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Australian long-tailed gall thrips (Thysanoptera: Phlaeothripinae, Leeuweniini), with comments on related Old World taxa

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Abstract The Tribe Leeuweniini is a group of Old World Phlaeothripinae species that feed and usually induce irregular galls on the leaves of rainforest trees. These thrips all have the last abdominal segment unusually elongate, but this is a variable and homoplastic character state, and the tribe remains ill-defined. Worldwide, 27 species in three genera are now recognised, with five other generic names here included as synonyms of *Leeuwenia* Karny. From Australia, six species in two genera are recorded here occurring in the eastern rainforests. Four newly described Australian species and their host plants are: *Leeuwenia diospyri* sp. n. (*Diospyros pentamera*–Ebenaceae); *L. polyosmae* sp. n. (*Polyosma cunninghamii*–Grossulariaceae); *L. scolopiae* sp. n. (*Scolopia braunii*–Flacourtiaceae); and *L. tetrastigmae* sp. n. (*Tetrastigma nitens*–Vitaceae). The host association of *L. convergens* Hood is not known, but the sixth species, *Neohoodiella jennibeardae* Mound and Williams, breeds on two unrelated plants of which the leaves are similar in texture – *Ficus coronata* (Moraceae) and *Rhipogonum elseyanum* (Smilacaceae).

Key words galls, *Leeuwenia*, *Neohoodiella*, rainforest trees.

INTRODUCTION

In contrast to other insects, adults of the 3500 named species in the thysanopteran family Phlaeothripidae have the tenth abdominal segment forming a complete tube. The anus is at the apex of this tube, although the gonopore is at its base between sternites eight and 10, depending on the sex. The function of the tube remains unclear, but its evolutionary origin may well have involved neoteny, because larvae in all families of Thysanoptera have the tenth abdominal segment tubular. For example, among the Thripidae, larvae of various species including the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), and the western flower thrips, *Frankliniella occidentalis* (Pergande), sometimes bear a small drop of liquid at the apex of the anal tube. Teerling (1995) demonstrated that this liquid includes an alarm pheromone. Among the Phlaeothripidae, adults of several unrelated species have been observed to raise the tube over the head in an apparently defensive gesture, and Suzuki *et al*. (1988) demonstrated that *Leeuwenia pasanii* (Mukaigawa) produces an alarm pheromone from the tube. Adults of the large leaf-feeding species in the related genus *Gigantothrips* Zimmermann, from the Afrotropical and Oriental Regions, also appear to produce repellents, because use of an aspirator to collect these thrips has been found to induce violent coughing. Similarly, Crespi and Mound (1997) reported the emission of a strong repellent from the anus of an undescribed species of *Katothrips* Mound that was found living in an abandoned weevil mine on an *Acacia* phyllode in Queensland.

This paper gives some account of the six Australian members of an Old World group of 27 described thrips species in which the abdominal tube is exceptionally long. The group is referred to as the Leeuweniini, but this tribe is poorly defined and its systematic relationships are far from clear. Notes are therefore included on non-Australian species, together with a discussion of the variation in structure of the tube amongst Phlaeothripidae, and some consideration of the problems of the supra-generic classification of this family. The pattern of variation amongst these thrips, including undescribed species from south-east Asia and New Caledonia, suggests that the group involves considerably more species. Most of the species for which there is any biological information induce simple galls or distortions on the leaves of rainforest plants, but these hosts involve several unrelated families. This work forms part of a larger project to understand the host associations of Australian thrips (Mound & Williams 2002; Mound 2002; Marullo 2003). The type material of the four new species is available in the Australian National Insect Collection, CSIRO, Canberra. The specific epithets of the new species have been derived from the generic names of their host plants.

DIVERSITY OF TUBE FORM

The shape of the tube in most adult Phlaeothripidae is simple, gently narrowing from base to apex, as in the common flower- and grass-associated species of the genus *Haplothrips* Amyot

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and Serville (Mound & Gillespie 1997). However, in a range of unrelated species the form of the tube is modified in various ways. In the subfamily Idolothripinae, all of which are spore-feeders (Mound 1974), a few species have the tube short, wider than long and broadly conical, and these have been observed to raise the tube over the head when disturbed such that the body outline suddenly becomes spherical and mite-like. This happens commonly in *Nesothrips propinquus* (Bagnall), a species that is abundant in tussocks of grass in Australia. In contrast, *Idolothrips spectrum* Haliday, the Australian giant thrips that feeds on fungal spores on dead leaves of *Eucalyptus* species, has the tube longer than the head and with densely setose margins (Mound & Palmer 1983).

