis	*E. ixorae?, E. tristis*
	Unplaced	*E. aleurotubae, E. confusa, E. mohyuddini, E. peltata, E. portoricensis*

* These two are new species (see Chapter 4; submitted to *Zoologica Scripta*).

5.4. Results

Encarsia species-group association of the whitefly species are shown in figures 5.1.and 5.2. With a few exceptions, most whiteflies are attacked by several *Encarsia* species belonging to different species-groups. For two economically important species, *Bemisia tabaci* (Gennadius) and *Trialeurodes vaporariorum* (Westwood), members of more than ten species-groups have been recorded from each (figs 5.1 and 5.2). In general, there was little indication of correlation between the species of a particular clade and *Encarsia* species-group, and it appears that widespread host switching has obscured any basic associations. However, the following results indicate that the evolution of aleyrodid-parasitoid (*Encarsia* species-group) affiliations does not seem to be totally random.

Before shuffling the states of the *Encarsia* species-group character between taxa (whiteflies), the length of the character were 156 and 148 for data sets A and B respectively. The results obtained after shuffling are summarised in figure 5.3. The minimum and maximum lengths were 159 and 168 for data set A, and 153 and 161 for data set B respectively. Considering the mean values (163.70 and 157.08 steps for data sets A and B respectively), after shuffling the states of the character, the length was about 8 steps longer for data set A and 9 steps longer for data set B.

5.5. Discussion

Whiteflies are the recorded host for 143 species of *Encarsia* (Heraty *et al.*, in press). In this genus, whitefly host ranges have been particularly studied for species

attacking *B. tabaci* and *T. vaporariorum*. For example, more than 40 *Encarsia* species have been reared from *B. tabaci* and more than 30 species from *T. vaporariorum* (Appendix 10). *Encarsia* species generally appear easily able to move on to new hosts and in some cases, apparent host specificity for those species that have been reared from a single host may be simply due to lack of rearings from different hosts.

Randomly shuffling the states of the character (*Encarsia* species-group) 200 times gave a null distribution of character lengths (fig. 5.3) with a mean character length of 163.70 (standard deviation = 1.79) and 157.08 (S.D. = 1.67) steps for data sets A and B respectively. This indicates that the states of this character fit the whitefly tree with significantly fewer steps (about 8-9 depending on data sets) than would occur by chance. It seems that the placement of *Encarsia* species within species-groups based on Polaszek's unpublished opinion show a very marginally better correlation between whiteflies and their parasitoids belonging to different *Encarsia* species-groups (for this data set the length of the character was about one step longer than another one after shuffling). In fact, in addition to the host switching mentioned above, the recognition of relationship between whiteflies and *Encarsia* species-groups is also contingent upon correct specific identification of *Encarsia* (and obviously whitefly species) as well as their placement within species-groups, which at the moment the taxonomy of both (whiteflies and *Encarsia*) are problematic.

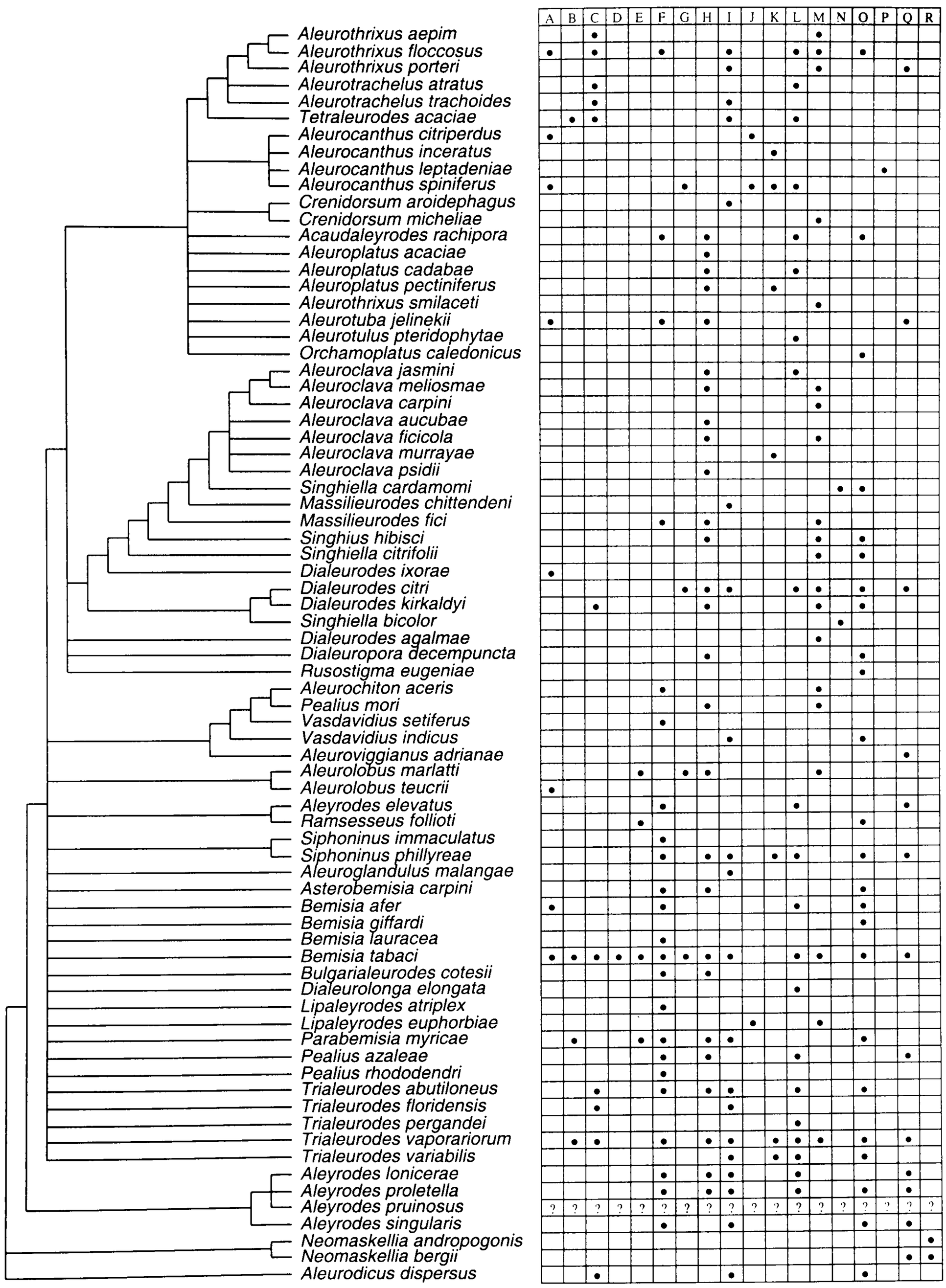


Fig. 5.1. *Encarsia* species-group association of the whitefly species selected for the morphological phylogenetic study (*Encarsia* species were assigned to species-groups based on the literature). A = *E. aurantii* group; B = *E. citrella* group; C = *E. cubensis* group; D = *E. duorunga* group; E = *E. elegans* group; F = *E. inaron* group; G = *E. longifasciata* group; H = *E. lutea* group; I = *E. luteola* group; J = *E. merceti* group; K = *E. opulenta* group; L = *E. parvella* group; M = *E. perflava* group; N = *E. septentrionalis* group; O = *E. strenua* group; P = *E. tremblayi* group; Q = *E. tricolor* group; R = *E. tristis* group.

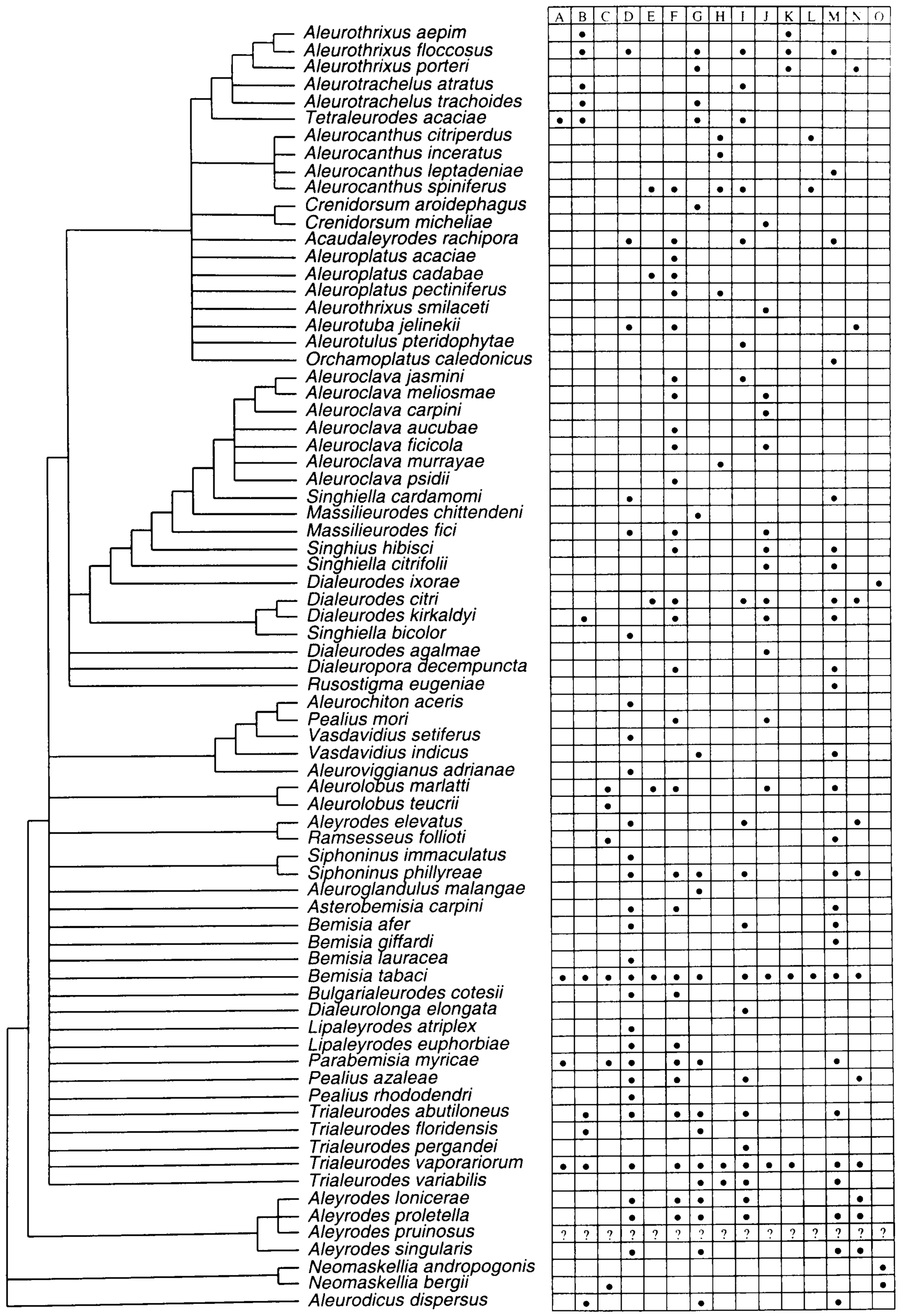
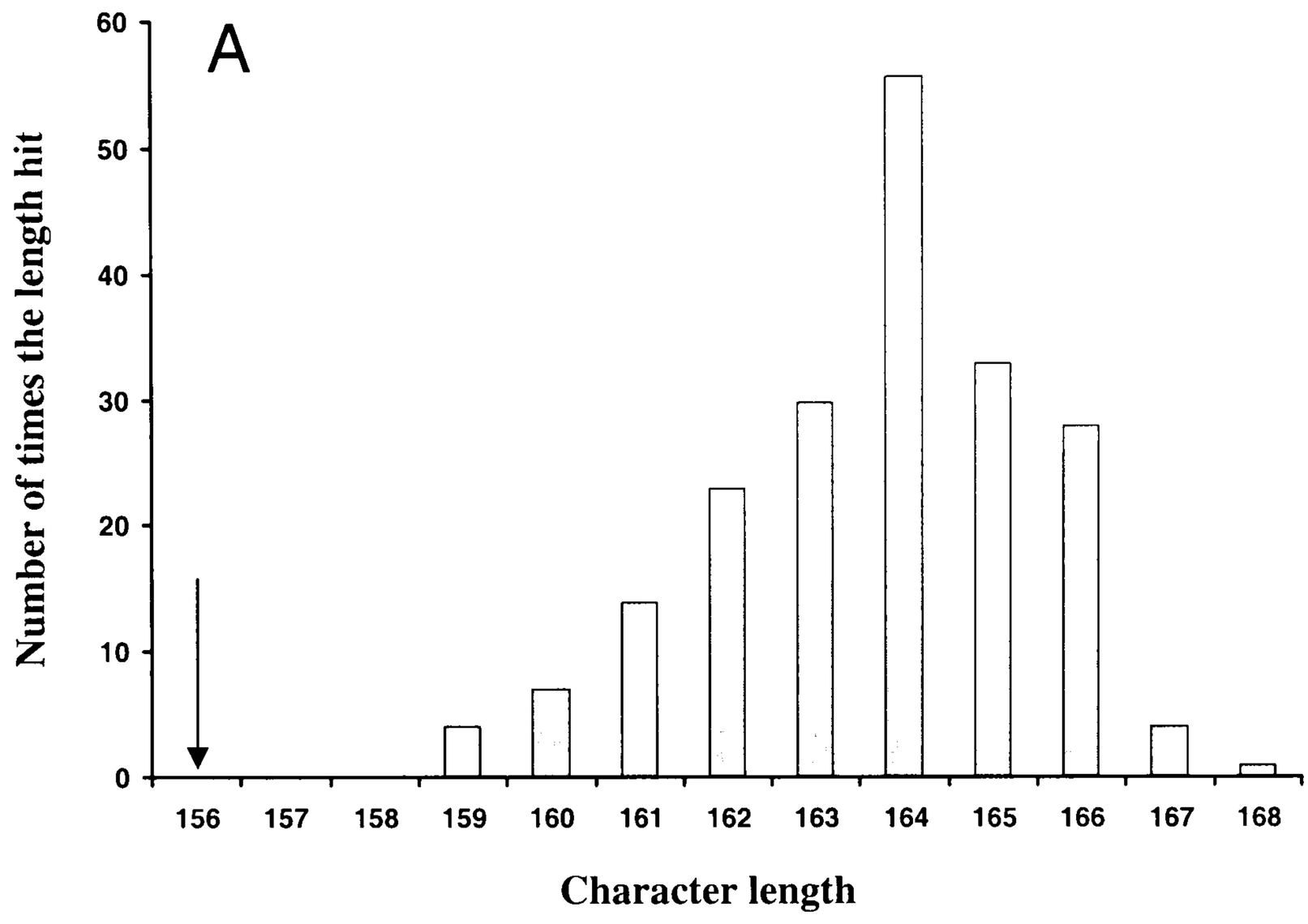


Fig. 5.2. *Encarsia* species-group association of the whitefly species selected for the morphological phylogenetic study (*Encarsia* species were assigned to species-groups based on Polaszek's unpublished opinion). A = *E. citrella* group; B = *E. cubensis* group; C = *E. elegans* group; D = *E. inaron* group; E = *E. longifasciata* group; F = *E. lutea* group; G = *E. luteola* group; H = *E. opulenta* group; I = *E. parvella* group; J = *E. perflava* group; K = *E. porteri* group; L = *E. smithi* group; M = *E. strenua* group; N = *E. tricolor* group; O = *E. tristis* group.



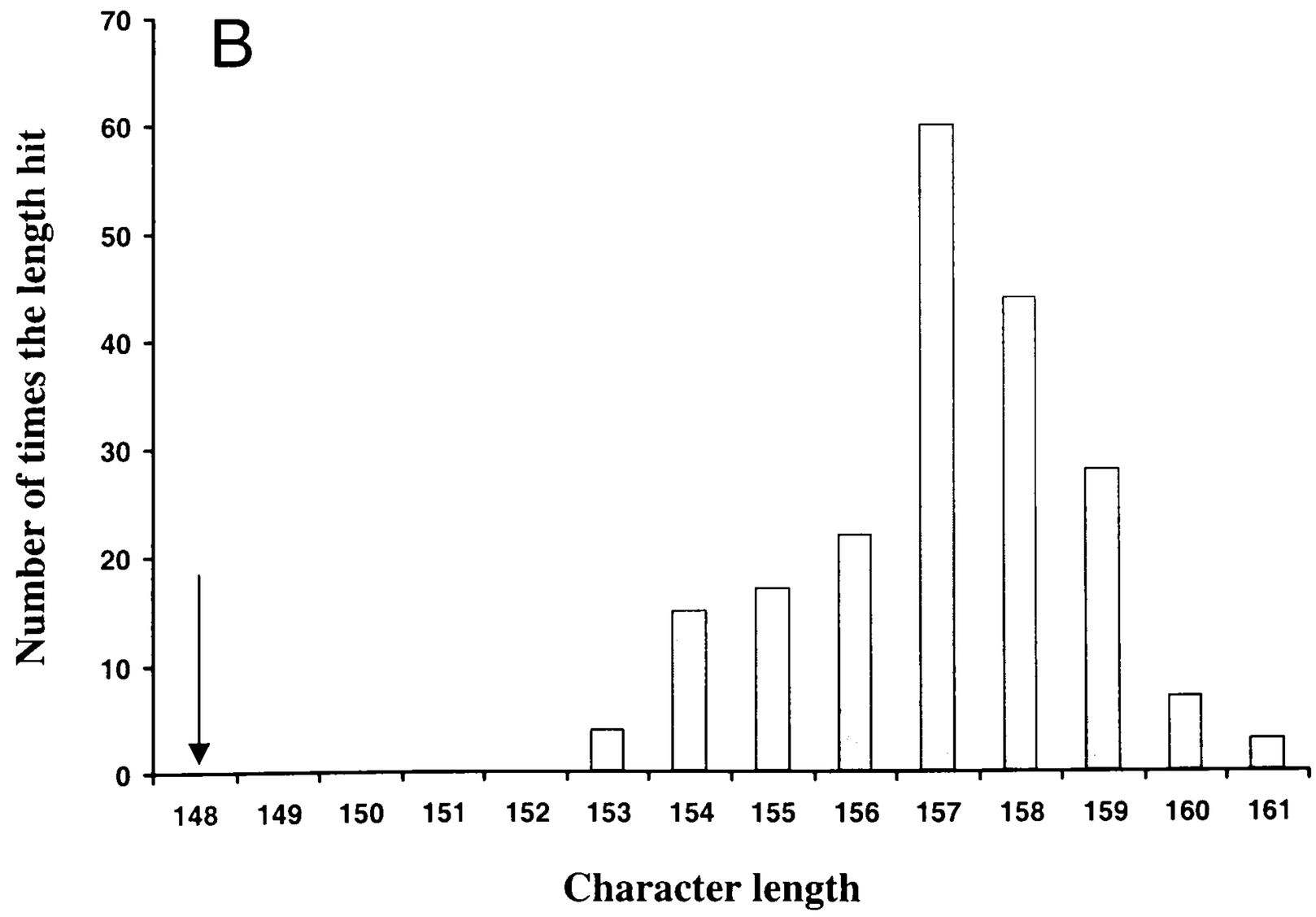


Fig. 5.3. Length of the *Encarsia* species-group character before (arrowed) and after 200 times shuffling of its states between whitefly species. A. data set A; B. data set B.

6

Conclusions

The importance of whiteflies as economic pests seems to be increasing constantly, and the problem is getting more serious especially due to an increase in dispersal range of certain pest species. It is also expected that difficulties in the identification of whiteflies, as well as a poor understanding of their relationships at generic/species level, will cause whiteflies to become of even greater economic importance. This is because a lack of adequate taxonomic information about a particular pest species will probably decrease the chance of success of any biological control programmes.

The results of the current study of the phylogenetic relationships within the Aleyrodinae indicate the inevitability of major further reclassification of this subfamily. Reassessing the current tribal level classification has revealed the inadequacy of the present classification at this level for the Aleyrodinae. Classification of whiteflies at genus and species levels relies almost entirely on characteristic features of the pupal case, so that most species have been described from their pupal cases only. A few adult characters have occasionally been used in generic or species descriptions, but no serious comparative study of adults has ever been attempted. In other words, adult characters have at most had only a supporting role, and only in a few cases. Since adults are unknown for the vast majority of described species, and considering the practical disadvantages of using adults taxonomically, which seems to be more than their advantages (see Martin, 2003), it would be desirable to modify current classification with the benefit of modern phylogenetic approaches. Therefore, in order to improve the puparium-based taxonomy of whiteflies, it is proposed that future taxonomic research should be focused on assessing the true significance of puparial characters. The first step for some characters was taken in this study and the results can be used in further studies, though probably the use of DNA sequence data will also be required.

Systematics and biological control are closely linked fields and the importance of systematic contributions to biological control programmes has been well

documented for over more than half a century (e.g. Clausen, 1942; Compere, 1969; DeBach & Rosen, 1991; Schauff & LaSalle, 1998).

Regarding the main parasitoids of whiteflies, *Encarsia* species, molecular and morphometric techniques have recently shown their usefulness in addressing some taxonomic problems surrounding theses parasitoids. Using a combination of both techniques in the current study resolved such problems in *Encarsia* species belonging to the *inaron* and *luteola* species-groups. Both species-groups were well supported as monophyletic groups in molecular phylogenetic analyses, but unlike the *luteola* group, the *inaron* group can not currently be recognised by discrete morphological characters. The definition of the *inaron* group was here modified, showing that Hayat's (1998) and previous markers' definitions are unworkable, but the group was best characterized in this study by the possession of a unique sequence of 29 bases in the D2 region of the 28s ribosomal DNA. However, morphological differences do exist between the species but their morphological definitions need further study. Applying the same techniques for analysing five closely-related species belonging to the *luteola* group, of which four belonged to the *meritoria*-complex, and all of which had a complex taxonomic history involving repeated misidentification and confusion, resulted in clear resolution of the complex, and consequently it was possible to correct much of the previous confusion surrounding this group of species.

In addition to those results presented here, I also sequenced D2-D3 regions of 28S rDNA gene for several other species of *Encarsia* as well as other genera of the Aphelinidae: Coccophaginae including *Coccobius* Ratzeburg, *Coccophagoides* Girault, *Coccophagus* Westwood, and *Encarsiella* Hayat, and did broader molecular phylogeny analyses of *Encarsia* (results not presented). These results, based on the phylogenetic analysis of the original sequence data as well as several retrieved from the GenBank databases, were presented in part by Pedata and Polaszek (2003). This showed that the monophyly of *Encarsia* is dubious, but interestingly, both *inaron*- and *luteola* species-groups were again recovered to be monophyletic.

Very few attempts have been made so far to produce a cladistic analysis for *Encarsia* either based on morphological or molecular data, and further studies are needed to find true evolutionary history of the genus. It is quite likely that the application of molecular techniques and phylogenetic approaches will enable us to

make major improvements to the taxonomy of *Encarsia* which is by any standard a difficult genus.

Appendix 1. The tribes of the Aleyrodinae and their included genera according to different authors.

Based on	Tribe	Included genera
Sampson, 1943	Aleurochitonini	*Aleurochiton* Tullgren
	Aleyrodini	*Acaudaleyrodes* Takahashi[1], *Aleurocanthus* Quaintance & Baker, *Aleurocerus* Bondar, *Aleurocybotus* Quaintance & Baker, *Aleuromarginatus* Corbett, *Aleuromigda* Singh, *Aleuropleurocelus* Drews & Sampson[2], *Aleuroputeus* Corbett, *Aleurothrixus* Quaintance & Baker, *Aleurotithius* Quaintance & Baker, *Aleurotrachelus* Quaintance & Baker, *Aleurotulus* Quaintance & Baker, *Aleyrodes* Latreille, *Bulgarialeurodes* Corbett, *Corbettia* Dozier, *Crenidorsum* Russell[3], *Frauenfeldiella* Gomez-Menor[4], *Hempelia* Sampsom & Drews, *Hesperaleyrodes* Sampson, *Heteraleyrodes* Takahashi[5], *Laingiella* Corbett, *Luederwaldtiana* Hempel, *Mexicaleyrodes* Sampson & Drews, *Nealeyrodes* Hempel, *Neoaleurodes* Bondar, *Pentaleyrodes* Takahashi, *Simplaleurodes* Goux[6], *Tetraleurodes* Cockerell, *Tetralicia* Harrison, *Zaphanera* Corbett
	Dialeurodini	*Acanthaleyrodes* Takahashi, *Acanthobemisia* Takahashi, *Africaleurodes* Dozier, *Aleuroclava* Singh, *Aleuroglandulus* Bondar, *Aleurolobus* Quaintance & Baker, *Aleuroparadoxus* Quaintance & Baker, *Aleuroplatus* Quaintance & Baker, *Aleuroporosus* Corbett, *Aleurotuberculatus* Takahashi, *Anomaleyrodes* Takahashi[7] & Mamet, *Asialeyrodes* Corbett, *Asterobemisia* Trehan, *Asterochiton* Maskell, *Bellitudo* Russell[8], *Bemisia* Quaintance & Baker, *Corbettella* Sampson, *Dialeurodes* Cockerell, *Dialeurolonga* Dozier[9], *Dialeuropora* Quaintance & Baker, *Dialeurotrachelus* Takahashi[10], *Malayaleyrodes* Corbett, *Metaleyrodes* Sampson, *Mixaleyrodes* Takahashi, *Neoaleurolobus* Takahashi[11], *Neoaleurotrachelus* Takahashi & Mamet[12], *Neobemisia* Visnya[13], *Nipaleyrodes* Takahashi[14], *Parabemisia* Takahashi[15], *Paraleurolobus* Sampson & Drews, *Pealius* Quaintance & Baker, *Plataleyrodes* Takahashi & Mamet[16], *Pseudaleurolobus* Hempel, *Pseudaleyrodes* Hempel, *Rhachisphora* Quaintance & Baker[17], *Roucasia* Goux[18], *Setaleyrodes* Takahashi, *Singhiella* Sampson, *Stenaleyrodes* Takahashi, *Taiwanaleyrodes* Takahashi, *Trialeurodes* Cockerell, *Trichoaleyrodes* Takahashi & Mamet[19], *Tuberaleyrodes* Takahashi, *Xenaleyrodes* Takahashi, *Xenobemisia* Takahashi[20]
	Neomaskellini	*Neomaskellia* Quaintance & Baker
	Siphoninini	*Siphoninus* Silvestri
Russell, 1947	Trialeurodini	*Aleuroparadoxus*, *Aleurotithius*, *Trialeurodes*, *Venezaleurodes* Russell[21]
Takahashi, 1954*	Aleurocanthini	*Aleurocanthus*, *Aleurotrachelus*, *Pentaleyrodes*
	Aleurolobini	*Acanthobemisia*, *Aleurolobus*, *Apobemisia* Takahashi, *Bemisia*, *Parabemisia*
	Aleyrodini	*Aleyrodes*, *Neopealius* Takahashi, *Odontaleyrodes* Takahashi, *Pealius*, *Setaleyrodes*
	Dialeurodini	*Aleurotuberculatus*, *Dialeurodes*, *Rhachisphora*, *Taiwanaleyrodes*
David, 1990**	Aleurocanthini	*Aleurocanthus*
	Aleurolobini	*Africaleurodes*[22], *Aleurolobus*, *Aleuropapillatus* Regu & David[23], *Asterochiton*, *Crescentaleyrodes* David & Jesudasan, *Orientaleyrodes* David[24]
	Aleuroplatini	*Aleuroplatus*, *Moundiella* David
	Aleyrodini	*Aleurocybotus*, *Aleuromarginatus*, *Aleurotrachelus*, *Aleurotulus*, *Aleyrodes*
	Bemisini	*Bemisia*, *Indoaleyrodes* David & Subramaniam, *Neopealius*, *Odontaleyrodes*, *Pealius*, *Setaleyrodes*
	Dialeurodini	*Aleuroclava*, *Aleurotuberculatus*, *Asialeyrodes*, *Cockerelliella* Sundararaj & David[25], *Dialeurodes*, *Dialeurolonga*, *Dialeuronomada* Quaintance & Baker[26], *Dialeuropora*, *Fippataleyrodes* Sundararaj & David[27], *Gigaleurodes* Quaintance & Baker[28], *Kanakarajiella* David & Sundararaj[29], *Martiniella* Jesudasan & David[30], *Minutaleyrodes* Jesudasan & David[31], *Rabdostigma* Quaintance & Baker[32], *Rhachisphora*, *Rusostigma* Quaintance & Baker, *Singhiella*, *Singhius* Takahashi, *Taiwanaleyrodes*
	Lipaleyrodini	*Lipaleyrodes* Takahashi
	Neomaskellini	*Acaudaleyrodes*, *Neomaskellia*
	Siphoninini	*Siphoninus*

Appendix 1. Continued.

Based on	Tribe	Included genera
	Tetraleurodini	*Tetraleurodes*
	Trialeurodini	*Trialeurodes*
	Zaphanerini	*Zaphanera*

* The whitefly genera of Japan only. ** The whitefly genera of India only.
1, 4-7, 9-20. Added by Sampson & Drews in 1956; 2. Added by Drews & Sampson in 1956; 3, 8. Added by Sampson in 1947; 21. Added by Russell in 1967; 22-24. Added by Regu & David in 1993; 25-32. Added by David & Sundararaj in 1993.

Appendix 2. Characters used to identify the tribes of Aleyrodinae according to different authors.

Based on	Tribe	Characters
Sampson[1], 1943; corrected in 1947	Aleurochitonini	Lingula elongate, much longer than wide. Dorsum completely covered with simple pores. Adults with radial$_1$, radial sector, and cubital veins in fore wing.
	Aleyrodini	Lingula elongate, much longer than wide. Dorsum with relatively few simple pores. Thoracic tracheal folds, combs, pores and anal fold absent. Adults with radial sector and cubital veins in fore wing and with tarsal paronychium.
	Dialeurodini	Lingula elongate, much longer than wide. Dorsum with relatively few simple pores. Thoracic tracheal folds and combs or pores, or pores or combs only, and anal fold, or only anal fold, present. Adults with radial sector and cubital veins in fore wing and with tarsal paronychium.
	Neomaskellini	Lingula extremely short, hardly longer than wide. Adults with radial sector vein only in fore wing.
	Siphoninini	Lingula elongate, much longer than wide. Dorsum with elongate, siphon-like wax tubes and with relatively few simple pores. Adults with radial sector and cubital veins in fore wing and lacking tarsal paronychium.
Russell[2], 1947	Trialeurodini	Main points: a submarginal row of disc pores and porettes with which are associated variously conspicuous papillae. Submargin and subdorsum not separated by a furrow. Submarginal setae shorter than the width of a submarginal ridge or without distinguishable setae. Vasiform orifice ending abruptly, its sides without minute spines. Thoracic tracheal folds without angular markings and usually without spines. Antennae not reaching to posterior thoracic spiracles.
Takahashi[2], 1954	Aleurocanthini	Tracheal pores or clefts absent, tracheal combs sometimes developed. Vasiform orifice not notched at the hind end, rounded, not elongated, sometimes elevated; lingula concealed under the operculum. Caudal furrow absent. Eyespots present in some species. Seventh abdominal segment nearly as long as, or a little shorter than, the six.
	Aleurolobini	Tracheal pores or clefts absent, tracheal combs sometimes developed. Vasiform orifice not notched at the hind end, subcordate, triangular or truncated at the hind end, elongated in some species; lingula exposed, knobbed and with a pair of long setae, sometimes large, knobbed part of lingula elongate, much longer than wide. Caudal furrow sometimes developed. Eyespots present in some species. Seventh abdominal segment much shortened at the median area in many genera.
	Aleyrodini	Tracheal pores or clefts absent, tracheal combs sometimes developed. Vasiform orifice not notched at the hind end, subcordate, triangular or truncated at the hind end, elongated in some species; lingula exposed, knobbed and with a pair of long setae, sometimes large, knobbed part of lingula globular, not distinctly longer than wide. Caudal furrow sometimes developed. Eyespots present in some species. Seventh abdominal segment much shortened at the median area in many genera.
	Dialeurodini	Tracheal pores or clefts usually present, if absent, vasiform orifice definitely notched at the hind end and caudal furrow distinctly defined, or lateral ridges (rhachis) developed on the abdomen and dorsum with many short spine-like setae, many of which are capitate. Lingula usually small, wanting long setae. Tracheal combs and eyespots lacking.
David[2], 1990	Aleurocanthini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Vasiform orifice elevated, rounded; lingula concealed by operculum. Margin with a single row of teeth or smooth. Submargin not separated from dorsal disc. Many prominent spines on the dorsum, often longer.
	Aleurolobini	Thoracic and caudal tracheal combs, clefts, or pores or furrows present. Submargin separated from dorsal disc. Margin generally toothed. Seventh abdominal segment much shortened at the median area in many genera. Eighth abdominal segment often trilobed. Caudal furrow sometimes discernible. Vasiform orifice nearly triangular or subcordate; lingula knobbed and exposed.

Appendix 2. Continued.

Based on	Tribe	Characters
	Aleuroplatini	Tracheal pores, clefts, folds, furrows absent but thoracic and caudal tracheal combs indicated. Submargin generally not separated from dorsal disc, if separated, eighth abdominal segment not trilobed. Margin toothed. Pores on dorsum variously distributed. Dorsum with a prominent central ridge terminating cephalad in a more or less arrow-shaped figure, or elevated and fringed with rounded protrusions around. Lingula usually concealed.
	Aleyrodini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Vasiform orifice not elevated; lingula generally exposed, knobbed, but in some concealed. Margin toothed or crenulate. Dorsum with rhachis and a pair of longitudinal fold in some genera. Seventh abdominal segment much shortened at the median area in many genera. Caudal furrow sometimes discernible.
	Bemisini	Tracheal pores, clefts, folds, furrows present but combs absent. Submargin generally not separated from dorsal disc, if separated, eighth abdominal segment not trilobed. Rhachis present or absent. Dorsum generally with setae/tubercles. Submargin with row of papillae. Margin with series of setae in some genera. Vasiform orifice subcordate or triangular or subrectangular, sometimes in a ribbed pyriform pit; lingula long or spatulate, setose and exposed.
	Dialeurodini	Tracheal pores, clefts, folds, furrows present but combs absent. Submargin generally not separated from dorsal disc, if separated, eighth abdominal segment not trilobed. Rhachis present or absent. Dorsum generally with setae/tubercles. Submargin with row of papillae. Margin with series of setae in some genera. Vasiform orifice cordate or subcordate; lingula usually small, concealed and wanting setae.
	Lipaleyrodini	Thoracic and caudal tracheal combs, clefts, or pores or furrows present. Submargin with wax plates in cluster arranged in a row.
	Neomaskellini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Vasiform orifice elevated, elongately elliptic or transversely oval; operculum transversely rectangular and extremely short, exposing lingula. Margin with a single row of teeth or smooth. Submargin not separated from dorsal disc. Rhachis sometimes present. Submargin in some with a row of setae.
	Siphoninini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Dorsum with elongate siphon-like wax tubes.
	Tetraleurodini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Vasiform orifice elevated, subcordate or rounded; lingula concealed by operculum. Margin with a single row of teeth or smooth. Submargin separated from dorsal disc.
	Trialeurodini	Tracheal pores, clefts, folds, furrows absent. Submargin generally not separated from dorsal disc, if separated, eighth abdominal segment not trilobed. Margin dentate, smooth or crenulate. Submargin with a row of disc pores and porettes with variously associated conspicuous papillae. Lingula exposed with a pair of setae. Caudal furrow discernible.
	Zaphanerini	Thoracic and caudal tracheal combs, clefts, or pores or furrows absent. Vasiform orifice elevated; lingula concealed by operculum. Margin with two rows of teeth. Submargin not separated from dorsal disc.

1. Pupal case and adult characters.
2. Pupal case characters only.

Appendix 3. Checklist of species examined for cladistic analysis. Underlined words and/or figures from slide labels were interpreted with some uncertainty. The list is arranged alphabetically based on the most recent name.

Aleyrodinae

1. *Acanthaleyrodes* Takahashi

A. callicarpae Takahashi
Taiwan: Taichung, 18.xii.1968, (Y.C. Chang), ex: Grape, 2/69, (5 slides).
Taiwan: Taichung, 2.xi.1968, (Y.C. Chang), ex: *Vitis vinifera*, (3 slides).

A. spiniferosa (Corbett)
Syntype, Malaya: Kuala Lumpur, 16.ii.1928, (G.H. Corbett), ex: *Diospyros* sp., B.M. 1932-511.

A. styraci Takahashi
Hong Kong: Pok Fu Lam, Reservoir Road, at Peak Road, 12.xii.2001, (J.H. Martin 7563), ex: *Rubus reflexus*, (3 slides).

2. *Acanthobemisia* Takahashi

A. distylii Takahashi
Japan: Nagasaki, 27.viii.1957, (R. Takahashi), ex: *Distylium racemosum*, 86/62, B.M. 1962-401, (4 slides).

3. *Acaudaleyrodes* Takahashi

A. africana (Dozier)
Syntype, Belgian Congo: Barumbu, i.1926, (J. Ghesquière), ex: *Desmodium* sp., B.M. 1933.
Nigeria: Ibadun, 20.i.1914, (W.A. Lambourn), ex: herbaceus plant, 204/61, B.M. 1916-190, (2 slides).

A. rachipora (Singh)
Syntypes, Egypt: Meadi, 12.viii.1931, ex: Pomegranate.
Syntype, Egypt: Myniah, 14.xi.1931, ex: *Alhagi* sp.
Cyprus: 10.x.1928, (H.M. Morris), ex: Pomegranate, I.B.E. 2052, 36/61, B.M. 1961-4, (3 slides).
Iraq: Abu-Ghraib, 23.xii.1961, ex: *Zizyphus* sp., C.I.E. 6763, 71/62, B.M. 1962-3, (2 slides).
Sudan: Red Sea Prov. nr Mismar, Atbara-Haiya Jct., 31.iii.1981, (J.H. Martin 3226), ex: *Calotropis procera*.
Sudan: S. Darfur, Ed Da'ein, 3.v.1981, (J.H. Martin 3373), ex: *Calotropis procera*.
India: Madras, Coimbatore, 23.viii.1962, ex: *Prosopis* sp., C.I.E. 15456.

A. tuberculata Bink-Moenen
Holotype, Chad: Bebedjia, 395 m, 16.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Anogeissus leiocarpus*, B.M. 1977-471.
Paratypes, Chad: Boro, 453 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Bridelia ferruginea*, B.M. 1977-471.

4. *Acutaleyrodes* Takahashi

A. palmae Takahashi
Syntypes, Réunion Island: Saint Philippe, xii.1955, (R. Paulian), ex: *Acanthophoenix rubra*.

5. *Africaleurodes* Dozier

A. coffeacola Dozier
Syntypes, Belgian Congo: Lodja, iii.1928, (J. Ghesquière), ex: *Coffea robusta*, B.M. 1933.
Nigeria: Bida, 26.x.1960, (M.O. Ezeigwe), ex: indet.
Aldabra Island: Middle camp, 15.viii.1974, (L.F.H. Merton), ex: *Canthium* sp., 3/74, (5 slides).

A. fulakariensis Cohic
Syntype, Congo: Brazzaville, Fulakary, 28.iii.1965, (R. Paulian), ex: *Neosloetropsis kamerunensis*, B.M. 1965-305.

A. hexalobi Bink-Moenen
Holotype + paratypes, Chad: Bentam, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1977-471.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 6.xi.1989, (L.D.C. Fishpool), ex: *Cryptolepis sanguinolenta*.

A. loganiaceae Dozier
Syntype, Belgian Congo: Sankuru, i.1928, (J. Ghesquière), ex: Loganiaceae, B.M. 1933.

A. ochnaceae Dozier
Syntype, Belgian Congo: Kole, 8.i.1928, (J. Ghesquière), ex: *Ochna* sp., B.M. 1933.
Nigeria: Ibadan, viii.1966, (E.A. James), ex: *Cola nitida*, 22/66.

6. *Agrostaleyrodes* Ko

A. arcanus Ko
Paratype, Taiwan: Wulai, 13.viii.1990, (C.C. Ko), ex: *Miscanthus* sp.

7. *Aleurocanthus* Quaintance & Baker

A. banksiae (Maskell)
Australia: Aldingo Scrub, xii.1967, (L.A. Mound), ex: *Banksia marginata*, 39/71, (3 slides).
Australia: Kangaroo Island, 18.ii.1990, (J.H. Martin 5661), ex: *Banksia ornata*, B.M. 1998-50.
Australia: nr Victor Harbour, 20.iv.1977, (P. Borrett), ex: *Banksia marginata*, 25/80.

A. calophylli (Kotinsky)
Syntypes, Fiji: Levuca, 30.x.1899, (A. Koebele), ex: *Calophyllum inophyllum*.

A. ceracroceus Martin
Paratypes, Australia: Queensland, creek-bed, 3 Km north of Cape Tribulation, 16.vii.1996, (J.H. Martin 6895), ex: *Neolitsea* spp., (2 slides).

A. citriperdus Quaintance & Baker
Hong Kong: 14.iv.1974, (D.S. Hill), ex: *Citrus* sp., (2 slides).
Hong Kong: Tai Pokau Orchard, 21.ii.1971, ex: Orange, C.I.E. 4663, 11/71, (2 slides).

A. cocois Corbett
Papua New Guinea: New Britain Prov., Gazelle Peninsula, Vunakanau, 18.v.1956, (J.L. Gressit), ex: *Cocos* sp., B.204, (2 slides).
Solomon Island: Kukum, 13.ii.1956, (E.S. Brown), ex: Coconut, C.I.E. 3898Aa/14609.
Solomon Island: Guadalcanal Kukum, 20.viii.1954, (E.S. Brown), ex: Coconut, C.I.E. 3177/13920.

A. delottoi Cohic
Paratype, Kenya: Nairobi, 27.viii.1958, (G. de Lotto), ex: *Chaetachme aristata*, 4/65, B.M. 1965-224.
Kenya: Langata, Nairobi, 7.v.1988, (J.H. Martin 5272), ex: *Pappea capensis*, B.M. 1988-188.

A. esakii Takahashi
Papua New Guinea: Morobe Prov. coast, Buso, 1.xi.1979, (J.H. Martin 2783), ex: *Pometia pinnata*, (2 slides).

A. gateri Corbett

West Malaysia: Selangor, Sardang, 7.ii.1985, (J.H. Martin 4417), ex: *Cocos nucifera*, (2 slides).

A. gordoniae Takahashi

Hong Kong: slopes of the Peak, above Pok Fu Lam Reservoir Road, 12.xi.1996, (J.H. Martin 6795), ex: *Gordonia axillaris*, (2 slides).

A. inceratus Silvestri

Hong Kong: rec'd., v.1990, ex: *Michelia champaca*, C.I.E. A.20977.

A. leptadeniae Cohic

Sudan: Wad Medani, xii.1961, (L.A. Mound), ex: *Leptadenia heterophylla*, 161/162.

A. spiniferus (Quaintance)

Syntypes, Tanzania: ?Dar es Salaam, ?iv.1902, (?A. Zimmermann), ex: ?*Citrus* sp., (2 slides).

India: Coimbatore, 14.iv.1967, (B.V. David), ex: Rose, 10/67, B.M. 1967-280.

Uganda: E. Buganda, Bulemezi, Sabawali, Bugema, 5.vi.1970, (D.N. McNutt), ex: *Citrus sinensis*, (2 slides).

Australia: Queensland, Stratford, Cairns, 8.viii.1983, (A.J. Wait), ex: Custard apple, (3 slides).

Micronesia: Kosrae I., vi.2001, ex: *Citrus* sp.

8. *Aleurocerus* Bondar

A. cerifer (Sampson & Drews)

Panama: Canal Zone, Cerro Galera, 26.iii.1983, (J.H. Martin 4154), ex: *Tetracera* sp., (2 slides).

Panama: Canal Zone, Barro Colorado I., 13.iii.1983, (J.H. Martin 3986), ex: *Tetracera* sp., (2 slides).

Costa Rica: Guanacaste Province, 60 Km south of Liberia, 26.i.1983, (J.H. Martin 3693), ex: *Mastichodendron ?capiri*, (2 slides).

A. flavomarginatus Bondar

Costa Rica: N. Heredia Province, 15 Km north of Puerto Viejo, 3.ii.1983, (J.H. Martin 3770), ex: *Heliconia* sp., (2 slides).

Ecuador: Mapo Coca, 16.v.1982, (G. Omore), ex: *Elaeis guineensis*, 80/82, (2 slides).

A. musae Russell

Mexico: San Diego, 31.vii.1995, (A. Endo), ex: *Zingiber* sp., 022090 CA, B.M. 1998-131.

Panama: Canal Zone, Pipeline Road, 19.iii.1983, (J.H. Martin 4050), ex: Bignoniaceae, (2 slides).

Panama: Canal Zone, Gamboa Hill, 20.iii.1983, (J.H. Martin 4088 B), ex: *Warszewiczia coccinea*, (2 slides).

Costa Rica: N. Heredia Province, 10 Km north of Puerto Viejo, 2.ii.1983, (J.H. Martin 3740), ex: indet., (2 slides).

A. palmae Russell

Paratypes, Mexico: intercepted at Dallas, Texas, U.S.A., 21.ii.1962, (L. Russell), ex: *Chamaedorea elegans*, ref. 62-15982, (2 slides).

Belize: Cayo, Chiquibul forest, Las Cuevas plots, 3.xi.1994, (J.H. Martin 6438), ex: *Pouteria* sp.

9. *Aleurochiton* Tullgren

A. acerinus Haupt

Czechoslovakia: Radotin, 2.iii.1969, (J. Zahradnik), ex: *Acer campestris*, (2 slides).

England: Kent, Polhill Down, near Sevenoaks, 28.v.1983, (W.R. Dolling), ex: *Acer campestre*, 2/83, (2 sides).

Italy: Sicily, (CT), Bronte, 30.x.1981, (C. Rapisarda), ex: *Acer campestre*, 50/84.

Hungary: Szarvas, 21.vi.1990, (V.F. Eastop 19144), ex: *Acer campestre*.

A. aceris (Modeer)

England: Hants, Alice Holt forest, 29.vii.1984, (J.H. Martin 4363), ex: *Acer platanoides*, (2 slides).

England: Hants, Alice Holt forest near Alton, 10.vii.1994, (J.H. Martin 6419), ex: *Acer platanoides*.

Netherlands: Bennekom, 7.x.1971, (V.F. Eastop), ex: *Acer platanoides*, 7/72, (3 slides).

A.forbesii (Ashmead)

U.S.A.: Illinois, Urbana, 10.x.1970, (L.A. Mound), ex: *Acer saccharinum*, 29/71, (4 slides).

U.S.A.: Maryland, Prince Georges Co Beaver Dam Rd, 2.vii.1998, (J.H. Martin 7103), ex: *Acer rubrum*, (2 slides).

A. pseudoplatani Visnya

Sicily: (CT/ME), Monti Nebrodi, near Bronte, 10.x.1985, (J.H. Martin 5068), ex: *Acer pseudoplatanus*, (2 slides).