Amongst the Phlaeothripinae, the members of one fungus-feeding group in Australia, commonly referred to as the Urothripini (Mound 1972), have the tube elongate and slender with the anal setae exceptionally long. Leaf-feeding phlaeothripines show an even greater diversity in tube form. Some species on *Casuarina* trees have the tube heavily sculptured and sharply expanded basally (Mound 1970), and on *Acacia* there are species with the tube short and bee-hive shaped or with hook-like tubercles apically (Mound 1971). Similarly on *Acacia*, some species of *Dunatothrips* Moulton have the tube shorter than wide, and all the species of *Sartrithrips* Mound and Morris have a curious supra-anal projection that is not found in any other member of the Phlaeothripidae (Mound & Morris 2001). The range of tube form amongst Australian Phlaeothripinae suggests that this structure, probably in association with volatile chemicals produced through the anus, plays some significant role in the biology of some species.

PHLAEOTHRIPINAE SUPRA-GENERIC CLASSIFICATION

Almost half of the 340 genera of Phlaeothripinae currently recognised worldwide each includes only a single species, and a further 25% of these genera each includes 10 species or fewer. Moreover, there is no functional classification of these genera below subfamily level. Priesner (1961) produced a tribal classification that has been widely quoted but which has little or no support in the form of suitable character states. Mound and Marullo (1996), following Stannard (1957), recognised three broad 'lineages' within this subfamily that, although weakly defined structurally, at least reflect significant differences in biologies. These three lineages are the *'Liothrips'*-lineage of leaf-feeding species, the *'Phlaeothrips'*-lineage of hyphal-feeding species, and the *'Haplothrips'*-lineage of flower-feeding species.

Members of the *'Liothrips'*-lineage are found worldwide, and these species usually have only one sense cone on the third antennal segment, but three (more rarely two) on the fourth segment. This lineage includes *Liothrips* Uzel, which with 250 species is the second largest genus of Thysanoptera, together with a considerable number of small or monotypic genera mainly from India (Ananthakrishnan & Sen 1980). Many of these genera are not defined satisfactorily, and structural diversity among them is low. Within the genus *Liothrips*, the uniformity of structure between species is such that Priesner (1968) did not consider illustrations were needed when describing 40 new species and two new subgenera. Most of these species remain known from single samples, and there have been no serious studies on intra- and interpopulation variation.

TRIBE LEEUWENIINI

One of the putative tribes within the Phlaeothripinae, the Leeuweniini, was distinguished by Priesner (1961) from other leaf-feeding members of this subfamily on the basis of the extreme elongation of the tube, the tenth abdominal segment ('often as long as the rest of the abdominal segments together'). However, amongst the species referred to the Leeuweniini the tube varies in both actual and relative length, and it is particularly short in two of the new species described below from eastern Australia. Moreover, several species belonging to genera that are excluded from the Leeuweniini, particularly *Gynaikothrips* Zimmermann and *Gigantothrips* species that induce leaf-roll galls in the Old World, have the tube longer than the head. Because, as indicated above, tube elongation occurs in various unrelated Phlaeothripidae, this character state is not satisfactory as an apomorphy defining this tribe.

Ananthakrishnan (1970) provided a key to five genera that he recognised as comprising the Leeuweniini, but he clearly misplaced *Holurothrips* Bagnall amongst these. This is a genus of spore-feeding thrips of the subfamily Idolothripinae, judging from the broad maxillary stylets and the contents of the gut (Mound 1974; Mound & Palmer 1983). Ananthakrishnan (1969) erected *Kochummania* for a single Indian species, *K. excelsa*, from galls on *Litsea coriacea* (Lauraceae). This Indian species has the head similar in shape and sculpture (Fig. 20) to some species of *Leeuwenia* Karny but the tube rather short (scarcely 1.3 times as long as the head). Moreover, the body bears many exceptionally long setae, each approximately as long as the width of the head. In contrast, the members of the other three genera in that key, *Leeuwenia*, *Hoodiella* Karny and *Varshneyia* Ananthakrishnan (= *Takahashia* Ananthakrishnan), all have the tube more than twice as long as the head, and the major setae short to very short. Bournier (1997) added *Neohoodiella* to the Leeuweniini, for a single species from New Caledonia, with the body setae as long as in *Kochummania* but the tube as long as in *Leeuwenia* species.

Three monobasic genera from Mauritius described by Mamet (1967) should also be considered. *Dyscolothrips priesneri* Mamet has the tube four times as long as its basal width but without the prominent marginal setae of typical Leeuweniini, and appears to be intermediate between *Leeuwenia* and *Gynaikothrips*. *Hapsidothrips curtispinis* Mamet and *Maurithrips spinulosus* Mamet both have the tube almost five times as long as its basal width, but both differ from typical Leeuweniini species in having the head elevated medially with long, deeply retracted, maxillary stylets. The

relationships of these three taxa remain unclear, but a fourth monobasic genus from Mauritius, *Mametiella* Priesner, is listed below as a synonym of *Leeuwenia*.

No species of the Leeuweniini is known from the New World, the species being distributed between Mauritius, south-east Asia, Australia and the Pacific. There appears to be no single character state that defines this tribe among the leaf-feeding species comprising the *Gigantothrips*/*Gynaikothrips*/*Liothrips* complex. Some members of *Gynaikothrips* and *Gigantothrips* have the tube long but with the rest of the body large, whereas *Leeuwenia* species generally have the tube relatively long compared to the rather small body. Phylogenetically, the Leeuweniini probably represents an aberrant group within the *'Liothrips'*-lineage that is paraphyletic with respect to some species group within the *Gigantothrips*/*Gynaikothrips*/*Liothrips* complex, and the name is used here as a matter of convenience rather than as a definable phylogenetic group. There are no strong reasons for considering the three genera *Kochummania*, *Leeuwenia* and *Neohoodiella* as closely related to each other, because tube elongation could easily be polyphyletic. If they are closely related, then it is curious that the species exhibit a polarisation for the major setae on the body to be either exceptionally long or unusually short.

Members of the Leeuweniini share most of the following character states: antennal segment III with one sense cone, IV with two sense cones; head wider across cheeks than across eyes, postocular setae rarely developed, vertex usually with numerous short setae; vertex and pronotum strongly sculptured; pronotal anteromarginal and posteroangular setae usually not developed; prosternal basantra usually absent; fore tarsus usually without lateral tooth; forewing always without duplicated cilia, wing surface often coarsely granulate; abdominal tergites never with more than two pairs of wing retaining setae; tube longer than head, lateral margins with prominent setae, anal setae short.

Neohoodiella Bournier

Neohoodiella Bournier (1997). Type species *N. grandisetis* Bournier, by monotypy.

Erected for a single species from New Caledonia, a second species was described subsequently from rainforests in eastern Australia. *Neohoodiella jennibeardae* Mound and Williams (2003) has the tube almost four times as long as the head, and the head bears a remarkable bifurcate tubercle on its anterior margin (Fig. 19). These two species resemble the only known species of *Kochummania* in having the mesopraesternum eroded medially, thus producing two lateral triangles, and all three species have the maxillary stylets deeply retracted and close together in the head, with the mouth cone long and pointed. In contrast, in *Leeuwenia* species the mesopraesternum is entire, and the mouthparts less elongate. *Neohoodiella grandisetis* has a pair of sigmoid wing-retaining setae on the eighth tergite, and the spiracles on this tergite are in the usual lateral position, whereas *N. jennibeardae* has no sigmoid setae on the eighth tergite, and the spiracles are dorsal in females (not males) because the ventrolateral sclerites are expanded.