Netherlands: Amerongen, 28.ix.1975, (R.M. Bink-Moenen), ex: *Acer pseudoplatanus*, B.M. 1976-56, (2 slides).

10. *Aleuroclava* Singh

A. aucubae (Kuwana)

Japan: Osaka, Taishi, 3.xi.1956, (R. Takahashi), ex: *Paederia* sp., 76/62, B.M. 1962-401, (2 slides).

Japan: Tokyo, 9.x.1963, (H. Takada), ex: *Celtis* sp.

A. bifurcata (Corbett)

Paratype, Malaya: Kajang, 4.v.1927, (G. H. Corbett), ex: *Nephelium lappaceum*, B.M. 1932.511.

West Malaysia: Pahang Prov., Tioman I., Kampung Tekek, 20.iii.1984, (J.H. Martin 4309), ex: indet.

West Malaysia: Pahang Prov., Taman Negara, Tembeling path, 11.iii.1984, (J.H. Martin 4250), ex: indet.

A. citrifolii (Corbett)

India: Punjab, 29.iii.1926, (M.A. Husain), ex: *Citrus* sp., I.B.E. 309.

Pakistan: Peshawar, 31.i.1963, (L.A. Mound), ex: *Murraya exotica*, 10/64.

A. euryae (Kuwana)

Japan: Odaiga - Hara, near Nara, 18.viii.1956, (R. Takahashi), ex: *Trochodendron* sp., 73/62, B.M. 1962-401.

A. ficicola (Takahashi)

Taiwan: Wufeng, 18.iv.1994, (K.C. Chou), ex: *Morus* sp., B.M. 1994.

Taiwan: Wufeng, 9.v.1994, (K.C. Chou), ex: *Morus* sp., B.M. 1994.

A. filamentosa (Corbett)

Brunei: Belait, Peat Swamp forest, East of Seria, 4.x.1992, (J.H. Martin 6122), ex: indet.

A. hikosanensis (Takahashi)

Japan: Mt. Ikoma, near Osaka, 18.ix.1955, (R. Takahashi), ex: Buxa, 78/62, B.M. 1962-401, (2 slides).

A. jasmini (Takahashi)

Hong Kong: Kowloon, 29.viii.1979, (J.H. Martin 2478), ex: indet., (2 slides).

Singapore: Ayer Rajah, housing blocks, 10.iv.2000, (J.H. Martin 7338), ex: *Jasminum* sp.

Singapore: Ayer Rajah, housing blocks, 10.iv.2000, (J.H. Martin 7334), ex: *Citrus* sp.

Taiwan: Formosa, Tobacco Res. Inst., 12.iv.1967, (Y.C. Chang), ex: *Murraya paniculata*, 9/67, B.M. 1967-258.

A. magnoliae (Takahashi)

Japan: Odaiga - Hara near Nara, 16.viii.1956, (R. Takahashi), ex: Lauraceae, 75/62, B.M. 1962-401.

A. murrayae (Singh)

Pakistan: Peshawar, 31.i.1963, (L.A. Mound), ex: *Murraya exotica*, 9/64, C.I.E. 19214.

Pakistan: Peshawar, 31.i.1963, (L.A. Mound), ex: *Murraya exotica*, 9/64.

A. nigeriae (Mound)

Paratype, Nigeria: Ibadan, 28.ix.1956, ex: Guava, 54/59.

Paratype, Nigeria: Ibadan, Moor Plantation, xii.1960, (M.O. Ezeigwe), ex: *Psidium guajava*, (2 slides).

Paratype, Nigeria: Kusheriki, ix.1960, (L.A. Mound), ex: indet., (2 slides).

A. piperis (Takahashi)

Japan: Enoshima, 31.viii.1949, (R. Takahashi), ex: *Piper* sp., 74/62, B.M. 1962-401, (2 slides).

A. psidii (Singh)

Taiwan: Formosa: Tobacco Res. Inst., 3.iv.1967, (Y.C. Chang), ex: *Litchi chinensis*, 4/67, B.M. 1967-186.

Taiwan: Taichung, 10.ix.1967, (Y.C. Chang), ex: *Prunus salicinia*, 20/67, B.M. 1967-592.

Taiwan: Taichung, 18.xii.1968, (Y.C. Chang), ex: Grape, 2/69.

A. pulcherrimus (Corbett)

Java: Jakarta, Kemang, 16.xii.1979, (J.H. Martin 2953), ex: indet.

A. similis (Takahashi)

Japan: Asakawa, near Tokyo, 27.vii.1949, (R. Takahashi), ex: *Pieris japonica*, 77/62, B.M. 1962-401, (2 slides).

11. *Aleurocybotus* Quaintance & Baker

A. graminicolus (Quaintance)

Paralectotype, U.S.A.: Florida, Lake City, 25.vii.1898, (Prof. Rolfs), Q 6775, ex: Grass, B.M. 1998-131.

A. occiduus Russell

Paratype, U.S.A.: California, ix-x.1961, (L.D. Anderson), ex: Grass, 8/65, B.M. 1965-451, (2 slides).

U.S.A.: California, El Centro Imp. Co., 5.x.1961, (O.V. Wadgner), ex: *Sorghum* sp., B.M. 1968-368.

12. *Aleuroduplidens* Martin

A. eucalyptifolia Martin

Paratypes, Australia: ACT, Molonglo Gorge (near Queanbeyan, NSW), 8.xii.1996, (J.H. Martin 6852), ex: *Eucalyptus nortonii*, B.M. 1998-50, (2 slides).

Paratypes, Australia: S.A., Belair, National Park, 29.iv.1957, (D.C. Swan), ex: *Eucalyptus* sp., (3 slides).

Australia: WA, Bungle Bungles, Frog Hole Gorge, 8.v.2000, (J.H. Martin 7443), ex: *Eucalyptus saplings*.

A. santali Martin

Paratypes, Australia: Queensland, Mt. Isa, 3.x.1996, (P. De Barro 66), ex: *Santalum lanceolatum*, (2 slides).

Paratypes, Australia: Queensland, 25 mi. W. of Dalby, ix.1985, (L.A. Mound), ex: indet., B.M. 1998-51, (2 slides).

A. triangularis Martin

Paratype, Australia: Northern Territory, King's Canyon, 5.ii.1990, (J.H. Martin 5643), ex: *Acacia ?mcdonnelliensis*, B.M. 1998-50, (2 slides).

A. wellsae Martin

Paratypes, Australia: Victoria, Merbein South, near Mildura, 27.i.1997, (A. Wells), ex: *Acacia melvillei*, B.M. 1998-50, (3 slides).

Paratypes, Australia: River Murray, 30 mls, N. of Overland Corner, 10.x.1965, (D.E. Symon), ex: *Acacia wilhelmiana*, 3/66, B.M. 1966-50, (3 slides).

13. *Aleuroglandulus* Bondar

A. magnus Russell

Costa Rica: Guanacaste Province, Santa Rosa Nat. park, 6.iii.1990, (J.M. Cox 63), ex: indet.

A. malangae Russell

Costa Rica: Turrialba, 14.xii.1981, (A. King), ex: *Colocasia* sp., 2/82.

Costa Rica: Turrialba, 640 m., Trop. Agric. Centre, C.A.T.I.E., 2.iii.1983, (J.H. Martin 3954), ex: *Colocasia* sp., (4 slides).

A. striatus Sampson & Drews

Costa Rica: N. Heredia Province, 10 Km north of Puerto Viejo, 2.ii.1983, (J.H. Martin 3739), ex: indet., (2 slides).

A. subtilis Bondar

Panama: Darién, Ensenada del Guayabo, sea level - 250 m., 11.i.1983, (J.H. Martin 3588), ex: *Psidium guajava*, (2 slides).

Panama: Canal Zone, Gamboa Hill, 20.iii.1983, (J.H. Martin 4095), ex: Bombacaceae.

Panama: Canal Zone, Barro Colorado I., 13.iii.1983, (J.H. Martin 3987), ex: *Inga ?pezizifera*.

Panama: Canal Zone, Barro Colorado I., 17.iii.1983, (J.H. Martin 4032), ex: *?Palicourea guianensis*, (2 slides).

14. *Aleuroinanis* Martin

A. myrtacei Martin

Paratypes, Australia: Queensland, strand 2 Km north of Cape Tribulation, 15.xii.1996, (J.H. Martin 6883), ex: *Syzygium* sp., B.M. 1998-50.

15. *Aleurolobus* Quaintance & Baker

A. diastematus Bink-Moenen

Sudan: S. Darfur, Ed Da'ein, 3.v.1981, (J.H. Martin 3371), ex: *Guiera senegalensis*.

Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 28.iv.1981, (J.H. Martin 3332), ex: *Salix subserrata*.

A. graminicola Bink-Moenen

Paratypes, Chad: Baïbokoum, 700 m., 8.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Cymbopogon giganteus*, B.M. 1977-471, (2 slides).

A. hargreavesi Dozier

Syntype, Uganda: Kampala, 16.ii.1928, (H. Hargreaves 0182), ex: *Hyparrhenia* sp.

Nigeria: Enugu, 15.i.1957, (V.F. Eastop 6558), ex: indet.

A. marlatti (Quaintance)

Paralectotypes, Japan: Hokata, 21.v.1901, (Quaintance 10227, via Marlatt), ex: Orange.

Australia: Queensland, rocky coast, 3 Km north of Cape Tribulation, 16.xii.1996, (J.H. Martin 6897), ex: ? Euphorbiaceae, B.M. 1998-50.

Australia: Queensland, strand 2 Km north of Cape Tribulation, 15.xii.1996, (J.H. Martin 6888), ex: *Clerodendron inerme*, B.M. 1998-50.

Australia: Queensland, Cape Tribulation, 18.xii. 1996, (J.H. Martin 6909), ex: *Aegiceras corniculatus*, B.M. 1998-50, (2 slides).

A. moundi David & Subramaniam

India: Kovilpatti, 31.i.1967, (B.V. David), ex: *Bassia latifolia*, 10/67, B.M. 1967-280/16, (3 slides).
India: Coimbatore, 7.xi.1967, (B.V. David), ex: *Bassia longifolia*, 10/67, B.M. 1967-280/17.

A. onitshae Mound

Paratypes, Nigeria: Onitsha, 13.i.1957, (V.F. Eastop 6553), ex: *Phyllanthus floribundus*, 198/61.
Paratype, Nigeria: Onitsha, 14.i.1957, (V.F. Eastop 6553), ex: *Phyllanthus floribundus*.
Paratypes, Nigeria: Moor Plantation area, i.1961, (L.A. Mound), ex: *Flueggea virosa*.

A. styraci Takahashi

Japan: Tokyo, 16.ix.1950, (R. Takahashi), ex: *Styrax* sp., 80/62, B.M. 1962-401, (2 slides).

A. teucrii Mifsud & Palmeri

Paratypes, Malta: Gozo Island, Xlendi, valley side, 16.iii.1994, (D. Mifsud & G.W. Watson 91), ex: *Teucrium fruticanus*, (3 slides).

16. *Aleurolonga* Mound

A. cassiae Mound

Paratypes, Nigeria: Ibadan, Moor Plantation, i.1960, (L.A. Mound), ex: *Cassia siamea*, (2 slides).
Angola: 3mN Santa Comba, 8.iii.1972, (D. Hollis), ex: *Brachystegia* sp., 2/74, (2 slides).

17. *Aleuromarginatus* Corbett

A. corbettiaformis Martin

Paratypes, Papua New Guinea: Morobe Province coast, Buso, 10.x.1979, (J.H. Martin 2680), ex: *Desmodium umbellatum*, (3 slides).

A. dalbergiae Cohic

Chad: Bebedjia, 395 m, 22.xi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Pterocarpus lucens*, B.M. 1976-56.

A. kallarensis David & Subramaniam

Paratypes, India: Madras, Tambaram, 4.i.1970, (B.V. David), ex: Papilionaceous shrub, B.M. 1972-24.

A. littoralis Martin

Paratypes, Papua New Guinea: Morobe Province coast, Buso, 10.ix.1979, (J.H. Martin 2529), ex: ?*Derris trifoliata*, (2 slides).
West Malaysia: Pahang Prov., Pulau Tioman, kg Penuba, beach-top, 19.xi.1992, (J.H. Martin 6219), ex: *Desmodium umbellatum*, (2 slides).

A. marginiquus Martin

Paratypes, Australia: Western Australia, Perth, Forrestfield, 23.xi.1997, (P.J. Gullan), ex: *Daviesia horrida*.

A. moundi Martin

Paratypes, Australia: Queensland, 54 Km W. of Mitchel, 30.iii.1998, (L.A. Mound 3420), ex: *Acacia* ?*aneura*, B.M. 1998-51.

A. nemciae Martin

Paratypes, Australia: Western Australia, Darling District, West Talbot Road, 27.ix.1993, (M.D. Crisp 8517), ex: *Nemcia* sp.

A. nigrus Martin

Paratypes, Australia: New South Wales, Braidwood - Nelligen Road, scarp descent, 30.xi.1996, (J.H. Martin 6840), ex: *Oxylobium ilicifolium*, B.M. 1998-50, (2 slides).
Paratypes, Australia: Australian Capital Territory, Molonglo Gorge, 8.xii.1996, (J.H. Martin 6854), ex: *Acasia* sp., B.M. 1998-50.

A. serdangensis Takahashi

Syntype, Malaya: Serdang, 20.i.1945, (R. Takahashi), ex: indet., B.M. 1955-799.

A. tephrosiae Corbett

Chad: Bebedjia, 395 m, 15.viii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Tephrosia linearis*, B.M. 1976-56.

18. *Aleuropapillatus* Regu & David

A. kumariensis Regu &David

Paratype, India: Tamil Nadu, Mondaikadu, 4.viii. 1989, (K. Regu), ex: *Gmelina asiatica*.

19. *Aleuroparadoxus* Quaintance & Baker

A. arctostaphyli Russell

Paratype, U.S.A.: Boulder Creek, Calif., 13.x.1891, (V. Bailey), ex: *Arctostaphylos nummularia*, B.M. 1998-131.

A. gardeniae Russell

Paratypes, Mexico: 29.xii.1937, ex: *Gardenia* sp., B.M. 1998-131.
Paratypes, Mexico: 10.xii.1936, (J.M. Singleton), ex: *Gardenia* sp., B.M. 1998-131.

A. ilicicola Russell

Paratype, U.S.A.: Alabama, Gulf Shores, 12.i.1944, (L.A. Mayer), ex: *Ilex* sp., B.M. 1998-131.

A. iridescens (Bemis)

?Paralectotype, U.S.A.: California, Santa Clara Valley, 1.iv.1901, (F.E. Bemis 7084), ex: *Heteromeles arbutifolia*, B.M. 1998-131.
U.S.A.: California, C. Costa Co., Russelmann Park, 21.v.1968, (R.F. Wilkey), ex: *Rhamnus crocea* var. *ilicifolia*, B.M. 1998-131.

A. punctatus Quaintance & Baker

Chile: Santiago, Univ. campus, ix.1995, (V.F. Eastop), ex: indet., (2 slides).

20. *Aleuroplatus* Quaintance & Baker

A. acaciae Bink-Moenen

Paratypes, Egypt: Aswan, Elefantine, 21.i.1977, (F.A. Bink & R.M. Bink-Moenen), ex: *Acacia tortilis*.
Sudan: Khartoum North, 11.iv.1981, (J.H. Martin 3265), ex: *Pithecollobium dulce*, (2 slides).

A. berbericolus Quaintance & Baker

U.S.A.: California, Trial, Oregon in quarantine Hornbrook, 6.x.1966, (B. Palmer), ex: *Mahonia aquifolium*, 25/66, (4 slides).

A. bossi Takahashi

Kenya: Westermann's Safari Camp, 30 Km S. of Voi, 16.v.1988, (J.H. Martin 5312), ex: ?Oleaceae, B.M. 1988-188.
Kenya: ~20 Km S. W. of Malindi, inland, 19.v.1988, (J.H. Martin 2348), ex: *Ochna mossambicensis*, B.M. 1988-188.
Sudan: Kordofan, En Nahud - Wad, Banda route, 22.iv.1981, (J.H. Martin 3314), ex: *Boscia senegalensis*.

A. cadabae Priesner & Hosny

Sudan: Kassala Province, Jebel Kassala, 5.iv.1981, (J.H. Martin 3254), ex: *Cadaba rotundifolia*, (2 slides).

A. cockerelli (Ihering)

Syntypes, Brazil: S. Paulo Prov., (?V. Ihering), ex: *Baccaris paucifloscula*, B.M. 1920-107.

A. cococolus Quaintance & Baker

Belize: Cayo, Chiquibul forest, San Pastor track, 14.ii.1996, (J.H. Martin 6668), ex: *pimenta dioica*.
Belize: Cayo, Chiquibul forest, Millionario - Grano de Oro, 12.ii.1996, (J.H. Martin 6645), ex: *Guettarda combesii*.

A. dorsipallidus Martin

Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Toraut forest, 11.iii.1985, (J.H. Martin 4639), ex: probably *Taxotrophis ilicifolius*, (2 slides).
Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Toraut forest, 20.iii.1985, (J.H. Martin 4709), ex: *Taxotrophis ilicifolius*.
Paratypes, Indonesia: Sulawesi Utara, lakeside, Danau Mooat, Gunung Muajat, 22.iii.1985, (J.H. Martin 4716), ex: ?*Palaquium* sp.

A. epigaeae Russell
Paratypes, Canada: at Boston, 26.v.1939, (W.J. Ehinger), ex: *Epigaea repens*, B.M. 1998-131.

A. evodiae Takahashi
Syntypes, Réunion Island: Plaine des Affouches, v.1957, (J. Bosser), ex: *Evodia* sp., 111/62, B.M. 1962-401.

A. fici Takahashi
Taiwan: Taipei, 1.ii.1987, (C.C. Ker), ex: *Ficus vasculosa*, B.M. 1987-197.

A. ilicis Russell
U.S.A.: Texas, in quarantine at Sanders, Arizona, 13.xi.1965, (A.T. Guest), ex: *Ilex* sp., 25/66, (2 slides).

A. incisus Quaintance & Baker
Ceylon: Haputalo, xii.1904, ex: *Ostodes zeylanica*, B.M. 1927-451.

A. pectiniferus Quaintance & Baker
Paratype, India: Tamil Nadu, Burliar, 20.vi.1985, (R.W.A. Jesudasan), ex: *Cinnamomum* sp., B.M. 1987-185.
Paralectotypes, Ceylon: Peradeniya, i.1905, (E.E. Green), ex: *Ficus gibbosa*, B.M. 1927-451.
Australia: Northern Territory, Kakadu Nat. Park, Ubirr rocks, 35 Km N. of Jabiru, 22.xii.1996, (J.H. Martin 6956), ex: *Strychnos* sp., B.M. 1998-50.
Hong Kong: Lantau Island, near Tung Chung, 16.x.1990, (J.H. Martin 5779), ex: indet.
Hong Kong: Lantau Island, near Tung Chung, 16.x.1990, (J.H. Martin 5781), ex: *Aguilaria sinensis*.

A. periplocae (Dozier)
Syntype, Belgian Congo: Barumbu, viii.1925, (J. Ghesquière 592), ex: *Periploca nigrescens*.

A. perseaphagus Martin *et al.*
Paratypes, Madeira: Funchal, Lombo da Boa Vista, 3.vii.1993, (via M. Pita C220), ex: *Persea americana*, (2 slides).
Paratypes, Madeira: Santa Cruz village, 20.ii.1994, (A.F. Aguiar), ex: *Persea americana*.

A. quercusaquaticae (Quaintance)
U.S.A.: Virginia, Vienna, 18.viii.1912, (A.C. Baker 15), ex: Chestnut, B.M. 1924-137.

21. *Aleuropleurocelus* Drews & Sampson

A. nigrans (Bemis)
U.S.A.: California, Pasadena, 26.ii.1945, (R.H. Smith), ex: *Rhamnus californica*, B.M. 1998-131.

22. *Aleuropteridis* Mound

A. eastopi Mound
Holotype, Ghana: Tafo, 12.v.1957, (V.F. Eastop 6982), ex: Fern, 109/61.
Paratypes, Ghana: Tafo, 12.v.1957, (V.F. Eastop 6982), ex: Fern, 109/61, (3 slides).

A. filicicola (Newstead)
Syntypes, England: Surrey, Kew Gardens, ?1890, (J.W. Douglas 1205), ex: *Pteris togoensis* & *Cyclosorus dentatus*, 97/61, B.M. 1904-120, (2 slides).
Syntypes, Tanzania (German East Africa): Sigithal near Amani, 4.viii.1902, (A. Zimmermann 18), ex: Fern, 49/62, (4 slides).

A. hargreavesi Mound
Syntypes, Sierra Leone: Freetown, Mokinma, 9.ix.1924, (E. Hargreaves), ex: Bush fern, 108/61.

A. jamesi Mound
Syntypes, Nigeria: Ibadan, Moor Plantation, Ajibi V., 2.x.1959, (E.A. James), ex: *Pteris togoensis*, C.I.E. 5387, 21/60, B.M. 1960-101, (4 slides).
Syntypes, Nigeria: Ibadan, Moor Plantation, Ajibi V., 29.xii.1960, (E.A. James), ex: *Pteris togoensis*.

23. *Aleuroputeus* Corbett

A. perseae Corbett
West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 11.iii.1984, (J.H. Martin 4260), ex: indet. small tree, (2 slides).
Indonesia: Java, Jakarta, Kemang, 16.xii.1979, (J.H. Martin 2952), ex: *Psidium guajava*.

24. *Aleurothrixus* Quaintance & Baker

A. aepim (Göldi)
Brazil: 23.v.1978, (M. Samways "A"), ex: *Manihot* sp., 8/78.
Brazil: 23.v.1978, (M. Samways "B"), ex: *Manihot* sp., 8/78.

A. antidesmae Takahashi
Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Toraut forest, near base camp, 6.v.1985, (J.H. Martin 4926), ex: indet.
Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Toraut forest, near base camp, 30.iii.1985, (J.H. Martin 4767), ex: ?Myrtaceae.
Hawaiian Islands: Maui, Wailuku, 3.iv.1999, (J.H. Martin 7201), ex: *calophyllum inophyllum*.

A. bondari Costa Lima
Brazil: Vicosa, (H.L. Parker 953-16), ex: *Triumfetta semitriloba*, 44-27574, B.M. 1998-131.

A. floccosus (Maskell)
Singapore: Napier/Cluny Rds, Botanic Gardens, 11.iv.2000, (J.H. Martin 7364), ex: *Citrus retusa*, (2 slides).
Singapore: Napier/Cluny Rds, Botanic Gardens, 11.iv.2000, (J.H. Martin 7363), ex: *Noringi crenulata*.

A. interrogationis (Bemis)
U.S.A.: California, Arcadia, 3.xi.1970, (H.G. Walker), ex: *Ceanothus cyaneus*, B.M. 1998-131.
U.S.A.: California, Riverside, 11.v.1961, (L.A. Mound), ex: *Ceanothus* sp., 91/61, B.M. 1961-369, (2 slides).
U.S.A.: California, Riverside, 13.ii.1957, (M. Johnson), ex: *Ceanothus* sp.

A. lucumai Costa Lima
Brazil: Vicosa, 25.v.1944, (H.L. Parker 953-26), ex: *Citrus* sp., 44-27574, B.M. 1998-131.

A. myrtacei Bondar
Belize: Cayo, Chiquibul forest, Las Cuevas plots, 17.xi.1994, (J.H. Martin 6491), ex: *Pimenta dioica*, (2 slides).

A. porteri *Quaintance & Baker*
Syntypes, Chile: Villa del Mar, 1.iv.1899, (D.G. Fairchild) ex: Solanaceae, B.M. 1998-131.

A. proximans Bondar
?Syntypes, Brazil: xii.1922, (G. Bondar 653), ex:

Lauraceae, B.M. 1998-131, (2 slides).
A. smilaceti Takahashi
Taiwan: Kenting, 4.iv.1986, (C.C. Ker.), ex: *Gardenia* sp., B.M. 1987-197.

25. *Aleurotithius* Quaintance & Baker

A. timberlakei Quaintance & Baker
U.S.A.: California, San Diego, Encanto, 10.iv.1968, (R. Thomas), ex: *Eriodictyon crassifolium*, B.M. 1968-368, (2 slides).
U.S.A.: California, Pala, 1.xi.1950, (R.A. Flock via L.A. Mound), ex: *Eriodictyon* sp., 87/61, B.M. 1961-369.

26. *Aleurotrchelus* Quaintance & Baker

A. alpinus Takahashi
Taiwan: 20.x.1989, (C.C. Ko), ex: *Polygonum* sp.
A. ampullatus *Bink-Moenen*
Paratypes, Chad: Boro, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Burkea africana*, B.M. 1977-471.
A. asparagi (Lewis)
Syntypes, South Africa: Natal, iv.1893, (R.T. Lewis), ex: *Asparagus* sp., B.M. 1893-75, (2 slides).
A. atratus Hempel
Topotype, Brazil: Bahia, 7.xii.?23, (G. Bondar), ex: *Cocus nucifera*, B.M. 1924-44.
Tenerife: Canary Islands, Santa Cruz de T., 22.v.1997, (J.H. Martin 7072 & E.H. Suarez), ex: *Arecastrum* sp., (3 slides).
A. camelliae (Kuwana)
Japan: Hyogo, 15.iv.1956, (R. Takahashi), ex: *Camellia japonica*, 83/62, B.M. 1962-401, (2 slides).
A. duplicatus Bink-Moenen
Paratypes, Chad: Bebedjia, 28.xi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Mitragyna inermis*, B.M. 1977-471.
A. fumipennis (Hempel)
Brazil: Mato, Grosso, 25.iii.1968, (O.W. Richards), ex: Grass, B.M. 1968-260, (2 slides).
A. limbatus (Maskell)
Holotype, Australia: Victoria, nr McKenzie Falls, 23,viii.1965, (D.E. Symon), ex: *Styphelia adscendens*.
Australia: Victoria, nr McKenzie Falls, 23,viii.1965, (D.E. Symon), ex: *Styphelia adscendens*, 3/65, B.M. 1966-50, (2 slides).
A. longispinus Corbett
Syntypes, Ceylon: Telloola, xi.1905, (E.E. Green), ex: indet. 86/61, B.M. 1927-451, (2 slides).
A. minutus Takahashi
Singapore: Botanic Garden, 15.ix.1980, (D.H. Murphy), ex: Annonacae, 10/85.
A. multipapillus Singh
Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Toraut forest, near base camp, 14.iii1985, (J.H. Martin 4660), ex: Bamboo.
A. obscurus *Bink-Moenen*
Paratypes, Chad: Boro, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Daniella oliveri*, B.M. 1977-471.
A. tarennae Bink-Moenen
Paratype, Chad: Timberi, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Tarenna* sp., B.M. 1977-471.
A. tracheifer *(Quaintance)*
Belize: Cayo, Chiquibul forest, Las Cuevas, Monkey Tail trail, 17.ii.1996, (J.H. Martin 6685), ex: *Strychnos* sp.
Belize: Cayo, Chiquibul forest, Las Cuevas, Monkey Tail trail, 5.iii.1996, (J.H. Martin 6752), ex: woody recumbent, (2 slides).
Panama: Canal Zone, Barro Colorado I., 1.i.1983, (J.H. Martin 3478), ex: *Mouriri myrtilloides*.
A. trachoides (Back)
Tahiti; Papeete, 0-50 m., 8.iii.1979, (N.L.H. Krauss), ex: Vine, ?Convolvulaceae, (2slides).
Costa Rica: Guanacaste Province, 100 Km S. E. of Liberia, 29.i.1983, (J.H. Martin 3734), ex: Simaroubaceae.

27. *Aleurotuba* Tremblay & Iaccarino

A. jelinekii (Frauenfeld)
England: Mddx., Staines station, 31.x.1976, (J.H. Martin 1660), ex: *Viburnum ?tinus*.
England: Notts., Radcliffe -on- Trent, 5.iv.1986, (J.H. Martin 5069), ex: *Viburnum tinus*, (2 slides).
England: London, Battersea Park, 7.xi.1976, (J.H. Martin 1674), ex: *Viburnum ?tinus*.
Morocco: 45 Km S. of Oujda, Col de Jerada, 23.iv.1992, (J.H. Martin 6060), ex: *Viburnum tinus*, B.M. 1992-73.
Morocco: Western Rif, 20 Km S.W. of Chefchaouene, Ouezzane Road, 29.iv.1992, (J.H. Martin 6085), ex: *Arbutus unedo*, B.M. 1992-73.
France: Corsica, Gorges, de la Restonica, 23.v.1990, (J.H. Martin 5716), ex: *Arbutus unedo*.

28. *Aleurotulus* Quaintance & Baker

A. anthuricola Nakahara
Paratypes, Colombia: at Miami, 28.iii.1984, (J. Russo), ex: *Anthurium* sp.
A. arundinacea Singh
Papua New Guinea: Morobe Prov. coast, Buso, 21.ix.1979, (J.H. Martin 2598), ex: Bamboo.
A. nephrolepidis (Quaintance)
Type series, England: Surrey, Kew Gardens, 17.ix.1937, (C.B. Williams), ex: Ferns, 166/62, B.M. 1962-643, (2 slides).
Azores: São Miguel, road to Sete Cidades, 27.ix.1998, (A. Polaszek & E.M. Hernandez-Suares), ex: *Blechnum spicant*, (2 slides).
Brazil: S.P., ?Campinas, rec'd., iii.1982, (A. Lourencao), ex: *Pteris* sp., 3/82.
A. pteridophytae Martin
Paratypes, Costa Rica: North Heredia Province, La Selva Biological Reserve, xi.1992, (L.A. Mound), ex: *Selaginella eurynota*, (4 Slides).
Venezuela: Parque Nacional, El Cumbre, 2.xii.1938, (A.H.G. Alston), ex: *Anemia phyllitidis*, 162/60, (2 slides).

29. *Aleuroviggianus* Iaccarino

A. adanaensis Bink-Moenen
Paratypes, Turkey: Adana, 19.iv.1987, (H. Elekcioglu), ex: *Quercus coccifera*, 22/87, (4 slides).
Syria: Idleeb, 15.v.1995, (Badar Munir), ex: *Quercus calliprinos*, B.M. 1995-187.
A. adrianae Iaccarino
Italy: nr Naples, x.1981, (F.M. Iaccarino), ex: *Quercus ilex* group, 281/81.
Morocco: Middle Atlas, Ifrane, 25.iv.1992, (J.H. Martin 6067), ex: *Quercus* sp., B.M. 1992-73.

Morocco: Western Rif, 5 Km S. of Chefchaouene, roadside, 19.iv.1992, (J.H. Martin 6043), ex: *Quercus ?suber*, B.M. 1992-73.
Costa Rica: Cargèse, 31.x.1998, (J.H. Martin 7189), ex: *Quercus ilex*, (2 slides).

A. graecus Bink-Moenen
Holotype, Greece: Corfu, Kerkira Kariotikon, 13.v.1980, (F.A. Bink & R.M. Bink-Moenen), ex: *Quercus coccifera*.

A. halperini Bink-Moenen
Paratypes, Israel: Golan Heights, 5.xii.1967, (J. Halperin), ex: *Quercus calliprinos*.
Paratype, Israel: Tivon, 20.xii.1958, (M. Sternlicht 3811), ex: *Quercus calliprinos*, C.I.E. 5001/16428.
Turkey: Içel, 30.iii.1987, (H. Elekcioglu), ex: *Quercus coccifera*, (2 slides).

A. polymorphus Bink-Moenen
Paratypes, Spain: Colmenar Viejo, 12.v.1978, (F.A. Bink & R.M. Bink-Moenen), ex: *Quercus rotundifolia*, (2 slides).
Paratype, France: Pyrenées Or., N.W. of Ille-s-Têt, 11.v.1987, (F.A. Bink & R.M. Bink-Moenen), ex: *Quercus ilex*.
Morocco: Western Rif, 5 Km S. of Chefchaouene, roadside, 19.iv.1992, (J.H. Martin 6043), ex: *Quercus ?suber*, B.M. 1992-73 (2slides).
Morocco: 45 Km S. of Oujda, Col de Jerada, 23.iv.1992, (J.H. Martin 6064), ex: *Quercus coccifera*, B.M. 1992-73.

A. zonalus Bink-Moenen
Paratype, Greece: Crete, Montes Psiloriti, 5.vii.?1942, (L.A. Mound & R.M. Bink), ex: *Quercus coccifera*.
Paratypes, Greece: Crete, Omalus, 8.v.1979, (F.A. Bink & R.M. Bink-Moenen), ex: *Quercus coccifera*.

30. *Aleyrodes* Latreille

A. amnicola Bemis
U.S.A.: California, Vista, San Diego, 14.xi.1966, (Waldrip & Kruz), ex: indet., 8/72, (3 slides).

A. elevatus Silvestri
Spain: Almeria Province, gorge N of Berja, Road A337, 9.x.1998, (J.H. Martin 7162), ex: *Ficus carica*, (2 slides).
France: Corsica, Ile Rousse, 4.vii.1980, (J.H. Martin 3028), ex: *Ficus ?carica*, 47/80.

A. lonicerae Walker
England: London, New Cross, 21.x.1968, (J.M. Palmer), ex: *Lonicera serotina*, 5/69, (3 slides).
England: Notts., Radcliffe -on- Trent, 4.x.1980, (J.H. Martin 3108), ex: *Lonicera periclymenum*, 50/80.
England: Notts., Radcliffe -on- Trent, 18.ix.1982, (J.H. Martin 3448), ex: *Mentha* sp., 57/82.
Austria: Ossiach, 14.viii.1966, (V.F. Eastop), ex: *Aegopodium podograria*.

A. proletella (Linnaeus)
Angola: C.E. Cavaco, 7.xii.1970, (P. Carvalho), ex: *Brassica oleracea*, 17616/1571, (2 slides).
Austria: Ossiach, 6.viii.1966, (V.F. Eastop), ex: *Chelidonium* sp., (2 slides).
England: Kent, Dunton Green, 30.ix.1969, (W.R. Dolling), ex: *Aegopodium podograria*, 3/80, (2 slides).
Tenerife: Canary Islands, La Matanza de Acentejo, 20.v.1997, (J.H. Martin 7058), ex: *Lactuca serriola*.
Malta: Gozo Island, Xlendi, gariugue habitat, valley side, 16.iii.1994, (G.W. Watson 90), ex: *Reichardia picroides*.

A. pruinosus Bemis
Type material: U.S.A.: Colorado, Boulder, pre 1912, (T.D.A. Kockerell), ex: indet., 96/61, B.M. 1912-49.
U.S.A.: California, San Diego, 24.x.1966, (J. Kenyon), ex: *Heteromeles arbutifolia*, 8/12, (2 slides).
U.S.A.: California, Riverside, 11.ii.1957, (M. Frost), ex: *Photinia arbutifolia*.

A. singularis Danzig
Paratype, U.S.S.R.: Georgia, Marneul District, 1962, (T. Charcharidze), ex: *Euphorbia* sp., 4/66, B.M. 1966-67, (4 slides).

31. *Aleyrodiella* Danzig

A. lamellifera Danzig
Paratypes, U.S.S.R.: Vladivostock, Okeanskaya, 31.viii.1961, (E.M. Danzig), ex: *Ulmus laciniata*.

32. *Apobemisia* Takahashi

A. kuwanai (Takahashi)
Japan: Amani, Oshima, 6.iv.1960, (R. Takahashi), ex: *Ficus pumila*, 87/62, B.M. 1962-401, (3 slides).

33. *Arachnaleyrodes* Bink-Moenen

A. insignis Bink-Moenen
Paratypes, Chad: Bebedjia, 395 m, 27.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Combretum hypopilinum*, B.M. 1976-56, (2 slides).
Paratypes, Chad: Baïbokoum, 700 m, 9.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Combretum glutinosum*, B.M. 1976-56.

34. *Asialeyrides* Corbett

A. lushanensis Ko
Paratypes, Taiwan: Lushanwenchuan, 6.ix.1986, (C.C. Ko), ex: *Syzygium buxifolium*, B.M. 1987-197, (2 slides).

A. maesae (Takahashi)
Taiwan: Hapan, 11.i.1987, (C.C. Ko), ex: indet., B.M. 1987-197.

35. *Asterobemisia* Trehan

A. carpini (Koch)
England: Herts., near Barford, 18.iv.1936, (C.B. Williams), ex: Hornbeam, 133/60, B.M. 1960-483, (2 slides).
England: Herts., Harpenden, Bluebell Wood, 16.x.1935, (C.B. Williams), ex: Hornbeam, 94/61, B.M. 1969-483, (2 slides).

A. dentata Danzig
Turkmenistan: Kapem, Dag, 10.x.1988, ex: *Rhamnus* sp.

A. obenbergeri (Zahradnik)
Paratype, Czechoslovakia: Mohelno, Moravia Occid., 29.ix.1954, ex: *Thymus* sp.
Paratypes, Czechoslovakia: Mohelno, 30.viii.1957, (J. Zahradnik), ex: *Thymus* sp., B.M. 1969-370.

36. *Asterochiton* Maskell

A. cordiae David & Subramaniam
Paratype, India: Madras, 19.vii.1971, (B.V. David), ex: *Cordia myxa*, B.M. 1972-24.

A. pittospori Dumbleton
New Zealand: Auckland, i.1979, (L.A. Mound 1346), ex: *Pittosporum eugenioides*, (2 slides).

37. *Bellitudo* Russell

B. Jamaicae Russell

Paratype, Jamaica: Holly Mount, 25-27.v.1904, (W.R. Maxon), ex: *Coccoloba longiflora*, B.M. 1998-131.
West Indies: Jamaica, La Rozelle, Morant Bay, 16.iv.1969, (K. Heinze 12), ex: *Coccoloba unifera*.
Jamaica: La Rozelle, 23.x.1969, (K. Heinze), ex: *Coccoloba unifera*, B.M. 1998-131.

B. hispaniolae Russell
Haiti: Port-au-Prince, 28.v.1930, (H.L. Dozier), ex: *Coccoloba unifera*, B.M. 1998-131.

38. *Bemisaleyrodes* Cohic

B. brideliae Bink-Moenen
Paratypes, Chad: Boro, 450 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Bridelia ferruginea*, B.M. 1976-56, (3 slides).

B. pauliani Cohic
Paratype, Nigeria: Ibadan, 29.x.1960, (F.A. Squire), ex: *Ficus* sp.
Paratype, Cameroon: Bamenda, 2.xi.1957, (V.F. Eastop), ex: *Ficus* sp.

39. *Bemisia* Quaintance & Baker

B. afer (Priesner & Hosny)
Israel: Slopes of Wadi Keren, after Zuriel, Upper Galilee, 15.x.1968, (D. Gerling 132), ex: *Smilax aspersa*, B.M. 1969-220.
Israel: Yoknean Junclion, nr Zikhron Yaekov., 15.x.1968, (D. Gerling 013), ex: *Morus* sp., B.M. 1969-220.
Pakistan: Lyallpur, 24.viii.1966, (J.I. Qureshi 102), ex: *Morus alba*, 21/66, (2 slides).
Pakistan: Lyallpur, 25.viii.1966, (J.I. Qureshi 104), ex: *Dalbergia sissoo*, 21/66.
Iraq: Mosul University, 1977 ?, ex: *Bauhinia* sp., No. 35, C.I.E. A.10124.
Iran: Fars, Shiraz, 28.x.1990, (M. Zarrabi 8), ex: *Rosa canina*.

B. antennata Gameel
Chad: Bebedjia, 395 m, 4.vii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Cordia africana*, B.M. 1976-56.
Sudan: Wad Medani, x.1961, (L.A. Mound), ex: *Ficus sycamora*.
Sudan: Wad Medani, xi.1961, (L.A. Mound), ex: *Ficus sycamora*.
Sudan: Wad Medani, i.1962, (L.A. Mound), ex: *Ficus sycamora*, B.M. 1963-777.
Sudan: Wad Medani, v.1962, (L.A. Mound), ex: *Ficus sycamora*.
Sudan: Wad Medani, 1962, (L.A. Mound), ex: *Ficus sycamora*.

B. berbericola (Cockerell)
U.S.A.: California, Riverside, 11.v.1961, (L.A. Mound), ex: *Photinia arbutifolia*, 86/61, B.M. 1961-369.
U.S.A.: California, Riverside, 11.v.1961, (L.A. Mound), ex: *Ceanothus arbutitifolia*, 93/61, B.M. 1961-369.
U.S.A.: California, Riverside, 11.v.1961, (L.A. Mound), ex: *Ceanothus* sp., 91/61, B.M. 1961-369, (2 slides).

B. combreticula Bink-Moenen
Holotype, Chad: Bebedjia, 395 m, 27.vii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Anogeissus leiocarpus*.

B. formosana Takahashi
Taiwan: Chihpenwenchuan, 26.ix.1989, (I.C. Hsu), ex: *Setaria palmifolia*, B.M. 1994, (3 slides).

B. giffardi (Kotinsky)
Australia: Queensland, Koah, 19.iii.1959, (G.W. Saunders), ex: *Citrus* sp., C.I.E. 5435 1686, 40/60, B.M. 1960-240.
Australia: Adelaide, Highgate, iv.1958, (H.M. Brookes), ex: Orange, 88/58, B.M. 1965-517.
Hong Kong: NT, Sek Kong, 1.iii.1990, (J.H. Martin 5681), ex: *Citrus* sp.
Nepal: Kathmandu, 15.iv.1965, (K.C. Sharma), ex: *Citrus* sp., C.I.E. 8855.A266, B.M. 196.
Tahiti: Fada, ix.1976, (M. Monnot), ex: *Citrus aurantiifolia*, C.I.E. A.10644, 10/82.

B. gigantea Martin
Australia: Queensland, Happy Valley, 3 Km W. of Babinda, 3.v.1998, (C. Burwell & C. Rodriguez), ex: *Elaeocarpus angustifolius*, B.M. 1998-51, (3 slides).

B. guieriae *Bink-Moenen*
Sudan: Kordofan, 100 Km W. of Umm, Ruwaba, EL Obeid Road, 18.iv.1981, (J.H. Martin 3296), ex: *Guiera senegalensis*, (2 slides).

B. hirta Bink-Moenen
Sudan: N. Darfur, EL Fasher, 25.iv.1981, (J.H. Martin 3329), ex: *Boscia senegalensis*.
Sudan: Kassala Prov., Jebel Kassala, 6.iv.1981, (J.H. Martin 3258), ex: *Boscia senegalensis*.
Sudan: Kordofan, 20 Km W. of EL Obeid, 18.iv.1981, (J.H. Martin 3300), ex: *Boscia senegalensis*.

B. lauracea Martin *et al.*
Paratypes, Madeira: Faja da Noguiera, 28.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6553), ex: *Ocotea foetens*, (2 slides).
Paratypes, Madeira: cliffs above Seixal, 200-300 m, 29.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6556), ex: *Laurus azorica*, (2 slides).
Paratype, Madeira: Fanal, 1150 m. N. E. of Rabacal, 30.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6574), ex: *Laurus azorica*.
Paratypes, Madeira: Fanal, 1150 m. N. E. of Rabacal, 30.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6575), ex: *Ocotea foetens*.

B. mesasiatica Danzig
Paratype, Tadjikistan, 15.vi.1964, (E. Danzig), ex: *Exochorda alberti*.

B. pongamiae Takahashi
West Malaysia: Pahang Prov., Tioman I., Kampung Tekek, 16.iii.1984, (J.H. Martin 4272), ex: ?Leguminosae, (2 slides).
Philippine Islands: Palawan, st. paul N. P., Sabang H. Q., 24.i.1988, (J.H. Martin 5163), ex: strand legume vine, B.M. 1988-2.
Philippine Islands: Palawan, Puerto Princesa, White Beach, 27.i.1988, (J.H. Martin 5177), ex: strand Leguminosae shrub, B.M. 1988-2.
Taiwan: Taipei, 6.ix.1985, (C.C. Ko), ex: *Pongamia pinnata*.

B. silvatica (Danzig)
Paratypes, U.S.S.R.: Alekseyevka, Lazarevskaya, District, 11.viii.1960, (E.M. Danzig), ex: *Rhododendron flavum*.

B. subdecipiens Martin
Paratypes, Australia: Kangaroo Island, Flinders Chase N. P., 17.ii.1990, (J.H. Martin 5652), ex: *Melaleuca* sp., B.M. 1998-50, (2 slides).

B. tabaci Gennadius
Jordan: 1977, (K. Makkouk 21), ex: *Solanum lycopersicon*, 105/84, (2 slides).
Kuwait: Al-Jabriyah, 10.i.1977, (W. Al-Houty), ex: *Solanum melongena*, 6/77, (2 slides).
Greece: N. Evia, Isteia, viii.1982, (A. Kourmadas), ex: *Hibiscus esculentus*, 34/82.
Iran: Gorgan, Ghalandar mahaleh, 1.xi.1986, ex: Cotton, C.I.E. A18482, (2 slides).
Iran: Gorgan, ?.xi.1986, ex: Cotton, C.I.E. A18482.
Iran: Khuzistan, Ramin, 2.iii.1978, (V.F. Eastop 15893), ex: Euphorbiaceae, 129/81.
Iran: Khuzistan, Ahvaz, 6.ii.1978, (V.F. Eastop 15787), ex: *Malva* sp. or ?*Hibiscus* sp., 120/81.
Iraq: Haidei, 21.vi.1961, ex: Cotton, C.I.E. 6384-18046, B.M. 1962-3, (2 slides).
B. tuberculata Bondar
Paraguay: iv.1995, (Romero), ex: *Manihot esculenta*, P95-042, (2 slides).
Colombia: Ciat, Valle Palmira, viii.1997, (M. Pilar Hernandez), ex: *Yuca* sp.

40. *Bemisiella* Danzig
B. artemisiae Danzig
Paratypes, Russia: Voronezh, 3.viii.1999, (J. Yavrilov) ex: *Artemisia vulgaris*, BMNH (E) 2000-64.

41. *Brazzaleyrodes* Cohic
B. eriococciformis Cohic
Belgian Congo: Yang-Steui, 13.xii.1936, (J. Ghesquière 3472), ex: *Cynometra hankei*.

42. *Bulgarialeurodes* Corbett
B. cotesii (Maskell)
Syntypes, Bulgaria: 30.viii.1930, (Dr P. Tchorbadjiev), ex: *Rosa damascena*, B.M. 1935-284.
Iran: Fars, Shiraz, 28.x.1990, (M. Zarrabi 8), ex: *Rosa canina*.

43. *Calluneyrodes* Zahradnik
C. callunae (Ossiannilsson)
?Syntype, Sweden: Södermanland, Nacka Erstavik, 27.x.1946, (Ossiannilsson).

44. *Chitonaleyrodes* Martin
C. canberrensis Martin
Paratype, Australia: Canberra, A.C.T., viii.1968, (L.A. Mound), ex: *Callistemon* sp., 34/71, (4 slides).
Paratypes, Australia: Canberra, A.C.T., i.1968, (L.A. Mound), ex: *Callistemon* sp., 33/71, (2 slides).

45. *Cockerelliella* Sundararaj & David
C. curcumae (Corbett)
West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 4.iii.1984, (J.H. Martin 4220), ex: Musaceae, (2 slides).
West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 2.iii.1984, (J.H. Martin 4191), ex: Zingiberaceae.
West Malaysia: Cameron Highlands, nr Ringlet, ~1000 m, 14.ii.1985, (J.H. Martin 4489), ex: Zingiberaceae.
West Malaysia: Genting Highlands, ~3000′, 10.ii.1985, (J.H. Martin 4445), ex: Zingiberaceae.
C. psidii (Corbett)
Singapore: Bukit Timah, Forest Reserve, 13.v.2000, (J.H. Martin 7465), ex: indet.
Papua New Guinea: Morobe Prov. coast, Buso, 9.x.1979, (J.H. Martin 2681), ex: *Premna* sp., (2 slides).
Papua New Guinea: Morobe Prov. coast, Buso, 3.x.1979, (J.H. Martin 2655), ex: *Myrtella* sp.
Papua New Guinea: Morobe Prov. coast, Buso, 12.x.1979, (J.H. Martin 2687), ex: *Anisoptera thurifera*, (2 slides).
Papua New Guinea: Morobe Prov. coast, Lasanga Island, 7.xi.1979, (J.H. Martin 2817), ex: indet. tree, (2 slides).

46. *Cohicaleyrodes* Bink-Moenen
C. alternans (Cohic)
?Paratype, Congo: Brazzaville, 17.iv.1964, (F. Cohic), ex: Papilionaceae, B.M. 1965-305.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 13.x.1989, (L.D.C. Fishpool 17), ex: *Terminalia ivorensis*.
C. crossopterygis Bink-Moenen
Paratypes, Chad: Boro, 453 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: Crossopteryx febrifuga.
C. obscura Bink-Moenen
Holotype, Chad: Timberi, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Tarenna* sp.
C. platisepali (Cohic)
Paratype, Congo: Brazzaville, 16.iv.1965, (F. Cohic), ex: *Platysepalum vanderystii*, B.M. 1965-305.
C. quadrilongispinae Bink-Moenen
Paratypes, Chad: Bebedjia, 395 m, 23.vii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Cissus* sp.
Paratype, Chad: Bebedjia, 395 m, 25.x.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Cissus* sp.
Paratypes, Chad: Doba, 21.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Paullinia pinnata*.
C. recurvispina (Cohic)
Syntype, Congo: Brazzaville, 21.iii.1964, (F. Cohic), ex: *Tetracera alnifolia*, B.M. 1965-305.
Chad: Doba, 27.xii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1973-226.

47. *Combesaleyrodes* Cohic
C. bouqueti Cohic
Syntype, Congo: Brazzaville, 25.ii.1965, (F. Cohic), ex: *Colletoecema dewevrei*, B.M. 1965-305.
C. tauffliebi cohic
Syntype, Congo: Brazzaville, 25.ii.1965, (F. Cohic), ex: *Urophyllum hirtellum*, B.M. 1965-305.

48. *Corbettia* Dozier
C. baphiae Russell
Kenya: Matuga, 4.ix.1982, (I. Robertson 3361), ex: *Cassia* sp., 54/82, (2 slides).
Malawi: Bunda, Lilongwe, 17.xi.1995, (Y. Tembo), ex: *Sesbania sesban*.
C. bauhiniae Cohic
Sudan: Bahr el Ghazal Prov., N. of Aweil, 9.v.1981, (J.H. Martin 3387), ex: *Piliostigma* sp., (2 slides).
Sudan: S. Darfur, Kas-Nyala Road, 1.v.1981, (J.H. Martin 3368), ex: *Bauhinia|Piliostigma* sp., (2 slides).
C. graminis Mound
Paratypes, Nigeria: Onitsha, 13.i.1957, (V.F. Eastop 6544), ex: Gramineae, (3 slides).
C. isoberliniae Bink-Moenen
Paratypes, Chad: Boro, 453 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Isoberlinia doka*, B.M. 1976-56, (2 slides).
C. lonchocarpi Bink-Moenen

Paratypes, Chad: Boro, 450 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *lonchocarpus laxiflorus*, B.M. 1976-56, (2 slides).

C. millettiacola Dozier

Paralectotype, Belgian Congo: Sankuru, Kole, 22.i.1928, (J. Ghesquière), ex: *Millettia versicolor*, B.M. 1933.

Nigeria: Ibadan, Moor Plantation, 10.v.1956, (V.F. Eastop 5929), ex: *Lonchocarpus sericeus*.

Nigeria: Olokomeji, (V.F. Eastop 5942), ex: *Mucuna* sp.

Chad: Bebedjia, 395 m, 30.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Swartzia madagascariensis*, B.M. 1976-65, (2 slides).

C. tamarindi Takahashi

Chad: Bebedjia, 395 m, 19.ix.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Tamarindus indicus*, B.M. 1976-56, (2 slides).

49. *Crenidorsum* Russell

C. aroidephagus Martin & Aguiar

Paratypes, Costa Rica: San José, 22.i.1983, (J.H. Martin 3648), ex: ?*Philodendron*, (2 slides).

Paratypes, Madeira: Funchal, 16.iii.1999, (A. Aguiar C873), ex: *Epipremnum aureus*, (2 slides).

Paratypes, Germany: Berlin, Botanic Gardens, iii.2001, (P. Baufeld), ex: *Philodendron gloriosum*, (2 slides).

Paratype, U.S.A.: Hawaii, Foster Botanical Gardens, 10.iv.2001, (B. Kumashiro & J. Dooley), ex: Aroid. B.M.N.H. (E) 2001-140.

C. celebes Martin

Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 18.iv.1985, (J.H. Martin 4881), ex: ?Proteaceae (cf. *Helicia* sp.), (4 slides).

Paratype, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 12.v.1985, (J.H. Martin 4940), ex: ?Sapotaceae.

Paratypes, Indonesia: Sulawesi Utara, lakeside, Danau Mooat, Gunung Muajat, 22.iii.1985, (J.H. Martin 4720), ex: *Persea americana*.

Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 15.iv.1985, (J.H. Martin 4846), ex: *Weinmannia* sp.

C. commune Russell

Paratype, Bahamas: Harbour Island, 18.ii.-4.iii.1907, (E.G. Britton), ex: *Coccoloba laurifolia*, B.M. 1998-131.

Paratypes, Navassa Island: 6.i.1930, (H. Rehder), ex: *Coccoloba laurifolia*, B.M. 1998-131.

C. lasangensis Martin

Paratypes, Papua New Guinea: Morobe Province coast, Lasanga Island, 18.ix.1979, (J.H. Martin 2586), ex: *Musa* sp., (2 slides).

C. magnisetae Russell

Paratype, Haiti: Massif, Port Margot, (E.L. Ekman), ex: *Coccoloba retusa*, B.M. 1998-131.

Haiti: Morne-d-Cabrits, 19.xii.1930, (H.L. Dozier), ex: *Bunchosia* sp., B.M. 1998-131.

C. malpighiae Russell

Puerto Rico: Guajataca, Gorge, 13.iii.1952, (Martorell & L.M. Russell), ex: *Torrubia fragans*, B.M. 1998-131.

C. micheliae (Takahashi)

Hong Kong: NT, Tai Po Kau, headland forest, 21.xi.1999, (J.H. Martin 7247), ex: *Embelia laeta*, (2 slides).

C. millennium Martin

Holotype, Australia: Northern Territory, Kakadu Nat. Park, Gubara Walk, Burdulba Creek, 20 Km S. of Jabiru, 22.xii.1996, (J.H. Martin 6954), ex: *Xanthostemon eucalyptoides*.

C. morobensis Martin

Paratypes, Papua New Guinea: Morobe Province coast, Buso, 3.x.1979, (J.H. Martin 2655), ex: *Myrtella* sp., (3 slides).

Paratype, Papua New Guinea: Morobe Province coast, Buso riverbank, 11.ix.1979, (J.H. Martin 2531), ex: ?*Decaspermum* sp.

Paratype, Papua New Guinea: Morobe Province coast, Buso riverbank, 12.ix.1979, (J.H. Martin 2547), ex: indet.

C. stigmaphylli Russell

Paratypes, Cuba: Hanabanilla Falls, near Cumanayagua, Santa Clara, 7.iv.1925, (J.G. Myers Q.Z. 3388), ex: *Stigmaphyllon sagraeanum*, B.M. 1998-131.

Puerto Rico: El Asomante Rd, 21.iii.1952, (Martorell & L.M. Russell), ex: *Stigmaphyllon tomentosum*, B.M. 1998-131.

C. tuberculatum Russell

Paratype, Puerto Rico: West of Ponce, 26.x.1902, (A.A. Heller), ex: *Coccoloba obtusifolia*, B.M. 1998-131.

Puerto Rico: Central Aguirre, 25.vi.1925, (H.L. Dozier), ex: *Cordia* sp.

50. *Crescentaleyrodes* David & Jesudasan

C. paulianae (Cohic)

Ivory Coast: Lamto, 25.xi.1988, (J.S. Noyes), ex: *Sorghastrum bipennatum*, (3 slides).

C. semilunaris (Corbett)

Syntypes, Ceylon: Colombo, xi.1903, (E.E. Green), ex: *Cymbopogon* sp., 232/61, B.M. 1927-451, (4 slides).

India: Vellayani, (via New Delhi), 5.viii.1985, ex: *Cymbopogon flexuosus*, C.I.E. A.17357, 25/85.

India: Burliar, 20.vi.1985, (B.V. David), ex: *Cymbopogon* sp., (2 slides).

Brunei: Borneo, Penanjong, 3.iii.1989, (J.H. Martin 5432), ex: Coastal grass, B.M. 1989-89.

51. *Cryptolingula* Martin & Carver

C. perplexa Martin & Carver

Paratypes, Australia: S.A., Black Hill, 14.ix.1952, (D.E. Symon), ex: indet., (4 slides).

52. *Dialeurodes* Cockerell

D. agalmae Takahashi

Hong Kong: Lantau Island, Po Lin, Monastery – Tung Chung path, 26.xi.1999, (J.H. Martin 7300), ex: *Schefflera octophylla*, (2 slides).

D. ara Corbett

Singapore: Napier, Cluny Rds, 29.xii.1996, Botanic Gardens, (J.H. Martin 6991), ex: *Calophyllum* sp., (2 slides).

D. armatus David & Subramaniam

Paratypes, India: Coimbatore, 5.xi.1966, (B.V. David), ex: *Azadirachta indica*, B.M. 1972-24.

D. bicornicauda Martin

Paratypes, Australia: Queensland, 2 Km north of Cape Tribulation, 14.xii.1996, (J.H. Martin 6881), ex: *Dysoxylum parasiticum*, (2 slides).

D. cerifera Quaintance & Baker

?Syntypes, South Africa: Am. Bur. Ent. Coll., B.M. 1921-35, (6 slides).

D. cinnamomi Takahashi
Taiwan: Shihmen, 23.i.1987, (C.C. Ker), ex: indet., B.M. 1987-197.
D. citri (Ashmead)
U.S.S.R.: Truziya, Batumi, 23.viii.1960, (E.M. Danzig), ex: *Citrus* sp., B.M. 1963-708.
Turkey: Adana, 1976, ex: *Citrus* sp., C.I.E. A.9030, 8/77.
U.S.A.: Florida, Nursery at Enfield, Middlesex, 19.xi.1974, ex: *Citrus mitis*.
Greece: Corfu, (Olive Inst.), vii.1979, (S. Pappas), ex: indet., 13/80.
Algeria: Boufarik, 14.xi.1978, (F.D. Bennett), ex: *Citrus* sp., C.I.E. A.10842.
Italy: Vicenza, Po Valley, x.1993, ex: *Ligustrum* sp., I.I.E. 22957.
Taiwan: Meifeng, 9.vi.1986, (C.C. Ker), ex: *Prunus phaeosticta*, B.M. 1987-197.
Taiwan: Wuling, 10.xi.1986, (C.C. Ker), ex: *Eriobotrya deflexa*, B.M. 1987-197.
D. cyathispinifera Corbett
?Syntype, Malaya: Kuala Lumpur, 11.iii.1929, (G.H. Corbett), ex: indet., B.M. 1932-511.
D. decaspermi Martin
Paratypes, Papua New Guinea: Morobe Province coast, Buso, 10.ix.1979, (J.H. Martin 2528), ex: *Decaspermum* sp., (4 slides).
Paratypes, Papua New Guinea: Morobe Province coast, Buso riverbank, 16.x.1979, (J.H. Martin 2713), ex: *Decaspermum* sp.
Paratypes, Papua New Guinea: Morobe Province coast, Buso riverbank, 13.x.1979, (J.H. Martin 2690), ex: ?*Decaspermum* sp.
Paratypes, Papua New Guinea: Morobe Province coast, Buso riverbank, 23.x.1979, (J.H. Martin 2755), ex: *Decaspermum* sp.
D. dubia Corbett
West Malaysia: Pahang Prov., Taman Negara, Tembeling path, 12.iii.1984, (J.H. Martin 4263), ex: indet., (3 slides).
D. emarginata (Mound)
Holotype, Nigeria: Olokomeji, near Ibadan, iii.1961, (E.A. James), ex: *Cola cordifolia*.
Paratypes, Nigeria: Olokomeji, near Ibadan, iii.1961, (E.A. James), ex: *Cola cordifolia*, (2 slides).
D. erythrinae Corbett
Indonesia: Java, Jogjakarta, Hotel Santika, 14.i.2001. (P. De Barro), ex: indet., (2 slides).
D. ixorae Singh
?Syntypes, India: Madras, (Y. Ram Chandra Rao), ex: *Ixora coccinea*, (2 slides).
?Syntypes, India: Chepauk, Madras, 10.viii.1907, (E. Ballard), ex: *Ixora coccinea*, B.M. 1916-75.
Denmark: import fm. Sri Lanka, 1994, Ministry of Agriculture, Sample no. 1057/94, ex: *Ixora odorata*, I.I.E. 23154.
D. joholensis Corbett
West Malaysia: Pahang Prov., Taman Negara, Tembeling path, 12.iii.1984, (J.H. Martin 4261), ex: indet., (3 slides).
D. kirkaldyi (Kotinsky)
Paralectotypes, Hawaii: Honolulu, Hawaiian Sugar Planters Experimental Station, 22.viii.1906, (J. Kotinsky / Quaintance collection Q.4107), ex: Jessamine, B.M. 1998-131, (2 slides).
Malaya: Kuala Lumpur, 16.x.1973, (L.A. Mound), ex: *Pittosporum ferrugineum*, 68/84.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 20.ix.1989, (L.D.C. Fishpool), ex: *Clerodendron* sp.
Cyperus: ex: *Jasminum sambac*.
D. lanceolata Takahashi
Singapore: Botanic Gardens, 15.ix.1980, (D.H. Murphy), ex: *Bhesa panicula*, 14/85, (2 slides).
D. minahassai Martin
Paratypes, Indonesia: Sulawesi Utara, Gunung Mogogonipa, 13.vi.1985, (J.H. Martin 5025), ex: *Eugenia caryophyllata*, (2 slides).
Paratypes, Indonesia: Sulawesi Utara, Gunung Mogogonipa, 8.iv.1985, (J.H. Martin 4806), ex: *Eugenia caryophyllata*.
D. mirabilis Takahashi
Hong Kong: NT, Tai Lung Farm, Sheung Shui, 13.xii.2001, (J.H. Martin 7539A), ex: *Aporusa dioica*.
D. platicus Bondar
Brazil: Bahia, 7.xii.1923, (G. Bondar), ex: Myrtaceae, B.M. 1924-44.

53. *Dialeurolobus* Danzig

D. rhamni Bink-Moenen
Paratypes, Israel: 1 Km S. Solomon's pools, Judaean Hills, 18.ix.1968, (D. Gerling), ex: *Rhamnus* sp., (2 slides).
Iran: Fars, Farashband, 22.x.1990, (M. Zarrabi 19), ex: *Punica granatum*, (2 slides).
Turkey: Iskenderun, 15.xii.1986, (via N. Hygun 3), ex: *Punica granatum*.

54. *Dialeurolonga* Dozier

D. africana (Newstead)
Syntypes, Nigeria: Ibadan, Moor Plantation, v.1917, (C.O. Farquharson), ex: *Salacia* sp., (4 slides).
D. communis Bink-Moenen
Holotype, Chad: Bebedjia, 395 m, 26.xii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Allophylus africanus*, B.M. 1976-56.
Paratype, Chad: Bebedjia, 395 m, 26.xii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Allophylus africanus*, B.M. 1976-56.
Paratype, Chad: Baïbokoum, 500 m, 19.xi.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Citrus* sp., B.M. 1976-56.
Sudan: Wad Medani, xi.1961, (L.A. Mound), ex: *Citrus* sp., B.M. 1963-777, (2 slides).
D. elliptica Takahashi
Madagascar: Ihosy, v.1951, (R. Takahashi), ex: *Plumeria* sp., 104/62, B.M. 1962-401, (3 slides).
D. elongata Dozier
Syntypes, India: Punjab, 29.iii.1926, (M.A. Husain), ex: *Citrus* sp., I.B.E. 309, (2 slides).
Syntypes, India: Punjab, ?1928, (M.A. Husain), ex: *Citrus* sp., I.B.E. 309, 46/61, cf. B.M. 1928-181, (2 slides).
Syntypes, India: Punjab, (M.A. Husain), ex: *Citrus* sp., I.B.E. 309, B.M. 1928-181.
India: Maharashtra, Akola, 10.i.1985, ex: *Citrus* sp., C.I.E. A.17113, (2 slides).
D. hoyti Mound
Holotype + paratype, Nigeria: Agege, near Lagos, xi.1959, (C.P. Hoyt), ex: Coffee.
Paratypes, Nigeria: Agege, near Lagos, xi.1959, (C.P. Hoyt), ex: ?Coffee, (4 slides).

Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 22.xi.1989, (L.D.C. Fishpool 81), ex: *Trichilia heudelotii*.

D. maculata (Singh)

Patatypes, India: Madras, 3.viii.1971, (B.V. David), ex: *Ficus religiosa*, B.M. 1972-24.

D. nemoralis Bink-Moenen

Holotype, Chad: Bentam (Donia), 451 m, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1976-56.

Paratype, Chad: Bentam (Donia), 451 m, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1976-56.

D. phyllarthronis Takahashi

Madagascar: Antsirabé, vii.1955, (R. Paulian), ex: Cerisier du Brésil, 106/62, B.M. 1962-401, (3 slides).

D. ravensarae Takahashi & Mamet

Syntypes, Madagascar: Besanatrihely, Haut Sambirano, 1000 m, x. 1949, (R. Paulian), ex: *Ravensara* sp.

D. rusostigmoides Martin

Paratypes, Australia: Queensland, Cooper's Creek, 20 Km S. of Cape Tribulation, 18.xii.1996, (J.H. Martin 6915), ex: indet., B.M. 1998-50, (2 slides).

D. swainei Martin

Paratypes, Australia: Queensland, Broadbeach, viii-ix.1970, (G. Swaine), ex: *Ficus* sp., 16/71, (6 slides).

D. tenella Takahashi

Syntypes, Madagascar: Ambilobé, iv.1951, (R. Paulian), ex: Barabanja, 103/62, B.M. 1962-401, (2 slides).

Syntype, Madagascar: Ambilobé, iv.1951, (R. Paulian), ex: Barabanja.

D. trialeuroides Takahashi & Mamet

Syntypes, Madagascar: Antsohihy, x.1949, (R. Paulian), ex: indet.

55. *Dialeuropora* Quaintance & Baker

D. brideliae (Takahashi)

Taiwan: Keelung, 28.vi.1990, (C.C. Ko), ex: indet., B.M. 1994, (2 slides).

Taiwan: Hungyeh, 26.ii.1990, (C.C. Ko), ex: indet.

D. decempuncta (Quaintance & Baker)

Paralectotypes, Sri Lanka: Royal Botanic Gardens, 7.x.1910, (R.S. Woglum / Quaintance collection Q. 6729A), ex: *Cinnamomum* sp., B.M. 1998-131, (3 slides).

Hong Kong: NT, East Ping Chau I, 5.xii.2001, (J.H. Martin 7528), ex: *Celtis* sp.

Hong Kong: Lantau Island, hillside E. of Shek Pik Reservoir, 15.xi.1996, (J.H. Martin 6820), ex: *Glochidion eriocarpum*.

Hong Kong: Victoria Peak, Harlech Road, 22.x.1990, (J.H. Martin 5826), ex: *Litsea glutinosa*.

West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 11.iii.1984, (J.H. Martin 4259), ex: *Flemingia macrophylla*, (2 slides).

Australia: WA, Kununurra, 5.v.2000, (J.H. Martin 7430), ex: *Eucalyptus grandifolia*.

D. mangiferae (Corbett)

West Malaysia: Pahang Prov., Genting Highlands at 2000′, 24.iii.1984, (J.H. Martin 4314), ex: *Mangifera indica*.

D. papillata Cohic

Syntype, Congo: Brazzaville, 5.iii.1965, (F. Cohic), ex: *Platysepalum vanderystii*, B.M. 1965-305.

Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 5.x.1989, (L.D.C. Fishpool 8), ex: *Microdesmis puberula*.

Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 17.xi.1989, (L.D.C. Fishpool 79), ex: *Smeathmannia pubescens*.

Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 28.iv.1981, (J.H. Martin 3348), ex: *Ficus ?capensis*.

Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 30.iv.1981, (J.H. Martin 3358), ex: *Syzygium guineense*, (2 slides).

Cameroon: Mbalmayo, viii.2000, (A. Polaszek), ex: *Musa* sp., (2 slides).

D. silvarum (Corbett)

West Malaysia: Pahang Prov., Tioman I., Kampung Tekek, 16.iii.1984, (J.H. Martin 4276), ex: ?Leguminosae, (3 slides).

D. viburni (Takahashi)

Taiwan, Nanjenshan, 24.ii.1990, (C.C. Ko), ex: indet.

Taiwan, Nanjenshan, 24.ii.1990, (C.C. Ko), ex: indet., B.M. 1994.

Taiwan, Loloshan, 13.ii.1987, (C.C. Ko), ex: *Turpinia formosana*, B.M. 1994.

56. *Disiphon* Russell

Disiphon sp.

Belize: Cayo, Chiquibul forest, Las Cuevas plots, 6.xi.1994, (J.H. Martin 6462), ex: *Piper* sp., (2 slides).

Belize: Cayo, Chiquibul forest, Grano de Oro track, 22.xi.1994, (J.H. Martin 6506), ex: ?Laurel.

57. *Dumbletoniella* Jesudasan & David

D. callistemoni Martin

Paratypes, Australia: A.C.T., Canberra, Black Mountain, Nat. Botanic Gardens, 27.xi.1996, (J.H. Martin 6833), ex: *Callistemon shiresii*, B.M. 1998-50, (2 slides).

Paratypes, Australia: A.C.T., Canberra, Black Mountain, Nat. Botanic Gardens, 27.xi.1996, (J.H. Martin 6833), ex: *Callistemon* sp., B.M. 1998-50.

Australia: New South Wales, Univ. W. Sydney, Hawkesbury – Richmond campus, 15.iv.2000, (J.H. Martin 7387), ex: *Callistemon* sp., (2 slides).

D. eucalypti (Dumbleton)

Paratypes, New Zealand: Waikakaho, Blenheim, 3.xi.1950, (L.J. Dumbleton), ex: *Eucalyptus globulus*, (3 slides).

New Zealand: ?Nelson, ?Waskaho, ex: *Eucalyptus globulus*, 9/65, B.M. 1964-721, (2 slides).

New Zealand: ?Nelson, ?Waskaho, ex: *Eucalyptus globulus*, B.M. 1964-721.

New Zealand: ?Nelson, ex: *Eucalyptus globulus*, 9/65, B.M. 1964-721.

D. pittospori Martin & Carver

Paratypes, Australia: Victoria, Mallee, 1925, (J.E. Dixon), ex: *Pittosporum phylliraeoides*, 32/61, B.M. 1961-4, (3 slides).

Paratypes, Australia: Adelaide, Waite Hill, 23.xi.1967, (L.A. Mound), ex: *Pittosporum phylliraeoides*, 36/71, (3 slides).

D. rotunda Martin & Carver

Paratypes, Australia: Vic, Indigo, 17.ix.1914, (E.E. Pescott), ex: *Eucalyptus leucoxylon*.

Paratypes, Australia: Queensland, Barakula, 5.x.1939, ex: *Eucalyptus crebra*, (4 slides).

Paratypes, Australia: Western Australia, Perth, King's Park, 4.iii.1959, (V.F. Eastop 7362), ex: *Banksia* sp. (?*Dryandra* sp.), 149/61, B.M. 1960-144. (In the original description ex: *Eucalyptus* sp.).

D. xanthorrhoeae Martin

Paratypes, Australia: S.A., Kangaroo Island, Flinders Chase N. P., 17.ii.1990, (J.H. Martin 5657), ex: *Xanthorrhoea australis*, B.M. 1998-50, (5 slides).

58. *Extensaleyrodes* Bink-Moenen

E. akureensis (Mound)

Holotype, Nigeria: Akure, 8.i.1957, (V.F. Eastop 6511), ex: indet., 65/61.

Paratypes, Nigeria: Akure, 8.i.1957, (V.F. Eastop 6511), ex: indet., 65/61, (2 slides).

E. falcata Bink-Moenen

Holotype, Chad: Boro, 453 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Isoberlinia doka*, B.M. 1976-56.

Paratypes, Chad: Boro, 453 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Isoberlinia doka*, B.M. 1976-56, (2 slides).

59. *Fascaleyrodes* Bink-Moenen

F. palmae (Gameel)

Nigeria: Moor Plantation area, iii.1961, (?L.A. Mound), ex: Palm, (2 slides).

Nigeria: Moor Plantation area, iv.1961, (?L.A. Mound), ex: Palm.

F. rara Bink-Moenen

Holotype, Chad: Donia (Bentam, in the original description), 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*.

Paratypes, Chad: Donia (Bentam, in the original description), 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*.

60. *Filicaleyrodes* Takahashi

F. bosseri Takahashi

Syntypes, Madagascar: Tsimbazaza, Tananarive, viii.1956, (J. Bosser), ex: Fern, 114/61, B.M. 1961-455.

F. williamsi (Trehan)

Lectotype, England: Surrey, Kew Gardens, 17.ix.1937, (K.N. Trehan and/or C.B. Williams), ex: *Oleandra africana*, 207/62, B.M. 1962-643.

Type series, England: Surrey, Kew Gardens, 20.i.1937, (K.N. Trehan and/or C.B. Williams), ex: *Oleandra* sp., 207/62, B.M. 1962-643.

Type series, England: Surrey, Kew Gardens, ii.1938, ex: Ferns.

61. *Fippataleyrodes* Sundararaj & David

F. indica Sundararaj & David

Paratype, India: Cumbum, 10.i.1988, (S. Selvakumaran), ex: *Ficus racemosa*.

F. litseae ?Sundararaj & David

Paratype, India: Mahableshwar, 28.iii.1987, (B.V. David), ex: *Litsea stocksii*.

62. *Gagudjuia* Martin

G. allosyncarpiae Martin

Paratypes, Australia: Northern Territory, Kakadu Nat. Park, Gubara Walk, Burdulba Creek, 20 Km S. of Jabiru, 22.xii.1996, (J.H. Martin 6955), ex: *Allosyncarpia ternata*, (6 slides).

63. *Gomenella* Dumbleton

G. dryandrae (Takahashi)

Lectotype, Australia: Western Australia, Nedlands, 20.v.1940, (K.R. Norris), ex: *Dryandra floribunda*, 7/40, B.M. 1955-799.

Australia: Western Australia: Perth, King's Park, 4.iii.1959, (V.F. Eastop 7362×1), ex: *Banksia* sp. (or ?*Dryandra* sp.), B.M. 1960-144.

Australia: New South Wales, Cowan, 24.x.1978, (F. Wheelhouse 10), ex: *Banksia spinulosa*, C.I.E. A.12322.

U.S.A. ex-Australia: New York, 30.iii.1974, (R. Scott), ex: *Banksia hookeriana*, B.M. 1998-131.

G. multipora Dumbleton

Paratype, New Caledonia: Tinip, 4.xi.1954, (L.J. Dumbleton), ex: indet., B.M. 1964-221.

64. *Harpaleyrodes* Bink-Moenen

H. tuberculata Bink-Moenen

Paratypes, Chad: Bebedjia, 390 m, 17.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Combretum hypopilinum*, B.M. 1977-471, (3 slides).

65. *Hempelia* Sampson & Drews

H. chivelensis Sampson & Drews

Syntype, Mexico: Chivela, Oaxaca, iv.1926, (G.F. Ferris), ex: indet., B.M. 1998-131.

Belize: Cayo, Chiquibul forest, Las Cuevas Res. Stn, 4.xi.1994, (J.H. Martin 6451), ex: *Persea* ?*americana*, (3 slides).

Belize: Cayo, Chiquibul forest, Las Cuevas clearing, 10.ii.1996, (J.H. Martin 6633), ex: *Persea* sp.

66. *Heteraleyrodes* Takahashi

H. bambusicola Takahashi

Holotype, Malaya: Kuala Lumpur, 13.iii.1944, (R. Takahashi), ex: Bamboo, B.M. 1955-799.

West Malaysia: Kuala Lumpur, Lake Gardens, 11.ii.1985, (J.H. Martin 4454), ex: Bamboo.

67. *Heterobemisia* Takahashi

H. alba Takahashi

Syntype, Japan: Odaig-ahara, Nara Pref., 15.viii.1956, (R. Takahashi), ex: *Itea japonica*.

68. *Indoaleyrodes* David & Subramaniam

I. glochidioni Martin & Carver

Paratypes, Australia: Queensland, Great Keppel Island, 2.vii.1991, (J.J. Bruhl & G.N. Batianoff), ex: *Glochidion lobocarpum*, B.M. 1998-51, (2 slides).

Australia: Queensland, 50 Km S. of Bowen, 20.iv.2001, (P. De Barro 76), ex: *Glochidion* sp.

I. laos (Takahashi)

Paratypes: India: Coimbatore, 25.iii.1967, (B.V. David), ex: *Morinda tinctoria*, B.M. 1972-24, (2 slides).

India: Madras, 6.i.1972, (B.V. David), ex: *Morinda tinctoria*, 3/72, (4 slides).

I. pseudoculatus Martin

Paratypes, Papua New Guinea: Morobe Province coast, Buso, 8.x.1979, (J.H. Martin 2674), ex: *Syzygium* sp., (4 slides).

69. *Kanakarajiella* David & Sundararaj

K. vulgaris (Singh)

India: Chikmugalur, Coffee Research Stn, i-ii.1969, ex: Coffee, C.I.E. A2803, 1/69, (4 slides).

Burma: Rangoon, 28.viii.1984, (T.J. Crowe), ex: *Jasminum* sp., C.I.E. A16401, 147/84, (2 slides).

70. *Leucopogonella* Dumbleton

L. pallida Dumbleton

Paratypes, New Caledonia: Plum, (L.J. Dumbleton), ex: *Leucopogon* sp., B.M. 1964- 721.

L. simila Dumbleton

Paratypes, New Caledonia: Plum, (L.J. Dumbleton), ex: *Leucopogon* sp., B.M. 1964- 721.

71. *Lipaleyrodes* Takahashi

L. atriplex (Froggatt)
Paralectotype, Australia: N.S.W. Broken hill, 25.v.1911, (W.W. Froggatt), ex: Saltbush, (2 slides).
L. breyniae (Singh)
Maldives: Addu Atoll, Feydhoo, 12.xi.1993, (G.W. Watson 100), ex: *Phyllanthus distichus*, I.I.E. 22974, (4 slides).
L. crossandrae David & Subramaniam
Paratypes, India: Coimbatore, 18.xi.1966, (B.V. David), ex: *Achyranthes aspera*, B.M. 1972-24, (2 slides).
L. euphorbiae David & Subramaniam
Paratypes, India: Madurai, 28.i.1967, (B.V. David), ex: *Euphorbia prostrata*, B.M. 1972-24.
India: Hebbal, Bangalore, 20.vi.1997, (via A. Polaszek), ex: *Phyllanthus fratteranae*.
Kenya: Ganze, 30.xi.1983, (I. Robertson 9/9), ex: *Phyllanthus amarus*, 21/84, (3 slides).
L. phyllanthi Takahashi
Syntypes, Madagascar: Massif de l'Tremo, 1700 m, (J. Bosser), ex: *Phyllanthus* sp., 115/61, B.M. 1961-455.
Hong Kong: HK, Tai Tam, Interm. Reservoir, 6.xii.1999, (J.H. Martin 7311), ex: *Blumea* sp.

72. *Malayaleyrodes* Corbett
M. ?lumpurensis corbett
West Malaysia: Pahang Prov., Pulau Tioman I., Kampung Tekek, 17.ii.1985, (J.H. Martin 4509), ex: ?*Tetracera* sp.

73. *Marginaleyrodes* Takahashi
M. ixorae Takahashi
Syntypes, Madagascar: Between Mahattsinjo and Andriba, ex: *Ixora* sp., 102/62, B.M. 1962-401, (3 slides).

74. *Massilieurodes* Goux
M. americanus Jensen
U.S.A.: Maryland, Prince George's Co., Beltsville, Beaver Dam Road area, 2.vii.1998, (J.H. Martin 7108), ex: *Ilex* sp.
U.S.A.: Maryland, Prince George's Co., Beltsville, USDA campus, 3.vii.1998, (J.H. Martin 7112), ex: *Ilex* sp., (2 slides).
M. chittendeni (laing)
Lectotype, England: Ascot, 23.v.1928, (G. Fox-Wilson), ex: *Rhododendron* sp.
Paralectotypes, England: Ascot, vi.1928, (G. Fox-Wilson), ex: *Rhododendron* sp., (4 slides).
England: Surrey, Richmond Park, 19.vi.1984, (J.H. Martin 4352), ex: *Rhododendron* sp.
England: Surrey, Richmond Park, 27.vi.1984, (J.H. Martin 4353), ex: *Rhododendron* sp.
Italy: Cermenake (Co.), vi.2000, (M. Colombo 2), I.I.E. 24199, ex: *Rhododendron ifs*, B.M. (E) 2001-110.
M. euryae (Takahashi)
Syntypes, Taiwan: Neng Kao, 6.viii.1939, (R. Takahashi), ex: *Eurya glaberrima*, B.M. 1994, (3 slides).
M. fici (Takahashi)
Taiwan: Sanhsing, 23.ix.1993, (K.C. Chou), ex: *Ficus virgata*, B.M. 1994, (2 slides).
Taiwan: Taipei, 4.x.1986, (C.C. Ker), ex: *Bischofia javanica*.
Taiwan: Taichung, 5.ix.1967, (Y.C. Chang 8), ex: *Bischofia javanica*, 20/67, B.M. 1967-592, (3 slides).
M. setiger (Goux)
France: Corsica, Solenzara, Col de Larone road, D268, 27.x.1999, (J.H. Martin 7237), ex: *Viburnum tinus*.
Italy: Campania, Portici grounds, 10.vi.1987, (A. Polaszek & S. Laudonia), ex: *Viburnum* sp., C.I.E. A19249, 4/88, (2 slides).
Italy: Portici, 9.iv.1984, (F.M. Laccarino), ex: *Viburnum tinus*, 59/84.
Morocco: Middle Atlas, Ifrane, ± 1600 m, 26.iv.1992, (J.H. Martin 6076), ex: *Viburnum tinus*, B.M. 1992-73, (2 slides).

75. *Metabemisia* Takahashi
M. filicis Mound
Paratypes, Scotland: Edinburgh, Royal Botanic Gardens, glasshouse, 27.v.1966, (L.A. Mound & B.R. Pitkin), ex: *Dryopteris* sp., (4 slides).
Paratypes, Scotland: Edinburgh, Royal Botanic Gardens, glasshouse, 31.i.1966, (E.C. Pelham-Clinton), ex: Ferns, B.M. 1966-73, (4 slides).
M. palawana Martin
Paratypes, Philippine Islands: Palawan, Irawan/Iwahig, forest, 2000′, 11.ii.1988, (J.H. Martin 5265), ex: *Lastreopsis ?subsparsa*, B.M. 1988-2, (2 slides).

76. *Minutaleyrodes* Jesudasan & David
M. minuta (Singh)
India: Madras, 11.ii.1972, (B.V. David), ex: *Ixora coccinea*, B.M. 1972-24.
Singapore: Botanic Gardens, 15.ix.1980, (D.H. Murphy), ex: *Bhesa paniculata*, 14/58.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 1.xi.1989, (L.D.C. Fishpool 31), ex: *Ixora* sp.
Taiwan: Fengshan, 22.xi.1993, (K.C. Chou), ex: *Ixora* sp.
M. suishanus (Takahashi)
Philippine Islands: Palawan, Honda Bay, 7.ii.1988, (J.H. Martin 5251), ex: indet., B.M. 1988-2, (2 slides).

77. *Mixaleyrodes* Takahashi
M. ?polystichi Takahashi
Taiwan: Lienhuachih, 2.v.1994, (K.C. Chou), ex: *Angiopteris lygodiifolia*, B.M. 1994, (2 slides).

78. *Neoaleurotrachelus* Takahashi & Mamet
N. bertilloni (Cohic)
Syntype, Congo: Brazzaville, 21.iii.1964, (F. Cohic), ex: *Tetracera alnifolia*, B.M. 1965-305.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 6.xi.1989, (L.D.C. Fishpool 40), ex: *Cryptolepis sanguinolenta*.
N. graberi (Cohic)
Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 28.iv.1981, (J.H. Martin 3348), ex: *Ficus ?capensis*.
Sudan: Khartoum, Botanic Garden, 13.iv.1981, (J.H. Martin 3280), ex: indet., (2 slides).
Sudan: Wad Medani, xii.1962, (L.A. Mound), ex: *Zizyphus spinachrish*, B.M. 1963-777, (2 slides).
Sudan: Wad Medani, i.1962, (L.A. Mound), ex: *Lawsonia alba*, B.M. 1963-777.
Chad: Timberi, 407 m, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Gardenia triacantha*, 74/81.

79. *Neomaskellia* Quaintance & Baker
N. andropogonis Corbett

Syntypes, Ceylon: Bandarawalla, v.1906, (E.E. Green), ex: *Andropogon* sp., B.M. 1927-451.
Hong Kong: NT, west Tai Mo Shan, Country Park, Ho Pui reservoir, 13.xii.2001, (J.H. Martin 7567), ex: *Saccharum ?spontaneum*, (2 slides).
India: Lucknols, Inst. Sugar Cane Res., iv.1966, ex: Sugar Cane, C.I.E. A1284, 26/66, (2 slides).
West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 10.iii.1984, (J.H. Martin 4247), ex: *Saccharum* sp.
West Malaysia: Selangor Prov., Genting Highlands, 1.v.1994, (D.J. Williams 1507), ex: indet.
Pakistan, Rawalpindi, 1.iv.1960, ex: *Bauhinia variegata*, C.I.E. 18414, 16/63.

N. bergii (Signoret)
S. Nigeria: Ibadan, 6.i.1964, (W.A. Lambom), ex: Grass, 40/62, (2 slides).
E. Nigeria: Ikom, 11.ii.1957, (Eastop 6766), ex: Elephant grass.
Brunei: 1971, (Kassim bin Ahmad), ex: Sugar Cane, C.I.E. A4463/18, 1/71, (2 slides).
Seychelles: Mahé, v.1970, (P.L. Mathias), ex: Gramineae, 1/72, (3 slides).
Papua New Guinea: Morobe Prov., Lasanga Island, 20.x.1979, (J.H. Martin 2735), ex: *Saccharum ?officinarum*, (2 slides).
Papua New Guinea: Bubia, Dept. of Agriculture, 15.vii.1968, ex: Sugar Cane, C.I.E. A3299/12, 11/69.
Pakistan: Dacca, Locust Waming & Plant Quar. Dept., 27.vi.1967, ex: Sugar Cane, C.I.E. A1797/10, 16/67.
Topotypic, Fiji Islands: (R. Veitch), ex: Gramineae, B.M. 1915-240, (3 slides).

80. *Neopealius* Takahashi

N. rubi Takahashi
Taiwan: 24.xi.1993, (Warren), ex: *Rubus* sp., 22176/7, 93-1369, I.I.E. 22997.

81. *Nigrasialeyrodes* Martin & Carver

N. convexus Martin & Carver
Paratypes: Australia: Queensland, Townsville, James Cook University campus, 2.vi.1992, (D.W. Burrows), ex: *Melaleuca viridiflora*, B.M. 1998-51, (3 slides).
Paratypes: Australia: Queensland, Townsville, James Cook University campus, 19.xii.1991, ex: *Melaleuca quinquenervia*, B.M. 1998-51.

82. *Orchamoplatus* Russell

O. caledonicus (Dumbleton)
Paratype, New Caledonia: Noumea, 24.v.1955, (L.J. Dumbleton), ex: *Citrus* sp., B.M. 1964-721.
New Caledonia: 28.ii.1956, (J.F. Schoen 56-2755), ex: *Ochrosia* sp., B.M. 1998-131.

O. citri (Takahashi)
Australia: Adelaide, xi.1967, (L.A. Mound), ex: *Citrus* sp., 35/71, (4 slides).
Lord Howe Island: xi.2001, (L.A. Mound), ex: *Psidium cattelianum*, (2 slides).

O. dentatus (Dumbleton)
Paratype, New Caledonia: Carenage, 8.iv.1955, (L.J. Dumbleton), ex: Myrtaceae, B.M. 1964-721.
New Caledonia: near Nouméa, 1912, (Franc), ex: *Microsemma salicifolia*, (2 slides).

O. louiserussellae Martin
Paratypes, Australia: Queensland, strand 2 Km north of Cape Tribulation, 15.vii.1996, (J.H. Martin 6883), ex: *Syzygium* sp., B.M. 1998-50, (5 slides).

O. mammaeferus (Quaintance & Baker)
Lectotype, Samoa: Upolu, Apia, iv.1925, (P.A. Buxton & G.H. Hopkins), ex: Croton.
Paralectotypes, Samoa: Upolu, Apia, iv.1925, (P.A. Buxton & G.H. Hopkins), ex: Croton, (3 slides).
Cook Islands: Aitutaki, ii.1960, (N.L.K. Krauss 2), ex: indet., (3 slides).
Fiji: Viti Levu, Rakiraki, iv.1982, (L.A. Mound), ex: indet., 14/82.
Fiji: Nausori, 30.iii.1967, (G. Swaine), ex: Croton, C.I.E. A1757, 15/67.
Fiji: Viti Levu, Suva, 23.iii.1976, (P. Maddison), ex: *Codiaeum variegatum*, C.I.E. A9356.
French Polynesia: Tahiti, 9.vii.1976, (P. Maddison), ex: *Citrus reticulata*, C.I.E. A9023.
French Polynesia: Tahiti, 8.vii.1976, (P. Maddison), ex: *Citrus grandis*, C.I.E. A9023.

O. montanus (Dumbleton)
Pararypes, New Caledonia: Plaine des Lacs, 8.iv.1955, (L.J. Dumbleton), ex: indet., B.M. 1964-721, (2 slides).
New Caledonia: near Nouméa, 1912, (Franc), ex: *Microsemma salicifolia*, (2 slides).

O. niuginii Martin
Paratypes, Papua New Guinea: Morobe Prov. coast, Lasanga Island, 18.ix.1979, (J.H. Martin 2581), ex: *Calophyllum inophllum*, (4 slides).
Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 30.ix.1979, (J.H. Martin 2643), ex: *Calophyllum inophllum*, (2 slides).
Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 8.ix.1979, (J.H. Martin 2676), ex: *Durandea* sp., (2 slides).

O. noumeae Russell
Paratype, New Caledonia: Noumea, 31.x.1940, (F.X. Williams), ex: *Citrus* sp., B.M. 1998-131.

O. plumensis (Dumbleton)
Paratype, New Caledonia: Plum, (L.J. Dumbleton), ex: indet., B.M. 1964-721.

O. porosus (Dumbleton)
Paratype, New Caledonia: Carenage, 8.iv.1955, (L.J. Dumbleton), ex: Myrtaceae, B.M. 1964-721.

83. *Orientaleyrodes* David

O. zeylanicus (Corbett)
Syntypes, Sri Lanka: Trincomalee, v.1906, (T.B. Fletcher), ex: indet., B.M. 1927-451.
Syntypes, Sri Lanka: Trincomalee, vi.1906, (T.B. Fletcher), ex: indet., B.M. 1927-451, (3 slides).

84. *Orstomaleyrodes* Cohic

O. fimbriae (Mound)
Paratypes, Nigeria: Ibadan, Moor Plantation, ii.1961, (L.A. Mound), ex: *Cassia siamea*, (5 slides).
Paratypes, Nigeria: Ibadan, Moor Plantation, i.1961, (L.A. Mound), ex: *Cassia siamea*.
Paratypes, Nigeria: Ibadan, Moor Plantation, iii.1961, (E.A. James), ex: *Cassia siamea*.
Congo: Brazzaville, 29.i.1964, ex: *Caloncoba welwitschii*, Al 14-65, B.M. 1965-305.
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 3.xi.1989, (L.D.C. Fishpool 33), ex: *Milletia zechiana*.

85. *Papillipes* Bink-Moenen

P. spinifer Bink-Moenen
Holotype, Chad: Bebedjia, 395 m, 4.i.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Daniellia olivera*, B.M. 1977-471.

86. *Parabemisia* Takahashi

P. aceris (Takahashi)

Taiwan: Taipei, 15.i.1986, (C.C. Ker), ex: *Acer* sp., B.M. 1987-197.

P. jawani Martin

Paratypes, Papua New Guinea: Morobe Prov. coast, Jawani Island, 2.xi.1979, (J.H. Martin 2789), ex: ?*Timonius* sp., (5 slides).

P. lushanensis Ko & Luo

Paratypes, Taiwan: Nengkao, 24.x.1989, (C.C. Ko), ex: indet.

P. myricae (Kuwana)

Australia: Queensland, Carnarvon Gorge, 24.x.2001, (P. De Barro 107), ex: *Glochidion* sp.

Israel: Hefar, Placcab, 26.ix.1978, (A. Sternlicht), ex: *Citrus* sp., 15/78.

Israel: Akko, iii.1979, (A. Sternlicht), ex: *Citrus* or *Persea*, 1/69.

Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 20.xii.1989, (L.D.C. Fishpool 115), ex: *Persea americana*.

Turkey: Adana, 15.ii.1986, (E. Sekeroglu), ex: *Citrus* sp., 2/86.

P. myrmecophila Martin

Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 27.ix.1979, (J.H. Martin 2629), ex: *Cryptocarya* sp., (3 slides).

Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 27.ix.1979, (J.H. Martin 2626), ex: *Anisoptera thurifera*, (2 slides).

Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 27.ix.1979, (J.H. Martin 2627), ex: *Macaranga* sp.

Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 26.ix.1979, (J.H. Martin 2622), ex: *Prunus* sp.

Paratypes, Papua New Guinea: Morobe Prov. coast, Buso, 5.xi.1979, (J.H. Martin 2799), ex: *Prunus* sp.

87. *Paraleurolobus* Sampson & Drews

P. chamaedoreae Russell

Paratypes, Mexico: intercepted at San Antonio, U.S.A., 4.i.1970, (C. Parker), ex: *Chamaedorea* sp., B.M. 1998-131.