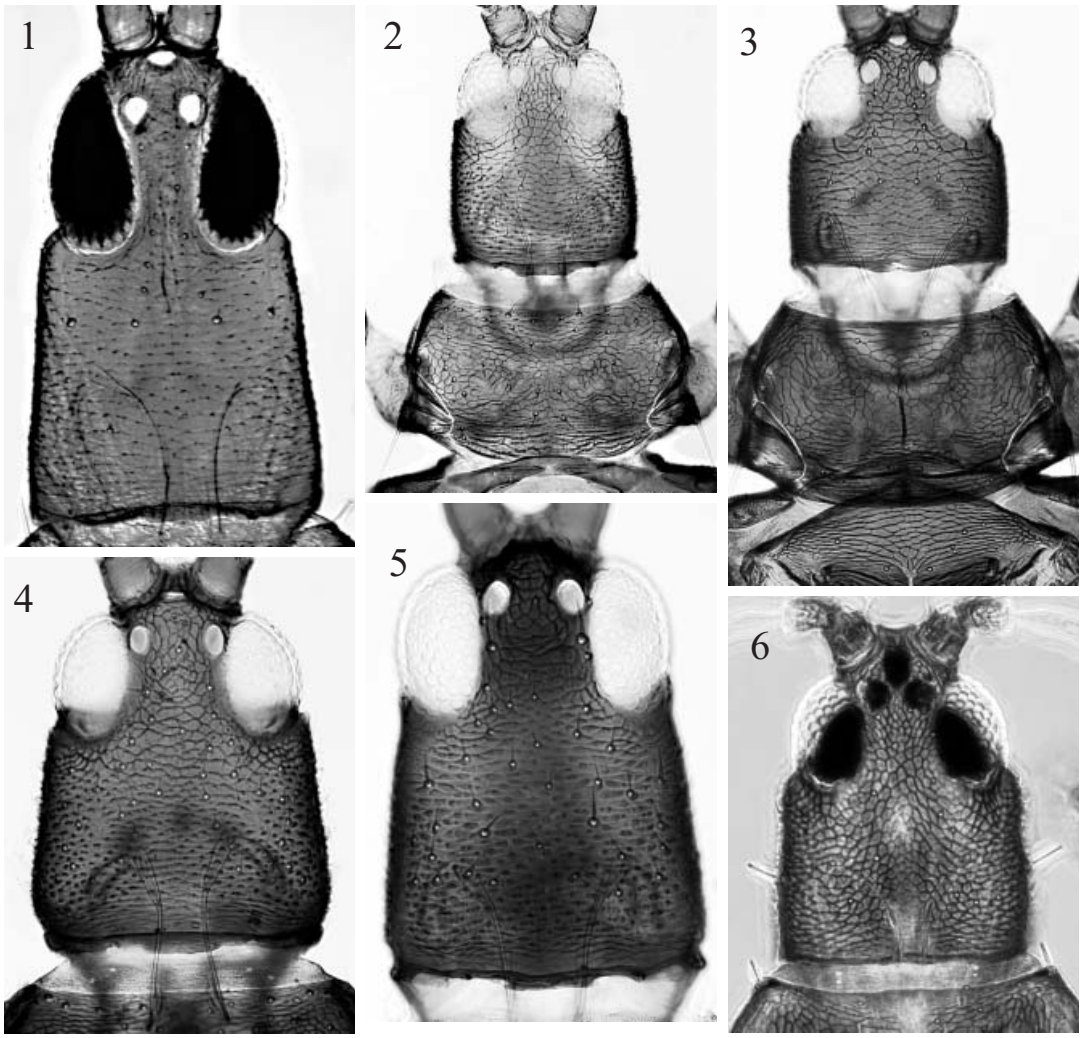
Populations of *N. jennibeardae* have been found on the leaves of two unrelated plant species, the monocotyledonous vine *Rhipogonum elseyanum* (Smilacaceae) and the dicotyledonous tree *Ficus coronata* (Moraceae). However, the leaves of the vine are not smooth as in other members of its genus, but rough and similar to those of the *Ficus*, the common sandpaper fig tree. These thrips lives freely on the under surface of these leaves, usually hiding under setae along the leaf veins without causing visible damage, in contrast to the leaf galling species of *Leeuwenia* and *Kochummania*.