Paratype, Mexico: intercepted at San Antonio, U.S.A., ix.1974, (C. Parker), ex: *Chamaedorea* sp.

Paratypes, Mexico: intercepted at San Antonio, U.S.A., 2.v.1970, (D. Johnston), ex: *Chamaedorea* sp., B.M. 1998-131.

Costa Rica: N. Heredia Province, ~10 Km north of Puerto Viejo, 2.ii.1983, (J.H. Martin 3746), ex: indet.

Costa Rica: N. Heredia Province, ~10 Km north of Puerto Viejo, 2.ii.1983, (J.H. Martin 3747), ex: ?*Flacoutiae* sp.

88. *Paulianaleyrodes* Cohic

P. splendens Cohic

Syntype, Congo: Brazzaville, 10.xii.1964, ex: *Dichapetalum brazzae*, B.M. 1965-305.

P. tetracerae Cohic

Syntype, Congo: Brazzaville, 8.i.1964, ex: *Tetracera alnifolia*, B.M. 1965-305.

89. *Pealius* Quaintance & Baker

P. akebiae (Kuwana)

Japan: Hikawa, Tokyo, 9.viii.1950, (R. Takahashi), ex: *Akebia lobata*, 97/62, B.M. 1962-401, (3 slides).

P. azaleae (Baker & Moles)

Paratypes, India: Ootacamund (Nilgiris), 7000′, 3.vii.1969, (B.V. David), ex: *Azalea indica*, B.M. 1972-24.

Australia: A.C.T., Canberra, Weston, 19.xi.1996, (J.H. Martin 6826), ex: *Azalea* sp., B.M. 1998-50, (3 slides).

England: Surrey, Wisley, R.H.S. gdns., xi.1968, (K.M. Harns), ex: *Azalea* sp.

England: Wisley, R.H.S. gdns., 8.vii.1965, (L.A. Mound 76), ex: *Rhododendron mucronatum*.

Taiwan: Fenchifu, 11.iii.1990, (C.C. Ko), ex: *Rhododendron* sp.

P. cryptus Martin

Paratypes, Australia: Northern Territory, Kakadu Nat. Park, Nawurlandja lookout, 25 Km S. of Jabiru, 21.xii.1996, (J.H. Martin 6948), ex: *Ficus platypodia*, B.M. 1998-50, (3 slides).

P. euryae (Takahashi)

Syntypes, Japan: Ome, nr Tokyo, 17.viii.1949, (R. Takahashi), ex: *Eurya* sp., 96/62, B.M. 1962-401, (3 slides).

P. fici Mound

Paratypes, Nigeria: Samaru, Zaria, 26.x.1960, (M.O. Ezeigwe), ex: *Ficus asperifolia*, (3 slides).

Paratypes, Nigeria: Agege nr Lagos, 10.viii.1960, (M.O. Ezeigwe), ex: *Ficus asperifolia*.

Paratype, Nigeria: Ibadan, Oyo Road, vi.1961, ex: *Ficus* sp.

Paratypes, Nigeria: Ibadan, 16.v.1956, (V.F. Eastop 5950), ex: *Ficus* sp.

Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 28.iv.1981, (J.H. Martin 3348), ex: *Ficus* ?*capensis*.

Sudan: S. Darfur, Jebel Marra, S. W. side, Wadi Golol, 29.iv.1981, (J.H. Martin 3353), ex: *Ficus* ?*glumosa*.

P. kelloggi (Bemis)

U.S.A.: California, Sacramento, 11.vii.1966, (R.F. Wilkey), ex: *Prunus lyoni*, 25/66, (8 slides).

P. liquidambari (Takahashi)

Taiwan: Taipei, 28.xii.1985, (C.C. Ko), ex: *Liquidambar formosana*.

Taiwan: Taipei, 22.xi.1985, (C.C. Ko), ex: *Liquidambar formosana*, B.M. 1987-197.

P. madeirensis Martin *et al.*

Paratypes, Madeira: Faja da Noguiera, hydro dam, 28.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6552), ex: *Picconia excelsa*, (2 slides).

Paratypes, Madeira: Ribeiro Frio, 800 m, 28.iii.1995, (J.H. Martin & A.F. Aguiar, JHM 6545), ex: *Picconia excelsa*, (2 slides).

Paratypes, Madeira: Santana, Caldeirao do Inferno, 985 m, 27.vi.1993, (M. Pita C214), ex: *Picconia excelsa*.

P. mori (Takahashi)

Taiwan: Taipei, 18.vi.1968, (Y.C. Chang), ex: *Morus australis*, 4/68, (4 slides).

Taiwan: Taipei, 26.iv.1992, (C.C. Ko), ex: *Ficus* sp.

Thailand: Bangkok, iii.1973, (K. Sombatsiri), ex: Mulberry, 6/73, (3 slides).

P. rhododendri Takahashi

Hawaiian Islands: Hawai'i, Akaka Falls, 10 mi. N. of Hilo, 5.iv.1999, (J.H. Martin 7207), ex: *Rhododendron* sp., (2 slides).

Hong Kong: H K Island west, University campus, 12.xi.1996, (J.H. Martin 6784), ex: *Rhododendron pulchrum*, (4 slides).
Japan: Minoh nr Osaka, 29.viii.1955, (R. Takahashi), ex: *Rhododendron* sp., 95/62, B.M. 1962-401, (3 slides).

90. *Pectinaleyrodes* Bink-Moenen

P. culcasiae (Cohic)
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 20.x.1989, (L.D.C. Fishpool 20), ex: *Culcasia liberica*, (2 slides).

P. triclisiae (Cohic)
Syntype, Belgian Congo: Brazzaville, 7.ix.1965, ex: *Triclisia gilletii*, B.M. 1965-305.
Chad: Donia, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: Annonaceae, B.M. 1976-56, (2 slides).

91. *Pentaleyrodes* Takahashi

P. cinnamomi (Takahashi)
Taiwan, Wulai, 27.xii.1931, (R. Takahashi), ex: *Machilus* sp., B.M. 1994, (3 slides).

P. hongkongensis Takahashi
Hong Kong: Pok Fu Lam, Country Park, below High West, 12.xii.2001, (J.H. Martin 7557), ex: *Litsea rotundifolia* var. *oblongifolia*, (2 slides).
Hong Kong: Victoria Peak, 3.iii.1990, (J.H. Martin 5693), ex: *Machilus chinensis*, (2 slides).

P. yasumatsui Takahashi
Japan: Nara, 10.v.1959, (R. Takahashi), ex: *Lindera* sp., 99/62, B.M. 1962-401, (5 slides).

92. *Pogonaleyrodes* Takahashi

P. fastousa Takahashi
Syntype, Madagascar: Manjakatompo, 2000 m, 24.v.1950, (R. Mamet), ex: indet., B.M. 1998-131.

P. zimmermanni (Newstead)
Syntypes, German East Africa (Tanzania): Amani, ix.1902, (A. Zimmermann 19), ex: Acanthaceae, 48/62, (2 slides).
Nigeria: Ibadan, Moor Plantation, xi.1959, (E.A. James), ex: indet.
Nigeria: Ibadan, Moor Plantation, vii.1960, (M.O. Ezeigwe), ex: indet.
Tanganyika: Tukuyu, South Highlands Prov., xii.1957, (R.G. Tapley), ex: *Coffea arabica*, C.I.E. 4678/15780, 51/62, B.M. 1962-3, (2 slides).
Cote d'Ivoire (Ivory Coast): 20 Km W. Abidjan, Adiopodoume, IIRSDA, 17.xi.1989, (L.D.C. Fishpool 74), ex: *Aidia genipiflora*.
Kenya: Gedi forest, south of Malindi, 17.v.1988, (J.H. Martin 5318), ex: *Tricalysia ovalifolia*.

93. *Pseudaleuroplatus* Martin

P. kiensis Martin
Paratypes, Australia: S.A., Kangaroo Island, 17.ii.1990, (J.H. Martin 5652), ex: *Melaleuca* sp., B.M. 1998-50, (2 slides).

94. *Ramsesseus* Zahradnik

R. follioti Zahradnik
Paratype, Egypt: Ramsesseum, 10.i.1963, (J. Zahradnik), ex: *Acacia* sp.

95. *Rhachisphora* Quaintance & Baker

R. alishanensis Ko *et al.*
Paratype, Taiwan: Alishan, 26.iv.1990, (C.C. Ko), ex: *Eurya* sp.
Paratypes, Taiwan: Alishan, 26.iv.1990, (C.C. Ko), ex: *Eurya strigillosa*.
Paratype, Taiwan: Tatachiaanpu, 27.iv.1990, (C.C. Ko), ex: *Eurya* sp.

R. elongatus Regu & David
Paratype, India: Kunnathoor, 24.i.1989, (K. Regu), ex: *Mimusops elengi*.

R. franksae Martin
Paratypes, Australia: Queensland, 2 Km north of Cape Tribulation, 13.xii.1996, (J.H. Martin 6870), ex: *Fagraea gracilipes*, B.M. 1998-50, (3 slides).

R. koshunensis (Takahashi)
Taiwan: Kentingkunyen, 22.i.1990, (W.J. Wu), ex: *Cinnamomum reticulatum*, (2 slides).

R. maesae (Takahashi)
Taiwan: Nanshanchi, 28.x.1989, (C.C. Ko), ex: *Maesa* sp.
Taiwan: Jihyuetan, 9.vi.1986, (C.C. Ker), ex: *Maesa japonica*, B.M. 1987-197.
Taiwan: Chiaochiwenchuan, 14.ii.1990, ex: ex: *Maesa* sp.
Malaya: Cameron Highlands, Tanah Rata, 12.x.1973, (L.A. Mound), ex: indet. shrub, 66/84.

R. rutherfordi (Quaintance & Baker)
India: Kunnathoor, 24.i.1989, (K. Regu), ex: *Loranthus elasticus*.

R. trilobitoides (Quaintance & Baker)
Ceylon: Sigiriya, 23.viii.1909, (E.E. Green), ex: indet., B.M. 1927-451.
Ceylon: Trincomalee, ix.1910, (E.E. Green), ex: ?Tree, B.M. 1927-451, (2 slides).
Ceylon: Maha, ix.1909, (E.E. Green), ex: *Memecylon* sp., B.M. 1927-451.
Ceylon: Kesbewa, iv.1903, (E.E. Green), ex: *Memecylon* sp., B.M. 1927-451.
Pakistan: Lahore, 24.iii.1981, ex: *Syzigium cumini*, C.I.E. A12961, (2 slides).
Philippine Islands: Palawan, Irawan forest, 1000′, 19.i.1988, (J.H. Martin 5133), ex: indet., B.M. 1988-2.

96. *Rositaleyrodes* Meganathan & David

R. oplismeni (Takahashi)
India: Kunnathoor, 25.i.1989, (K. Regu), ex: Grass.

97. *Rugaleyrodes* Bink-Moenen

R. angolensis (Cohic)
Chad: Doba, 389 m, 21.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Syzygium guineense*, 73/81.

R. bidentata Bink-Moenen
Holotype + paratypes, Chad: Baibokoum, 19.xi.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*.

R. tetracerae (Cohic)
Syntype, Congo: Brazzaville, 18.iii.1964, (F, Cohic), ex: *Tetracera alnifolia*, B.M. 1965-305.

98. *Rusostigma* Quaintance & Baker

R. eugeniae (Maskell)
Syntypes, India: Maharashtra, Poona, (W.M. Maskell), ex: *Eugenia jambolana*, 13/85, (3 slides).
India: Gujarat, Navsari, ix.1985, ex: *Syzygium* sp., C.I.E. 18160, 27/86, (2 slides).

R. radiirugosa (Quaintance & Baker)
Syntypes, Indonesia: Billiton Isle, 5.ii.1911, (R.S. Woglum), ex: Mango, Q.6727-A, B.M. 1998-131.
Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 10.v.1985, (J.H. Martin 4934), ex: [*Eugenia* sp.] *Syzygium* sp.
West Malaysia: Pahang Prov., Taman Negara, Bukit Teresek, 2.iii.1984, (J.H. Martin 4202), ex: indet.

Malaysia: Sarawak, Gn. Mulu Nat. Park, Kerangas plot, 14.x.1977, (D. Hollis M9/13), ex: indet., 53/82, (2 slides).
Singapore: Bukit Timah Forest, 31.iii.1989, (J.H. Martin 5543), ex: *Eugenia* sp., B.M. 1989-89.
Brunei: Temburong District, Sungai, Temburong, Kuala Baki, 16.x.1992, (J.H. Martin 6145), ex: indet.
R. tokyonis (Kuwana)
Japan: Tokyo, 9.viii.1949, (R. Takahashi), ex: *Sakakia* sp., 94/62, B.M. 1962-401, (3 slides).

99. *Russellaleyrodes* David

R. cumiugum (Singh)
Philippine Islands: Palawan, Irawan forest, 1000´, 19.i.1988, (J.H. Martin 5127), ex: indet., B.M. 1988-2.
Philippine Islands: Palawan, Irawan forest, 1000´, 21.i.1988, (J.H. Martin 5148), ex: indet., B.M. 1988-2.

100. *Setaleyrodes* Takahashi

S. mirabilis Takahashi
Taiwan: Wufeng, 24.v.1994, (K.C. Chou), ex: *Stephania japonica*, B.M. 1994, (3 slides).
Taiwan: Wufeng, Taiwan Agric. Res. Institute, 18.v.1994, (K.C. Chou), ex: *Stephania japonica*, B.M. 1994, (2 slides).
S. thretaonai David
Paratypes, India: Kerala, Walayar, 24.iii.1972, (B.V. David), ex: *Homonoia riparia*, 18/85.
Australia: Northern Territory, Humpty Doo, Solar Village, 45 Km S. E. of Darwin, 24.xii.1996, (J.H. Martin 6963), ex: *Ficus* sp.
S. vigintiseta Martin
Paratypes, Australia: Northern Territory, Humpty Doo, Solar Village, 45 Km S. E. of Darwin, 24.xii.1996, (J.H. Martin 6965), ex: *Acacia ?aulacocarpa*, B.M. 1998-50, (3 slides).

101. *Simplaleurodes* Goux

S. hemisphaerica Goux
Morocco: 45 Km S. of Oujda, Col de Jerada, 22.iv.1992, (J.H. Martin 6054), ex: Oleaceae, B.M. 1992-73.

102. *Singhiella* Sampson

S. bicolor (Singh)
India: New Delhi, iv.1964, (T.S. Muthukrishnan), ex: *Eugenia jambolana*, B.M. 1967-280/19, (2 slides).
Pakistan: Rawalpindi, 23.iv.1979, ex: *Eugenia jambolana*, C.I.E. A11232.
S. cardamomi (David & Subramaniam)
West Malaysia: Pahang Prov., Taman Negara, Kuala Tahan, 2.iii.1984, (J.H. Martin 4191), ex: Zingiberaceae, (2 slides).
Brunei: Borneo, nr Bukit Bedawan, 30.iii.1989, (J.H. Martin 5516), ex: Zingiberaceae, B.M. 1989-89.
S. chinensis (Takahashi)
Hong Kong: Lantau Island, Shek Pik – Taio Road, 18.x.1990, (J.H. Martin 5798), ex: *Machilus chinensis*.
S. citrifolii (Morgan)
Hong Kong: NT, Tai Lung Farm, Sheung Shui, 22.xi.1999, (J.H. Martin 7250), ex: *Citrus grandis*.
Hong Kong: NT, Tai Lung Farm, Sheung Shui, 22.xi.1999, (J.H. Martin 7252), ex: *Citrus paradisi*.
Hong Kong: HK, Botanical & Zoological Gardens, 7.xii.1999, (J.H. Martin 7319), ex: *Randia spinosa*.
Costa Rica: Turrialba, 13.iii.1990, (J.M. Cox 81), ex: *Citrus* sp.
Costa Rica: San Gerardo, nr San Isidro, 10.ii.1983, (J.H. Martin 3818), ex: *Citrus* sp.
Jamaica: Kingston, 26.x.1970, (L.A. Mound), ex: *Citrus* sp., 31/71.
Lebanon: Byblos, ix.2000, (M.R. Wilson), ex: *Citrus* sp.
U.S.A.: Florida, Nursery at Broxbourne, Herts., 19.xi.1974, ex: *Citrus mitis*.
S. delamarei (Cohic)
Chad: Doba, 389 m, 21.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1976-56.
Kenya: Gedi forest, south of Malindi, 17.v.1988, (J.H. Martin 5321), ex: *Monanthotaxis fornicata*, B.M. 1988-188.
S. kuraruensis (Takahashi)
Taiwan: Sanhsian, 22.vi.1990, (C.C. Ko), ex: *Machilus kusanoi*.
S. premnae Martin
Paratypes, Australia: Queensland, strand 2 Km north of Cape Tribulation, 13.xii.1996, (J.H. Martin 6862), ex: *Premna serratifolia*, B.M. 1998-50.
S. subrotunda (Takahashi)
Taiwan: Wuling, 11.x.1986, (C.C. Ker), ex: *Litsea akoensis*, B.M. 1987-197.
Taiwan: Fenchifu, 13.ii.1986, (C.C. Ker), ex: *Phoebe formosana*, B.M. 1987-197.

103. *Singhius* Takahashi

S. hibisci (Kotinsky)
Syntypes, Hawaii: Hilo, xi.1905, (B.M. Newell), ex: *Hibiscus roseorinctus*, B.M. 1923-278, (3 slides).
Hong Kong: Victoria Peak, 2.iii.1990, (J.H. Martin 5684), ex: ?*Bridelia monoica*.
Hong Kong: Wanchai, 25.ii.1990, (J.H. Martin 5667), ex: indet. shrub.
Taiwan: Wufeng, 8.xii.1985, (C.C. Ker), ex: *Mallotus japonicus*, B.M. 1987-197.
S. russellae (David & Subramaniam)
Paratypes, India: Valparai, 6000 ft, 16.iv.1967, (B.V. David), ex: indet., B.M. 1972-24.

104. *Siphoninus* Silvestri

S. immaculatus (Heeger)
England: Colchester, Essex, ii.1973, (E. Milne-Redhead), ex: Ivy, 11/73, (5 slides).
England: Camberley, Surrey, 25.viii.1920, (E.E. Green), ex: Ivy, B.M. 1930-488, (2 slides).
S. phillyreae (Haliday)
France: Corsica, Bussaglia, near Porto, 2.vii.1980, (J.H. Martin 3014), ex: *Crataegus* sp.
France: Corsica, Bussaglia, near Porto, 2.vii.1980, (J.H. Martin 3015), ex: *Fraxinus* sp.
Hungary: Budapest, Plant Protection Inst., 19.viii.1983, (L.A. Mound), ex: indet.
Spain: Cadiz Prov., E. of Grazalema, A372, 11.x.1998, (J.H. Martin 7170), ex: *Crataegus* sp.
Spain: Burgos Prov., Sanctuario de Santa Casilda, near Briviesca, 950 m, 6.viii.1993, (J.H. Martin 6294), ex: *Crataegus* sp.
England: Camberley, Surrey, 1.x.1927, (E.E. Green), ex: Hawthorn, B.M. 1930-488.
U.S.A.: California, U. Cal. Riverside campus, 3.vii.1990, (J. LaSalle), ex: *Citrus* sp.

105. *Taiwanaleyrodes* Takahashi

T. carpini Takahashi
Taiwan: Hapan, 17.vi.1994, (K.C. Chou), ex: *Maesa* sp., B.M. 1994, (2 slides).

T. meliosmae Takahashi
Japan: Kushimoto, Wakayama Prefecture, vi.1955, (R. Takahashi), ex: *Daphniphyllum* sp., 101/62, B.M. 1962-401, (5 slides).

106. *Tetraleurodes* Cockerell

T. acaciae (Quaintance)
Mexico: Tamaulipas state, Miquihuana, 1.iv.2001, (E. Danzig), ex: *Sophora secundaria*, (2 slides).
Hong Kong: Pok Fu Lam, Country Park, 10.xii.2001, (J.H. Martin 7545), ex: ?Mimosaceae, (2 slides).
Jamaica: Negril, 17.vi.1969, (M. Schuiling 39), ex: *Piscidia piscipula*, 10/69, (2 slides).

T. andropogoni (Dozier)
Syntypes, Belgian Congo: Lodja, x.1929, (J. Ghesquière), ex: *Andropogon* sp., B.M. 1933.
Uganda: W. Buganda, Kyadondo, 3900′, Kawanda Res. Stn, 25.iii.1971, (D.N. McNutt), ex: *Phragmanthera rufescens* var. *sigensis*, 9/72, (3 slides).
Belgian Congo: Brazzaville, 23.ii.1966, ex: *Loranthus* sp., Al 263-66.
Burundi: Rumonge, 3.ix.1983, (G. Remaudière), ex: *Elaeis guineensis*, 46/83.

T. banksiae Martin
Paratypes, Australia: S.A., Kangaroo Island, 17.ii.1990, (J.H. Martin 5654), ex: *Banksia marginata*, B.M. 1998-50, (3 slides).

T. bicolor Bink-Moenen
Turkey: Adana, 16.ii.1987, (via N. Uygun), ex: *Myrtus communis*, 13/87, (4 slides).

T. caulicola Nakahara
Paratypes, U.S.A.: California, Palm Canyon, 31.iii.1963, (L.D. Anderson), ex: *Dalea* sp., B.M. 1998-131.

T. confusa Nakahara
Paratypes, U.S.A.: Florida, Ormond Beach, 7.viii.1959, (Smith & Roberts), ex: *Magnolia virginiana*, B.M. 1998-131.

T. granulata Bink-Moenen
Paratypes, Chad: Doba, 21.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *gardenia triacantha*, B.M. 1977-471, (2 slides).
Paratypes, Chad: Bebedjia, 11.vii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hymenocardia acida*, B.M. 1977-471.
Paratypes, Chad: Donia, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hexalobus monopetalus*, B.M. 1977-471, (2 slides).

T. pluto Dumbleton
Australia: W.A. Ravensthorpe, 25.ix.1980, (H.J. Banks), ex: *Hakea* sp., (3 slides).

T. quercicola Nakahara
Paratypes, U.S.A.: Utah, iv.1966, (G.F. Knowlton), ex: Evergreen oak, B.M. 1998-131.

T. selachidentata Bink-Moenen
Paratypes, Chad: Bebedjia, 26.xi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Stereospermum kunthianum*.

T. stirlingiae Martin
Paratypes, Australia: intercepted at SFKIA, 26.x.1987, (T. Moreno 88 0550), ex: *Stirlingia* sp., B.M. 1998-131.
Paratypes, Australia: intercepted at San Francisco, 25.vii.1988, (A. Mendoza), ex: *Stirlingia latifolia*, B.M. 1998-131.

T. sulcistriatus Martin
Paratypes, Australia: Queensland, strand 2 Km north of Cape Tribulation, 15.xii.1996, (J.H. Martin 6887), ex: *Ficus microcarpa*, B.M. 1998-50.
Paratypes, Australia: Queensland, strand 2 Km north of Cape Tribulation, 13.xii.1996, (J.H. Martin 6866), ex: *Calophyllum inophyllum*, B.M. 1998-50, (2 slides).
Paratype, Australia: Northern Territory, Kakadu Nat. Park, Gubara Walk, Burdulba Creek, 20 Km S. of Jabiru, 22.xii.1996, (J.H. Martin 6954), ex: ?*Xanthostemon eucalyptoides*, B.M. 1998-50.

107. *Tetralicia* Harrison

T. ericae Harrison
Topotypes, England: Durham, Waldridge Fell, (B.J. Selman), ex: *Erica tetralix*, 10/65, (4 slides).
England: Surrey, Camberley, xi.1929, (E.E. Green), ex: *Erica tetralix*, B.M. 1929-545, (3 slides).

T. graminicola Bink-Moenen
Paratypes, Chad: Baibokoum, 8/9.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Hyparrhenia rufa*.

T. iberiaca Bink-Moenen
Paratypes, Portugal: Monchique, ca. 300 m, 29.iv.1978, (F.A. Bink & R.M. Bink-Moenen), ex: *Erica arborea*.

T. tuberculata Bink-Moenen
Holotype + paratypes, Chad: Bebedjia, 395 m, 11.vii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Vitex simplicifolia*.

108. *Trialeurodes* Cockerell

T. abutiloneus (Haldeman)
U.S.A.: Arizona, East of Roll, 22.ix.1954, (R.D. Dickson), ex: *Euphorbia* sp., B.M. 1998-131.
U.S.A.: Florida, Haven, 2.xi.1959, (V. Norton & F. Weems), ex: *Hibiscus mutabilis*, B.M. 1998-131.
U.S.A.: California, Three Rivers Tulore Co., 4.xi.1978, (L. Vet), ex: *Euphorbia supina*.

T. bruneiensis Martin
Paratypes, Brunei: Borneo, near Bukit Bedawan, 30.iii.1989, (J.H. Martin 5523), ex: Fern, B.M. 1989-89, (5 slides).

T. darwiniensis Martin
Paratypes, Australia: Northern Territory, Darwin, Nightcliff, foreshore, 20.xii.1996, (J.H. Martin 6931 & A. Wells), ex: *Flueggea* ?*virosa*, B.M. 1998-50, (5 slides).

T. dicksoniae Martin
Paratypes, Australia: Victoria, Tall Trees, nr Mansfield, 22.i.1990, (J.H. Martin 5621), ex: *Dicksonia antarctica*, B.M. 1998-50, (4 slides).

T. drewsi Sampson
U.S.A.: California, Sacramento, Sac. Co., 27.ii.1968, (P.W. Hiatt), ex: *Quercus ilex*, 9/68, B.M. 1968-368.

T. ericae Bink-Moenen
Paratypes, Netherlands: Leersum, reserve Leersumse Veld, 6.vi.1975, (R.M. Bink-Moenen), ex: *Erica tetralix*, B.M. 1976-56, (2 slides).
Netherlands: Ilpendam, reserve Ilpenveld, 29.v.1975, (F.A. Bink & R.M. Bink-Moenen), ex: *Erica tetralix*, B.M. 1976-56.
Netherlands: Amerongen, 27.iv.1975, (F.A. Bink & R.M. Bink-Moenen), ex: *Erica tetralix*, B.M. 1976-56.

T. floridensis (Quaintance)
U.S.A.: Florida, Tampa, 11.ii.1976, (C.W. Hale), ex: *Persea americana*, B.M. 1998-131.

Panama: Canal Zone, Barro Colorado I., 13.iii.1983, (J.H. Martin 3988), ex: *Inga* nr *pezizifera*.
Costa Rica: Guanacaste Province, 60 Km S. of Liberia, 26.i.1983, (J.H. Martin 3693), ex: *Mastichodendron ?capiri*, (2 slides).

T. pergandei (Quaintance)
U.S.A.: Florida, nr Brooksville, 11.ii.1922, (A.L. Quaintance 20590), ex: *Bignonia* sp., B.M. 1998-131.
U.S.A.: Maryland, Silver Spring, 1.ix.1941, (L.M. Russell), ex: *Rubus* sp., B.M. 1998-131.
?U.S.A.: pres. T.D.A. Cockerell, det. Quaintance, ex: Rose, B.M. 1923-178, (2 slides).
U.S.A.: Maryland, Allegany Co., Green Ridge, State Forest, 29.vi.1998, (J.H. Martin 7101), ex: *Crataegus* sp.

T. rex Martin
Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 18.iv.1985, (J.H. Martin 4869), ex: Fren.
Paratypes, Indonesia: Sulawesi Utara, Dumoga-Bone N.P., Clark's camp area, 18.iv.1985, (J.H. Martin 4879), ex: Fren, (3 slides).

T. vaporariorum (Westwood)
?Type series, England: "on leaf in Westwood's Taxonomic Series", Hope Department, Oxford, no data, (3 slides).
Syntypes, South Africa: Durban, Pretoria, Chief Entomologist, vi.1923, ex: *Nicotiana tabacum*, B.M. 1935-248, (2 slides).
England: Berkshire, Ascot, Silwood Park, 5.xi.1978, (J.H. Martin 2323), ex: *Solanum ducamara*, 9/78.
South Africa: GAU, Delmas, v.2000, (R. Tukker HA/60), ex: *Cucumis sativus*, B.M. 2001-198.
Azores: Pico, hotel grounds, 26.vi.2000, (A. Polaszek), ex: *Oenothera* sp.
Madeira: Portela, 550 m above Porto da Cruz, 28.iii.1995, (J.H. Martin 6560 & A.F. Aguiar), ex: *Ageratina* sp.
Iran: Isfahan, University of Technology, viii.1986, ex: *Nicotiana tabacum*, C.I.E. A18545, 2/87.
Iran: Fars, Badjgah, 13.x.1990, (M. Zarrabi 17), ex: *Cichorium intybus*.
Italy: Po River Valley, 1998, ex: Strawberry, C.I.E. A20129.
U.S.A.: California, Riverside Co., UCR campus, (L. Vet), ex: *Nicotiana glauca*.

T. variabilis (Quaintance)
U.S.A.: Florida, Miami, 1.xii.1921, (G.F. Moznette), ex: *Carica papaya*, B.M 1998-131.
Jamaica: Kingston, vii.1965, ex: *Carica papaya*, B.M 1965-433.
Belize: Cayo, Chiquibul forest, Las Cuevas, 6.xi.1994, (J.H. Martin 6463), ex: *Carica* sp., (2 slides).
Trinidad: Tableland, 3.xii.1991, I.I.E. 22137, ex: ex: *Carica papaya*.

119. *Tuberaleyrodes* Takahashi

T. machili Takahashi
Hong Kong: Victoria Peak, 3.iii.1990, (J.H. Martin 5693), ex: *Machilus chinensis*, (4 slides).

110. *Vasdavidius* Russell

V. cobarensis (Martin)
Paratypes, Australia: New South Wales, Cobar, 1979, ex: Pasture grass, C.I.E. 11292, (2 slides).

V. concursus (Ko)
Paratypes, Taiwan: Taipei City, 10.xii.1989, (T.C. Hsu), ex: Gramineae.
Paratypes, Taiwan: Taipei City, 30.i.1994, (K.C. Chou), ex: Gramineae.
Hong Kong: NT, west Tai Mo Shan, Country Park, Ho Pui area, 13.xii.2001, (J.H. Martin 7566), ex: *Saccharum ?spontaneum*, (2 slides).
Hong Kong: NT, E. side of Ma On Shan, Country Park, near Hebe Haven, 14.xi.1996, (J.H. Martin 6817), ex: Grass.

V. indicus (David & Subramaniam)
Paratypes, India: Coimbatore, 20.v.1966, (B.V. David), ex: *Chloris barbata*, B.M. 1972-24, (2 slides).
Nigeria: Ibadan, I.I.T.A., 20.ii.1983, (M.S. Alam), ex: Rice, C.I.E. A15041.
Nigeria: Badeggi, 25.x.1977, (S.A. Apeji), ex: Rice, C.I.E. A9972.
Burkina Faso (Upper Volta): Bo-Bo rice area, 31.vii.1973, (C.L. Tao), ex: *Oryza sativa*, C.I.E. A10811, 64/82, (2 slides).

V. setiferus (Quaintance & Baker)
Hong Kong: Tai Lung Farm, NT, 14.vii.1976, (R. Winney), ex: Grass, C.I.E. A9278, (2 slides).
Papua New Guinea: Morobe Prov. coast, Buso, 15.x.1979, (J.H. Martin 2702), ex: *Imperata cylindrica*, (3 slides).

111. *Venezaleurodes* Russell

V. pisoniae Russell
Paratypes, Venezuela: Ipare, near Altagracia de Orituco, xi.1966, (F.A. Lee), ex: *Pisonia macranthocarpa*, B.M. 1998-131, (2 slides).
Paratypes, Venezuela: Guarcio, near Altagracia de Orituco, Guatopo, xi.1966, ex: *Pisonia macranthocarpa*, (2 slides).

112. *Viennotaleyrodes* Cohic

V. bicolorata Martin
Paratypes, Australia: Queensland, 150 Km S. of Mackay, 19.vii.1968, (L.A. Mound), ex: *Acacia harpophylla*, 22/71, (9 slides).

V. bosciae Bink-Moenen
Holotype: Cameroun: 22 Km S. of Waza, 23.i.1966, (A.J.M. Leeuwenberg), ex: *Boscia senegalensis*.
Sudan: Bahr el Ghazal Prov., ~20 km N. of Aweil, 9.v.1981, (J.H. Martin 3386), ex: *Boscia senegalensis*, (2 slides).

V. curvisetosus Martin
Paratypes, Australia: New South Wales, Tamworth, 29.iii.1920, (W.W. Froggatt), ex: *Acacia pendula*, (4 slides).

V. fallax Bink-Moenen
Paratypes, Chad: Boro, 450 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Burkea africana*, B.M. 1976-56, (2 slides).
Paratypes, Chad: Boro, 443 m, 30.vii.1972, (F.A. Bink & R.M. Bink-Moenen), ex: *Burkea africana*, B.M. 1976-56.

V. lacunae Martin
Paratypes, Australia: ACT, Molonglo Gorge (near Queanbeyan, NSW), 8.xii.1996, (J.H. Martin 6849), ex: *Acacia rubida*, B.M. 1998-50, (4 slides).

V. megapapillae (Singh)
Hong Kong: Pok Fu Lam, Country Park, 10.xii.2001, (J.H. Martin 7547), ex: *Millettia* sp., (4 slides).
Taiwan: Hsini, 23.xii.1995, (K.C. Chou), ex: *Bauhinia championii*.

Taiwan: 22.i.1990, (Y.C. Shiau), ex: indet.

V. platysepali (Cohic)

Syntype, Congo: Brazzaville, 5.iii.1965, ex: *Platysepalum vanderystii*, B.M. 1965-305.

Chad: Galaba, 407 m, 2.ix.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Entada africana*, B.M. 1976-56, (2 slides).

Chad: Timberi, 435 m, 29.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Dialium guineense*, B.M. 1976-56.

113. *Xenaleyrodes* Takahashi

X. artocarpi Takahashi

Australia: Queensland, strand 2 Km north of Cape Tribulation, 13.xii.1996, (J.H. Martin 6863), ex: *Ficus microcarpa*, B.M. 1998-50, (2 slides).

Australia: Queensland, strand 2 Km north of Cape Tribulation, 15.xii.1996, (J.H. Martin 6887), ex: *Ficus microcarpa*, B.M. 1998-50.

Australia: Queensland, creek mouth 2 Km north of Cape Tribulation, 15.xii.1996, (J.H. Martin 6885), ex: *Pouteria obovoidea*, B.M. 1998-50.

Australia: Queensland, 2 Km north of Cape Tribulation, garden/orchard, 17.xii.1996, (J.H. Martin 6903), ex: *Pouteria caimito*, B.M. 1998-50.

Papua New Guinea: Morobe Prov. coast, Buso, 9.x.1979, (J.H. Martin 2681), ex: *Premna* sp., (2 slides).

X. broughae Martin

Paratypes, Papua New Guinea: S. Highlands Province, Eraue, 21.vii.1983, (E.J. Brough C630), ex: *Citrus* sp., C.I.E. A15579, 37/84, (7 slides).

X. fauceregius Martin

Paratypes, Australia: Northern Territory, King's Canyon, 5.ii.1990, (J.H. Martin 5643), ex: *Acacia ?mcdonnelliensis*, B.M. 1998-50.

Paratypes, Australia: New South Wales, Native Dog Bore, 1890, (W.W. Froggatt), ex: indet., (2 slides).

Australia: South Australia, 2 Km N. of Roxby Downs, 25.iv.2000, (J.H. Martin 7397), ex: *Acacia ?ramulosa*.

Australia: Queensland, 40 Km E. of St. George, 12.iv.2000, (L.A. Mound 3860), ex: *Acacia aneura*.

114. *Yleyrodes* Bink-Moenen

Y. isoberliniae Bink-Moenen

Paratypes, Chad: Boro, 440 m, 6.xii.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Isoberlinia doka*, B.M. 1977-471.

115. *Zaphanera* Corbett

Z. capparis Bink-Moenen

Paratypes, Chad: Bebedjia, 12.vi.1973, (F.A. Bink & R.M. Bink-Moenen), ex: *Capparis corymbosa*, B.M. 1977-471, (2 slides).

Sudan: Bahr el Ghazal Prov., 160 km S.W. of El Muglad, 7.v.1981, (J.H. Martin 3385), ex: indet. woody plant.

Z. cyanotis Corbett

Lectotype, Ceylon: Maskeliya, v.1911, (J. Pole), ex: *Cyanotis* sp., B.M. 1927-451.

Paralectotype, Ceylon: Maskeliya, v.1911, (J. Pole), ex: *Cyanotis* sp., B.M. 1927-451.

Paralectotypes, Ceylon: Pundaluoya, (E.E. Green), ex: *Cyanotis* sp., B.M. 1927-451, (2 slides).

Pakistan: Balakot, 12.iv.1963, ex: *Dicliptera roxburghii*, C.I.E. 19214, 2/64.

Z. niger (Maskell)

Australia: S.A., Mt Lofty Ranges, Basket Range, 1.i.2000, (J. Hardy), ex: *Acacia* sp., (2 slides).

Australia: S.A., Carey Gully, nr Adelaide, i.2000, (J. Hardy), ex: *Acacia* sp.

Australia: S.A., Adelaide, Crafers, 25.xii.1997, (L.A. Mound & A. Wells), ex: *Acacia melanoxylon*, (2 slides).

Australia: A.C.T., Canberra, Nat. Bot. Gdns, Black Mtn, 21.x.1994, (L.A. Mound), ex: *Acacia longifolia*.

Z. papyrocarpae Martin

Paratypes, Australia: S.A., Billakilina Station, 26.iv.2000, (J.H. Martin 7406), ex: *Acacia papyrocarpa*, (3 slides).

Paratypes, Australia: S.A., Roxby Downs, 27.iv.2000, (J.H. Martin 7408), ex: *Acacia papyrocarpa*, (3 slides).

Paratypes, Australia: S.A., Roxby Downs, 11.i.2000, (J. Hardy), ex: *Acacia papyrocarpa*.

Paratypes, Australia: S.A., Roxby Downs, 20.x.1999, (P. Bailey), ex: *Acacia papyrocarpa*.

Z. rhachisreticulata Martin

Paratypes, Australia: W.A., Wubin, iv.1997, (L.A. Mound), ex: *Acacia mackeyana*, B.M. 1998-51, (4 slides).

116. New genus 1

New genus 1 sp. 1

Belize: Cayo, Chiquibul Forest, Las Cuevas plots, 20.xi.1994, (J.H. Martin 6502), ex: Piperaceae, (2 slides).

Belize: Cayo, Chiquibul Forest, New Maria track, 12.ii.1996, (J.H. Martin 6647), ex: indet., (2 slides).

Belize: Cayo, Chiquibul Forest, San Pastor track, 28.xi.1994, (J.H. Martin 6523), ex: *Piper* sp., (3 slides).

Belize: Cayo, Chiquibul FR., Monkey Tail trail, 22.vi.2002, (J.H. Martin 7703), ex: *Piper* sp., (2 slides).

New genus 1 sp. 2

Belize: Cayo, Chiquibul Forest, Las Cuevas plots, 5.xi.1994, (J.H. Martin 6458), ex: *Piper* sp.

Belize: Cayo, Chiquibul Forest, Las Cuevas plots, 20.xi.1994, (J.H. Martin 6502), ex: Piperaceae.

Belize: Cayo, Chiquibul Forest, San Pastor Hill path, 26.ii.1996, (J.H. Martin 6710), ex: *Piper* sp.

Belize: Cayo, Chiquibul FR., Monkey Tail trail, 22.vi.2002, (J.H. Martin 7703), ex: *Piper* sp.

117. New genus 2

New genus 2 sp. 1

Costa Rica: Turrialba, 640 m, Trop. Agric. Centre, C.A.T.I.E., 3.iii.1983, (J.H. Martin 3964), ex: ?Myrtaceae, (2 slides).

Costa Rica: Turrialba, 640 m, Trop. Agric. Centre, C.A.T.I.E., 1.iii.1983, (J.H. Martin 3923), ex: *Hoffmannia* sp.

New genus 2 sp. 2

Costa Rica: Cerro, Chirripó Nat. Park, ~2600 m, 18.ii.1983, (J.H. Martin 3882), ex: indet., (2 slides).

Aleurodicinae

1. *Aleurodicus* Douglas

A. cocois (Curtis)

Paralectotypes, Barbados: (Sir R. Schomburgk), ex: Coconut tree, (3 slides).

A. dispersus Russell

Paratypes, U.S.A.: Florida, Key West, 12.vi.1964, (H.V. Weems), ex: Coconut Palm, (3 slides).
Hawaiian Islands: Oahu, Bishop, Museum grounds, 30.iii.1999, (J.H. Martin 7194), ex: *Colocasia esculenta*.
Hawaiian Islands: Hawai'i, coast, Kilauea Volcano, Pu'u O'o lava edge, 6.iv.1999, (J.H. Martin 7209), ex: indet. shrub.
Hawaiian Islands: Maui, Kailua, Hana route, Waianapanapa, 1.iv.1999, (J.H. Martin 7197), ex: *Hibiscus tiliaceus*.
Panama: Canal Zone, Cerro Galera, 26.iii.1983, (J.H. Martin 4144), ex: *Acalypha diversifolia*.
Panama: Darién, Ensenada del Guayabo, sea level - 250 m., 11.i.1983, (J.H. Martin 3582), ex: Leguminosae.

2. *Azuraleurodicus* Martin

A. pentarthrus Martin

Paratype, Belize: Cayo, Chiquibul forest, Grano de Oro track, 22.xi.1994, (J.H. Martin 6486), ex: *Guettarda ?combesii*.
Paratypes, Belize: Cayo, Chiquibul forest, Grano de Oro track, 16.xi.1994, (J.H. Martin 6486), ex: *Guettarda ?combesii*.
Paratypes, Belize: Cayo, Chiquibul For. Res., near Caracol Jct., 16.ii.1996, (J.H. Martin 6630A), ex: *Guettarda combesii*, (2 slides).

3. *Dialeurodicus* Cockerell

D. cockerellii (Quaintance)

Syntypes, Brazil: Campinas, São Paulo, 30.iii.1898, (F. Noak, via Cockerell), ex: Myrtaceae, B.M. 1998-131.
Brazil: São Paulo, Embu-Guaco, 29.v.-2.vi.1998, (A.E. Campos-Farinha), ex: *Psidium* sp., Lot #9805640, B.M. 1998-168.

4. *Eudialeurodicus* Quaintance & Baker

E. bodkini Quaintance & Baker

Syntypes, Guyana: Berbice, 2.iii.1915, (G.E. Bodkin), ex: *Erythrina glauca*, B.M. 1998-131, (2 slides).

5. *Octaleurodicus* Hempel

O. nitidus Hempel

?Syntypes, Brazil: Bahia, 7.xii.1923, (G. Bondar), ex: *Cocos nucifera*, B.M. 1924-44.

6. *Stenaleyrodes* Takahashi

S. vinsoni Takahashi

Paratype, New Caledonia: Noumea, 20.v.1955, (L.J. Dumbleton), ex: *Cocos nucifera*, B.M. 1964-721.
Réunion Island: Saint Denis, 14.x.1963, (J.G. Pointel), ex: Palm, B.M. 1998-131.

7. *Synaleurodicus* Solomon

S. hakeae Solomon

Lectotype, Australia: Western Australia, Perth, iii.1934, (M.E. Solomon), ex: *Hakea prostrata*, B.M. 1936-84.
Australia: Western Australia, Perth, King's Park, 26.ix.1967, (L.A. Mound 215), ex: *Hakea ?pritzelli*, (4 slides).

Appendix 4. Data matrix used in the cladistic analysis of the subfamily Aleyrodinae. Polymorphisms are coded as follows: A = 0&1, B = 0&2, C = 0&3, D = 0&6, E = 0&7, F = 1&2, G = 1&3, H = 1&8, K = 2&3, M = 2&5, N = 2&7, P = 0&1&2.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Ingroup	
Acanthaleyrodes callicarpae	1?01110101010101010?0?0?120000?10005??111231021?000?51101010010000000?01010010000000000000101000
Acanthaleyrodes spiniferosa	1?01111001010102131 10?0?0000?00005??110233021?000?50101110010000000?01010010000000000000101000
Acanthaleyrodes styraci	1?01110101010101020?0?0?120000?10005??111233021?000?51101010010000000?01010010000000000000101000
Acanthobemisia	20011101110111001212 0?0?1110?000020?000111031?201011100?01100000000?01010000000000000000101000
Acaudaleyrodes africana	2021110000?11121100?0?0?0210?01004??110002031?101001000?000B1100000?01110010000000000000101000
Acaudaleyrodes rachipora	2201110000?11111100?0?0?0210?01004??110002031?101001000?00021100000?01110010A0010000000101100
Acaudaleyrodes tuberculata	2021110000?11111100?0?0?0210?01004??110002031?101001000?01011100000?00110010100000000000101100
Acutaleyrodes	2001110110?101110?100?0?0010?00001??101216031?2A1040100?00100000000?01010000000000000000101000
Africaleurodes coffeacola	1?01110000?10100101A0?0?01013000025?010211031?2010411010110000000000?01010000000000000000101000
Africaleurodes fulakariensis	1?01110000?10100100?0?0?01013000020?010211031?2010411010110000000000?01010000000000000000010????
Africaleurodes hexalobi	1?01110000?10100101 00?0?01013000020?010211031?2010411010110000000000?01010000000000000000101000
Africaleurodes loganiaceae	1?01110000?11100100?0?0?01013000021?010215031?200?61101011000000000?01010000000000000000101000
Africaleurodes ochnaceae	1?01110000?10100100?0?0?01013000021?010211031?2010411010110000000000?01010000000000000000101000
Agrostaleyrodes	1?01110010?101020?0?0?0?0010?00105??000211021?000?00001110101000000?01010000000000000000101001
Aleurocanthus banksiae	2021110001111102100?0?101310?00005??11023300???00?01100?00001100000?10010000100000000000101000
Aleurocanthus calophylli	2301110101111102100?0?110200?001021?10023100???00?00100?00001000000?10100000000000000000101000
Aleurocanthus ceracroceus	2001110001110112100?0?130210?00005??10023300???00?00000?00000000000?10010000000000000000101000
Aleurocanthus citriperdus	2221110101110102100?10111210?00005??110031021?000?01100?00001000000?00000000100000000000101000
Aleurocanthus cocois	2201110101111112100?10110210?00105??110231021?011001100?00001000000?00000000001000000001010A0
Aleurocanthus delottoi	2201110101111112100?0?110310?00001??11013300???00?00100?00001100000?10100000100000000000101000
Aleurocanthus esakii	2021110001111122110?0?111310?00005??11013300???00?00000?00001000000?10000000000000000000101000
Aleurocanthus gateri	2301110001110112100?0?111310?00105??100131021?001000100?00001000000?10000000000000000000101100
Aleurocanthus gordoniae	2301110011110112100?0?111210?00105??11003300???00?00000?00001000000?00000000001000000000101000
Aleurocanthus inceratus	2301110111111112100?0?111110?00101??110231021?000?01000?00001100000?00000000100100000000101000
Aleurocanthus leptadeniae	2201110101111112100?0?111310?00005??100231021?000?01100?00001000000?00100000000100000000101100
Aleurocanthus spiniferus	2201110111110102100?10110310?00005??110133021?001000000?00001000000?10010000100100000000101000
Aleurocerus cerifer	210110?010?11122110?0?0?0211200000??10023400???00?01100?00101010000?10100000100000000000101000
Aleurocerus flavomarginatus	220110?010?11122110?0?0?0211200000??10023400???00?11100?00101010000?10100000100100000000101000
Aleurocerus musae	220110?010?11122110?0?0?0211200000??10023400???00?11100?00101010000?10100000100100000000101000
Aleurocerus palmae	220110?010?11122110?0?0?0211200000??10023400???00?11100?00101010000?10100000100100000000101000
Aleurochiton acerinus	2021110001010 10B1A100?0?1410?00003?1000235031?1110000011101000000000?01010000000000000000101000
Aleurochiton aceris	2021110001010100 10100?0?1410?00003?1000235031?1110011011101000000000?01010000000000000000101000
Aleurochiton forbesii	2121110000?10100100?0?0?1110?000020?010211031?201000000?00100000010?01010010000000000000101000
Aleurochiton pseudoplatani	2021110001010100100?0?0?1110?00003?1000235031?1110000011101010000000?01010000000000000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Aleuroclava aucubae	2001111001011102 0?0?0?0111300002 1?00123300???00?5110101001110001 0?0100100000000000000101000
Aleuroclava bifurcata	210111100101F1020?0?0?0?0110?00005??00023300???00?2110121001000001 0?0001001000000000000101000
Aleuroclava citrifolii	1?0111100101110 10?0?0?0111300005??00113300???00?5110120001100001 0?0001001000000000000101000
Aleuroclava euryae	2001111001011100 0?0?0?0111300005??00123300???00?0000121001100001 0?0100100000000000000101000
Aleuroclava ficicola	20011??0010121020?100?0?0110?00005??00123300???00?5000121001100001 0?0100100000000000000101000
Aleuroclava filamentosa	2101111001011102 0?0?0?0?0010?00005??00123300???00?5010121000000001 0?0001000000000000000101000
Aleuroclava hikosanensis	2001111001011100 0?0?0?0111300005??00123300???00?2000121001100001 0?0100101000000000000101000
Aleuroclava jasmini	2101111001011102 0?0?0?0?0110?00003?200123300???00?2110121001000001 0?0100100000000000000101000
Aleuroclava magnoliae	2001111001011 10?0?0?0?0?0110?00005??00123300???00?2110121011000001 0?0100100000000000000101000
Aleuroclava murrayae	1?0111100101110 20?0?0?0?0111300005??00113300???00?5000101001100001 0?0100100000000000000101000
Aleuroclava nigeriae	2101111000?111020?0?0?0?0110?00005??00123300???00?201012100A00000A0 ?010100A000000000000101000
Aleuroclava piperis	2101111001011102 0?0?0?0?0110?00005??00123300???00?2110121000000001 0?0100000000000000000101000
Aleuroclava psidii	1?0111100101010 20?0?0?0?0111300005??00123300???00?5000101001100001 0?0010010000000000000101000
Aleuroclava pulcherrimus	1?0111100101110 10?0?0?0?0111300005??00123300???00?5110101001000001 0?0100100000000000000101000
Aleuroclava similis	1?01111000?111000?0?0?0?0410?00005??00123300???00?5000101000000000 ?0100000000000000000101000
Aleurocybotus graminicolus	2001110001010 10?10100?0?1110?000020?010111031?2010100011101000000000 ?0100000000000000000101011
Aleurocybotus occiduus	2001110001010101101 00?0?1110?000023?010011031?2010100011101000000000 ?0100000000000000000101011
Aleuroduplidens eucalyptifolia	250110?0011101201 00?0?0?0110?00001??11013300???00?00100?00001000000 ?0100000100000000000101000
Aleuroduplidens santali	2501110001110101 1?0?0?0?0110?00001??11013300???00?01100?00100000000 ?0100000100000000000101000
Aleuroduplidens triangularis	250110?0011111011 10?0?0?0410?00005??11013300???00?41100?00100000000 ?0100000100000000000101000
Aleuroduplidens wellsae	250110?0011101011 00?0?0?0410?00005??11013300???00?4110120010100000 0?0100000100000000000101100
Aleuroglandulus magnus	1?0111000101010 01?0?0?0?0010?000024?010121031?4010411011101000000000 ?0001000001000000000101000
Aleuroglandulus malangae	0?0111000101010 11?0?0?0?0010?000024?010021031?4010411011101000000000 ?0001000001000000000101100
Aleuroglandulus striatus	0?0111000101010 01?0?0?0?0010?000024?011221031?4010411011101000000000 ?0001001000000000000101000
Aleuroglandulus subtilis	0?0111000101010 11?0?0?0?0010?000024?010021031?4010411011101000000000 ?0001000001000000000101100
Aleuroinanis	2601110010?11100100?0?0?0510?000021?000225031?201011100?00100000000 ?0100000000000000000101000
Aleurolobus diastematus	2101110111011100111 10?0?0401300005??011237011?2010311010111100000010 ?0100100000000000000101001
Aleurolobus graminicola	0?0111000101010010 0?0?0?0401300005??000233011?2010411011101100000000 ?0100101000000000000101010
Aleurolobus hargreavesi	1?0111000101010110 0?0?0?04011000021?000237011?2010411011101010000000 ?0100100000000000000101000
Aleurolobus marlatti	2001110001010100110?0?0?01113000020?010137011?2010411010101110000010 ?0100101000000000000101000
Aleurolobus moundi	1?0111011101010010100?0?01113000021?000237011?2010411010101010000000 ?0100000100100000000101010
Aleurolobus onitshae	2001110001010100140?0?0?01113000021?010137011?20100110101A101000000 ?010100A010000000000101010
Aleurolobus styraci	2001110001010100100?0?0?04013000023?010227011?2010411010111010000000 ?0100101000000000000101010
Aleurolobus teucrii	2001110001011100111 10?0?04013000021?000237011?2010001010101000001 00?0100000000000000000101000
Aleurolonga	1?1111000101010211100?0?11110000024?011223031?2010001012101000000000 ?1010000000000000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Aleuromarginatus corbettiaformis	2100110111011100 0?100?0?1110?000021?010215031?2010011013111200000000?0101010000010000000101001
Aleuromarginatus dalbergiae	2000110111011100 0?140?0?1110?001021?010215031?2010010010110010000000?0101010000010000000101001
Aleuromarginatus kallarensis	2000110111011100 0?140?0?1110?001021?010215031?200?0110101100100000000?0101010000010000000101001
Aleuromarginatus littoralis	2000110111010100 0?140?0?1110?000024?010215031?2010111010111000000000?0101000000010000000101001
Aleuromarginatus marginiquus	2000110111011120 0?100?0?1110?000021?010215031?700?0000101010000000000?1010000000000000000001001
Aleuromarginatus moundi	2000110111011110 0?140?0?0110?000021?011215031?701001100?01020000000?0101011000010000000101001
Aleuromarginatus nemciae	1?0011011101012 00?100?0?1110?000021?000225031?201000000?01100000000?1010000000000000000001001
Aleuromarginatus nigrus	2000110111011110 0?140?0?0110?001021?010215031?201000000?01101000000?0101011010010000000101001
Aleuromarginatus serdangensis	2001111001010100 0?100?0?0000?000121?10023300???00?21000?00100000000?1010000000010000000101000
Aleuromarginatus tephrosiae	2100110111011100 0?140?0?1110?000021?010215031?20100000131A100000000?0111001000010000000001001
Aleuropapillatus	1?0111011101110011110?0?01?13000020?010127031?2010000010101000001 00?0101000010000000001010A0
Aleuroparadoxus arctostaphyli	210?1110010101001?0?0?0?0110?00005??011037011?4010410010101000001 00?0101010001000000000101000
Aleuroparadoxus gardeniae	2101111001011101 1?0?0?0?0110?00005??011037011?4010611010101000001 00?0101011000100000000101000
Aleuroparadoxus ilicicola	2001111001011100 1?0?0?0?0110?00005??011037011?4010610010101000001 00?0101011000100000000101000
Aleuroparadoxus iridescens	2001111001011100 1?0?0?0?0110?00005??01A037011?4010611010101010001 00?0101010001000000000101000
Aleuroparadoxus punctatus	2101110001011100 1?0?0?0?0110?00105??010137011?4010411010101100001 00?0101011000000000000101000
Aleuroplatus acaciae	2021110000?121100?100?0?0110?000021?100023031?211001000?00100000000?0001000010000000000101000
Aleuroplatus berbericolus	2201110000?111000?0?0?0?0210?00105??11002300???00?41000?00001100000?0101000010010000000101000
Aleuroplatus bossi	2021110000?111010?100?0?1110?00005??1000330B1?001001100?00000000000?0010000010010000000101100
Aleuroplatus cadabae	2001110000?101020?0?0?0?0110?000021?10023700???00?01100?00000000000?0010000010010000000101100
Aleuroplatus cockerelli	210110?000?101000?0?0?0????0?00005??10013300???00?01100?00001100000?0111000000000000000101000
Aleuroplatus cococolus	2201110110?111010?0?0?0?0210?00005??11013300???00?11100?00000000000?0111000010010000000101000
Aleuroplatus dorsipallidus	2201110110?101020?0?0?0?0510?00005??10023300???00?01100?00011000000?0011001000010000000101000
Aleuroplatus epigaeae	2101110000?11112100?0?0?0210?00005??11012300???00?31100?00101100000?0101000010010000000101000
Aleuroplatus evodiae	2301110000?1111?100?0?0?0210?00005??10013300???00?01100?00001000000?1011001000010000000101000
Aleuroplatus fici	1?0111000101010 20?100?0?0110?000021?000235021?0010111010111000000000?0101001000000000000101000
Aleuroplatus ilicis	2201110110?111211?0?0?0?0210?00005??10011300???00?11000?00001000000?0101000010010000000101000
Aleuroplatus incisus	220?110000?1010?0?0?0?0?0510?00005??11013300???00?61000?00?01000000?0111000000010000000010??00
Aleuroplatus pectiniferus	2201110000?101000?100?0?0110?000021?10112100???00?41100?00000000000?0111000000010000000101000
Aleuroplatus periplocae	2201110010?111000?0?0?0?01?0?00005??100231021?010?00000?00000000000?0010000000000000000010????
Aleuroplatus perseaphagus	200110?000?111020?0?0?0?0210?00005??10013300???00?01100?00001000000?0011001010000000000101000
Aleuroplatus quercusaquaticae	200110?000?11101100?0?0?0210?00006??11013300???00?10000?00100000000?0111000010000000000101000
Aleuropleurocelus	202?10?110?111100?0?0?0?0110?00005??10023300???00?00000?00101000000?0101001010010000000010?000
Aleuropteridis eastopi	2021110010?10102100?0?0?0100?00005??110133011?701040000?00100000000?0101000000010000000101000
Aleuropteridis filicicola	2021110010?1010F10100?0?0100?00005??110233011?701041100?00100000000?0101000000010000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Aleuropteridis hargreavesi	2021110010?1110210100?0?0100?00005??110133011?701040000?00100000000?01010000000100000000101000
Aleuropteridis jamesi	2021110010?1010210100?0?0100?00005??110233011?701040000?00100000000?01010010000100000000101000
Aleuroputeus	2201110000?11102100?0?0?0110?001021?100225031?700?00100?01111000000?11010010000000000000101000
Aleurothrixus aepim	210110?010?11112110?0?0?0211200000??10023400???00?10100?00001000000?10100000000100000000101000
Aleurothrixus antidesmae	2201110000?1011010160?0?0110?00005??110133021?001001100?00100000000?10010000000100000000101000
Aleurothrixus bondari	210110?010?10122110?0?0?0411200000??10022400???00?01100?00001000000?10110000000100000000101000
Aleurothrixus floccosus	220110?010?11112110?0?0?0211200000??10023400???00?01100?00001000000?10110000000100000000101000
Aleurothrixus interrogationis	2101110010?111120?0?0?0?0410?00005??110121021?000?41100?00001000000?01110000000000000000101000
Aleurothrixus lucumai	220110?010?10102110?0?0?0211400000??100222031?100?00100?00001000000?10010000000100000000101000
Aleurothrixus myrtacei	220110?010?10112110?0?0?0211200000??100212031?100?11100?00001000000?10010000000100000000101000
Aleurothrixus porteri	200110?010?10112110?0?0?0211400000??100235021?000?01100?00001000000?10110000100100000000101000
Aleurothrixus proximans	220110?010?11112110?0?0?0211200000??10023500???00?11100?00001000000?10100000000100000000101000
Aleurothrixus smilaceti	2201110000?1011110160?0?0100?00005??110121021?001000000?00001000000?10010000000100000000010100?
Aleurotithius	1?01111001011101100?0?0?0100?00000??011215031?401000000?01100000100?01010100000000000000101000
Aleurotrachelus alpinus	2201110110?11100100?0?0?0110?01005??11023300???00?01100?00001000000?01010000000100000000101000
Aleurotrachelus ampullatus	2101110111111200?120?0?0110?01005??10013300???00?00000?00111100000?01010010100100000000101100
Aleurotrachelus asparagi	2001110000?1110?110?0?0?0111000005??10013300???00?01100?00001100000?00010000000100000000101100
Aleurotrachelus atratus	230110?010?111020?0?0?0?0211400005??10023300???00?01100?00001000000?11010000100100000000101000
Aleurotrachelus camelliae	2201110000?1110010100?0?0310?01005??11012100???00?40100?00001100000?01010000000100000000101000
Aleurotrachelus duplicatus	2211110010?101020?100?0?0210?01005??10013300???00?01100?00111100000?01010010100100000000101000
Aleurotrachelus fumipennis	1?01110001011101110?0?0?0401100005??110221021?001011100?00111000000?01010010000100000000101010A0
Aleurotrachelus limbatus	2001110001110101100?0?0?1611000005??10013300???00?00000?00001100000?01010000000100000000101000
Aleurotrachelus longispinus	2201110110?11112100?0?0?0210?01005??110033021?001000000?00001100000?00110000000100000000101000
Aleurotrachelus minutus	2201110010?11112100?0?0?0310?01005??10013300???00?00000?00001100000?00110010000100000000101000
Aleurotrachelus multipapillus	2001110110?101120?0?0?0?0010?010024?110111031?701000100?00001100000?01010010000100000000101000
Aleurotrachelus obscurus	2101110010?111200?0?0?0?0210?01003?110023500???00?01100?00001100000?10110010100100000000101000
Aleurotrachelus tarennae	230110?000?0?12010100?0?0311301005??10023300???00?01100?00001100000?11110010100100000000101000
Aleurotrachelus tracheifer	2201110010?101120?0?0?0?0210?01005??100133031?711001100?00101000000?10010000000100000000101000
Aleurotrachelus trachoides	220110?010?101020?0?0?0?0311400003?0100231031?611001100?00101000000?10010000100100000000101000
Aleurotuba	2101110110?11101100?0?0?0310?01005??11013300???00?10100?00011100000?01110000000110000000101000
Aleurotulus anthuricola	2101110010?11101100?0?0?0210?00003?0100115031?7A1000100?00101000000?10010000000100000000101000
Aleurotulus arundinacea	20211100010101021A100?0?0110?00003?0000225031?7A1000001110100000000?10100010000000000000101000
Aleurotulus nephrolepidis	2101110110?11102100?0?0?0210?00003?0100129031?7A1011100?00121000000?01010000000000000000101000
Aleurotulus pteridophytae	2101110110?10102100?0?0?0210?00005??100123031?7010A1100?00101000000?01110000000100000000101000
Aleuroviggianus adanaensis	2101110000?10101100?0?0?1110?000024?000211031?2A0?01101111100000000?01010000000000000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Aleuroviggianus adrianae	2021110001011101 0?100?0?1110?000024?010123021?000?000011100110000 00?0010010000000000000101000
Aleuroviggianus graecus	2101110111010100 0?0?0?1110?000020?000111031?2A0?000011111000000 00?0101000000000000000101000
Aleuroviggianus halperini	2021110001010100100?0?0?1110?000024?010111031?200?400010111000000 00?0001001000000000000101000
Aleuroviggianus polymorphus	202111000101010AA0A10?0?1110?000024?010111031?200?101010111A000000 0?000100A000000000000010100A
Aleuroviggianus zonalus	20B1110000?10100100?0?0?1110?000020?010211031?200?111010111000000 00?0101000000000000000101000
Aleyrodes amnicola	1?0111000101110010 0?0?0?0000?000020?010111031?201001100?00101000000 ?1010000000000000000101000
Aleyrodes elevatus	2001110001011102101 10?0?0000?000020?010111031?201000001010011000000 ?1010001000000000000010100A
Aleyrodes lonicerae	1?0111000101A10A10A00?0?0000?000020?010115031?201000101010111000000 ?1001000000000000000101000
Aleyrodes proletella	1?0111000101010010 0?0?0000?000021?000115031?201000101010101000000 ?1001000000000000000101000
Aleyrodes pruinosus	1?0111000101010010 0?0?0000?000021?010111031?201000101010101000000 ?1001000000000000000101000
Aleyrodes singularis	1?0111000101010110 0?0?0000?00005??110111031?201000100?00101000000 ?1001000000000000000010100A
Aleyrodiella	2101110000?101000?0?0?0?07013000021?000237011?200?000010101010001 00?0101001000000000000101000
Apobemisia	2021110000?101010?110?0?1110?000024?000211031?211000001111100000000 ?0001001000000000000101000
Arachnaleyrodes	2001110000?1112010100?0?0410?00001??11013300???00?41100?00100000001001010000000000000000101100
Asialeyrodes lushanensis	0?01111000?111000?100?0?01013000021?00023700???00?51101010000000000 ?0101000000000000000101000
Asialeyrodes maesae	0?0111100101110010 0?0?0?01011000021?11023700???00?61100?00101000000 ?0110001000000000000101000
Asterobemisia carpini	1?0111000101010001 00?0?0700?000020?010111031?201011100?111A0000000 ?0101001000000000000101000
Asterobemisia dentata	1?0111000101010010100?0?0700?000023?0101110300?01011100?11100000000 ?0101001000000000000101000
Asterobemisia obenbergeri	2101110001010100 0?100?0?0700?000020?0101110300?01011101010100000000 ?0101001000000000000101000
Asterochiton cordiae	1?0111000101010010110?0?01113000020?010117021?00101100101110000000 0?0101000000000000000010100A0
Asterochiton pittospori	1?0111000101010110110?0?0110?000020?010211031?70105110101000000000 ?0101001000000000000101000
Bellitudo hispaniolae	2101110001011102 0?0?0?01113000021?011237011?20106110101010000000 ?0101000000001100000010100?
Bellitudo jamaicae	2101110001011101 0?0?0?01113000021?011237011?40106110101010000000 ?0101000000001100000101000
Bemisaleyrodes brideliae	1?0111000101010014140?0?0810?000025?0102110300?01041101011010000010 ?0101001000000000000101010
Bemisaleyrodes pauliani	1?0111000101010014140?0?0900?001022?010211031?20104110101100000000 0?0101000000000000000101010
Bemisia afer	1?0111000101010001A0?0?0010?000025?0101170300?01011101011 1A0000000 ?010100A000000000000101000
Bemisia antennata	1?0111000101010010110?0?0110?000025?0101170300?01041101011010000000 ?0101001000000000000101010
Bemisia berbericola	1?0111000101010001A0?0?0010?000025?0101170300?01011101011110000000 ?0101001000000000000101000
Bemisia combreticula	2001110001010101 0?110?0?0110?000020?010111031?201000101011100000000 ?0101000000000000000101000
Bemisia formosana	1?0111000101010201A0?0?0100?000020?010117031?201001101011100000000 ?0101001000000000000101000
Bemisia giffardi	1?0111000101010101A0?0?0110?001023?0102170300?01011101011100000000 ?0101001000000000000101001
Bemisia gigantea	1?0111000101010001 00?0?0?0110?000025?010217031?201041101011100000000 ?0101000000000000000101000
Bemisia guieriae	1?0111011101110001 10?0?0110?000025?0100170300?01001001011110000000 ?0101001000000000000101000
Bemisia hirta	0?2111000101110101 10?0?0110?000020?010111031?201000001011110000000 ?0101001000000000000101000
Bemisia lauracea	2001110001010100101 00?0110?000125?010217031?201011101011100000000 ?1111001000000000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Bemisia mesasiatica	1?011100010111021011 0?0?0100?000020?010111031?2010000010101000000 0?1010000000000000000010100?
Bemisia pongamiae	2001110001010100141 40?0?1110?000022?010218031?2010411010101000000 00?0101000000000000000101010
Bemisia silvatica	0?011100010101001010 0?0?0700?000025?0101110300?0104110101110000000 00?0101001000000000000101000
Bemisia subdecipiens	2001110001010100?100 ?0?0110?000022?0102110301?0100000101110000000 00?0101001000000000000101000
Bemisia tabaci	1?011100010101011 01A0?0?0010?000020?010011031?2010110010111A0000000 ?010100A000000000000101000
Bemisia tuberculata	1?011100010101001010 0?0?0010?000020?010117031?2010110010111100000000 ?0101001000000000000101000
Bemisiella	2001110001010100101 00?0?0700?000022?010117031?201001100?1110000000 0?0101001000000000000101000
Brazzaleyrodes	1?211100010101010?1A 0?0?0110?000021?011221031?20??0100101010000000 0?0101000000000000000101001
Bulgarialeurodes	1?011100010101001 00?0?0?1110?000021?000111031?701000000?0110000000 0?0101000000000000000101000
Calluneyrodes	200110?000?1010010100?0?0110?000023?0101110301?0101110101110000000 00?0101000000000000000101010??
Chitonaleyrodes	1?0110?000?111000?100?0?0110?00005??000231021?000?0110101000000000 0?0101000000000000000101011
Cockerelliella curcumae	1?01111000?1110010100?0?0000?00015??01123300???00?511011101A00000A 0?0101001000000000000101000
Cockerelliella psidii	0?01111000?1110010100?0?0000?00015??00123300???00?511011100A00000A 0?0101001000000000000101000
Cohicaleyrodes alternans	2301110110?111120?0?0?140210?01001??10023300???00?00000?00000000000 ?0000000000000000000101000
Cohicaleyrodes crossopterygis	2201110110?11112100?0?0?0210?01001??10023300???00?01100?00001000000 ?0101001000000000000101000
Cohicaleyrodes obscura	2201110110?11110100?0?0?0210?01005??11023300???00?00100?00001100000 ?0011000000000000000101000
Cohicaleyrodes platysepali	2001110110?11102100?0?0?0210?01005??100223031?70100??00?0011110000 0?0101001000000000000010??00
Cohicaleyrodes quadrilongispinae	2201110100?11102100?0?0?0210?01005??10013300???00?01100?0111000000 0?0101000000000000000101000
Cohicaleyrodes recurvispina	2201110110?11122100?0?0?0610?01005??10023300???00?00000?00001100000 ?0011000000000000000101000
Combesaleyrodes bouqueti	0?211100010111000?100 ?0?1110?00005??100239031?710?30000?0111100000 0?0011001000000010000101000
Combesaleyrodes tauffliebi	0?211100010101020?100 ?0?1110?000021?100231031?710?30000?0111100000 0?0011001000000010000101000
Corbettia baphiae	0?211101110111020?1A 0?0?1110?000021?110215031?2A1011001311100000000 ?0001010010000000000001010A1
Corbettia bauhiniae	2001110111011102 1A0?0?0?1110?000021?110215031?2010001013111000000 00?0101010010000000000001010A1
Corbettia graminis	1?0?1101110111021A 0?0?0?1110?00001??110215031?20??0010131110000000 0?0101011000000000000101001
Corbettia isoberliniae	0?211101110111020?1A 0?0?1110?000021?110215031?2010110010111100000000 ?0001010010000000000001010A1
Corbettia lonchocarpi	2001110111011102140 ?0?0?1110?00005??110215031?2010011013111000000 00?0101010010000000000001010A1
Corbettia millettiacola	0?211101110111020?1A 0?0?1110?00005??110215031?2A1001101311100000000 ?0001010010000000000001010A1
Corbettia tamarindi	200?110111011102100?0?0?1110?000021?110215031?2010011010111000000 00?0101010010000000000101001
Crenidorsum aroidephagus	2101110A10?1110P0?0?0?0?0210?01015??1102290K1?EA1001101110101000000 ?0111000000000000100010100 0
Crenidorsum celebes	210111000101111P100?0?0?0610?01005??100133021?001000100?00001000000 ?1001000000100001000101000
Crenidorsum commune	2201110110?111100?0?0?0?0210?01005??10013300???00?0110121010100000 0?0111000000100001000101000
Crenidorsum lasangensis	2201110010?11102100?0?0?0210?01005??1002310K1?EA1001100?0110000000 0?0101000000000000000101000
Crenidorsum magnisetae	2201110110?1111010100?0?0210?01005??1001330C1?7AA0011012101000000 00?0111000000100001000101000
Crenidorsum malpighiae	2201110110?1111010100?0?0210?01005??10013300???00?0110121111000000 0?0111000000100001000101000
Crenidorsum micheliae	2201110110?1110A100?0?0?0210?01005??110133021?001000100?00101100000 ?0101000000100001000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Crenidorsum millennium	2201110110?111000?100?0?0610?010021?11023700???00?01100?00101100000?00110000000000000100010100?
Crenidorsum morobensis	2201110010?11111100?0?0?0610?01005??1001330C1?7A1011000?00101100000?10010000000100000000101000
Crenidorsum stigmaphylli	2201110110?1112010100?0?0210?01005??1001330C1?7AA001100?00100000000?01110000000100001000101000
Crenidorsum tuberculatum	2201?10110?111000?100?0?0210?01005??10013300???00?01101210110000000?01110000000100001000101000
Crescentaleyrodes paulianae	1?01110001010101110?0?0?0401100005??000221011?201041100?00100000000?01010000000000000101010A0
Crescentaleyrodes semilunaris	1?01110001010101110?0?0?04011000021?000221011?2010011012101000000000?10010000000000000101010A0
Cryptolingula	2020011110?111200?0?0?0?0410?00005??10020610???00?00000?00100000000?10100000000000000000001011
Dialeurodes agalmae	1?01110000?10100101000?0?0110?00001??011231021?000?61101010010000010?01010010000000000000101000
Dialeurodes ara	0?01110000?1110016170?0?0000?000021?000221031?2A0?51101010000000000?01010000000000000000101000
Dialeurodes armatus	0?01110001010100101000?0?0110?00005??01023300???00?61101010000000000?01010000000000000000101100
Dialeurodes bicornicauda	1?01111001011100100?0?0?0410?000021?001237031?311061101111000000000?01010010000000000000101000
Dialeurodes cerifera	2001110??1011100110?0?0?0700?00005??010231021?000?61101010000000000?01010000000100000000101000
Dialeurodes cinnamomi	1?01110001010100010?100?0?0100?000121?10023700???00?41101010100000000?01010010000000000000101000
Dialeurodes citri	1?01110000?10100101000?0?0110?00015??01123300???00?61101110000000000?01010010000000000000101000
Dialeurodes cyathispinifera	0?01110111010112 1N1H0?0?0111300005??10113300???00?50?01110011100000?00000000000000000000010101?
Dialeurodes decaspermi	0?01110001011110 0?130?0?0000?000021?100221031?2A0?61100?00000000000?01010000000000000000101010
Dialeurodes dubia	1?01111001010100131 30?0?0000?00001??01023300???00?01101110100000000?01010000000000000000101000
Dialeurodes emarginata	1?01110001010100010?100?0?0900?000024?010221031?100?71101010100000000?01010010000000000000101000
Dialeurodes erythrinae	2101110001010101 0?1A0?0?0110?000021?000137011?2010111010111011001 00?01010000000000000000101 0A0
Dialeurodes ixorae	1?01110001011100100?0?0?0110?00005??11023300???00?61101110000000000?01010010000000000000101000
Dialeurodes joholensis	1?01111001011100 0?0?0?0?0110?000021?101215031?200?50001110000000000?01010010000000000000101000
Dialeurodes kirkaldyi	1?01110001010 10A10100?0?0110?00015??01123300???00?61101110000000000?010100A000000000000101000
Dialeurodes lanceolata	2101111001011 1020?0?0?0?0010?00005??00123300???00?51101210000000010?01010010000000000000101000
Dialeurodes minahassai	0?01110001010100131 30?0?0000?000021?000221021?000?61101000000000000?01010000000000000000101000
Dialeurodes mirabilis	1?01111001011101 0?0?0?0?0110?00003?200123300???00?51101110010000010?01010010000000000000101000
Dialeurodes platicus	1?21110001010110 0?100?0?1110?00006??10023000???00?51100?00000000000?00010000000000000000101000
Dialeurolobus	200111000A01010010110?0?0410?000021?010137011?2010411010111010000000?01010000100000000000101000
Dialeurolonga africana	2001110001011 1000?0?0?0?0100?00005??110215031?401061101010000000000?01010000100000000000101100
Dialeurolonga communis	2001110001010 1000?0?0?0?0110?00005??110223031?401061101011A00000A00?01010100000000000000 1011A0
Dialeurolonga elliptica	1?01110001010 1000?0?0?0?0110?000024?110221031?4A1061100?10000000100?01010000000000000000101100
Dialeurolonga elongata	1?01110001011 1000?0?0?0?0110?000024?111221031?401061101010100000A00?01010A000000000000000 1011A0
Dialeurolonga hoyti	1?01110001011 1020?0?0?0?1110?00005??111227031?401061101010101000100?01010110000000000000101100
Dialeurolonga maculata	1?01110001011100100?0?0?0110?000021?0002310K1?BA0?41101011100000000?01010000000000000000101000
Dialeurolonga nemoralis	1?01110001011 1000?0?0?0?0110?00005??110221031?401061101010000000100?01010110000000000000101100
Dialeurolonga phyllarthronis	2001110001011 1000?0?0?0?0100?00005??110221031?401061100?00000000000?11010000000000000000 1011A0

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Dialeurolonga ravensarae	2001110001011100 0?0?0?1110?000024?111223021?001011101010100000100?0101010000000000000101110
Dialeurolonga rusostigmoides	1?0111000101010 00?100?0?0410?001024?010221031?401061101011000000000?0101001000000000000101000
Dialeurolonga swainei	2001110000?111000?0?0?0?1110?000021?110220031?400?61100?01100000000?1010000010000000000101000
Dialeurolonga tenella	1?0111000101010 00?100?0?0010?000021?110221031?401061101010000000000?0101000000000000000101100
Dialeurolonga trialeuroides	1?0111000101010 00?0?0?0?0110?000024?011221031?401041101010100000100?0101000000000000000101100
Dialeuropora brideliae	1?0111100101010 00?100?0?0010?00005??100231031?610?011011101A0000000?0101101000000000000101000
Dialeuropora decempuncta	1?0111100101010B12110?0?0000?00005??100231031?610?111011101000000000?0101A000000000000000101000
Dialeuropora mangiferae	1?0111100101010010100?0?0000?00005??100231021?000?411011101000000000?0101100000000000000101010
Dialeuropora papillata	1?0111100101010B10100?0?0010?00005??1002330K1?DA0?311010101A0000000?010110A000000000000000101000
Dialeuropora silvarum	1?0111100101010 20?100?0?0010?00005??1002K30C1?6A0?11100?00010000100?0101A010000000000000101000
Dialeuropora viburni	0?01111000?1110110100?0?0000?00005??100226031?610?41100?00100000000?0101100000000000000101000
Disiphon	2101110110?11102100?0?140210?01011??110221021?001010100?00101000000?0101000000000001000101000
Dumbletoniella callistemoni	1?0111000101010 20?0?0?0?0110?000024?0102210B1?000?111013111000000010?1010001000000000000101000
Dumbletoniella eucalypti	1?0111000101010 10?0?0?0?0110?00005??0102210B1?000?001013101000000000?0101001000000000000101000
Dumbletoniella pittospori	1?0111000101110 10?0?0?0?0110?00005??11023300???00?111011101010000000?0101000010000000000101000
Dumbletoniella rotunda	200110?000?100??0?0?0?0?0110?00005??0102K10B1?000?011011110000000000?1010000000000000000101000
Dumbletoniella xanthorrhoeae	2001110001010101 0?0?0?0?1110?000024?010121031?200?000011101100000000?0101001000000000000001010A0
Extensaleyrodes akureensis	1?0111000101010 00?100?0?0110?000024?010211031?201041101011000000000?0101000000000000000101000
Extensaleyrodes falcata	1?0111000101010 00?100?0?1110?00005??110211031?201041101011001000000?0101000000000000000101000
Fascaleyrodes palmae	2201110110?111120?100?0?0010?01005??100133011?701000100?00011001000?0101000000000000000101000
Fascaleyrodes rara	2201110110?111120?100?0?0010?01005??100133011?701000100?00011001000?0101000000000000000101000
Filicaleyrodes bosseri	1?0111000101110 00?0?0?0?0100?00005??111121011?401051101111101000100?0101000000000000000101000
Filicaleyrodes williamsi	1?0111000101110 00?0?0?0?0100?000020?011111031?401041001111100000100?1001000000000000000101000
Fippataleyrodes indica	1?0111000101010 00?110?0?0010?00005??10023300???00?001010101000000000?0101001000000000000101000
Fippataleyrodes litseae	1?0111000101110 00?130?0?0110?00005??10123300???00?001010001000000000?0101001000000000000101000
Gagudjuia	200110?110?111100?100?0?0100?000021?000234021?000?011110000100000010?1010001000000000000101000
Gomenella dryandrae	1?0110?000?100??0?0?0?0?0101300002 1?01123700???00?611010110000000000?1010000000000000000101000
Gomenella multipora	200110?000?10101110?0?0?0001300005??000233011?200?501011110100000000?1010001000000000000010??01
Harpaleyrodes	0?2?1101110111011A110?0?0101300005??01123300???00?001010010010000010?01010010A000000000001010A1
Hempelia	220110?010?10112110?0?0?0211200000??100222021?000?01100?00001000000?1011000000010000000101001
Heteraleyrodes	2101110110?10102100?110?0310?01005??100233021?001000101210101000000?0011000000000000001000101000
Heterobemisia	20011???010101000?100?0?0700?000023?010127011?201011101011100000000?0101000000010000000101000
Indoaleyrodes glochidioni	1?0110?000?101100?0?0?0?0100?000022?010111031?201051101001000000010?1010000000000000000101000
Indoaleyrodes laos	1?0111000101010 00?0?0?0?0110?000022?010211031?201061101001000000000?1011000000000000000101000
Indoaleyrodes pseudoculatus	0?0111000101010 0100?0?0?0100?000020?010211031?201061100?00100000000?1011000000000000100101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Kanakarajiella	1?01111000?1110010100?0?0010?00003?20112330B1?000?51101100100000000?0101001000000000000101000
Leucopogonella pallida	1?0110?000?111000?110?0?1110?00005??10023300???00?00100?00011000000?0101001000010000000101?00
Leucopogonella simila	1?0110?000?111210?110?0?1110?00006??10023000???00?00000?00101000000?0101000000010000000101000
Lipaleyrodes atriplex	2001110001010102100?0?0?0010?000024?010111031?2010001010110000000000?0101000000000000000101000
Lipaleyrodes breyniae	1?01110000?11101100?0?0?0110?000020?010011031?2A1001100?01000000000?0101000000000000001101000
Lipaleyrodes crossandrae	1?0111000101110110 0?0?0?00113000020?010014031?2A1000100?01100000000?0101000000000000001101000
Lipaleyrodes euphorbiae	1?0111000A011102100?0?0?01113000020?000011031?2A1001100?01100000000?0001000000000000001101000
Lipaleyrodes phyllanthi	1?01110000?11102100?0?0?00013000020?000011031?2A1001100?01100000000?0101000000000000001101000
Malayaleyrodes	0?01111000?1110?10100?0?0101100005??001231021?000?5???100000000000?0101001000000001000??????
Marginaleyrodes	2201110000?12110110?0?0?0211301005??10113300???00?01000?00100000000?1011000010010000000101000
Massilieurodes americanus	1?0111100101110P101A0?0?0010?00003?2011223021?000?21101110000000010?0101001000000000000101000
Massilieurodes chittendeni	1?01111000?1A10010100?0?0010?00003?201122300???00?01101110000000010?0101001000000000000101000
Massilieurodes euryae	1?0111100101110010100?0?0010?00005??011223021?000?51101110100000000?0101000000000000000101000
Massilieurodes fici	1?0111100101110013100?0?0010?00005??01123300???00?51101110100000000?0101000000000000000101000
Massilieurodes setiger	1?0111100101010010 1A0?0?0010?00005??011223021?000?21101110000000000?0101000000000000000101000
Metabemisia filicis	1?2111000101110211 0?0?0?1110?000023?010019031?2010600010101000000100?0101000000000000000101000
Metabemisia palawana	1?211100010111021G0?0?0?0110?00005??111119031?400?1000101011000000000?0101000000000000000101000
Minutaleyrodes minuta	1?01111000?111000?0?0?0?1410?00005??11023300???00?51001310010000000?0101001000000000000101000
Minutaleyrodes suishanus	1?0111A000?111000?0?0?0?1410?00005??11123300???00?51001210110000000?0101001000000000000101000
Mixaleyrodes	2001110?00?111010?0?0?0?0310?01005??110033011?201001100?00111000000?0111000000000000000101000
Neoaleurotrachelus bertilloni	2201110000?1011B12120?0?0210?01003?011022100???00?61100?00101000000?1111000000000001000101000
Neoaleurotrachelus graberi	2201110000?1011010120?0?0210?01003?011022100???00?61100?00101000000?1111000000000001000101000
Neomaskellia andropogonis	2001110001010102110?0?0?1110?00006??110212031?801000000?00101000000?0010000000000000000101001
Neomaskellia bergii	1?0111000101010211 0?0?0?1110?00016??110212031?801000000?00101000000?0000000000000000000101001
Neopealius	1?0111000101010001?100?0?0110?000024?000111031?2010401010101000000000?0101000000000000000101000
Nigrasialeyrodes	200110?000?10101100?0?0?0701100005??100231021?000?51100?00001000000?0101000000000000000101011
Orchamoplatus caledonicus	2001110001110102100?0?0?0200?00015??11013300???00?81100?0000000000110101000010000000000000101000
Orchamoplatus citri	2001110001110102100?0?0?0610?00005??11013300???00?81100?0000000000110101000000000000000000101000
Orchamoplatus dentatus	220110?001110112100?0?0?0200?00015??11013300???00?81000?0010000000111001000010000000000000101000
Orchamoplatus louiserussellae	1?0111000111011210 0?0?0?0200?00015??11023300???00?81100?0000000000111001000000000000000000101000
Orchamoplatus mammaeferus	1?0110?001110102100?0?0?0200?00015??11013300???00?81100?0010000000111001000000000000000000101000
Orchamoplatus montanus	1?0111000111011210 0?0?0?0200?00005??11013300???00?81100?0010000000111001000000000000000000101000
Orchamoplatus niuginii	1?0111000111011210 0?0?0?0200?00015??11013300???00?80000?0010000000111001000000000000000000101000
Orchamoplatus noumeae	1?0111000111010210 0?0?0?0200?00005??11013300???00?81100?0010000000110001000000000000000100101000
Orchamoplatus plumensis	0?0111000111010210 0?0?0?0200?00005??11013300???00?40100?0010000000111001000000000000000000101?00

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Orchamoplatus porosus	1?011100011101121 00?0?0200?00015??1?0127?31?200?80000?001000000011100100000000000100101000
Orientaleyrodes	1?01110000?11112110?0?0?04011000021?10013700???00?41101001100000000?10010000100000000001010A0
Orstomaleyrodes	220111000A110110100?0?0?0210?00005??1A023300???00?11100?00010000000?10010010000000000000101000
Papillipes	0?2010?000?10102110?0?0?1110?00005??11023300???00?0AA00?01100000100?01010100000000000000001001
Parabemisia aceris	2001110000?10100100?0?0?0110?000022?0002110300?01011101011100000000?01010000000000000000010100?
Parabemisia jawani	200010?001010101100?0?0?1110?000021?000221031?2A0?21101011000000000?10100000000000000000101001
Parabemisia lushanensis	2001110000?10100100?0?0?1110?000020?000211031?20100110101010000000?01010000000000000000101000
Parabemisia myricae	2101110000?10100100?0?0?1110?000020?010111031?20100A10101110000000?01010000000000000000101000
Parabemisia myrmecophila	2101110001010101100?0?0?1110?000024?010111031?20101010101110000000?01010000000000000000101000
Paraleurolobus	2301110110?111100?0?0?0?01011000021?10023700???00?41100?00100000000?10010000100100000000101000
Paulianaleyrodes splendens	2121110110?111020?0?0?0?0110?00005??100223021?000?00000?01110000010?01010010000000000000101000
Paulianaleyrodes tetracerae	1?21111110?111020?0?0?0?0110?00005??100223021?001000000?01100000010?01010110000000000000101000
Pealius akebiae	2201110000?10101100?0?0?0110?00005??000111031?7A10011011111000000000?01010000000000000000101000
Pealius azaleae	2001110001010102100?0?0?0110?00005??010111031?70101000111110000000?01010000000000000000101000
Pealius cryptus	2001110000?101020?110?0?1110?00003?2000211031?70100000101100000000?01010010000000000000101000
Pealius euryae	2201110000?10101100?0?0?0110?000020?000111031?20100000121110000000?01010000000000000000101000
Pealius fici	1?B111000A?1010111A10?0?1110?00003?2000225031?71101110110110000000?010100A0000000000000101000
Pealius kelloggi	2101110001012100100?0?0?0110?00005??000102031?101011100?00000000000?01010000000000000000101000
Pealius liquidambari	F0B1110001011102101 10?0?0110?00003?2000225031?7A0?10001101100000000?01010000000000000000010100?
Pealius madeirensis	1?01110001011102110?0?0?0110?00005??100111031?101001100?01000000000?01010000000000000000101000
Pealius mori	2001110000?1010F1A1A0?0?1110?00003?2000225031?7A10011011110000000100?01010110000000000000101000
Pealius rhododendri	2201110000?1010F1A0?0?0?1110?000020?010111031?20100000111110000000?01010000000000000000101000
Pectinaleyrodes culcasiae	2001110010?10102100?0?0?0210?00005??10023300???00?41100?00000000000?11010000000000000000101000
Pectinaleyrodes triclisiae	2001110000?12100100?0?0?0210?00001??11023300???00?41100?00000000000?11010000000000000000101000
Pentaleyrodes cinnamomi	2001110001010102110?0?0?0110?00005??01023300???00?01100?00100000000?01010000000100000000101000
Pentaleyrodes hongkongensis	2001110001010102110?0?0?0110?00005??01023300???00?01100?00100000000?01010000000100000000101000
Pentaleyrodes yasumatsui	2001110001010102110?0?0?0110?00005??01023300???00?01100?00100000000?01010000000100000000101000
Pogonaleyrodes fastuosa	1?21110001010100101 10?0?0110?00005??010233021?000?50001210100000010?01010010000000000000??????
Pogonaleyrodes zimmermanni	1?21110001010100140?0?0?0100?000021?010221031?20105000101010000010?01110010000000000000101000
Pseudaleuroplatus	200110?001110100100?0?0?0410?00005??11003300???00?01000?00100000000?01010000000100000000101000
Ramsesseus	1?2110?000?0?1000?110?0?1410?000021?110121031?20100010101010000000?01010000000000000000010??01
Rhachisphora alishanensis	1?01110000?1110011110?0?0210?010024?01123700???00?51101110001100000?01010000000000001000101000
Rhachisphora elongatus	1?01110111010101121K0?0?0010?00105??10123300???00?51101010001000000?00010000000000000000101010
Rhachisphora franksae	1?01110000?111001K130?0?0210?010021?100231021?010?51101110001100000?01010000000000000000101010
Rhachisphora koshunensis	0?011101110101001K130?0?0210?01001??11123300???00?51101110001100000?01010000000000000000101010

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Rhachisphora maesae	1?01110110?1010011110?0?0210?010024?00123700???00?51101110101100000?0101000000000000000101000
Rhachisphora rutherfordi	1?01110110?111001K130?0?1410?010024?11123700???00?61001010001100000?0101000000000000000101010
Rhachisphora trilobitoides	1?01110000?11100110?0?0?0210?01005??10123300???00?61101010001100000?0101000010000000000101000
Rositaleyrodes	1?01110001010102101 10?0?01011000021?010237011?2010411010101010000000?1101000010000000000101000
Rugaleyrodes angolensis	2201110000?1010B0?100?0?0610?01005??11011100???00?00100?00011100000?0111001000010000000101000
Rugaleyrodes bidentata	2101110000?1010010100?0?0210?01005??11021100???00?41100?00101000000?0111001000010000100101000
Rugaleyrodes tetracerae	2101110000?1010?0?100?0?0200?01005??11012100???00?00100?00011100000?0111001000010000000101000
Rusostigma eugeniae	1?01110001011100101 00?0?0100?000021?001221021?000?61101100100000000?0101000000000000000101000
Rusostigma radiirugosa	1?01110001011100 1C1C0?0?0100?000021?001221021?000?61101200100000000?0101000000000000000101000
Rusostigma tokyonis	1?01110001011120 0?100?0?0100?000021?100225021?000?61101200100000000?0101000000000000000101000
Russellaleyrodes	1?01110001010 10B10100?0?0210?00005??1002330B1?0A0?41101210001000000?1111100000000000000101000
Setaleyrodes mirabilis	2010110001010102110?0?0?1110?00003?2010221031?7A1010001F1111100000?0101001000000000000101000
Setaleyrodes thretaonai	2010110001010102111 10?0?1110?00003?2010221031?701010001F1111100000?0101001000000000000101000
Setaleyrodes vigintiseta	202110?000?10102110?0?0?0110?00003?1000235031?1110011010101000000?0101001000000000000101000
Simplaleurodes	2201110000?101100?100?0?0110?00005??10023300???00?00100?00001000000?0011000000100000000101?0?
Singhiella bicolor	1?01110001010100101 00?0?0110?00005??01123700???00?11101110100000000?0101000000000000000101000
Singhiella cardamomi	1?01110000?111000?130?0?0000?00005??001223021?000?51101110000000000?0101000000000000000101000
Singhiella chinensis	1?01110001010101151 50?0?0000?00005??01023300???00?00001110010000000?0101001000000000000101000
Singhiella citrifolii	1?01110000?1110013130?0?0010?00005??01023300???00?61101110000000000?0101000000000000000101000
Singhiella delamarei	1?01110001010101130?0?0?0110?00005??00023300???00?01101110010000100?0101010000000000000101000
Singhiella kuraruensis	1?01110000?11100130?0?0?0110?00005??10023300???00?51000?00000000000?0101000000000000000101000
Singhiella premnae	1?01111001011101130?0?0?0110?00005??000233021?0A0?11101110100000100?0101010000000000000101000
Singhiella subrotunda	1?01110001011102111A0?0?0100?00005??10023300???00?21001210000000100?0101010000000000000101000
Singhius hibisci	1?01111001011 10F0?0?0?0?0010?00003?100023300???00?21101110100000000?0101001000000000000101000
Singhius russellae	1?01111001011 1000?0?0?0?0010?00003?100023300???00?01101110110000010?0101001000000000000101000
Siphoninus immaculatus	1?01110001011102100?12140110?00005??110115031?201040100?00000000000?0000000000000000000101000
Siphoninus phillyreae	1?01110001011102100?12140110?00005??110105031?101040000?00100000000?0000000000000000000101000
Taiwanaleyrodes carpini	2101111001010102 0?0?0?0?01113000021?00113300???00?21001010010000010?0101001000000000000101000
Taiwanaleyrodes meliosmae	2121111001010 10F0?0?0?0?0110?00005??00113300???00?00101210000000000?0101001000000000000101000
Tetraleurodes acaciae	2201110110?1110F0?0?0?0?0211000005??10013300???00?01100?001A0000010?1001001000010000000101000
Tetraleurodes andropogoni	2201110100?100??0?0?0?0?0411100005??10023300???00?01100?00100000000?1011000010010000000101000
Tetraleurodes banksiae	1?0110?000?101000?0?0?0?0001300005??11023300???00?00000?01000000000?1010000000000000000101000
Tetraleurodes bicolor	2201110000?10111100?0?0?01A1301005??10023300???00?01100?00100000000?1011000000100000000101000
Tetraleurodes caulicola	2121110110?1110A0?0?0?0?0211000005??10023300???00?01100?00101000010?1011000000100000000101000
Tetraleurodes confusa	220110?110?111120?0?0?0?02111000021?10023300???00?01100?00100000000?1001000010010000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Tetraleurodes granulata	2101110010?1010F0?0?0?0?0401100001??10013300???00?01100?00101000000?0101001000010000000101000
Tetraleurodes pluto	2001110000?11110100?0?0?0401100003?110023400???00?41100?00001000000?0101000010010000000101010
Tetraleurodes quercicola	232110?000?0?110100?0?0?0211001005??10023300???00?01100?01101000000?1111000010010000000101000
Tetraleurodes selachidentata	2420010010?111120?0?0?0?0501100005??10023300???00?00000?01100000000?0101000000010000000101000
Tetraleurodes stirlingiae	200110?000?0?0??0?0?0?0?0211200001??10013700???00?01100?00101100000?0101000010000000000101100
Tetraleurodes sulcistriatus	220110?001110102100?0?0?0211100005??10013300???00?01100?00001000000?1001001010000000000101000
Tetralicia ericae	1?21110000?101010?0?0?0?0110?00005??11013300???00?00000?00111000000?0101000000000000000101000
Tetralicia graminicola	1?21110010?111020?0?0?0?0110?00005??10013300???00?00100?00111000000?0101000000010000000101000
Tetralicia iberiaca	1?2?10?000?111000?0?0?0?0110?00005??10023300???00?00000?00101100000?0101000000010000000101000
Tetralicia tuberculata	2021110010?111020?0?0?0?0110?00005??11023300???00?00000?00111000000?0101001000000000000101000
Trialeurodes abutiloneus	200011000101010A0?0?0?0?0110?000024?011111031?401000001011100000100?01010A000000000000101001
Trialeurodes bruneiensis	200111000101010100?0?0?0?0110?000024?011111031?401000001011100000100?0101000000000000000101001
Trialeurodes darwiniensis	200111000101010000?0?0?0?0110?000024?010221031?401000001011100000100?0101000000000000000101100
Trialeurodes dicksoniae	200110?001010100?0?0?0?0110?000024?011111031?401010001011100000100?0101000000000000000101000
Trialeurodes drewsi	2001110000?101000?0?0?0?0110?000024?011111031?401000001011100000100?1111010000000000000010100?
Trialeurodes ericae	1?0011011101010000?0?0?0?1110?000024?010111031?401000000?01100000100?1111010000000000000101001
Trialeurodes floridensis	200111000101010000?0?0?0?0110?0000M4?011227011?401041001011110000100?0101001000000000000101001
Trialeurodes pergandei	1?0111000101010100?0?0?0?0110?000024?011111031?401000001011100000100?1101000000000000000101101
Trialeurodes rex	1?0011000101110100?0?0?0?0010?000024?000121031?401000000?01100000100?1010000000000000100101000
Trialeurodes vaporariorum	200111000101010100?0?0?0?0110?000024?011121031?401040001011100000100?11010A000000000000101001
Trialeurodes variabilis	200111000101010100?0?0?0?0110?000024?011127031?401000001011 1A0000A00?1001000000000000000101101
Tuberaleyrodes	1?0111100101110211110?0?0000?00005??011233021?000?01101110010000000?0101001000000000000101000
Vasdavidius cobarensis	200111000101111100?100?0?1110?000021?110215031?201000000?00100000000?0010000000000000000101001
Vasdavidius concursus	210111000101110110100?0?1110?000024?010115031?201000001110100000000?0101000000000000000101000
Vasdavidius indicus	202111000101110F1A100?0?1110?000024?010115031?201000001111101000000?0101000000000000000101000
Vasdavidius setiferus	200111000101010012 0?0?0?1110?000021?110215031?2A1000001110101000000?0101000000000000000101000
Venezaleurodes	F0011100010101000?130?0?0110?000020?011217031?401001101011100000100?1111010000000000000101001
Viennotaleyrodes bicolorata	200011000101010020?0?0?0?1110?00105??11013300???00?40000?01100000000?1010001000000000000001001
Viennotaleyrodes bosciae	202011011101110211110?0?0110?00105??11023300???00?00000?00110000000?0001001000010000000001001
Viennotaleyrodes curvisetosus	200011011101110010?0?0?0?11?0?00005??110233011?201001100?00100000010?1001001000000000000010A1
Viennotaleyrodes fallax	202011011101010020?100?0?0110?00105??110215031?201000000?01110000000?1001001000010000000001001
Viennotaleyrodes lacunae	200010?1110100??0?0?0?0?1111100005??110223021?001000100?00000000000?1010000010000000000001011
Viennotaleyrodes megapapillae	0?2011011101010020?0?0?0?1110?00105??110233011?201041100?01100000000?1011001000000000000001001
Viennotaleyrodes platysepali	202011011101010020?1C0?0?0110?00105??110233011?201000000?01110000000?1001001000000000000001001
Xenaleyrodes artocarpi	202011000111011210 0?120?0100?00015??1110210B1?000?40000?00000000000?0101000010000000000101000

Appendix 4. Continued.

	1 2 3 4 5 6 7 8 9 123456789012345678901234567890123456789012345678901234567890123456789012345678901234
Xenaleyrodes broughae	2421110001110112100?120?0600?00015??11023300???00?00000?00100000000?01010000100100000000101000
Xenaleyrodes fauceregius	2020110001111102111112140600?00015??110221021?000?00000?00101000000?10110001000000000000101000
Yleyrodes	2001110001110100100?0?0?11111000020?000211031?20101110100010000000?01010000000000000000101000
Zaphanera capparis	2101110000?10102110?0?0?01A0?00005??10023300???00?01100?00101000000?01010000100100000000101000
Zaphanera cyanotis	2101110000?10102110?0?0?0210?00005??10023300???00?01100?00101000000?01010000100100000000101100
Zaphanera niger	200110?000?11100130?0?0?1410?00005??110233011?200?01100?00100000000?01010010000000000000101010
Zaphanera papyrocarpae	200110?000?1110013130?0?1410?00005??110233011?200?01101310101000000?01010010000000000000101011
Zaphanera rhachisreticulata	250110?000?11100130?0?0?1410?00005??110223011?200?01100?00101000000?01010000100100000100101010
New genus 1 sp 1	2621110000?1110B0?0?0?0?0610?00005??10023300???01001100?00101000000?01010000000000000000101000
New genus 1 sp 2	2121110000?111020?0?0?0?0610?00005??10023300???01011100?00101000000?01010010000000000000101000
New genus 2 sp 1	1?011100011101021G130?0?0110?000024?11123300???01051101010010000000?01010010000000000000101010
New genus 2 sp 2	1?211100011101021G130?0?0110?00005??10023300???00?51101010010000010?01010010000000000000010??10
Out-groups	
Stenaleyrodes	2001110110?1211010100?0?0100?000020?0000181300?01140000?00100000100?10100000000100000000001011
Dialeurodicus	0?01110110?1110010100?0?0010?000021?0002151 31?501140000?00100000000?10100000000000000000011011
Aleurodicus cocois	0?0010?110?1210110100?0?0110?00005??0002151302?11100000?01100000000?10100010001000000000011010
Aleurodicus dispersus	0?0010?110?12101100?0?0?0100?000021?0002151302?11100000?01000000000?10100000001000000000011010
Azuraleurodicus	0?0110?000?1210A100?0?0?1110?00003?0000216131?511100000?01100000000?00100000001000000000011010
Eudialeurodicus	1?01110110?1010010100?0?0000?00006??100228031?801000000?01000000000?01110010001000000000011011
Octaleurodicus	1?0110?110?1110010100?0?0000?000024?010215131?201100000?00100000000?01110000001100000000001101?
Synaleurodicus	1?0110?000?12100120?0?0????0?00005??110218131?2A0?00000?00100000100?10000000001000000000001100?

For monobasic genera and/or those genera, for which only one species were available for study, the names of species were deleted in the data matrix in order to be indicated in the obtained trees from the other genera with multiple representative species. See appendix 3 for the species names of these genera.

Appendix 5. Host plant association of the whitefly species selected for the phylogenetic study. An asterisk indicates families unplaced to order but included in higher groups. All botanical names follow the system of the Angiosperm Phylogeny Group (Bremer *et al.*, 1998; Soltis *et al.*, 2000; Bremer *et al.*, 2003). Pteridophyta (ferns) are unplaced to higher group (§ shows orders of Pteridophyta). ‡ shows the only gymnosperm record (unplaced to higher group). Bold taxa are out-groups.

Species	Host plant family	Host plant order	Host plant higher group
Acanthaleyrodes callicarpae	Euphorbiaceae, Rosaceae, Verbenaceae, Vitaceae*	Lamiales, Malpighiales, Rosales	euasterids I, eurosids I, rosids
Acanthaleyrodes spiniferosa	Ebenaceae	Ericales	asterids
Acanthaleyrodes styraci	Styracaceae	Ericales	asterids
Acanthobemisia distylii	Hamamelidaceae	Saxifragales	core eudicots
Acaudaleyrodes africana	Fabaceae	Fabales	eurosids I
Acaudaleyrodes rachipora	Euphorbiaceae, Fabaceae	Fabales, Malpighiales	eurosids I
Acaudaleyrodes tuberculata	Combretaceae, Euphorbiaceae	Malpighiales, Myrtales	eurosids I, rosids
Acutaleyrodes palmae	Arecaceae	Arecales	commelinids
Africaleurodes coffeacola	Combretaceae, Euphorbiaceae, Malvaceae, Rhamnaceae, Rubiaceae, Sapindaceae	Gentianales, Malpighiales, Malvales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, rosids
Africaleurodes fulakariensis	Moraceae	Rosales	eurosids I
Africaleurodes hexalobi	Annonaceae, Apocynaceae	Gentianales, Magnoliales	euasterids I, magnoliids
Africaleurodes loganiaceae	Icacinaceae*, Loganiaceae, Malvaceae, Pandaceae, Rubiaceae, Salicaceae	Gentianales, Malpighiales, Malvales	euasterids I, eurosids I, eurosids II
Africaleurodes ochnaceae	Malvaceae, Ochnaceae	Malpighiales, Malvales	eurosids I, eurosids II
Agrostaleyrodes arcanus	Poaceae	Poales	commelinids
Aleurocanthus banksiae	Myrtaceae, Proteaceae	Myrtales, Proteales	eudicots, rosids
Aleurocanthus calophylli	Clusiaceae	Malpighiales	eurosids I
Aleurocanthus ceracroceus	Lauraceae, Monimiaceae, Myrtaceae	Laurales, Myrtales	magnoliids, rosids
Aleurocanthus citriperdus	Rutaceae	Sapindales	eurosids II
Aleurocanthus cocois	Arecaceae, Lauraceae, Myrtaceae	Arecales, Laurales, Myrtales	commelinids, magnoliids, rosids
Aleurocanthus delottoi	Rutaceae, Ulmaceae	Sapindales, Rosales	eurosids I, eurosids II
Aleurocanthus esakii	Rosaceae	Rosales	eurosids I
Aleurocanthus gateri	Arecaceae	Arecales	commelinids
Aleurocanthus gordoniae	Theaceae	Ericales	asterids
Aleurocanthus inceratus	Magnoliceae, Rutaceae	Magnoliales, Sapindales	eurosids II, magnoliids
Aleurocanthus leptadeniae	Apocynaceae, Brassicaceae, Zygophyllaceae*	Brassicales, Gentianales	euasterids I, eurosids I, eurosids II
Aleurocanthus spiniferus	Annonaceae, Convolvulaceae, Ebenaceae, Elaeocarpaceae, Euphorbiaceae, Hamamelidaceae, Lardizabalaceae, Rosaceae, Rutaceae, Sabiaceae*, Salicaceae, Vitaceae*	Ericales, Magnoliales, Malpighiales, Oxalidales, Ranunculales, Rosales, Sapindales, Saxifragales, Solanales	asterids, core eudicots, euasterids I, eudicots, eurosids I, eurosids II, magnoliids, rosids
Aleurocerus cerifer	Dilleniaceae*, Sapotaceae	Ericales	asterids, core eudicots
Aleurocerus flavomarginatus	Arecaceae, Musaceae	Arecales, Zingiberales	commelinids
Aleurocerus musae	Bignoniaceae, Rubiaceae, Zingiberaceae	Gentianales, Lamiales, Zingiberales	euasterids I, commelinids

Aleurocerus palmae	Arecaceae, Sapotaceae	Arecales, Ericales	asterids, commelinids
Aleurochiton acerinus	Sapindaceae	Sapindales	eurosids II
Aleurochiton aceris	Sapindaceae	Sapindales	eurosids II
Aleurochiton forbesii	Sapindaceae	Sapindales	eurosids II
Aleurochiton pseudoplatani	Sapindaceae	Sapindales	eurosids II
Aleuroclava aucubae	Aquifoliaceae, Araliaceae, Caprifoliaceae, Cornaceae, Juglandaceae, Lauraceae, Moraceae, Oleaceae, Pittosporaceae, Rosaceae, Rubiaceae, Rutaceae, Salicaceae, Theaceae, Ulmaceae	Apiales, Aquifoliales, Cornales, Dipsacales, Ericales, Fagales, Gentianales, Lamiales, Laurales, Malpighiales, Rosales, Sapindales	asterids, euasterids I, euasterids II, eurosids I, eurosids II, magnoliids
Aleuroclava bifurcata	Sapindaceae	Sapindales	eurosids II
Aleuroclava citrifolii	Rutaceae	Sapindales	eurosids II
Aleuroclava euryae	Aquifoliaceae, Ericaceae, Lauraceae, Magnoliaceae, Theaceae, Trochodendraceae	Aquifoliales, Ericales, Laurales, Magnoliales	asterids, euasterids II, magnoliids
Aleuroclava ficicola	Moraceae	Rosales	eurosids I
Aleuroclava filamentosa	Euphorbiaceae, Rubiaceae	Gentianales, Malpighiales	euasterids I, eurosids I
Aleuroclava hikosanensis	Aquifoliaceae, Buxaceae, Lauraceae, Pittosporaceae, Theaceae	Apiales, Aquifoliales, Ericales, Laurales	asterids, euasterids II, magnoliids
Aleuroclava jasmini	Combretaceae, Euphorbiaceae, Myrsinaceae, Oleaceae, Rubiaceae, Rutaceae	Ericales, Gentianales, Lamiales, Malpighiales, Myrtales, Sapindales	asterids, euasterids I, eurosids I, eurosids II, rosids
Aleuroclava magnoliae	Actinidiaceae, Betulaceae, Clethraceae, Cornaceae, Ericaceae, Fabaceae, Hamamelidaceae, Lauraceae, Magnoliaceae, Oleaceae, Rosaceae, Sapindaceae, Saxifragaceae	Cornales, Ericales, Fabales, Fagales, Lamiales, Laurales, Magnoliales, Rosales, Sapindales, Saxifragales	asterids, core eudicots, euasterids I, eurosids I, eurosids II, magnoliids
Aleuroclava murrayae	Lauraceae, Proteaceae, Rutaceae	Laurales, Proteales, Sapindales	eudicots, eurosids II, magnoliids
Aleuroclava nigeriae	Anacardiaceae, Bignoniaceae, Combretaceae, Ebenaceae, Loganiaceae, Moraceae, Myrtaceae, Rubiaceae, Salicaceae, Sapindaceae, Sapotaceae, Simaroubaceae, Ulmaceae, Verbenaceae	Ericales, Gentianales, Lamiales, Malpighiales, Myrtales, Rosales, Sapindales,	asterids, euasterids I, eurosids I, eurosids II, rosids
Aleuroclava piperis	Piperaceae	Piperales	magnoliids
Aleuroclava psidii	Caprifoliaceae, Euphorbiaceae, Lauraceae, Moraceae, Myrsinaceae, Myrtaceae, Rosaceae, Salicaceae, Sapindaceae, Ulmaceae	Dipsacales, Ericales, Laurales, Malpighiales, Myrtales, Rosales, Sapindales	asterids, euasterids II, eurosids I, eurosids II, magnoliids, rosids
Aleuroclava pulcherrimus	Fabaceae	Fabales	eurosids I
Aleuroclava similis	Aquifoliaceae, Ericaceae, Theaceae	Aquifoliales, Ericales	asterids, euasterids II
Aleurocybotus graminicolus	Poaceae	Poales	commelinids
Aleurocybotus occiduus	Cyperaceae, Poaceae	Poales	commelinids
Aleuroduplidens eucalyptifolia	Myrtaceae	Myrtales	rosids
Aleuroduplidens santali	Santalaceae	Santalales	core eudicots
Aleuroduplidens triangularis	Fabaceae	Fabales	eurosids I
Aleuroduplidens wellsae	Fabaceae	Fabales	eurosids I

Aleuroglandulus magnus	Arecaceae	Arecales	commelinids
Aleuroglandulus malangae	Araceae	Alismatales	monocots
Aleuroglandulus striatus	Polygonaceae	Caryophyllales	core eudicots
Aleuroglandulus subtilis	Arecaceae, Rubiaceae	Arecales, Gentianales	commelinids, euasterids I
Aleuroinanis myrtacei	Myrtaceae	Myrtales	rosids
Aleurolobus diastematus	Combretaceae, Salicaceae	Malpighiales, Myrtales	eurosids I, rosids
Aleurolobus graminicola	Poaceae	Poales	commelinids
Aleurolobus hargreavesi	Poaceae	Poales	commelinids
Aleurolobus marlatti	Araceae, Daphniphyllaceae, Moraceae, Rutaceae, Ulmaceae	Alismatales, Rosales, Sapindales, Saxifragales	core eudicots, eurosids I, eurosids II, monocots
Aleurolobus moundi	Sapotaceae	Ericales	asterids
Aleurolobus onitshae	Euphorbiaceae	Malpighiales	eurosids I
Aleurolobus styraci	Styracaceae	Ericales	asterids
Aleurolobus teucrii	Lamiaceae	Lamiales	euasterids I
Aleurolonga cassiae	Fabaceae	Fabales	eurosids I
Aleuromarginatus corbettiaformis	Fabaceae	Fabales	eurosids I
Aleuromarginatus dalbergiae	Fabaceae	Fabales	eurosids I
Aleuromarginatus kallarensis	Fabaceae	Fabales	eurosids I
Aleuromarginatus littoralis	Fabaceae	Fabales	eurosids I
Aleuromarginatus marginiquus	Fabaceae	Fabales	eurosids I
Aleuromarginatus moundi	Fabaceae	Fabales	eurosids I
Aleuromarginatus nemciae	Fabaceae	Fabales	eurosids I
Aleuromarginatus nigrus	Fabaceae	Fabales	eurosids I
Aleuromarginatus serdangensis	Host indet.		
Aleuromarginatus tephrosiae	Fabaceae	Fabales	eurosids I
Aleuropapillatus kumariensis	Verbenaceae	Lamiales	euasterids I
Aleuroparadoxus arctostaphyli	Ericaceae	Ericales	asterids
Aleuroparadoxus gardeniae	Ebenaceae, Rubiaceae	Ericales, Gentianales	asterids, euasterids I
Aleuroparadoxus ilicicola	Aquifoliaceae	Aquifoliales	euasterids II
Aleuroparadoxus iridescens	Lamiaceae, Rhamnaceae, Rosaceae	Lamiales, Rosales	euasterids I, eurosids I
Aleuroparadoxus punctatus	Anacardiaceae, Euphorbiaceae, Rosaceae, Salicaceae	Malpighiales, Rosales, Sapindales	eurosids I, eurosids II
Aleuroplatus acaciae	Fabaceae	Fabales	eurosids I
Aleuroplatus berbericolus	Aquifoliaceae, Berberidaceae	Aquifoliales, Ranunculales	euasterids II, eudicots
Aleuroplatus bossi	Apocynaceae, Brassicaceae, Canellaceae, Meliaceae, Polygalaceae, Smilacaceae	Brassicales, Canellales, Fabales, Gentianales, Liliales, Sapindales	euasterids I, eurosids I, eurosids II, magnoliids, monocots
Aleuroplatus cadabae	Apocynaceae, Brassicaceae	Brassicales, Gentianales	euasterids I, eurosids II
Aleuroplatus cockerelli	Asteraceae	Asterales	euasterids II
Aleuroplatus cococolus	Arecaceae, Myrtaceae	Arecales, Myrtales	commelinids, rosids
Aleuroplatus dorsipallidus	Cunoniaceae, Lauraceae, Moraceae	Laurales, Oxalidales, Rosales	eurosids I, magnoliids
Aleuroplatus epigaeae	Ericaceae, Lauraceae	Ericales, Laurales	asterids, magnoliids

Aleuroplatus evodiae	Rutaceae	Sapindales	eurosids II
Aleuroplatus fici	Moraceae	Rosales	eurosids I
Aleuroplatus ilicis	Aquifoliaceae, Ericaceae, Lauraceae	Aquifoliales, Ericales, Laurales	asterids, euasterids II, magnoliids
Aleuroplatus incisus	Clusiaceae, Euphorbiaceae	Malpighiales	eurosids I
Aleuroplatus pectiniferus	Betulaceae, Euphorbiaceae, Malvaceae, Moraceae, Myrtaceae, Rutaceae, Salicaceae, Theaceae	Ericales, Fagales, Malpighiales, Malvales, Myrtales, Rosales, Sapindales	asterids, eurosids I, eurosids II, rosids
Aleuroplatus periplocae	Apocynaceae	Gentianales	euasterids I
Aleuroplatus perseaphagus	Lauraceae	Laurales	magnoliids
Aleuroplatus quercusaquaticae	Fagaceae	Fagales	eurosids I
Aleuropleurocelus nigrans	Boraginaceae*, Caprifoliaceae, Ericaceae, Fagaceae, Lamiaceae, Lauraceae, Ranunculaceae, Rhamnaceae, Rosaceae	Dipsacales, Ericales, Fagales, Lamiales, Laurales, Ranunculales, Rosales	asterids, euasterids I, euasterids II, eudicots, eurosids I, magnoliids
Aleuropteridis eastopi	Oleandraceae	§Aspleniales	
Aleuropteridis filicicola	Oleandraceae, Pteridaceae, Thelypteridaceae	§Aspleniales, §Parkeriales	
Aleuropteridis hargreavesi	Undetermined fern		
Aleuropteridis jamesi	Pteridaceae	§Parkeriales	
Aleuroputeus perseae	Lauraceae, Myrtaceae	Laurales, Myrtales	magnoliids, rosids
Aleurothrixus aepim	Asteraceae, Convolvulaceae, Euphorbiaceae, Rubiaceae, Rutaceae	Asterales, Gentianales, Malpighiales, Sapindales, Solanales	euasterids I, euasterids II, eurosids I, eurosids II
Aleurothrixus antidesmae	Euphorbiaceae	Malpighiales	eurosids I
Aleurothrixus bondari	Malvaceae	Malvales	eurosids II
Aleurothrixus floccosus	Anacardiaceae, Annonaceae, Apocynaceae, Asteraceae, Chrysobalanaceae, Ebenaceae, Liliaceae, Loranthaceae, Malvaceae, Myrtaceae, Nyctaginaceae, Polygonaceae, Rubiaceae, Rutaceae, Sapotaceae, Solanaceae, Zygophyllaceae*	Asterales, Ericales, Caryophyllales, Gentianales, Liliales, Magnoliales, Malpighiales, Malvales, Myrtales, Santalales, Sapindales, Solanales	asterids, core eudicots, euasterids I, euasterids II, eurosids I, eurosids II, magnoliids, monocots, rosids
Aleurothrixus interrogationis	Rhamnaceae	Rosales	eurosids I
Aleurothrixus lucumai	Sapotaceae	Ericales	asterids
Aleurothrixus myrtacei	Myrtaceae	Myrtales	rosids
Aleurothrixus porteri	Anacardiaceae, Lauraceae, Myrtaceae, Rutaceae, Sapotaceae, Solanaceae, Verbenaceae	Ericales, Lamiales, Laurales, Myrtales, Sapindales, Solanales,	asterids, euasterids I, eurosids II, magnoliids, rosids
Aleurothrixus proximans	Lauraceae	Laurales	magnoliids
Aleurothrixus smilaceti	Smilacaceae	Liliales	monocots
Aleurotithius timberlakei	Boraginaceae*		euasterids I
Aleurotrachelus alpinus	Rosaceae	Rosales	eurosids I
Aleurotrachelus ampullatus	Fabaceae	Fabales	eurosids I
Aleurotrachelus asparagi	Liliaceae	Liliales	monocots
Aleurotrachelus atratus	Arecaceae	Arecales	commelinids
Aleurotrachelus camelliae	Theaceae	Ericales	asterids
Aleurotrachelus duplicatus	Rubiaceae	Gentianales	euasterids I

Aleurotrachelus fumipennis	Poaceae	Poales	commelinids
Aleurotrachelus limbatus	Ericaceae, Fabaceae	Ericales, Fabales	asterids, eurosids I
Aleurotrachelus longispinus	Rubiaceae	Gentianales	euasterids I
Aleurotrachelus minutus	Moraceae	Rosales	eurosids I
Aleurotrachelus multipapillus	Poaceae	Poales	commelinids
Aleurotrachelus obscurus	Fabaceae	Fabales	eurosids I
Aleurotrachelus tarennae	Rubiaceae	Gentianales	euasterids I
Aleurotrachelus tracheifer	Loganiaceae, Melastomataceae	Gentianales, Myrtales	euasterids I, rosids
Aleurotrachelus trachoides	Asteraceae, Bignoniaceae, Casuarinaceae, Convolvulaceae, Dioscoreaceae, Melastomataceae, Rubiaceae, Solanaceae, Verbenaceae	Asterales, Dioscoreales, Fagales, Gentianales, Lamiales, Myrtales, Solanales	euasterids I, euasterids II, eurosids I, monocots, rosids
Aleurotuba jelinekii	Adoxaceae, Ericaceae, Myrtaceae	Dipsacales, Ericales, Myrtales	asterids, euasterids II, rosids
Aleurotulus anthuricola	Araceae	Alismatales	monocots
Aleurotulus arundinacea	Poaceae	Poales	commelinids
Aleurotulus nephrolepidis	Aspleniaceae, Blechnaceae, Cyatheaceae, Dryopteridaceae (Aspidiaceae), Oleandraceae, Pteridaceae, Schizaeaceae, Thelypteridaceae, Woodsiaceae	§Aspleniales, §Cyatheales, §Parkeriales, §Schizaeales	
Aleurotulus pteridophytae	Selaginellaceae, Pteridaceae, Schizaeaceae	§Parkeriales, §Schizaeales, §Selaginellales	
Aleuroviggianus adanaensis	Fagaceae	Fagales	eurosids I
Aleuroviggianus adrianae	Fagaceae	Fagales	eurosids I
Aleuroviggianus graecus	Fagaceae	Fagales	eurosids I
Aleuroviggianus halperini	Fagaceae	Fagales	eurosids I
Aleuroviggianus polymorphus	Fagaceae	Fagales	eurosids I
Aleuroviggianus zonalus	Fagaceae	Fagales	eurosids I
Aleyrodes amnicola	Salicaceae	Malpighiales	eurosids I
Aleyrodes elevatus	Euphorbiaceae, Moraceae	Malpighiales, Rosales	eurosids I
Aleyrodes lonicerae	Apiaceae, Asteraceae, Balsaminaceae, Brassicaceae, Campanulaceae, Caprifoliaceae, Clusiaceae, Euphorbiaceae, Grossulariaceae, Lamiaceae, Onagraceae, Oxalidaceae, Papaveraceae, Ranunculaceae, Rosaceae, Scrophulariaceae, Urticaceae, Violaceae	Apiales, Asterales, Brassicales, Dipsacales, Ericales, Lamiales, Malpighiales, Myrtales, Oxalidales, Ranunculales, Rosales, Saxifragales	asterids, core eudicots, euasterids I, euasterids II, eudicots, eurosids I, eurosids II, rosids
Aleyrodes proletella	Apiaceae, Asteraceae, Balsaminaceae, Berberidaceae, Brassicaceae, Campanulaceae, Euphorbiaceae, Fabaceae, Fagaceae, Papaveraceae, Ranunculaceae, Scrophulariaceae	Apiales, Asterales, Brassicales, Ericales, Fabales, Fagales, Lamiales, Malpighiales, Ranunculales	asterids, euasterids I, euasterids II, eudicots, eurosids I, eurosids II
Aleyrodes pruinosus	Euphorbiaceae, Rosaceae, Rhamnaceae	Malpighiales, Rosales	eurosids I
Aleyrodes singularis	Euphorbiaceae	Malpighiales	eurosids I

Aleyrodiella lamellifera	Ulmaceae	Rosales	eurosids I
Apobemisia kuwanai	Moraceae	Rosales	eurosids I
Arachnaleyrodes insignis	Combretaceae	Myrtales	rosids
Asialeyrodes lushanensis	Myrtaceae	Myrtales	rosids
Asialeyrodes maesae	Myrsinaceae	Ericales	asterids
Asterobemisia carpini	Anacardiaceae, Betulaceae, Cannabaceae, Caprifoliaceae, Ericaceae, Fabaceae, Fagaceae, Grossulariaceae, Malvaceae, Ranunculaceae, Rosaceae, Salicaceae, Sapindaceae, Saxifragaceae, Ulmaceae	Dipsacales, Ericales, Fabales, Fagales, Malpighiales, Malvales, Ranunculales, Rosales, Sapindales, Saxifragales	asterids, core eudicots, euasterids II, eudicots, eurosids I, eurosids II
Asterobemisia dentata	Moraceae	Rosales	eurosids I
Asterobemisia obenbergeri	Lamiaceae	Lamiales	euasterids I
Asterochiton cordiae	Boraginaceae*		euasterids I
Asterochiton pittospori	Pittosporaceae	Apiales	euasterids II
Bellitudo hispaniolae	Polygonaceae	Caryophyllales	core eudicots
Bellitudo jamaicae	Polygonaceae	Caryophyllales	core eudicots
Bemisaleyrodes brideliae	Euphorbiaceae	Malpighiales	eurosids I
Bemisaleyrodes pauliani	Moraceae, Ulmaceae	Rosales	eurosids I
Bemisia afer	Lythraceae, Moraceae, Rutaceae	Myrtales, Rosales, Sapindales	eurosids I, eurosids II, rosids
Bemisia antennata	Boraginaceae*, Fabaceae, Moraceae	Fabales, Rosales	euasterids I, eurosids I
Bemisia berbericola	Berberidaceae, Euphorbiaceae, Moraceae, Rhamnaceae, Rosaceae	Malpighiales, Ranunculales, Rosales	eudicots, eurosids I
Bemisia combreticula	Combretaceae	Myrtales	rosids
Bemisia formosana	Poaceae	Poales	commelinids
Bemisia giffardi	Boraginaceae*, Oleaceae, Rutaceae	Lamiales, Sapindales	euasterids I, eurosids II
Bemisia gigantean	Elaeocarpaceae	Oxalidales	eurosids I
Bemisia guieriae	Combretaceae	Myrtales	rosids
Bemisia hirta	Brassicaceae	Brassicales	eurosids II
Bemisia lauracea	Lauraceae	Laurales	magnoliids
Bemisia mesasiatica	Caprifoliaceae, Rosaceae	Dipsacales, Rosales	euasterids II, eurosids I
Bemisia pongamiae	Fabaceae	Fabales	eurosids I
Bemisia silvatica	Anacardiaceae, Betulaceae, Ericaceae, Fabaceae, Fagaceae, Rhamnaceae, Rosaceae	Ericales, Fabales, Fagales, Rosales, Sapindales	asterids, eurosids I, eurosids II
Bemisia subdecipiens	Myrtaceae	Myrtales	rosids
Bemisia tabaci	Acanthaceae, Amaranthaceae, Anacardiaceae, Annonaceae, Apiaceae, Apocynaceae, Araceae, Aristolochiaceae, Asteraceae, Bignoniaceae, Bixaceae, Brassicaceae, Cannabaceae, Caprifoliaceae, Chrysobalanaceae, Cistaceae, Clusiaceae, Commelinaceae, Convolvulaceae, Cucurbitaceae, Ericaceae, Euphorbiaceae, Fabaceae, Fagaceae,	Alismatales, Apiales, Asterales, Brassicales, Caryophyllales, Commelinales, Cucurbitales, Dipsacales, Ericales, Fabales, Fagales, Gentianales, Geraniales, Lamiales, Laurales, Magnoliales, Malpighiales, Malvales, Myrtales, Oxalidales, Piperales, Poales, Ranunculales, Rosales, Sapindales, Saxifragales, Solanales, Zingiberales	asterids, commelinids, core eudicots, euasterids I, euasterids II, eudicots, eurosids I, eurosids II, magnoliids, monocots, rosids

	Geraniaceae, Grossulariaceae, Lamiaceae, Lauraceae, Linaceae, Loganiaceae, Lythraceae, Malvaceae, Menispermaceae, Moraceae, Moringaceae, Musaceae, Myrtaceae, Nyctaginaceae, Oleaceae, Oxalidaceae, Passifloraceae, Pedaliaceae, Poaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rubiaceae, Rutaceae, Salicaceae, Sapindaceae, Scrophulariaceae, Solanaceae, Thymelaeaceae, Ulmaceae, Urticaceae, Verbenaceae, Zygophyllaceae*		
Bemisia tuberculata	Euphorbiaceae	Malpighiales	eurosids I
Bemisiella artemisiae	Asteraceae	Asterales	euasterids II
Brazzaleyrodes eriococciformis	Fabaceae	Fabales	eurosids I
Bulgarialeurodes cotesii	Rosaceae	Rosales	eurosids I
Calluneyrodes callunae	Ericaceae	Ericales	asterids
Chitonaleyrodes canberrensis	Fabaceae	Fabales	eurosids I
Cockerelliella curcumae	Musaceae, Zingiberaceae	Zingiberales	commelinids
Cockerelliella psidii	Dipterocarpaceae, Magnoliaceae, Meliaceae, Moraceae, Myrtaceae, Verbenaceae	Lamiales, Magnoliales, Malvales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, magnoliids, rosids
Cohicaleyrodes alternans	Clusiaceae, Combretaceae, Connaraceae, Euphorbiaceae, Fabaceae, Loganiaceae, Rubiaceae, Salicaceae, Verbenaceae	Fabales, Gentianales, Lamiales, Malpighiales, Myrtales, Oxalidales	euasterids I, eurosids I, rosids
Cohicaleyrodes crossopterygis	Combretaceae, Rubiaceae	Gentianales, Myrtales	euasterids I, rosids
Cohicaleyrodes obscura	Rubiaceae	Gentianales	euasterids I
Cohicaleyrodes platysepali	Fabaceae, Zingiberaceae	Fabales, Zingiberales	commelinids, eurosids I
Cohicaleyrodes quadrilongispinae	Annonaceae, Bignoniaceae, Combretaceae, Euphorbiaceae, Fabaceae, Loganiaceae, Melastomataceae, Moraceae, Rubiaceae, Sapindaceae, Verbenaceae, Vitaceae*	Fabales, Gentianales, Lamiales, Magnoliales, Malpighiales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, magnoliids, rosids
Cohicaleyrodes recurvispina	Annonaceae, Dilleniaceae*, Moraceae, Rubiaceae	Gentianales, Magnoliales, Rosales	core eudicots, euasterids I, eurosids I, magnoliids
Combesaleyrodes bouqueti	Rubiaceae	Gentianales	euasterids I
Combesaleyrodes tauffliebi	Dilleniaceae*, Rubiaceae	Gentianales	core eudicots, euasterids I
Corbettia baphiae	Fabaceae	Fabales	eurosids I
Corbettia bauhiniae	Fabaceae	Fabales	eurosids I
Corbettia graminis	Poaceae	Poales	commelinids
Corbettia isoberliniae	Fabaceae	Fabales	eurosids I
Corbettia lonchocarpi	Fabaceae	Fabales	eurosids I
Corbettia millettiacola	Apocynaceae, Fabaceae	Fabales, Gentianales	euasterids I, eurosids I
Corbettia tamarindi	Fabaceae	Fabales	eurosids I
Crenidorsum aroidephagus	Araceae	Alismatales	monocots

Crenidorsum celebes	Cunoniaceae, Lauraceae	Laurales, Oxalidales	eurosids I, magnoliids
Crenidorsum commune	Polygonaceae	Caryophyllales	core eudicots
Crenidorsum lasangensis	Musaceae	Zingiberales	commelinids
Crenidorsum magnisetae	Polygonaceae	Caryophyllales	core eudicots
Crenidorsum malpighiae	Malpighiaceae	Malpighiales	eurosids I
Crenidorsum micheliae	Magnoliaceae, Myrsinaceae	Ericales, Magnoliales	asterids, magnoliids
Crenidorsum millennium	Myrtaceae	Myrtales	rosids
Crenidorsum morobensis	Myrtaceae	Myrtales	rosids
Crenidorsum stigmaphylli	Malpighiaceae	Malpighiales	eurosids I
Crenidorsum tuberculatum	Polygonaceae	Caryophyllales	core eudicots
Crescentaleyrodes paulianae	Poaceae	Poales	commelinids
Crescentaleyrodes semilunaris	Poaceae	Poales	commelinids
Cryptolingula perplexa	Host indet.		
Dialeurodes agalmae	Araliaceae	Apiales	euasterids II
Dialeurodes ara	Moraceae	Rosales	eurosids I
Dialeurodes armatus	Meliaceae	Sapindales	eurosids II
Dialeurodes bicornicauda	Meliaceae	Sapindales	eurosids II
Dialeurodes cerifera	Celastraceae	Celastrales	eurosids I
Dialeurodes cinnamomi	Lauraceae	Laurales	magnoliids
Dialeurodes citri	Apocynaceae, Araliaceae, Arecaceae, Bignoniaceae, Boraginaceae*, Caprifoliaceae, Ebenaceae, Euphorbiaceae, Fagaceae, Hamamelidaceae, Lauraceae, Lythraceae, Magnoliaceae, Malpighiaceae, Meliaceae, Moraceae, Myrsinaceae, Myrtaceae, Oleaceae, Proteaceae, Rosaceae, Rubiaceae, Rutaceae, Sabiaceae*, Simaroubaceae, Smilacaceae, Staphyleaceae, Theaceae, Vitaceae*	Arecales, Apiales, Crossosomatales, Dipsacales, Ericales, Fagales, Gentianales, Lamiales, Laurales, Liliales, Magnoliales, Malpighiales, Myrtales, Proteales, Rosales, Sapindales, Saxifragales	asterids, commelinids, core eudicots, euasterids I, euasterids II, eudicots, eurosids I, eurosids II, magnoliids, monocots, rosids
Dialeurodes cyathispinifera	Host indet.		
Dialeurodes decaspermi	Myrtaceae	Myrtales	rosids
Dialeurodes dubia	Host indet.		
Dialeurodes emarginata	Loganiaceae, Malvaceae	Gentianales, Malvales	euasterids I, eurosids II
Dialeurodes erythrinae	Fabaceae	Fabales	eurosids I
Dialeurodes ixorae	Rubiaceae, Sapotaceae	Ericales, Gentianales	asterids, euasterids I
Dialeurodes joholensis	Host indet.		
Dialeurodes kirkaldyi	Apocynaceae, Combretaceae, Loganiaceae, Lythraceae, Malpighiaceae, Malvaceae, Oleaceae, Rubiaceae, Rutaceae, Verbenaceae	Gentianales, Lamiales, Malpighiales, Malvales, Myrtales, Sapindales	euasterids I, eurosids I, eurosids II, rosids
Dialeurodes lanceolata	Celastraceae	Celastrales	eurosids I
Dialeurodes minahassai	Myrtaceae	Myrtales	rosids
Dialeurodes mirabilis	Host indet.		

Dialeurodes platicus	Myrtaceae	Myrtales	rosids
Dialeurolobus rhamni	Lythraceae, Rhamnaceae	Myrtales, Rosales	eurosids I, rosids
Dialeurolonga africana	Celastraceae	Celastrales	eurosids I
Dialeurolonga communis	Loganiaceae, Rubiaceae, Rutaceae, Sapindaceae	Gentianales, Sapindales	euasterids I, eurosids II
Dialeurolonga elliptica	Apocynaceae	Gentianales	euasterids I
Dialeurolonga elongata	Rubiaceae, Rutaceae, Sapindaceae	Gentianales, Sapindales	euasterids I, eurosids II
Dialeurolonga hoyti	Rubiaceae	Gentianales	euasterids I
Dialeurolonga maculata	Cunoniaceae	Oxalidales	eurosids I
Dialeurolonga nemoralis	Annonaceae	Magnoliales	magnoliids
Dialeurolonga phyllarthronis	Bignoniaceae	Lamiales	euasterids I
Dialeurolonga ravensarae	Lauraceae	Laurales	magnoliids
Dialeurolonga rusostigmoides	Host indet.		
Dialeurolonga swainei	Moraceae	Rosales	eurosids I
Dialeurolonga tenella	Apocynaceae	Gentianales	euasterids I
Dialeurolonga trialeuroides	Host indet.		
Dialeuropora brideliae	Euphorbiaceae, Lardizabalaceae, Lauraceae	Malpighiales, Ranunculales, Laurales	eudicots, eurosids I, magnoliids
Dialeuropora decempuncta	Annonaceae, Araceae, Boraginaceae*, Dipterocarpaceae, Euphorbiaceae, Fabaceae, Lauraceae, Meliaceae, Moraceae, Rosaceae, Salicaceae, Verbenaceae	Alismatales, Fabales, Lamiales, Laurales, Magnoliales, Malpighiales, Malvales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, magnoliids, monocots
Dialeuropora mangiferae	Anacardiaceae	Sapindales	eurosids II
Dialeuropora papillata	Annonaceae, Arecaceae, Euphorbiaceae, Fabaceae, Linaceae, Malvaceae	Arecales, Fabales, Magnoliales, Malpighiales, Malvales	commelinids, eurosids I, eurosids II, magnoliids
Dialeuropora silvarum	Host indet.		
Dialeuropora viburni	Caprifoliaceae	Dipsacales	euasterids II
Disiphon sp.	Myrtaceae, Piperaceae?	Myrtales, Piperales?	magnoliids?, rosids
Dumbletoniella callistemoni	Myrtaceae	Myrtales	rosids
Dumbletoniella eucalypti	Myrtaceae	Myrtales	rosids
Dumbletoniella pittospori	Pittosporaceae	Apiales	euasterids II
Dumbletoniella rotunda	Myrtaceae	Myrtales	rosids
Dumbletoniella xanthorrhoeae	Liliaceae	Liliales	monocots
Extensaleyrodes akureensis	Host indet.		
Extensaleyrodes falcata	Fabaceae	Fabales	eurosids I
Fascaleyrodes palmae	Arecaceae	Arecales	commelinids
Fascaleyrodes rara	Annonaceae	Magnoliales	magnoliids
Filicaleyrodes bosseri	Undetermined fern		
Filicaleyrodes williamsi	Aspleniaceae, Blechnaceae, Dryopteridaceae (Aspidiaceae), Oleandraceae, Schizaeaceae, Thelypteridaceae, Woodsiaceae	§Aspleniales, §Schizaeales	
Fippataleyrodes indica	Lauraceae, Moraceae, Myrsinaceae, Salicaceae	Ericales, Laurales, Malpighiales, Rosales	asterids, eurosids I, magnoliids

Fippataleyrodes litseae	Lauraceae	Laurales	magnoliids
Gagudjuia allosyncarpiae	Myrtaceae	Myrtales	rosids
Gomenella dryandrae	Proteaceae	Proteales	eudicots
Gomenella multipora	Host indet.		
Harpaleyrodes tuberculata	Combretaceae	Myrtales	rosids
Hempelia chivelensis	Lauraceae	Laurales	magnoliids
Heteraleyrodes bambusicola	Poaceae	Poales	commelinids
Heterobemisia alba	Grossulariaceae	Saxifragales	core eudicots
Indoaleyrodes glochidioni	Euphorbiaceae	Malpighiales	eurosids I
Indoaleyrodes laos	Euphorbiaceae, Rubiaceae	Malpighiales	eurosids I
Indoaleyrodes pseudoculatus	Myrtaceae	Myrtales	rosids
Kanakarajiella vulgaris	Asteraceae, Fabaceae, Myrtaceae, Oleaceae, Rubiaceae	Asterales, Fabales, Gentianales, Lamiales, Myrtales	euasterids I, euasterids II, eurosids I, rosids
Leucopogonella pallida	Ericaceae	Ericales	asterids
Leucopogonella simila	Ericaceae	Ericales	asterids
Lipaleyrodes atriplex	Amaranthaceae	Caryophyllales	core eudicots
Lipaleyrodes breyniae	Euphorbiaceae	Malpighiales	eurosids I
Lipaleyrodes crossandrae	Acanthaceae, Amaranthaceae	Lamiales, Caryophyllales	core eudicots, euasterids I
Lipaleyrodes euphorbiae	Euphorbiaceae	Malpighiales	eurosids I
Lipaleyrodes phyllanthi	Asteraceae, Euphorbiaceae	Asterales, Malpighiales	euasterids II, eurosids I
Malayaleyrodes ?lumpurensis	Moraceae	Rosales	eurosids I
Marginaleyrodes ixorae	Rubiaceae	Gentianales	euasterids I
Massilieurodes americanus	Aquifoliaceae, Betulaceae, Cornaceae, Ebenaceae, Ericaceae, Hamamelidaceae, Magnoliaceae, Oleaceae, Symplocaceae	Aquifoliales, Cornales, Ericales, Fagales, Lamiales, Magnoliales, Saxifragales	asterids, core eudicots, euasterids I, euasterids II, eurosids I, magnoliids
Massilieurodes chittendeni	Ericaceae	Ericales	asterids
Massilieurodes euryae	Theaceae	Ericales	asterids
Massilieurodes fici	Euphorbiaceae, Moraceae, Myrsinaceae, Rhamnaceae, Rutaceae, Theaceae, Ulmaceae	Ericales, Malpighiales, Rosales, Sapindales	asterids, eurosids I, eurosids II
Massilieurodes setiger	Adoxaceae	Dipsacales	euasterids II
Metabemisia filicis	Davalliaceae, Dryopteridaceae (Aspidiaceae), Oleandraceae, Pteridaceae, Thelypteridaceae	§Aspleniales, §Parkeriales	
Metabemisia palawana	Dryopteridaceae	§Aspleniales	
Minutaleyrodes minuta	Celastraceae, Rubiaceae	Celastrales, Gentianales	euasterids I, eurosids I
Minutaleyrodes suishanus	Lauraceae, Myrsinaceae	Ericales, Laurales	asterids, magnoliids
Mixaleyrodes ?polystichi	Dryopteridaceae (Aspidiaceae), Marattiaceae, Pteridaceae	§Aspleniales, §Marattiales, §Parkeriales	
Neoaleurotrachelus bertilloni	Apocynaceae, Bignoniaceae, Dilleniaceae*, Euphorbiaceae, Loganiaceae, Meliaceae, Menispermaceae, Moraceae, Ochnaceae, Rubiaceae	Gentianales, Lamiales, Malpighiales, Ranunculales, Rosales, Sapindales	core eudicots, euasterids I, eudicots, eurosids I, eurosids II

Neoaleurotrachelus graberi	Annonaceae, Bignoniaceae, Celastraceae, Combretaceae, Euphorbiaceae, Lythraceae, Meliaceae, Moraceae, Myrtaceae, Rhamnaceae, Rubiaceae	Celastrales, Gentianales, Lamiales, Magnoliales, Malpighiales, Myrtales, Sapindales, Rosales	euasterids I, eurosids I, eurosids II, magnoliids, rosids
Neomaskellia andropogonis	Poaceae	Poales	commelinids
Neomaskellia bergii	Poaceae	Poales	commelinids
Neopealius rubi	Fabaceae, Lamiaceae, Lauraceae, Rosaceae	Fabales, Lamiales, Laurales, Rosales	euasterids I, eurosids I, magnoliids
Nigrasialeyrodes convexus	Myrtaceae	Myrtales	rosids
Orchamoplatus caledonicus	Moraceae, Rutaceae, Ulmaceae	Rosales, Sapindales	eurosids I, eurosids II
Orchamoplatus citri	Rutaceae	Sapindales	eurosids II
Orchamoplatus dentatus	Loranthaceae, Myrtaceae	Myrtales, Santalales	core eudicots, rosids
Orchamoplatus louiserussellae	Loranthaceae, Myrtaceae	Myrtales, Santalales	core eudicots, rosids
Orchamoplatus mammaeferus	Euphorbiaceae, Myrtaceae, Rutaceae	Malpighiales, Myrtales, Sapindales	eurosids I, eurosids II, rosids
Orchamoplatus montanus	Araliaceae, Cunoniaceae, Ericaceae	Apiales, Ericales, Oxalidales	asterids, euasterids II, eurosids I
Orchamoplatus niuginii	Clusiaceae, Linaceae	Malpighiales	eurosids I
Orchamoplatus noumeae	Rutaceae	Sapindales	eurosids II
Orchamoplatus plumensis	Host indet.		
Orchamoplatus porosus	Myrtaceae	Myrtales	rosids
Orientaleyrodes zeylanicus	Brassicaceae	Brassicales	eurosids II
Orstomaleyrodes fimbriae	Bignoniaceae, Combretaceae, Fabaceae, Salicaceae, Sapindaceae, Ulmaceae	Fabales, Lamiales, Malpighiales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, rosids
Papillipes spinifer	Fabaceae	Fabales	eurosids I
Parabemisia aceris	Sapindaceae	Sapindales	eurosids II
Parabemisia jawani	Host indet.		
Parabemisia lushanensis	Host indet.		
Parabemisia myricae	Ebenaceae, Elaeocarpaceae, Ericaceae, Fagaceae, Lauraceae, Moraceae, Myricaceae, Myrsinaceae, Myrtaceae, Rosaceae, Rubiaceae, Rutaceae, Salicaceae, Theaceae	Ericales, Fagales, Gentianales, Laurales, Malpighiales, Myrtales, Oxalidales, Rosales, Sapindales	asterids, euasterids I, eurosids I, eurosids II, magnoliids, rosids
Parabemisia myrmecophila	Dipterocarpaceae, Euphorbiaceae, Lauraceae, Rosaceae	Laurales, Malpighiales, Malvales, Rosales	eurosids I, eurosids II, magnoliids
Paraleurolobus chamaedoreae	Arecaceae	Arecales	commelinids
Paulianaleyrodes splendens	Dichapetalaceae	Malpighiales	eurosids I
Paulianaleyrodes tetracerae	Annonaceae, Clusiaceae, Cucurbitaceae, Dilleniaceae*	Cucurbitales, Magnoliales	core eudicots, eurosids I, magnoliids
Pealius akebiae	Lardizabalaceae	Ranunculales	eudicots
Pealius azaleae	Ericaceae	Ericales	asterids
Pealius cryptus	Moraceae	Rosales	eurosids I
Pealius euryae	Theaceae	Ericales	asterids
Pealius fici	Moraceae	Rosales	eurosids I
Pealius kelloggi	Fagaceae, Rosaceae	Fagales	eurosids I
Pealius liquidambari	Hamamelidaceae	Saxifragales	core eudicots

Pealius madeirensis	Oleaceae	Lamiales	euasterids I
Pealius mori	Moraceae, Salicaceae	Malpighiales, Rosales	eurosids I
Pealius rhododendri	Ericaceae	Ericales	asterids
Pectinaleyrodes culcasiae	Annonaceae, Araceae, Connaraceae, Malvaceae	Alismatales, Magnoliales, Malvales, Oxalidales	eurosids I, eurosids II, magnoliids, monocots
Pectinaleyrodes triclisiae	Annonaceae, Bignoniaceae, Connaraceae, Dilleniaceae*, Euphorbiaceae, Fabaceae, Meliaceae, Menispermaceae, Rubiaceae, Salicaceae,Verbenaceae	Fabales, Gentianales, Lamiales, Magnoliales, Malpighiales, Oxalidales, Ranunculales, Sapindales	core eudicots, euasterids I, eudicots, eurosids I, eurosids II, magnoliids
Pentaleyrodes cinnamomi	Lauraceae	Laurales	magnoliids
Pentaleyrodes hongkongensis	Lauraceae	Laurales	magnoliids
Pentaleyrodes yasumatsui	Lauraceae	Laurales	magnoliids
Pogonaleyrodes fastuosa	Host indet.		
Pogonaleyrodes zimmermanni	Acanthaceae, Rubiaceae	Gentianales, Lamiales	euasterids I
Pseudaleuroplatus kiensis	Myrtaceae	Myrtales	rosids
Ramsesseus follioti	Fabaceae	Fabales	eurosids I
Rhachisphora alishanensis	Theaceae	Ericales	asterids
Rhachisphora elongatus	Sapotaceae	Ericales	asterids
Rhachisphora franksae	Loganiaceae	Gentianales	euasterids I
Rhachisphora koshunensis	Lauraceae	Laurales	magnoliids
Rhachisphora maesae	Myrsinaceae	Ericales	asterids
Rhachisphora rutherfordi	Loranthaceae	Santalales	core eudicots
Rhachisphora trilobitoides	Boraginaceae*, Melastomataceae, Myrtaceae, Rubiaceae, Sapindaceae, Sapotaceae	Ericales, Gentianales, Myrtales, Sapindales	asterids, euasterids I, eurosids II, rosids
Rositaleyrodes oplismeni	Poaceae	Poales	commelinids
Rugaleyrodes angolensis	Icacinaceae*, Marantaceae, Ochnaceae	Malpighiales, Zingiberales	commelinids, euasterids I, eurosids I
Rugaleyrodes bidentata	Annonaceae	Magnoliales	magnoliids
Rugaleyrodes tetracerae	Dichapetalaceae, Dilleniaceae*, Linaceae, Loganiaceae, Meliaceae, Myrtaceae, Ochnaceae	Gentianales, Malpighiales, Myrtales, Sapindales	core eudicots, euasterids I, eurosids I, eurosids II, rosids
Rusostigma eugeniae	Myrtaceae	Myrtales	rosids
Rusostigma radiirugosa	Anacardiaceae, Myrtaceae	Myrtales, Sapindales	eurosids II, rosids
Rusostigma tokyonis	Aquifoliaceae, Theaceae	Aquifoliales, Ericales	asterids, euasterids II
Russellaleyrodes cumiugum	Host indet.		
Setaleyrodes mirabilis	Menispermaceae, Moraceae	Ranunculales, Rosales	eudicots, eurosids I
Setaleyrodes thretaonai	Euphorbiaceae, Moraceae	Malpighiales, Rosales	eurosids I
Setaleyrodes vigintiseta	Fabaceae	Fabales	eurosids I
Simplaleurodes hemisphaerica	Oleaceae	Lamiales	euasterids I
Singhiella bicolor	Myrtaceae	Myrtales	rosids
Singhiella cardamomi	Zingiberaceae	Zingiberales	commelinids
Singhiella chinensis	Lauraceae	Laurales	magnoliids

Singhiella citrifolii	Moraceae, Rubiaceae, Rutaceae	Gentianales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II
Singhiella delamarei	Annonaceae	Magnoliales	magnoliids
Singhiella kuraruensis	Lauraceae	Laurales	magnoliids
Singhiella premnae	Verbenaceae	Lamiales	euasterids I
Singhiella subrotunda	Lauraceae	Laurales	magnoliids
Singhius hibisci	Annonaceae, Asteraceae, Convolvulaceae, Euphorbiaceae, Lauraceae, Malvaceae, Moraceae, Oleaceae, Salicaceae, Solanaceae, Ulmaceae, Vitaceae*	Asterales, Lamiales, Laurales, Magnoliales, Malpighiales, Malvales, Rosales, Solanales	euasterids I, euasterids II, eurosids I, eurosids II, magnoliids, rosids
Singhius russellae	Host indet.		
Siphoninus immaculatus	Araliaceae	Apiales	euasterids II
Siphoninus phillyreae	Fabaceae, Lythraceae, Oleaceae, Rhamnaceae, Rosaceae, Rutaceae	Fabales, Lamiales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, rosids
Taiwanaleyrodes carpini	Betulaceae, Lauraceae, Myrsinaceae	Ericales, Fagales, Laurales	asterids, eurosids I, magnoliids
Taiwanaleyrodes meliosmae	Daphniphyllaceae, Lauraceae, Sabiaceae*, Sapindaceae	Laurales, Sapindales, Saxifragales	core eudicots, eudicots, eurosids II, magnoliids
Tetraleurodes acaciae	Anacardiaceae, Burseraceae, Caprifoliaceae, Euphorbiaceae, Fabaceae, Geraniaceae, Moraceae, Myrtaceae, Nyctaginaceae, Rhamnaceae, Rosaceae, Salicaceae, Solanaceae, Urticaceae	Caryophyllales, Dipsacales, Fabales, Geraniales, Malpighiales, Myrtales, Rosales, Sapindales, Solanales	core eudicots, euasterids I, euasterids II, eurosids I, eurosids II, rosids
Tetraleurodes andropogoni	Annonaceae, Arecaceae, Clusiaceae, Connaraceae, Costaceae, Euphorbiaceae, Fabaceae, Linaceae, Loranthaceae, Poaceae, Rutaceae, Salicaceae	Arecales, Fabales, Magnoliales, Malpighiales, Oxalidales, Poales, Santalales, Sapindales, Zingiberales	commelinids, core eudicots, eurosids I, eurosids II, magnoliids
Tetraleurodes banksiae	Proteaceae	Proteales	eudicots
Tetraleurodes bicolor	Myrtaceae	Myrtales	rosids
Tetraleurodes caulicola	Fabaceae	Fabales	eurosids I
Tetraleurodes confusa	Fagaceae, Lauraceae, Magnoliaceae, Theaceae	Ericales, Fagales, Laurales, Magnoliales	asterids, eurosids I, magnoliids
Tetraleurodes granulata	Annonaceae, Combretaceae, Euphorbiaceae, Fabaceae, Loganiaceae, Rubiaceae	Fabales, Gentianales, Magnoliales, Malpighiales, Myrtales	euasterids I, eurosids I, magnoliids, rosids
Tetraleurodes pluto	Fabaceae	Fabales	eurosids I
Tetraleurodes quercicola	Fagaceae	Fagales	eurosids I
Tetraleurodes selachidentata	Anacardiaceae, Annonaceae, Bignoniaceae, Boraginaceae*, Combretaceae, Euphorbiaceae, Fabaceae, Loganiaceae, Rhamnaceae, Rubiaceae, Verbenaceae	Fabales, Gentianales, Lamiales, Magnoliales, Malpighiales, Myrtales, Rosales, Sapindales	euasterids I, eurosids I, eurosids II, magnoliids, rosids
Tetraleurodes stirlingiae	Proteaceae	Proteales	eudicots
Tetraleurodes sulcistriatus	Avicenniaceae, Clusiaceae, Moraceae, Myrtaceae	Lamiales, Malpighiales, Myrtales, Rosales	euasterids I, eurosids I, rosids
Tetralicia ericae	Ericaceae	Ericales	asterids
Tetralicia graminicola	Poaceae	Poales	commelinids
Tetralicia iberiaca	Ericaceae	Ericales	asterids
Tetralicia tuberculata	Verbenaceae	Lamiales	euasterids I

Trialeurodes abutiloneus	Acanthaceae, Apocynaceae, Asteraceae, Balsaminaceae, Boraginaceae*, Brassicaceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Geraniaceae, Hamamelidaceae, Lamiaceae, Lythraceae, Malvaceae, Moraceae, Myrtaceae, Onagraceae, Oxalidaceae, Polygonaceae, Portulacaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rutaceae, Sapindaceae, Scrophulariaceae, Solanaceae, Ulmaceae, Urticaceae, Verbenaceae, Violaceae	Asterales, Brassicales, Caryophyllales, Cucurbitales, Ericales, Fabales, Gentianales, Geraniales, Lamiales, Malpighiales, Malvales, Myrtales, Oxalidales, Ranunculales, Rosales Sapindales, Saxifragales, Solanales	asterids,core eudicots, euasterids I, euasterids II, eudicots, eurosids I, eurosids II, rosids
Trialeurodes bruneiensis	Thelypteridaceae	§Aspleniales	
Trialeurodes darwiniensis	Euphorbiaceae	Malpighiales	eurosids I
Trialeurodes dicksoniae	Dicksoniaceae	§Cyatheales	
Trialeurodes drewsi	Fagaceae	Fagales	eurosids I
Trialeurodes ericae	Ericaceae	Ericales	asterids
Trialeurodes floridensis	Anacardiaceae, Annonaceae, Bignoniaceae, Chrysobalanaceae, Convolvulaceae, Dilleniaceae*, Lauraceae, Fabaceae, Lythraceae, Malpighiaceae, Malvaceae, Meliaceae, Myrtaceae, Polygonaceae, Rhamnaceae, Rubiaceae, Rutaceae, Sapotaceae, Verbenaceae, Zygophyllaceae*	Caryophyllales, Ericales, Fabales, Gentianales, Lamiales, Laurales, Magnoliales, Malpighiales, Malvales, Myrtales, Rosales, Sapindales, Solanales	asterids, euasterids I, core eudicots, eurosids I, eurosids II, magnoliids, rosids
Trialeurodes pergandei	Bignoniaceae, Caprifoliaceae, Hydrangeaceae, Oleaceae, Rosaceae, Rutaceae, Smilacaceae	Cornales, Dipsacales, Lamiales, Liliales, Rosales, Sapindales	asterids, euasterids I, euasterids II, eurosids I, eurosids II, monocots
Trialeurodes rex	Undetermined fern		
Trialeurodes vaporariorum	Acanthaceae, Alismataceae, Anacardiaceae, Apocynaceae, Aquifoliaceae, Araceae, Araliaceae, Asteraceae, Balsaminaceae, Begoniaceae, Berberidaceae, Bignoniaceae, Boraginaceae*, Brassicaceae, Campanulaceae, Caprifoliaceae, Caryophyllaceae, Clusiaceae, Convolvulaceae, Cucurbitaceae, Cunoniaceae, Ebenaceae, Ericaceae, Euphorbiaceae, Fabaceae, Fagaceae, Garryaceae, Geraniaceae, Gesneriaceae, Grossulariaceae, Haloragaceae, Hamamelidaceae, Hydrangeaceae, Iridaceae, Juglandaceae, Lamiaceae, Lauraceae, Liliaceae, Loganiaceae, Lythraceae, Magnoliaceae, Malvaceae, Melianthaceae, Myrtaceae, Oleaceae, Onagraceae, Oxalidaceae, Papaveraceae, Passifloraceae, Pedaliaceae, Phytolaccaceae, Pittosporaceae, Platanaceae, Plumbaginaceae, Polemoniaceae, Polygalaceae, Polygonaceae,	Alismatales, Apiales, Aquifoliales, Asparagales, Asterales, Brassicales, Caryophyllales, Cornales, Cucurbitales, ‡Cycadales, Dipsacales, Ericales, Fabales, Fagales, Garryales, Gentianales, Geraniales, Lamiales, Laurales, Liliales, Magnoliales, Malpighiales, Malvales, Myrtales, Oxalidales, Proteales, Ranunculales, Rosales, Sapindales, Saxifragales, Solanales	asterids, core eudicots, euasterids I, euasterids II, eudicots, eurosids I, eurosids II, magnoliids, monocots, rosids

	Primulaceae, Proteaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rubiaceae, Rutaceae, Salicaceae, Sapindaceae, Sapotaceae, Scrophulariaceae, Smilacaceae, Solanaceae, Thymelaeaceae, Tropaeolaceae, Ulmaceae, Urticaceae, Verbenaceae, Violaceae, Vitaceae*, ‡Zamiaceae		
Trialeurodes variabilis	Caricaceae, Euphorbiaceae, Polygonaceae, Rubiaceae, Rutaceae, Sapindaceae	Brassicales, Caryophyllales, Gentianales, Malpighiales, Sapindales	core eudicots, euasterids I, eurosids I, eurosids II
Tuberaleyrodes machili	Lauraceae	Laurales	magnoliids
Vasdavidius cobarensis	Poaceae	Poales	commelinids
Vasdavidius concursus	Poaceae	Poales	commelinids
Vasdavidius indicus	Poaceae	Poales	commelinids
Vasdavidius setiferus	Pandanaceae, Poaceae, Rutaceae	Poales	commelinids
Venezaleurodes pisoniae	Nyctaginaceae	Caryophyllales	core eudicots
Viennotaleyrodes bicolorata	Fabaceae	Fabales	eurosids I
Viennotaleyrodes bosciae	Brassicaceae	Brassicales	eurosids II
Viennotaleyrodes curvisetosus	Fabaceae	Fabales	eurosids I
Viennotaleyrodes fallax	Fabaceae	Fabales	eurosids I
Viennotaleyrodes lacunae	Fabaceae	Fabales	eurosids I
Viennotaleyrodes megapapillae	Fabaceae	Fabales	eurosids I
Viennotaleyrodes platysepali	Fabaceae	Fabales	eurosids I
Xenaleyrodes artocarpi	Clusiaceae, Lauraceae, Lecythidaceae, Moraceae, Musaceae, Sapindaceae, Sapotaceae, Verbenaceae	Ericales, Lamiales, Laurales, Malpighiales, Rosales, Sapindales, Zingiberales	asterids, commelinids, euasterids I, eurosids I, eurosids II, magnoliids
Xenaleyrodes broughae	Rutaceae	Sapindales	eurosids II
Xenaleyrodes fauceregius	Fabaceae	Fabales	eurosids I
Yleyrodes isoberliniae	Fabaceae	Fabales	eurosids I
Zaphanera capparis	Brassicaceae	Brassicales	eurosids II
Zaphanera cyanotis	Acanthaceae, Commelinaceae	Commelinales, Lamiales	commelinids, euasterids I
Zaphanera niger	Fabaceae	Fabales	eurosids I
Zaphanera papyrocarpae	Fabaceae	Fabales	eurosids I
Zaphanera rhachisreticulata	Fabaceae	Fabales	eurosids I
New genus 1 sp. 1	Piperaceae	Piperales	magnoliids
New genus 1 sp. 2	Piperaceae	Piperales	magnoliids
New genus 2 sp. 1	Rubiaceae	Gentianales	euasterids I
New genus 2 sp. 2	Host indet.		
Aleurodicus cocois	Anacardiaceae, Annonaceae, Arecaceae, Chrysobalanaceae, Euphorbiaceae, Fabaceae, Lauraceae, Malvaceae, Moraceae, Musaceae, Myrtaceae, Piperaceae, Polygonaceae, Rubiaceae	Arecales, Caryophyllales, Fabales, Gentianales, Laurales, Magnoliales, Malpighiales, Malvales, Myrtales, Piperales, Rosales, Sapindales, Zingiberales	commelinids, core eudicots, euasterids I, eurosids I, eurosids II, magnoliids, rosids
Aleurodicus dispersus	Acanthaceae, Anacardiaceae, Annonaceae,	Alismatales, Apiales, Arecales, Asparagales,	asterids, commelinids, core

	Apocynaceae, Araceae, Araliaceae, Arecaceae, Begoniaceae, Burseraceae, Clusiaceae, Combretaceae, Euphorbiaceae, Fabaceae, Lamiaceae, Lauraceae, Lecythidaceae, Moraceae, Musaceae, Myrtaceae, Orchidaceae, Polygonaceae, Rosaceae, Rubiaceae, Rutaceae, Sapotaceae, Solanaceae	Caryophyllales, Cucurbitales, Ericales, Fabales, Gentianales, Lamiales, Laurales, Magnoliales, Malpighiales, Myrtales, Rosales, Sapindales, Solanales, Zingiberales	eudicots, euasterids I, euasterids II, eurosids I, eurosids II, magnoliids, monocots, rosids
Azuraleurodicus pentarthrus	Rubiaceae	Gentianales	euasterids I
Dialeurodicus cockerellii	Myrtaceae	Myrtales	rosids
Eudialeurodicus bodkini	Fabaceae	Fabales	eurosids I
Octaleurodicus nitidus	Arecaceae	Arecales	commelinids
Stenaleyrodes vinsoni	Arecaceae	Arecales	commelinids
Synaleurodicus hakeae	Proteaceae	Proteales	eudicots

Appendix 6. Raw data of measurements (continuous variables) used for the morphometric analyses of the *Encarsia inaron* species-groups. A = *E. estrellae*; B = *E. inaron*; CLV = clava length; DPS = distance between placoid sensilla; F1L = flagellomere 1 length; F2L = flagellomere 2 length; F3L = flagellomere 3 length; F4L = flagellomere 4 length; F5L = flagellomere 5 length; F6L = flagellomere 6 length; FUN = funicle length; FWL = fore wing length; FWW = fore wing width; GNL = male genitalia length; HDW = head width; HFL = hind femur length; HTL = hind tibia length; MBL = meso-basitarsus length; MFL = marginal fringe length; MTS = mesotibial spur length; OVL = ovipositor length; PL = pedicel length; RL = radicle length; SCL = scutellum length; SCW = scutellum width; SL = scape length; Sp. = species; SVL = second valvifer length; TVL = third valvula length; ? = missing data; – = inapplicable. Measurements are in microns.

Sp.	HDW	RL	SL	PL	F1L	F2L	F3L	F4L	FUN	F5L	F6L	CLV	FWL	FWW	MFL	SCL	SCW	DPS	HFL	HTL	MBL	MTS	SVL	TVL	OVL	GNL
A♀	340	42.5	135	55	75	82.5	77.5	75	310	70	77.5	147.5	830	355	85	120	190	52.5	192.5	265	75	52.5	140	65	205	–
A♀	350	40	130	50	70	65	70	75	280	72.5	75	147.5	840	350	85	125	200	37.5	190	255	85	55	155	60	215	–
A♀	335	40	127.5	47.5	65	67.5	67.5	75	275	70	77.5	147.5	810	340	95	125	190	55	175	237.5	80	55	150	60	210	–
A♀	305	37.5	107.5	45	55	57.5	57.5	60	230	60	65	125	640	265	67.5	92.5	165	47.5	142.5	205	62.5	40	145	60	205	–
A♀	350	40	127.5	50	67.5	65	67.5	67.5	267.5	65	70	135	770	320	75	115	190	47.5	180	247.5	70	47.5	150	55	205	–
B♀	255	37.5	95	40	37.5	45	45	45	172.5	45	52.5	97.5	540	225	65	87.5	150	30	135	182.5	40	32.5	115	55	170	–
B♀	340	35	125	50	60	67.5	60	60	247.5	55	62.5	117.5	730	340	70	110	200	35	175	230	65	40	130	60	190	–
B♀	330	40	117.5	42.5	55	57.5	60	60	232.5	57.5	60	117.5	720	330	67.5	105	190	22.5	175	235	65	45	120	70	190	–
B♀	340	45	125	50	62.5	60	62.5	60	245	57.5	57.5	115	710	330	65	105	195	25	180	240	62.5	42.5	115	72.5	187.5	–
B♀	260	40	105	40	50	50	52.5	52.5	205	52.5	57.5	110	610	280	55	95	170	25	140	200	55	40	110	67.5	177.5	–
B♀	300	40	110	40	55	50	55	55	215	55	55	110	630	?	50	90	180	40	162.5	215	65	40	110	85	195	–
B♀	?	40	137.5	50	67.5	67.5	67.5	67.5	270	60	65	125	740	310	57.5	100	?	45	180	255	80	45	160	70	230	–
B♀	312.5	37.5	115	45	47.5	57.5	57.5	57.5	220	55	57.5	112.5	610	265	65	92.5	155	42.5	137.5	205	70	35	125	57.5	182.5	–
B♀	345	40	142.5	50	?	?	?	?	?	?	?	?	740	310	55	112.5	180	45	167.5	255	95	40	162.5	70	232.5	–
B♀	347.5	45	140	50	57.5	70	70	67.5	265	65	62.5	127.5	735	310	60	115	195	42.5	177.5	225	77.5	42.5	157.5	65	222.5	–
B♀	340	40	115	47.5	47.5	60	57.5	57.5	222.5	52.5	52.5	105	650	295	55	102.5	180	25	175	235	60	42.5	130	70	200	–
B♀	320	32.5	112.5	42.5	52.5	50	50	52.5	205	50	52.5	102.5	590	245	55	?	?	?	145	190	60	40	125	60	185	–
B♀	285	35	100	40	42.5	40	42.5	45	170	45	47.5	92.5	525	220	60	80	135	?	130	167.5	50	35	115	55	170	–
B♀	280	?	130	40	40	50	50	50	190	47.5	55	102.5	610	280	50	100	175	35	165	215	50	37.5	120	65	185	–
B♀	295	40	100	40	50	55	52.5	52.5	210	52.5	55	107.5	650	295	52.5	105	175	37.5	155	220	55	37.5	130	65	195	–
B♀	285	?	130	42.5	47.5	50	47.5	50	195	50	52.5	102.5	670	295	60	105	175	37.5	155	215	55	37.5	120	80	200	–
B♀	320	35	122	45	50	55	55	55	215	57.5	60	117.5	670	300	55	107.5	175	47.5	167.5	220	60	35	120	70	190	–
B♀	325	40	120	45	55	60	57.5	?	?	?	?	?	700	305	50	107.5	185	45	167.5	225	65	42.5	130	65	195	–
B♀	345	40	125	45	57.5	62.5	62.5	57.5	240	?	?	?	700	320	52.5	110	182.5	45	165	222.5	60	40	132.5	67.5	200	–
B♀	330	37.5	115	45	47.5	55	55	55	212.5	52.5	60	112.5	650	290	55	100	170	42.5	152.5	210	57.5	40	125	65	190	–
B♀	300	37.5	110	45	45	50	55	50	200	45	50	95	610	265	57.5	95	165	40	145	200	50	37.5	115	60	175	–
B♀	320	37.5	127.5	45	62.5	67.5	62.5	65	257.5	60	65	125	690	295	70	105	165	42.5	132.5	225	85	40	135	62.5	197.5	–
B♀	280	30	105	37.5	42.5	47.5	47.5	47.5	185	47.5	52.5	100	560	230	65	85	145	22.5	130	185	55	40	135	55	190	–

Appendix 6. Continued.

Sp.	HDW	RL	SL	PL	F1L	F2L	F3L	F4L	FUN	F5L	F6L	CLV	FWL	FWW	MFL	SCL	SCW	DPS	HFL	HTL	MBL	MTS	SVL	TVL	OVL	GNL
B♀	?	40	135	50	60	70	67.5	65	262.5	62.5	70	132.5	750	320	65	110	195	40	170	240	85	40	152.5	70	222.5	–
B♀	330	47.5	135	50	62.5	70	72.5	67.5	272.5	65	70	135	770	340	75	115	175	45	175	225	80	40	160	85	245	–
B♀	295	40	110	?	?	?	?	?	?	?	?	?	660	300	80	97.5	165	40	135	195	55	?	110	55	165	–
B♀	?	42.5	130	50	60	62.5	60	60	242.5	55	60	115	800	350	65	115	210	30	185	255	65	45	132.5	75	207.5	–
B♀	365	45	130	50	60	62.5	60	62.5	245	60	65	125	780	360	75	120	195	50	167.5	245	65	40	130	70	200	–
B♀	350	45	125	50	55	57.5	57.5	60	230	55	62.5	117.5	750	350	70	117.5	185	47.5	157.5	230	62.5	35	120	72.55	192.55	–
B♀	350	40	115	42.5	55	55	55	60	225	57.5	60	117.5	635	270	45	110	170	37.5	150	220	60	35	107.5	65	172.5	–
B♀	345	40	105	40	52.5	52.5	52.5	52.5	210	52.5	55	107.5	600	265	50	110	182.5	40	147.5	210	60	40	120	60	180	–
B♀	270	22.5	100	45	60	55	55	55	225	50	55	105	610	270	50	100	157.5	?	135	210	55	30	?	?	?	–
B♀	300	40	110	45	55	55	55	57.5	222.5	55	57.5	112.5	650	280	50	110	130	32.5	155	225	60	40	?	60	?	–
B♀	345	40	117.5	47.5	60	57.5	57.5	60	235	57.5	55	112.5	645	290	50	110	175	37.5	170	240	65	37.5	115	57.5	172.5	–
B♀	300	35	115	45	57.5	55	55	55	222.5	50	55	105	630	275	47.5	110	155	35	145	210	70	40	105	60	165	–
B♀	?	37.5	115	50	45	55	50	55	205	52.5	52.5	105	645	290	55	110	175	42.5	160	215	55	37.5	130	65	195	–
B♀	290	37.5	112.5	45	45	57.5	57.5	57.5	217.5	55	57.5	112.5	600	250	60	92.5	150	37.5	135	197.5	70	40	130	67.5	197.5	–
B♀	330	45	125	50	62.5	55	60	62.5	240	57.5	60	117.5	705	300	65	115	182.5	35	157.5	230	65	45	145	72.5	217.5	–
B♀	350	50	135	?	?	?	?	?	?	?	?	?	810	380	70	120	190	40	?	250	65	40	127.5	75	202.5	–
B♀	320	35	110	45	57.5	55	55	52.5	220	50	47.5	97.5	590	250	57.5	97.5	162.5	30	?	?	67.5	40	137.5	65	202.5	–
B♀	300	40	115	45	60	60	62.5	60	242.5	55	60	115	720	320	72.5	105	187.5	42.5	165	240	80	40	137.5	70	207.5	–
B♀	255	37.5	110	40	32.5	50	47.5	47.5	177.5	50	55	105	525	210	65	85	160	32.5	150	182.5	60	30	137.5	60	197.5	–
B♀	360	45	130	50	65	60	60	62.5	247.5	57.5	65	122.5	750	320	50	120	195	50	165	250	70	45	130	70	200	–
B♀	325	37.5	117.5	45	55	55	55	55	220	50	60	110	?	?	52.5	100	170	42.5	150	215	55	35	125	70	195	–
B♀	375	50	145	50	75	72.5	75	70	292.5	65	70	135	?	?	45	115	190	55	150	260	90	45	150	80	230	–
B♀	370	50	140	55	75	72.5	70	67.5	285	60	72.5	132.5	690	290	60	120	190	45	165	260	85	40	160	80	240	–
B♀	350	45	135	55	62.5	65	65	65	257.5	65	67.5	132.5	730	310	60	115	175	42.5	160	250	80	40	150	75	225	–
B♀	325	40	130	50	57.5	60	62.5	60	240	55	60	115	630	270	65	100	165	45	155	230	70	37.5	150	65	215	–
B♀	350	42.5	150	50	70	75	77.5	80	302.5	72.5	65	137.5	850	380	70	127.5	210	35	180	275	92.5	45	170	70	240	–
B♀	375	45	145	55	67.5	72.5	72.5	75	287.5	62.5	65	127.5	830	365	70	122.5	200	47.5	195	277.5	92.5	42.5	147.5	77.5	225	–
B♀	350	40	140	55	75	75	75	77.5	302.5	65	65	130	810	350	65	125	215	40	175	270	90	42.5	155	70	225	–
B♀	380	50	155	55	80	77.5	75	72.5	305	65	67.5	132.5	850	375	62.5	120	?	50	200	280	95	47.5	172.5	67.5	240	–
B♀	335	37.5	125	45	57.5	65	60	60	242.5	55	57.5	112.5	660	285	60	100	162.5	42.5	140	215	77.5	40	140	70	210	–
B♀	365	45	140	52.5	62.5	65	67.5	65	260	57.5	65	122.5	835	377.5	75	122.5	205	42.5	172.5	270	72.5	45	137.5	70	207.5	–
B♀	317.5	40	117.5	47.5	55	55	57.5	57.5	225	52.5	60	112.5	740	340	72.5	107.5	182.5	37.5	165	220	57.5	35	115	?	?	–
B♀	355	42.5	142.5	57.5	67.5	65	67.5	65	265	62.5	67.5	130	900	430	75	122.5	205	45	195	272.5	82.5	45	137.5	67.5	205	–

Appendix 6. Continued.

Sp.	HDW	RL	SL	PL	F1L	F2L	F3L	F4L	FUN	F5L	F6L	CLV	FWL	FWW	MFL	SCL	SCW	DPS	HFL	HTL	MBL	MTS	SVL	TVL	OVL	GNL
B♀	335	47.5	125	50	60	62.5	65	62.5	250	65	57.5	122.5	750	245	?	120	170	42.5	155	250	85	40	155	65	220	–
B♀	?	45	115	52.5	50	55	55	55	215	52.5	57.5	110	700	310	60	110	205	45	170	230	60	45	127.5	65	192.5	–
B♀	295	35	110	40	67.5	62.5	60	62.5	252.5	60	65	125	820	395	65	122.5	205	47.5	175	262.5	70	45	130	70	200	–
A♂	325	45	130	50	100	110	100	95	–	87.5	85	172.5	770	325	85	115	180	45	160	250	82.5	42.5	–	–	–	280
A♂	350	40	145	47.5	112.5	122.5	117.5	105	–	92.5	95	187.5	850	360	82.5	125	195	47.5	195	285	90	55	–	–	–	290
A♂	350	45	130	45	105	115	117.5	115	–	105	95	200	810	?	85	125	195	47.5	180	255	90	55	–	–	–	225
A♂	305	40	127.5	40	100	110	105	100	–	95	87.5	182.5	670	275	70	105	165	37.5	160	235	75	42.5	–	–	–	250
A♂	327.5	45	135	50	95	120	110	105	–	97.5	85	182.5	800	335	80	117.5	180	45	187.5	275	85	50	–	–	–	275
A♂	335	50	135	45	102.5	120	110	107.5	–	100	90	190	840	340	95	127.5	197.5	37.5	185	275	87.5	52.5	–	–	–	270
B♂	260	40	100	40	72.5	72.5	72.5	72.5	–	70	70	140	590	255	67.5	95	167.5	35	150	197.5	57.5	35	–	–	–	165
B♂	325	40	120	40	97.5	105	100	95	–	90	90	180	680	295	65	107.5	180	25	170	235	75	45	–	–	–	175
B♂	345	45	117.5	35	90	95	90	85	–	87.5	82.5	170	680	290	70	105	200	25	175	230	70	42.5	–	–	–	200
B♂	?	40	130	45	90	95	95	95	–	90	90	180	710	315	62.5	105	190	40	180	255	85	45	–	–	–	220
B♂	305	37.5	97.5	35	70	75	75	70	–	67.5	60	127.5	570	250	65	87.5	155	30	140	182.5	50	37.5	–	–	–	175
B♂	320	40	122.5	35	85	105	97.5	95	–	87.5	90	177.5	675	305	57.5	110	165	40	150	225	80	37.5	–	–	–	195
B♂	305	42.5	115	40	80	87.5	85	80	–	80	77.5	157.5	610	270	47.5	105	165	32.5	165	222.5	60	40	–	–	–	210
B♂	315	40	115	40	72.5	80	82.5	77.5	–	77.5	75	152.5	600	255	60	100	162.5	45	150	220	70	40	–	–	–	147.5
B♂	325	45	115	40	75	82.5	80	80	–	75	77.5	152.5	615	260	55	102.5	160	37.5	150	205	70	40	–	–	–	180
B♂	310	40	115	37.5	70	80	77.5	72.5	–	72.5	67.5	140	585	250	57.5	95	160	42.5	152.5	195	60	40	–	–	–	165
B♂	280	37.5	102.5	35	65	70	67.5	70	–	67.5	65	132.5	550	225	60	85	140	35	135	175	57.5	35	–	–	–	155
B♂	300	40	120	40	85	90	90	90	–	85	87.5	172.5	660	300	55	110	172.5	42.5	162.5	225	65	37.5	–	–	–	210
B♂	320	37.5	117.5	35	80	100	95	92.5	–	87.5	82.5	170	630	280	55	105	170	27.5	165	220	65	40	–	–	–	185
B♂	315	42.5	115	35	82.5	90	90	90	–	?	?	?	630	280	55	100	165	40	140	215	65	37.5	–	–	–	180
B♂	315	40	105	35	72.5	85	87.5	82.5	–	82.5	80	162.5	600	270	55	95	155	37.5	150	210	55	37.5	–	–	–	190
B♂	300	35	90	35	52.5	67.5	67.5	67.5	–	57.5	62.5	120	510	215	60	80	130	20	120	170	50	35	–	–	–	140
B♂	297.5	42.5	120	40	75	85	85	82.5	–	72.5	75	147.5	715	310	75	110	177.5	35	160	230	80	37.5	–	–	–	?
B♂	322.5	40	130	45	85	90	90	90	–	85	85	170	750	330	65	117.5	180	32.5	170	240	80	40	–	–	–	175
B♂	320	45	125	47.5	92.5	110	102.5	95	–	95	90	185	810	370	75	125	195	35	172.5	260	87.5	40	–	–	–	200
B♂	345	40	137.5	45	95	97.5	97.5	97.5	–	92.5	90	182.5	745	340	65	120	180	37.5	160	247.5	75	45	–	–	–	220
B♂	340	40	125	40	87.5	95	95	97.5	–	92.5	90	182.5	720	335	67.5	120	180	37.5	155	230	75	40	–	–	–	215
B♂	235	32.5	110	42.5	80	87.5	87.5	82.5	–	82.5	77.5	160	630	270	50	110	140	30	147.5	225	67.5	35	–	–	–	?
B♂	280	40	110	35	72.5	85	85	85	–	80	80	160	585	245	57.5	97.5	145	37.5	140	205	70	37.5	–	–	–	170
B♂	290	37.5	115	40	80	80	70	70	–	75	85	160	600	255	60	102.5	157.5	35	157.5	210	72.5	35	–	–	–	197.5

Appendix 6. Continued.

Sp.	HDW	RL	SL	PL	F1L	F2L	F3L	F4L	FUN	F5L	F6L	CLV	FWL	FWW	MFL	SCL	SCW	DPS	HFL	HTL	MBL	MTS	SVL	TVL	OVL	GNL
B♂	325	42.5	120	40	80	80	80	80	–	75	75	150	645	290	65	105	160	32.5	170	220	75	42.5	–	–	–	197.5
B♂	330	40	125	40	90	95	92.5	92.5	–	90	85	175	660	290	55	110	180	45	155	240	75	45	–	–	–	220
B♂	345	40	125	45	97.5	105	100	100	–	97.5	90	187.5	710	320	50	110	187.5	42.5	160	250	80	45	–	–	–	200
B♂	320	40	125	40	85	85	85	82.5	–	75	75	150	730	320	60	110	170	40	150	240	85	40	–	–	–	195
B♂	340	50	142.5	45	90	97.5	100	95	–	95	90	185	720	325	55	125	190	52.5	185	265	90	50	–	–	–	220
B♂	325	40	130	42.5	80	82.5	85	85	–	85	87.5	172.5	670	290	55	105	170	45	157.5	225	70	40	–	–	–	195
B♂	325	40	125	40	90	95	90	85	–	80	85	165	680	300	55	105	165	37.5	160	245	85	45	–	–	–	200
B♂	320	40	122.5	35	87.5	102.5	95	95	–	87.5	75	162.5	740	325	70	100	180	30	155	222.5	85	40	–	–	–	200
B♂	365	50	145	45	95	112.5	107.5	107.5	–	97.5	95	192.5	830	365	62.5	130	200	47.5	185	280	100	45	–	–	–	235
B♂	325	42.5	125	40	80	90	85	85	–	75	85	160	680	295	50	110	165	32.5	?	?	70	?	–	–	–	185
B♂	300	37.5	105	40	75	85	85	80	–	80	80	160	620	260	57.5	95	150	32.5	160	215	70	35	–	–	–	180
B♂	340	40	145	45	97.5	110	105	102.5	–	95	95	190	780	360	60	120	175	35	172.5	270	90	45	–	–	–	200
B♂	325	47.5	130	42.5	90	100	100	97.5	–	95	90	185	770	365	70	117.5	190	40	175	250	75	40	–	–	–	230
B♂	325	45	130	45	85	97.5	92.5	95	–	90	95	185	660	290	60	117.5	185	37.5	175	250	85	45	–	–	–	180
B♂	280	40	115	40	85	95	92.5	87.5	–	85	77.5	162.5	710	305	70	95	155	22.5	152.5	210	77.5	40	–	–	–	?
B♂	310	40	122.5	40	87.5	92.5	87.5	87.5	–	82.5	77.5	160	660	290	60	107.5	160	22.5	165	230	82.5	45	–	–	–	190
B♂	350	47.5	110	40	85	95	90	90	–	90	85	175	690	310	45	115	195	37.5	175	237.5	75	40	–	–	–	195

Appendix 7. Discrete variables used for the morphometric analyses of the *Encarsia inaron* species-groups. A = *E. estrellae*; B = *E. inaron*; Mbl = numbers of setae on the left side of mid lobe of the mesoscutum; Mbr = numbers of setae on the right side of mid lobe of the mesoscutum; S1-S6 = numbers of longitudinal sensilla (rhinaria) of the antennal flagellomeres 1-6; Sbl = numbers of setae on left side lobe of the mesoscutum; Sbr = numbers of setae on right side lobe of the mesoscutum; Sp. = species; T1l-T4l = numbers of setae on the left side of tergites 1-4; T1r-T4r = numbers of setae on the right side of tergites 1-4; T5-T7 = number of setae on tergites 5-7; ? = missing data; – = not counted.

Sp.	S1	S2	S3	S4	S5	S6	Mb l	Mb r	Sb l	Sb r	T1 l	T1 r	T2 l	T2 r	T3 l	T3 r	T4 l	T4 r	T5	T6	T7
A♀	2	2	3	3	4	2	3	3	3	3	0	0	1	1	1	1	1	1	8	6	4
A♀	4	2	2	4	4	4	3	3	3	3	0	0	1	1	1	1	1	1	6	6	6
A♀	2	2	2	4	3	3	3	3	3	3	0	0	1	1	1	1	1	1	6	6	5
A♀	2	2	2	3	3	2	3	3	3	3	0	0	1	1	0	0	1	0	6	6	4
A♀	2	3	3	4	4	3	4	4	3	3	0	0	1	1	1	1	1	1	5	5	5
B♀	0	1	2	3	3	3	4	4	3	3	2	2	2	2	2	2	1	2	5	5	4
B♀	1	2	2	3	3	3	3	3	3	3	3	3	2	3	3	3	4	4	9	6	4
B♀	1	2	2	3	3	3	3	3	3	3	1	2	3	2	2	2	3	2	6	6	3
B♀	2	2	2	3	3	3	4	3	3	3	2	2	2	2	2	3	2	3	6	6	4
B♀	1	3	3	3	4	3	3	3	3	3	2	2	2	2	2	2	2	1	6	5	4
B♀	2	2	2	3	3	3	4	4	3	3	2	2	2	2	2	2	1	1	6	5	4
B♀	2	4	4	4	3	3	4	4	3	3	1	?	2	?	2	?	3	?	5	6	?
B♀	0	2	2	3	3	?	3	3	3	3	2	2	1	1	1	1	?	1	5	6	4
B♀	?	?	?	?	?	?	4	5	3	3	1	2	3	2	2	1	2	2	7	4	4
B♀	1	4	3	4	4	3	3	3	3	3	1	1	2	2	2	2	3	3	8	6	4
B♀	1	2	2	3	3	3	4	3	3	3	1	2	2	2	3	3	4	2	7	3	4
B♀	3	3	3	4	4	3	3	3	3	3	1	2	1	2	2	2	2	2	7	6	4
B♀	2	2	3	3	3	3	3	3	3	3	1	2	2	2	2	2	2	2	5	4	4
B♀	2	2	3	4	4	3	4	4	3	3	?	?	?	?	?	?	?	?	?	6	?
B♀	2	2	3	3	3	3	4	4	3	3	?	?	?	?	?	?	?	?	?	?	?
B♀	2	2	3	3	3	3	3	3	3	3	0	1	1	1	1	1	1	1	?	?	4
B♀	2	3	2	3	3	3	4	4	3	3	2	2	2	2	2	2	3	3	8	6	4
B♀	1	2	2	?	?	?	4	4	3	3	3	1	2	2	2	3	2	3	8	5	4
B♀	1	2	2	3	?	?	4	4	3	3	1	1	2	2	2	1	1	1	8	5	4
B♀	1	2	2	3	3	3	3	4	3	3	1	1	2	2	2	2	2	2	7	5	4
B♀	1	2	2	3	3	3	4	3	3	3	1	1	2	1	2	2	2	1	7	6	4
B♀	1	2	2	3	3	3	4	4	3	3	1	1	2	2	2	2	1	2	7	6	4
B♀	1	2	3	3	3	3	3	3	3	3	1	2	2	2	2	2	1	2	9	6	4
B♀	2	3	3	3	4	4	4	4	3	3	2	2	2	2	2	2	2	2	7	6	4
B♀	2	3	4	4	3	3	3	3	3	3	2	2	2	2	2	3	2	2	6	4	3
B♀	?	?	?	?	?	?	3	3	4	3	2	2	2	2	2	3	1	1	4	?	4
B♀	2	2	2	3	3	3	4	4	3	3	2	2	2	4	3	2	2	2	9	6	4
B♀	2	2	2	3	3	2	4	4	3	3	1	2	3	3	3	2	4	2	7	5	4
B♀	2	2	2	3	2	3	4	3	3	3	2	2	2	2	2	4	2	3	7	4	4
B♀	3	3	4	3	3	3	3	4	3	3	1	1	1	1	2	2	2	2	6	8	4
B♀	4	3	3	4	3	3	3	3	3	3	2	2	3	2	2	3	2	3	10	6	4
B♀	2	3	2	4	4	3	3	3	?	?	3	2	2	2	2	2	2	2	6	5	?
B♀	3	3	4	4	4	3	3	4	?	?	1	?	2	?	2	?	2	?	?	?	?
B♀	3	3	3	3	4	3	3	3	3	3	1	2	?	2	?	1	2	2	10	6	4
B♀	4	3	3	4	4	3	3	2	3	3	?	?	?	?	?	?	?	?	?	5	4
B♀	1	2	2	3	3	3	4	4	3	3	?	?	?	?	?	?	?	?	?	?	?
B♀	0	2	2	3	3	3	4	3	3	3	1	1	2	2	2	1	2	1	6	4	4
B♀	2	3	3	5	4	3	3	3	3	3	3	4	2	4	3	3	3	4	11	5	4
B♀	?	?	?	?	?	?	4	4	3	3	2	2	2	2	2	2	1	1	4	4	4
B♀	3	3	4	3	3	?	3	3	3	3	?	2	1	2	1	1	1	1	5	7	4
B♀	2	2	3	3	3	3	4	4	3	3	3	?	2	?	2	?	2	?	7	4	?
B♀	0	2	2	3	3	3	4	4	4	3	12	11	9	9	8	8	8	7	11	7	3
B♀	2	3	1	2	2	2	4	4	3	3	3	2	2	2	2	2	?	2	7	4	4
B♀	1	2	2	3	2	3	4	4	3	3	1	0	2	2	2	2	3	2	6	4	4
B♀	4	4	4	4	5	3	4	4	3	3	2	2	2	3	2	3	4	3	8	4	4

Appendix 7. Continued.

Sp.	S1	S2	S3	S4	S5	S6	Mb l	Mb r	Sb l	Sb r	T1 l	T1 r	T2 l	T2 r	T3 l	T3 r	T4 l	T4 r	T5	T6	T7
B♀	3	4	4	4	4	3	3	3	3	3	3	3	3	3	4	3	5	3	10	4	3
B♀	2	2	2	3	3	3	4	4	3	3	3	0	2	1	2	1	3	2	5	6	4
B♀	1	2	3	4	4	3	3	3	3	3	2	1	2	2	2	0	2	2	6	6	4
B♀	2	3	3	4	4	3	4	4	3	3	2	2	2	3	2	3	3	3	9	6	4
B♀	2	2	3	3	3	3	4	4	3	3	2	2	2	2	3	2	2	2	4	6	4
B♀	2	3	3	3	3	3	4	3	3	3	2	2	1	2	2	2	2	2	10	6	4
B♀	3	3	4	4	3	3	5	4	3	4	1	2	3	2	3	2	3	2	10	6	4
B♀	0	1	3	2	2	2	4	4	3	3	0	2	0	1	0	1	0	0	5	4	3
B♀	2	2	2	3	3	3	3	4	3	3	3	3	2	2	3	3	3	3	8	6	4
B♀	1	2	2	3	3	3	3	4	3	3	2	2	1	2	2	2	2	?	?	?	?
B♀	1	2	2	3	3	3	4	5	3	3	2	2	3	2	2	1	2	3	11	6	4
B♀	1	2	3	3	3	2	4	3	3	3	2	2	2	2	3	2	3	2	7	6	4
B♀	1	2	2	3	3	3	4	3	2	3	2	2	2	3	2	2	2	2	10	4	4
B♀	1	2	2	3	3	3	4	3	3	3	2	2	3	2	2	2	2	2	7	6	4
A♂	–	–	–	–	–	–	4	4	3	3	0	0	1	1	1	1	1	1	5	4	4
A♂	–	–	–	–	–	–	4	4	3	3	0	0	1	1	1	1	1	1	8	6	5
A♂	–	–	–	–	–	–	4	4	3	3	0	0	1	1	1	1	1	1	6	5	6
A♂	–	–	–	–	–	–	2	3	3	3	0	0	1	1	1	1	1	1	6	5	4
A♂	–	–	–	–	–	–	3	3	3	3	1	1	1	1	1	1	1	1	6	6	7
A♂	–	–	–	–	–	–	3	3	3	3	0	1	1	1	1	1	1	1	7	6	7
B♂	–	–	–	–	–	–	2	3	3	3	0	0	1	1	0	0	1	1	4	6	4
B♂	–	–	–	–	–	–	4	4	3	3	2	1	1	2	1	1	1	3	4	6	4
B♂	–	–	–	–	–	–	3	3	3	3	2	1	1	2	2	2	2	2	6	6	4
B♂	–	–	–	–	–	–	4	4	3	3	2	1	2	2	2	2	2	2	7	6	4
B♂	–	–	–	–	–	–	2	3	3	3	?	?	1	1	2	1	1	1	6	4	3
B♂	–	–	–	–	–	–	4	4	3	3	2	?	2	?	2	2	2	1	6	5	4
B♂	–	–	–	–	–	–	4	3	3	3	0	1	2	2	2	2	3	2	6	6	4
B♂	–	–	–	–	–	–	3	3	3	2	1	0	2	2	2	2	3	2	7	6	4
B♂	–	–	–	–	–	–	3	3	3	3	1	1	2	2	2	2	2	2	6	6	4
B♂	–	–	–	–	–	–	3	3	3	3	1	1	2	2	2	2	2	2	6	6	4
B♂	–	–	–	–	–	–	3	3	3	3	1	1	2	2	1	1	2	2	6	6	4
B♂	–	–	–	–	–	–	4	4	3	3	2	2	2	2	2	2	2	2	7	6	4
B♂	–	–	–	–	–	–	4	4	3	3	0	1	1	1	1	1	1	1	6	6	4
B♂	–	–	–	–	–	–	3	4	3	3	0	1	1	2	1	2	1	3	7	6	3
B♂	–	–	–	–	–	–	4	4	3	3	1	0	1	2	1	1	1	1	5	6	4
B♂	–	–	–	–	–	–	3	3	3	3	1	1	2	2	1	1	2	1	6	6	4
B♂	–	–	–	–	–	–	4	3	3	3	2	1	2	2	2	2	1	3	5	4	4
B♂	–	–	–	–	–	–	4	4	3	3	1	1	2	2	2	2	3	3	7	4	3
B♂	–	–	–	–	–	–	4	4	3	3	1	1	2	2	2	3	2	3	4	5	4
B♂	–	–	–	–	–	–	3	4	3	3	1	2	2	2	3	3	3	2	9	5	4
B♂	–	–	–	–	–	–	3	4	3	3	2	2	2	2	2	2	2	2	9	5	4
B♂	–	–	–	–	–	–	4	5	?	?	1	2	2	?	1	?	2	2	5	6	3
B♂	–	–	–	–	–	–	4	3	3	3	0	1	2	1	1	2	2	1	6	6	4
B♂	–	–	–	–	–	–	3	4	3	3	1	0	2	2	2	2	2	2	5	4	4
B♂	–	–	–	–	–	–	3	3	3	3	1	1	0	2	2	2	3	3	4	4	4
B♂	–	–	–	–	–	–	4	3	3	3	1	1	2	2	2	3	2	3	6	6	4
B♂	–	–	–	–	–	–	4	4	3	3	2	2	2	2	2	2	2	3	8	6	4
B♂	–	–	–	–	–	–	5	4	3	3	2	2	2	2	2	1	2	1	4	4	4
B♂	–	–	–	–	–	–	4	4	3	3	2	2	2	2	2	3	3	3	6	6	4
B♂	–	–	–	–	–	–	4	4	3	3	1	2	2	2	2	2	2	2	6	5	2
B♂	–	–	–	–	–	–	4	4	3	3	1	1	1	1	2	2	4	4	6	6	4
B♂	–	–	–	–	–	–	5	4	3	3	2	2	2	2	2	2	1	2	6	6	4
B♂	–	–	–	–	–	–	4	4	2	3	2	2	2	2	3	2	3	3	4	6	4
B♂	–	–	–	–	–	–	5	4	3	3	2	2	0	1	2	2	1	0	3	4	?
B♂	–	–	–	–	–	–	3	4	3	3	0	0	2	0	2	0	2	0	6	4	4
B♂	–	–	–	–	–	–	4	4	3	3	2	1	2	2	2	2	2	2	7	4	?

Appendix 7. Continued.

Sp.	S1	S2	S3	S4	S5	S6	Mb l	Mb r	Sb l	Sb r	T1 l	T1 r	T2 l	T2 r	T3 l	T3 r	T4 l	T4 r	T5	T6	T7
B♂	–	–	–	–	–	–	3	4	3	3	2	1	2	2	2	2	2	2	6	5	4
B♂	–	–	–	–	–	–	4	4	3	3	2	2	2	2	2	2	3	2	7	6	4
B♂	–	–	–	–	–	–	3	3	3	3	2	1	2	2	2	2	1	2	4	6	4
B♂	–	–	–	–	–	–	2	3	3	3	?	2	2	2	1	2	2	2	6	5	4
B♂	–	–	–	–	–	–	4	4	3	3	2	2	3	2	2	2	3	3	10	6	4

Appendix 8. Raw data of length ratios (first seven columns) and area ratios (ar) used for the morphological analyses of the *Encarsia meritoria* species-complex. A = *E. dispersa*; B = *E. californica*; C = *E. hispida*; D = *E. meritoria*; E = *E. haitiensis*; F1-F6 = flagellomere 1-flagellomere 6.

Species	F3/F1	F2/F1	F3/F2	F5/F1	F6/F1	F6/F5	F6/F4	F3/F1 ar	F2/F1 ar	F3/F2 ar
A	1.6309	1.6488	0.9892	1.6236	1.9257	1.1861	1.1324	1.7503	1.8815	0.9303
A	1.6201	1.6675	0.9716	1.8081	1.7491	0.9674	1.0181	1.7733	1.7338	1.0228
A	1.5797	1.7626	0.8963	1.8873	1.8637	0.9875	1.0297	1.7508	1.9553	0.8954
A	1.4858	1.6360	0.9082	1.6214	1.7032	1.0505	1.0588	1.8815	1.9308	0.9745
A	1.3965	1.4235	0.9810	1.8348	1.9038	1.0376	1.1234	1.3954	1.3966	0.9991
A	1.5090	1.5814	0.9542	1.6088	1.6834	1.0464	1.0186	1.6758	1.8167	0.9224
A	1.9732	2.0606	0.9576	2.2305	2.2401	1.0043	1.0549	2.4329	2.3585	1.0315
A	1.3761	1.4240	0.9663	1.5451	1.5663	1.0137	1.1121	1.7418	1.8575	0.9377
A	1.4750	1.5012	0.9825	1.6656	1.6265	0.9766	1.0667	1.7987	2.1875	0.8223
A	1.5428	1.5996	0.9645	1.6427	1.6853	1.0259	1.0811	1.9080	1.9317	0.9877
A	1.5387	1.7625	0.8730	1.8131	1.7386	0.9589	1.0204	1.5705	1.7319	0.9068
A	1.4365	1.5359	0.9353	1.5096	1.6036	1.0623	1.0274	1.6270	1.8367	0.8858
A	1.4501	1.5670	0.9254	1.6095	1.7208	1.0691	0.9882	1.8930	1.8819	1.0059
A	1.5330	1.5056	1.0182	1.6324	1.7287	1.0590	1.0933	1.8487	1.7018	1.0863
A	1.4869	1.5675	0.9486	1.6861	1.6032	0.9508	1.0169	1.9033	1.7950	1.0603
A	1.6594	1.6269	1.0200	1.7654	1.7224	0.9756	1.0297	1.6387	1.7322	0.9460
A	1.7919	1.8538	0.9666	2.1181	2.2846	1.0786	1.2029	2.0416	2.0480	0.9969
A	1.5218	1.6503	0.9222	1.5851	1.7118	1.0799	1.0485	1.9259	2.2010	0.8750
A	1.4052	1.5833	0.8875	1.5719	1.5635	0.9946	1.0358	1.5182	1.6849	0.9010
A	1.4695	1.5833	0.9281	1.5163	1.6760	1.1053	1.1193	1.7358	1.7895	0.9700
A	1.6278	1.8669	0.8719	1.7921	2.0608	1.1500	1.1611	1.6166	1.9006	0.8506
A	1.4629	1.6135	0.9067	1.6221	1.6788	1.0349	1.0524	1.8127	1.9345	0.9370
A	1.4912	1.6700	0.8930	1.6310	1.7019	1.0435	1.0698	1.7824	1.9751	0.9024
A	1.4070	1.4928	0.9425	1.5643	1.4827	0.9478	1.0358	1.3867	1.5508	0.8942
A	1.7929	1.8108	0.9901	1.7701	1.9341	1.0926	1.0009	1.7448	1.8908	0.9228
A	1.4087	1.4793	0.9523	1.6339	1.5857	0.9705	1.0440	1.6540	1.9504	0.8480
A	1.5302	1.5792	0.9690	1.7390	1.7255	0.9922	1.0210	1.7861	1.7716	1.0082
A	1.5807	1.7232	0.9173	1.7690	1.8331	1.0363	1.1120	1.6990	1.7835	0.9527
A	1.6741	1.6679	1.0038	1.8126	1.8613	1.0269	1.0506	1.7518	1.8088	0.9685
A	1.6170	1.7786	0.9092	1.7731	1.7450	0.9842	1.0051	1.9549	2.1578	0.9060
A	1.6306	1.6064	1.0151	1.9134	2.1148	1.1052	1.1332	1.9854	1.8049	1.1000
A	1.5416	1.7764	0.8678	1.7742	1.8510	1.0433	1.0902	1.8174	2.0338	0.8936
A	1.5508	1.6994	0.9125	1.7048	1.8307	1.0739	1.1170	1.7010	1.8505	0.9192
A	1.8024	2.0452	0.8813	2.0082	2.1602	1.0757	1.0688	1.9100	2.2776	0.8386
A	1.6582	1.7966	0.9230	1.7829	1.8470	1.0359	1.0311	1.8856	2.0826	0.9054
B	1.3213	1.1965	1.1043	1.2492	1.3961	1.1176	1.0864	1.4227	1.2256	1.1609
B	1.1295	1.0762	1.0495	1.0977	1.0782	0.9823	0.9204	1.2734	1.3212	0.9638
B	1.3408	1.1380	1.1782	1.2216	1.3499	1.1051	1.0950	1.4507	1.2270	1.1823
B	1.1421	1.0878	1.0499	1.2232	1.2966	1.0600	1.0842	1.3377	1.1230	1.1912
B	1.3223	1.1333	1.1668	1.2445	1.3748	1.1047	1.0313	1.5618	1.3882	1.1250
B	1.1411	1.1271	1.0124	1.1708	1.2893	1.1012	1.1281	1.6272	1.2372	1.3153
B	1.2484	1.1224	1.1123	1.2493	1.3268	1.0620	1.0475	1.3749	1.0906	1.2607
B	1.2545	1.1135	1.1266	1.2366	1.2229	0.9889	1.0081	1.5657	1.5068	1.0390
B	1.4088	1.2998	1.0838	1.3144	1.5314	1.1651	1.1247	1.5790	1.2213	1.2929
B	1.3611	1.2954	1.0507	1.3562	1.4743	1.0870	1.1042	1.5421	1.3713	1.1246
B	1.2485	1.2141	1.0283	1.2872	1.3245	1.0290	1.0718	1.3886	1.2405	1.1194
B	1.2936	1.0109	1.2797	1.3672	1.3104	0.9584	1.0277	1.6341	1.0797	1.5135
B	1.1956	1.1565	1.0338	1.1848	1.2953	1.0932	1.0555	1.4173	1.2805	1.1068
B	1.3377	1.2670	1.0558	1.3816	1.5244	1.1034	1.1194	1.3511	1.2056	1.1207
B	1.1358	1.0426	1.0894	1.1986	1.2768	1.0652	0.9910	1.2829	1.1811	1.0862
B	1.3868	1.2033	1.1525	1.4087	1.5384	1.0921	1.0996	1.8013	1.3156	1.3692
B	1.5320	1.3036	1.1752	1.5622	1.5926	1.0194	0.9934	1.6787	1.2976	1.2937
B	1.4239	1.1600	1.2275	1.3300	1.4515	1.0914	1.0570	1.5215	1.1561	1.3160
B	1.1546	0.9813	1.1767	1.2203	1.2327	1.0101	1.0458	1.1909	1.0194	1.1683
B	1.2813	1.1769	1.0887	1.3536	1.3981	1.0328	1.1504	1.3692	1.1774	1.1629

Appendix 8. Continued.

Species	F3/F1	F2/F1	F3/F2	F5/F1	F6/F1	F6/F5	F6/F4	F3/F1 ar	F2/F1 ar	F3/F2 ar
B	1.3672	1.2719	1.0750	1.3362	1.4538	1.0880	1.1170	1.5238	1.2810	1.1895
B	1.4142	1.3945	1.0142	1.4013	1.4562	1.0392	0.9982	1.6949	1.3125	1.2913
B	1.3595	1.2624	1.0769	1.3577	1.5729	1.1585	1.1810	1.5972	1.3058	1.2231
B	1.5314	1.3814	1.1086	1.4957	1.6304	1.0901	1.0485	1.5594	1.3966	1.1165
B	1.2161	1.1545	1.0533	1.2603	1.3644	1.0826	1.0696	1.4179	1.2600	1.1253
B	1.3728	1.2820	1.0682	1.3643	1.5272	1.1193	1.0515	1.5523	1.3642	1.1373
B	1.3112	1.1106	1.1806	1.4660	1.5897	1.0844	1.2467	1.6389	1.1466	1.4294
C	1.5758	1.2281	1.2831	1.7585	2.0151	1.1459	1.1724	1.7799	1.2595	1.4132
C	1.5580	1.2127	1.2847	2.0228	2.1732	1.0743	1.3402	1.4899	1.0158	1.4668
C	1.3869	1.0616	1.3064	1.6097	1.7591	1.0928	1.1461	1.5982	1.1362	1.4066
C	1.6569	1.2310	1.3460	1.8582	1.9460	1.0472	1.0123	1.8082	1.3155	1.3746
C	1.5649	1.2186	1.2842	1.7462	1.9579	1.1213	1.0941	1.6786	1.2177	1.3785
C	1.5705	1.2793	1.2276	1.8141	1.8229	1.0049	1.0058	1.7524	1.2317	1.4227
C	1.2838	1.1227	1.1435	1.4712	1.6455	1.1185	1.1609	1.5219	1.1045	1.3780
C	1.4097	1.1522	1.2235	1.7003	1.8712	1.1006	1.1411	1.4688	1.2842	1.1437
C	1.4995	1.1227	1.3356	1.7034	1.9588	1.1499	1.2010	1.4978	1.1948	1.2536
C	1.3866	1.1160	1.2424	1.7155	1.7004	0.9912	1.1339	2.3877	1.5055	1.5860
C	1.5478	1.2310	1.2573	1.7985	2.0596	1.1451	1.1203	1.6505	1.3034	1.2663
C	1.8972	1.3047	1.4541	2.1210	2.2792	1.0746	1.0546	2.0253	1.3378	1.5139
C	1.5218	1.2293	1.2380	1.7069	1.7929	1.0504	1.0551	2.1164	1.5240	1.3888
C	1.5044	1.1569	1.3004	1.6290	1.9024	1.1678	1.2032	1.5517	1.2576	1.2338
C	1.4136	1.0575	1.3367	1.6431	1.7606	1.0715	1.1264	1.7538	1.1730	1.4951
C	1.4813	1.2208	1.2134	1.6394	1.8468	1.1265	1.1397	1.8794	1.3283	1.4149
C	1.4475	1.2221	1.1845	1.5781	1.7104	1.0838	1.1327	1.7049	1.2843	1.3275
C	1.5500	1.2429	1.2471	1.6638	1.9570	1.1762	1.2167	1.9251	1.3181	1.4605
C	1.6771	1.1996	1.3981	1.8056	1.8653	1.0331	1.1149	1.9676	1.3068	1.5056
C	1.6592	1.4075	1.1788	1.8530	1.8959	1.0232	1.0262	1.9180	1.4412	1.3308
C	1.5198	1.1595	1.3107	1.6944	1.8028	1.0640	1.0685	1.9405	1.1573	1.6767
C	1.5136	1.2532	1.2078	1.7612	1.8689	1.0612	1.1374	1.6667	1.1985	1.3906
C	1.7811	1.3195	1.3498	1.8556	2.2571	1.2164	1.2658	2.2590	1.5298	1.4766
C	1.5929	1.2808	1.2436	1.8457	2.0256	1.0975	1.2467	1.7693	1.3208	1.3396
C	1.5104	1.2353	1.2227	1.6348	1.6987	1.0391	1.0613	1.7055	1.1853	1.4389
C	1.6197	1.3502	1.1996	1.8155	2.1133	1.1640	1.2243	2.0985	1.6266	1.2901
C	1.5081	1.2313	1.2248	1.6742	1.9286	1.1519	1.1493	1.8686	1.2965	1.4412
C	1.4416	1.1810	1.2206	1.6657	1.7702	1.0627	1.0344	1.4219	1.1366	1.2510
C	1.5700	1.1974	1.3112	1.8224	1.9325	1.0604	1.1705	1.6317	1.0457	1.5604
C	1.5922	1.3234	1.2031	1.9295	2.1310	1.1045	1.2524	1.4564	1.1631	1.2522
C	1.5667	1.2010	1.3044	1.5156	1.9045	1.2566	1.2237	1.6438	1.0740	1.5305
C	1.4551	1.2276	1.1854	1.6125	1.8334	1.1370	1.2464	1.6751	1.1379	1.4722
C	1.6809	1.3876	1.2113	1.5751	1.8549	1.1777	1.1453	2.0315	1.5462	1.3139
C	1.6207	1.4059	1.1528	1.6821	1.9339	1.1497	1.0805	1.8513	1.6288	1.1366
C	1.8028	1.3152	1.3707	2.0612	2.2710	1.1018	1.2725	1.9143	1.3222	1.4478
C	1.6504	1.3735	1.2016	1.7082	2.0647	1.2087	1.3060	1.8462	1.3164	1.4025
C	1.6060	1.1762	1.3654	1.6764	1.9425	1.1587	1.1969	1.5656	1.1017	1.4210
C	1.3572	1.0953	1.2391	1.6795	1.7972	1.0700	1.2115	1.5222	1.0222	1.4892
C	1.3708	1.0976	1.2490	1.5747	1.8694	1.1872	1.2646	1.9484	1.2392	1.5724
C	1.3708	1.0976	1.2490	1.5747	1.8694	1.1872	1.2646	1.9484	1.2392	1.5724
C	1.6355	1.2818	1.2759	1.8480	2.1416	1.1589	1.2565	1.7575	1.3006	1.3513
C	1.5088	1.1424	1.3207	1.6133	1.8653	1.1562	1.1578	2.5849	1.5425	1.6758
C	1.5662	1.0962	1.4287	1.7939	2.0314	1.1324	1.2313	1.8434	1.1219	1.6431
C	1.5530	1.2338	1.2587	2.0529	2.3783	1.1585	1.3958	1.7861	1.3289	1.3441
C	1.6388	1.3680	1.1980	1.9884	2.3245	1.1690	1.1937	2.0224	1.4918	1.3556
C	1.6430	1.3588	1.2092	1.9340	2.4163	1.2494	1.3152	1.8329	1.4858	1.2336
C	1.5534	1.2976	1.1972	1.6535	1.8136	1.0968	1.0802	1.8098	1.3503	1.3403
C	1.4219	1.1689	1.2164	1.8142	1.8750	1.0335	1.1851	1.6905	1.1939	1.4159
C	1.5714	1.1493	1.3672	1.7741	1.9550	1.1020	1.2034	1.4847	0.9991	1.4860
C	1.7604	1.4401	1.2224	1.8929	1.9897	1.0511	1.1223	2.4416	1.5191	1.6072

Appendix 8. Continued.

Species	F3/F1	F2/F1	F3/F2	F5/F1	F6/F1	F6/F5	F6/F4	F3/F1 ar	F2/F1 ar	F3/F2 ar
C	1.5705	1.3348	1.1766	1.5993	1.7404	1.0882	1.1328	1.7810	1.3922	1.2793
C	1.5296	1.2690	1.2053	1.7239	2.0611	1.1956	1.3110	1.8494	1.3504	1.3695
C	1.5642	1.2424	1.2590	1.7516	1.8619	1.0630	1.2011	2.1595	1.5860	1.3616
C	1.5019	1.1648	1.2894	1.8368	1.8226	0.9923	1.0685	1.6245	1.0971	1.4807
C	1.4999	1.2378	1.2118	1.6570	1.8938	1.1429	1.1828	1.4811	1.1841	1.2508
C	1.5389	1.2420	1.2391	1.7151	2.1755	1.2684	1.2896	1.7901	1.4262	1.2552
C	1.5444	1.2483	1.2372	1.6980	1.8149	1.0688	1.0801	1.7487	1.2325	1.4188
C	1.4450	1.2010	1.2031	1.5986	1.9270	1.2054	1.2038	1.5748	1.2311	1.2791
C	1.3693	1.1567	1.1838	1.5457	1.8052	1.1679	1.2168	1.8343	1.4681	1.2495
C	1.3458	1.0844	1.2411	1.5043	1.7029	1.1320	1.1368	1.5985	1.1693	1.3671
C	1.5765	1.3211	1.1933	1.8731	1.9857	1.0601	1.1212	1.7353	1.3554	1.2803
C	1.4962	1.2546	1.1926	1.8084	1.9674	1.0879	1.2344	2.1058	1.4795	1.4233
C	1.5082	1.1252	1.3404	1.6480	1.9138	1.1613	1.2828	1.9262	1.2385	1.5552
C	1.5794	1.3044	1.2108	1.7256	1.8577	1.0766	1.1641	1.9201	1.3934	1.3779
C	1.5179	1.1956	1.2696	1.6666	2.0376	1.2226	1.2811	2.0924	1.1859	1.7644
C	1.7535	1.3457	1.3030	1.9875	2.1683	1.0909	1.1811	2.1167	1.4710	1.4390
C	1.7016	1.2465	1.3651	1.8821	2.1312	1.1323	1.1776	1.9793	1.3347	1.4830
C	1.8647	1.4993	1.2437	2.2165	2.3472	1.0590	1.1025	2.3901	1.6273	1.4688
D	1.8314	1.4177	1.2918	1.8825	2.1159	1.1240	1.2968	2.0588	1.6471	1.2500
D	1.4807	1.2718	1.1642	1.4359	1.6894	1.1765	1.1291	1.8195	1.3114	1.3874
D	1.4417	1.3656	1.0557	1.5178	1.6349	1.0772	1.1450	1.5514	1.4496	1.0702
E	1.6556	1.4839	1.1157	1.7935	1.9037	1.0615	1.1203	1.9649	1.7812	1.1031
E	1.5071	1.4759	1.0211	1.7352	1.7829	1.0275	1.0970	1.7710	1.5977	1.1085
E	1.7358	1.6740	1.0369	2.0203	2.0535	1.0164	1.0937	1.8447	1.6893	1.0920
E	1.5228	1.3657	1.1151	1.7002	1.6926	0.9955	1.0215	2.1111	1.8311	1.1529
E	1.6250	1.4615	1.1118	1.8140	1.9810	1.0921	1.1190	1.6471	1.5205	1.0833
E	1.6881	1.4484	1.1655	1.7204	1.8256	1.0611	1.0611	1.9026	1.5441	1.2322
E	1.9873	1.6192	1.2273	2.1261	2.1580	1.0150	1.1562	2.0615	1.6418	1.2556
E	1.6731	1.6938	0.9878	1.9397	1.9996	1.0309	1.0076	1.6177	1.4873	1.0877
E	1.4479	1.4541	0.9957	1.7661	2.1098	1.1946	1.2711	1.7934	1.6908	1.0607
E	1.7125	1.7091	1.0020	1.9897	2.1311	1.0711	1.1079	2.2849	1.7107	1.3356
E	1.6930	1.6672	1.0155	1.7776	2.0673	1.1630	1.1140	1.9564	1.7943	1.0904
E	1.6138	1.6073	1.0041	1.7250	1.8849	1.0927	1.0912	1.6812	1.6319	1.0302

Appendix 9. Three linear measurements taken from the ovipositor system of the *Encarsia meritoria* species-complex. Ratios were used for bivariate analysis. A = *Encarsia dispersa*; B = *E. haitiensis*; 2nd V.L. = second valvifer length; 3rd V.L. = third valvula length; T.O.L = total ovipositor length.

Species	3rd V.L.	2nd V.L.	T.O.L.	T.O.L./2nd V.L.	3rd V.L./ 2nd V.L.
A	271.312	446.014	664.568	1.490	0.608
A	243.526	438.443	640.864	1.462	0.555
A	259.557	430.192	637.700	1.482	0.603
A	268.931	455.725	667.188	1.464	0.590
A	284.965	464.634	689.351	1.484	0.613
A	286.225	453.499	677.886	1.495	0.631
A	189.763	330.220	483.182	1.463	0.575
A	280.223	448.769	668.797	1.490	0.624
A	278.255	438.207	645.812	1.474	0.635
A	265.189	479.435	696.690	1.453	0.553
A	256.827	441.239	647.884	1.468	0.582
A	206.652	367.643	508.485	1.383	0.562
B	337.218	445.728	754.398	1.693	0.757
B	373.526	459.010	852.424	1.857	0.814
B	286.128	383.298	677.103	1.767	0.746
B	340.165	458.402	791.926	1.728	0.742
B	316.891	437.200	748.901	1.713	0.725
B	305.644	426.986	776.999	1.820	0.716
B	353.282	431.530	799.181	1.852	0.819
B	297.473	358.064	598.021	1.670	0.831
B	319.331	389.082	803.084	2.064	0.821
B	320.782	418.803	836.167	1.997	0.766
B	341.784	434.118	811.874	1.870	0.787
B	312.247	410.026	803.802	1.960	0.762

Appendix 10. Parasitoid association of the whitefly species selected for the morphological phylogenetic study. [1] Hyperparasitoid.

Whitefly species	Parasitoid wasps
Acaudaleyrodes rachipora	*Encarsia acaudaleyrodis, Encarsia davidi, Encarsia galilea, Encarsia inaron, Encarsia lutea, Encarsia mineoi, Encarsia protransvena, Encarsia sophia, Eretmocerus mundus, Eretmocerus rajasthanicus, Eretmocerus roseni*
Aleurocanthus citriperdus	*Ablerus macrochaeta*[1], *Amitus hesperidum, Encarsia divergens, Encarsia merceti, Encarsia smithi, Eretmocerus serius*
Aleurocanthus inceratus	*Ablerus macrochaeta*[1], *Encarsia clypealis, Encarsia opulenta, Eretmocerus orientalis*
Aleurocanthus leptadeniae	*Encarsia tremblayi*
Aleurocanthus spiniferus	*Ablerus connectens*[1], *Ablerus macrochaeta*[1], *Amitus hesperidum, Encarsia clypealis, Encarsia divergens, Encarsia ishii, Encarsia longifasciata, Encarsia merceti, Encarsia nipponica, Encarsia obtusiclava, Encarsia opulenta, Encarsia smithi, Eretmocerus orientalis, Eretmocerus serius, Eretmocerus silvestri*
Aleurochiton aceris	*Amitus aleurodinis, Amitus minervae, Encarsia aleurochitonis, Encarsia margaritiventris, Euderomphale secreta*
Aleurochiton forbesii	*Amitus aleurodinis*
Aleuroclava aucubae	*Encarsia lutea*
Aleuroclava ficicola	*Encarsia bothrocera, Encarsia cibcensis, Encarsia echinocera, Encarsia lutea, Encarsia perflava*
Aleuroclava jasmini	*Encarsia lutea, Encarsia nipponica*
Aleuroclava murrayae	*Encarsia longicauda*
Aleuroclava psidii	*Encarsia lutea*
Aleuroclava similes	*Eretmocerus zippanguiphagus*
Aleurocybotus occiduus	*Euderomphale hyalina*
Aleuroglandulus malangae	*Amitus aleuroglanduli, Encarsia formosa, Encarsia haitiensis, Encarsia hispida*
Aleurolobus hargreavesi	*Encarsia* sp.
Aleurolobus marlatti	*Encarsia ancistrocera, Encarsia confusa?, Encarsia davidi, Encarsia elegans, Encarsia longifasciata, Encarsia lutea, Encarsia sophia?, Eretmocerus aleurolobi, Eretmocerus siphonini*
Aleurolobus teucrii	*Encarsia olivina*
Aleuroplatus acaciae	*Encarsia lutea*
Aleuroplatus cadabae	*Ablerus pumilus*[1], *Encarsia abatei, Encarsia aleuroplati, Eretmocerus cadabae, Eretmocerus mundus*
Aleuroplatus pectiniferus	*Encarsia ishii, Encarsia lutea, Encarsia perplexa*
Aleuroplatus periplocae	*Eretmocerus* sp.
Aleurothrixus aepim	*Encarsia aleurothrixi, Encarsia porteri*
Aleurothrixus bondari	*Encarsia* sp.
Aleurothrixus floccosus	*Amitus spiniferus, Cales noacki, Encarsia aleurothrixi, Encarsia americana, Encarsia basicincta, Encarsia cubensis, Encarsia desantisi, Encarsia dispersa, Encarsia haitiensis, Encarsia hispida, Encarsia inaron, Encarsia noahi, Encarsia porteri, Encarsia portoricensis, Encarsia quaintancei, Encarsia sophia, Encarsia variegata, Encarsiella* sp., *Eretmocerus californicus, Eretmocerus haldemani, Eretmocerus paulistus, Eretmocerus*

	portoricensis, *Eretmocerus serius*, *Euderomphale aleurothrixi*, *Euderomphale flavimedia*, *Marietta picta*[1], *Metaphycus* sp., *Neopomphale aleurothrixi*, *Plagiomerus cyaneus*, *Signiphora flava*[1], *Signiphora townsendi*[1], *Signiphora xanthographa*[1]
Aleurothrixus porteri	*Cales noacki*, *Encarsia hispida*, *Encarsia porteri*, *Encarsia tricolor*, *Eretmocerus corni*
Aleurothrixus smilaceti	*Encarsia bothrocera*
Aleurotrachelus atratus	*Cales noacki*, *Encarsia lanceolata*, *Encarsia nigricephala*
Aleurotrachelus trachoides	*Encarsia cubensis*, *Encarsia formosa*, *Encarsia hispida*
Aleurotuba jelinekii	*Amitus aleurotubae*, *Amitus* sp. near *aleurotubae**, *Cales noacki*, *Encarsia aleurotubae*, *Encarsia lutea*, *Encarsia margaritiventris*, *Encarsia tricolor*, *Eretmocerus longicornis*
Aleurotulus nephrolepides	*Cales noacki*
Aleurotulus pteridophytae	*Encarsia sueloderi*
Aleuroviggianus adrianae	*Amitus vesuvianus*, *Encarsia aleuroilicis*
Aleyrodes elevatus	*Encarsia inaron*, *Encarsia pergandiella*, *Encarsia tricolor*
Aleyrodes lonicerae	*Cales noacki*, *Encarsia formosa*, *Encarsia inaron*, *Encarsia lutea*, *Encarsia meritoria*, *Encarsia pergandiella*, *Encarsia tricolor*, *Euderomphale chelidonii*
Aleyrodes proletella	*Encarsia davidi*, *Encarsia formosa*, *Encarsia hispida*, *Encarsia inaron*, *Encarsia lutea*, *Encarsia melanostoma*, *Encarsia noahi*, *Encarsia pergandiella*, *Encarsia sophia*, *Encarsia tricolor*, *Eretmocerus mundus*, *Euderomphale cerris*, *Euderomphale chelidonii*, *Euderomphale gomer*, *Euderomphale insularis*, *Neochrysocharis formosa*
Aleyrodes pruinosus	*Encarsia peltata*, *Euderomphale flavimedia*
Aleyrodes singularis	*Encarsia dichroa*, *Encarsia estrellae*, *Encarsia formosa*, *Encarsia hispida*, *Encarsia inaron*, *Encarsia noahi*, *Encarsia sophia*, *Encarsia tricolor*, *Euderomphale gomer*
Asterobemisia carpini	*Encarsia asterobemisiae*, *Encarsia coryli*, *Encarsia inaron*, *Encarsia longicornis*, *Encarsia lutea*, *Encarsia sophia*, *Eretmocerus mundus*, *Euderomphale cerris*
Bemisia afer	*Cales noacki*?, *Encarsia estrellae*?, *Bemisia levadicola*?, *Encarsia galilea*, *Encarsia melanostoma*?, *Encarsia noahi*?, *Encarsia pergandiella*?, *Encarsia silvestrii*, *Encarsia sophia*, *Eretmocerus mundus*?, *Eretmocerus roseni*, *Euderomphale bemisiae*, *Euderomphale cortinae*?, *Euderomphale gomer*?
Bemisia giffardi	*Encarsia strenua*
Bemisia lauracea	*Encarsia levadicola*
Bemisia tabaci	*Adelencyrtus moderatus*, *Amitus bennetti*, *Encarsia acaudaleyrodis*, *Encarsia adusta*, *Encarsia aleurochitonis*, *Encarsia azimi*, *Encarsia bimaculata*, *Encarsia brevivena*, *Encarsia californica*, *Encarsia cibcensis*, *Encarsia citrella*, *Encarsia citri*, *Encarsia davidi*, *Encarsia desantisi*, *Encarsia duorunga*, *Encarsia elegans*, *Encarsia formosa*, *Encarsia guadeloupae*, *Encarsia hamoni*, *Encarsia hispida*, *Encarsia inaron*, *Encarsia japonica*, *Encarsia lanceolata*, *Encarsia longifasciata*, *Encarsia longivalvula*, *Encarsia lutea*, *Encarsia luteola*, *Encarsia melanostoma*?, *Encarsia meritoria*, *Encarsia mineoi*, *Encarsia mohyuddini*, *Encarsia nigricephala*, *Encarsia oakeyensis*, *Encarsia paracitrella*, *Encarsia pergandiella*, *Encarsia polaszeki*, *Encarsia porteri*, *Encarsia protransvena*, *Encarsia pseudocitrella*, *Encarsia quaintancei*, *Encarsia reticulata*, *Encarsia sophia*, *Encarsia strenua*, *Encarsia synaptocera*, *Encarsia tricolor*, *Eretmocerus aligarhensis*, *Eretmocerus californicus*, *Eretmocerus diversiciliatus*, *Eretmocerus emiratus*, *Eretmocerus eremicus*, *Eretmocerus haldemani*, *Eretmocerus hayati*, *Eretmocerus joeballi*, *Eretmocerus masii*, *Eretmocerus melanoscutus*, *Eretmocerus mundus*, *Eretmocerus queenslandensis*, *Eretmocerus serius*, *Eretmocerus staufferi*, *Eretmocerus tejanus*, *Metaphycus* sp., *Neochrysocharis formosa*, *Signiphora* sp.[1]
Bulgarialeurodes cotesii	*Encarsia inaron*, *Encarsia lutea*, *Eretmocerus nikolskajae*

Crenidorsum aroidephagus	*Cales noacki*, *Encarsia hispida*
Crenidorsum micheliae	*Encarsia bothrocera*, *Encarsia synaptocera*
Dialeurodes agalmae	*Encarsia cibcensis*
Dialeurodes citri	*Encarsia abundantia*, *Encarsia citri*, *Encarsia citrofila*, *Encarsia formosa*, *Encarsia lahorensis*, *Encarsia longifasciata*, *Encarsia longivalvula*, *Encarsia lutea*, *Encarsia magnivena*, *Encarsia protransvena*, *Encarsia sophia*, *Encarsia strenua*, *Encarsia tricolor*, *Eretmocerus* sp. *Signiphora aleyrodis*[1]
Dialeurodes ixorae	*Encarsia ixorae*
Dialeurodes kirkaldyi	*Encarsia abundantia*, *Encarsia bothrocera*, *Encarsia lahorensis*, *Encarsia lutea*, *Encarsia nigricephala*, *Encarsia protransvena*, *Encarsia strenua*, *Eretmocerus rosei*, *Eretmocerus mundus*
Dialeurolonga communis	*Eretmocerus* sp.
Dialeurolonga elongata	*Encarsia aseta*
Dialeuropora decempuncta	*Encarsia dialeuroporae*, *Encarsia longivalvula*
Filicaleyrodes williamsi	*Encarsia* sp.
Lipaleyrodes atriplex	*Encarsia azimi*
Lipaleyrodes euphorbiae	*Encarsia lipaleyrodis*, *Encarsia tinctoriae*, *Eretmocerus adustiscutum*, *Eretmocerus flavus*, *Euderomphale* sp.
Massilieurodes chittendeni	*Encarsia formosa*
Massilieurodes fici	*Encarsia ancistrocera*, *Encarsia azimi*, *Encarsia lutea*
Neomaskellia andropogonis	*Encarsia tristis*
Neomaskellia bergii	*Ablerus* sp.[1], *Encarsia isaaci*, *Encarsia tristis*, *Eretmocerus delhiensis*, *Eretmocerus mundus*, *Eretmocerus paulistus*, *Eretmocerus serius*, *Syrphophagus* sp.[1]
Orchamoplatus caledonicus	*Encarsia neocala*
Orchamoplatus citri	*Cales orchamoplati*
Orchamoplatus mammaeferus	*Encarsia* sp.
Parabemisia myricae	*Cales noacki*, *Encarsia azimi*, *Encarsia collecta*, *Encarsia hispida*, *Encarsia lutea*, *Encarsia meritoria*, *Encarsia protransvena*, *Encarsia pseudocitrella*, *Encarsia sophia*, *Encarsia strenua*, *Eretmocerus debachi*, *Eretmocerus furuhashii*
Pealius azaleae	*Encarsia gautieri*, *Encarsia inaron*, *Encarsia lutea*, *Encarsia pergandiella*, *Encarsia tricolor*
Pealius mori	*Encarsia bothrocera*, *Encarsia cibcensis*, *Encarsia lutea*
Pealius rhododendri	*Encarsia azimi*
Ramsesseus follioti	*Encarsia elegans*, *Encarsia ramsesi*
Rusostigma eugeniae	*Encarsia strenua*
Simplaleurodes hemisphaerica	*Amitus rugosus*
Singhiella bicolor	*Encarsia septentrionalis*
Singhiella cardamomi	*Encarsia dialeurodis*, *Encarsia septentrionalis*
Singhiella citrifolii	*Encarsia lahorensis*, *Encarsia perstrenua*, *Encarsia protransvena*, *Encarsia strenua*

Singhius hibisci	*Encarsia bothrocera*, *Encarsia cibcensis*, *Encarsia lutea*, *Encarsia sophia*, *Eretmocerus corni*
Siphoninus immaculatus	*Encarsia inaron*
Siphoninus phillyreae	*Encarsia azimi*, *Encarsia davidi*, *Encarsia dichroa*, *Encarsia galilea*, *Encarsia gautieri*, *Encarsia hispida*, *Encarsia inaron*, *Encarsia lutea*, *Encarsia mineoi*, *Encarsia punicae*, *Encarsia siphonini*, *Encarsia strenua*, *Eretmocerus corni*, *Eretmocerus diversiciliatus*, *Eretmocerus mundus*, *Eretmocerus siphonini*, *Pachyneuron* sp.[1]
Taiwanaleyrodes carpini	*Encarsia bothrocera*, *Encarsia perflava*
Taiwanaleyrodes meliosmae	*Encarsia cibcensis*, *Encarsia lutea*
Tetraleurodes acaciae	*Encarsia dispersa*, *Encarsia hispida*, *Encarsia lanceolata*, *Encarsia nigricephala*, *Encarsia paracitrella*, *Eretmocerus portoricensis*, *Signiphora* sp.[1]
Trialeurodes abutiloneus	*Amitus aleurodinis*, *Encarsia californica*, *Encarsia coquilletti*, *Encarsia formosa*, *Encarsia hispida*, *Encarsia lutea*, *Encarsia meritoria*, *Encarsia nigricephala*, *Encarsia pergandiella*, *Encarsia protransvena*, *Eretmocerus eremicus*, *Eretmocerus haldemani*, *Eretmocerus staufferi*
Trialeurodes floridensis	*Encarsia hispida*, *Encarsia meritoria*, *Encarsia nigricephala*
Trialeurodes pergandei	*Encarsia lanceolata*
Trialeurodes vaporariorum	*Amitus fuscipennis*, *Cales noacki*, *Encarsia adusta*, *Encarsia azimi*, *Encarsia bellottii*, *Encarsia bimaculata*, *Encarsia californica*, *Encarsia citrella*, *Encarsia citri*, *Encarsia costaricensis*, *Encarsia formosa*, *Encarsia guadeloupae*, *Encarsia hamoni*, *Encarsia hispida*, *Encarsia inaron*, *Encarsia japonica*, *Encarsia lutea*, *Encarsia luteola*, *Encarsia lycopersici*, *Encarsia melanostoma*, *Encarsia meritoria*, *Encarsia mineoi*, *Encarsia nigricephala*, *Encarsia noahi*, *Encarsia oakeyensis*, *Encarsia pergandiella*, *Encarsia porteri*, *Encarsia protransvena*, *Encarsia quaintancei*, *Encarsia sophia*, *Encarsia synaptocera*, *Encarsia tricolor*, *Encarsia ustulata*, *Eretmocerus californicus*, *Eretmocerus corni*, *Eretmocerus eremicus*, *Eretmocerus haldemani*, *Eretmocerus mundus*, *Eretmocerus warrae*, *Euderomphale ezzati*, *Signiphora coquilletti*[1]
Trialeurodes variabilis	*Amitus macgowni*, *Encarsia bellottii*, *Encarsia formosa*, *Encarsia hispida*, *Encarsia pergandiella*, *Encarsia protransvena*, *Encarsia sophia*
Vasdavidius indicus	*Encarsia japonica*, *Encarsia luteola*, *Encarsia sophia*
Vasdavidius setiferus	*Encarsia persequens*
Zaphanera papyrocarpae	*Zarhopaloides anaxenor*
Aleurodicus cocois	*Chartocerus* sp.[1], *Encarsiella aleurodici*, *Entedononecremnus* sp.
Aleurodicus dispersus	*Aleuroctonus vittatus*, *Encarsia dispersa*, *Encarsia guadeloupae*, *Encarsia nigricephala*, *Encarsia sophia*, *Encarsiella aleurodici*, *Encarsiella noyesi*
Azuraleurodicus pentarthrus	*Dirphys aphania*, *Encarsiella pithecura*
Eudialeurodicus bodkini	*Encarsiella magniclava*, *Entedononecremnus unicus*
Synaleurodicus sp.	*Aphobetus moundi*[1]

* This species was collected by me (unpublished data).

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