Leeuwenia Karny

Leeuwenia Karny (1912). Type species *L. gladiatrix* Karny, by monotypy.
Hoodiella Karny (1923). Type species *Leeuwenia convergens* Hood, by monotypy. **Syn. n.**
Hystricothripoides Fulmek (1924). Type-species *H. karnyi* Fulmek, by monotypy. **Syn. n.**
Takahashia Ananthakrishnan (1970). Type species *Leeuwenia pugnatrix* Priesner, by monotypy (junior homonym of *Takahashia* Cockerell 1896). **Syn. n.**
Varshneyia Ananthakrishnan (1973); replacement name for *Takahashia* Ananthakrishnan.
Mametiella Priesner (1949). Type species *M. ardisiae* Priesner, by monotypy. **Syn. n.**

The type species of this genus is distinctive, with the tube long (4 times as long as the head, 16 times as long as its basal width), slightly swollen medially and heavily setose (Fig. 13), and the head has the cheeks swollen behind the eyes but without postocular setae. *Hoodiella* was erected for an Australian species with the head longer and less expanded behind the eyes (Fig. 1), and with the tube more slender with fewer and more prostrate setae. *Hystricothripoides* was erected for a species that is similar in appearance to *L. gladiatrix* but has well-developed postocular setae, as does *L. karnyiana* (Fig. 6). *Takahashia* was erected for a species with the head essentially similar to that of *Hoodiella* but a little less constricted behind the eyes, and the tube with more erect marginal setae. Finally, *Mametiella* was erected for a species with the tube approximately seven times as long as its basal width but rather sparsely setose, much as in the new Australian species *L. diospyri,* described below. The pattern of variation between the 27 named species in Table 1, also between several undescribed species from New Caledonia, New Guinea and parts of south-east Asia, is such that it has not proved possible to distinguish any of these genera from *Leeuwenia*. The constriction of the head behind the eyes, also the production of a tooth on the cheeks just behind the eyes, can be affected by the slide-mounting method and thus the angle at which the head is viewed. The marginal setae on the tube are prominent and erect only in some of those species in which the tube is exceptionally long; these setae are not prominent in species with the tube shorter.

Ananthakrishnan (1970) provided an illustrated key to 13 of the 27 species now listed in *Leeuwenia*. However, that key involves several problems. Couplets 4–7 appear to be incor-



Figs 1–6. Heads of *Leeuwenia* spp. (**1**) *L. convergens*; (**2**) *L. diospyri*; (**3**) *L. polyosmae*; (**4**) *L. scolopiae*; (**5**) *L. tetrastigmae*; (**6**) *L. karnyiana*.

rectly numbered, leading to uncertainties in interpretations of character states, and some of the character states in the key are non-discriminatory. Moreover, the statement that the tube of *L. eugeniae* is '23 times its greatest width' is incorrect, as is evident from the illustration provided. The tube of this species varies in length between 14 and 15 times its maximum width, depending on the body size of individuals. Unfortunately, a key to Indian *Leeuwenia* species by Varatharajan and Sen (2000) repeats the errors in that of Ananthakrishnan, although an earlier key by Ananthakrishnan (1964), to three species of *Leeuwenia* from India, states the correct figure of 14–15 for the tube of *L. eugeniae*, and attributes the figure of 23 to another species, *L. maculans*. Examination of the type specimen of *L. maculans* at the Senckenberg Museum, Frankfurt, confirmed that the correct figure for this species should be 13, as is indicated in the original description.

The significance of some of the described species in this genus requires substantiation. Most of them were described on 'silhouette characters' with no mention of the structure of the thoracic sclerites. At least nine of the 27 species are based on single individuals, thus there is no allowance for variation in body size, and the unique holotype of *L. indica* has apparently been lost. The host plant for nine of the species is given as *Eugenia* (Myrtaceae), and two of these, *L. coriacea* and *L. eugeniae*, are based on individuals of differing sizes that possibly represent the same species. Moreover, *L. vorax* is very similar, whereas *L. caelatrix* has a much broader head and the tube broad medially. The tube is also broad medially in *L. aculeatrix* and *L. gladiatrix*, but in these the postocular setae are developed on the head, as they are also in *L. karnyi* and *L. karnyiana* (Fig. 6). The last of this series of nine species recorded from *Eugenia*, *L. seriatrix*, is less robust in structure with the head more similar to that of *L. pasanii*. Thus, although the identity of some of these nine species might be questioned, there is no doubt that several distinct members of the genus are associated in Asia with the single plant genus *Eugenia*.

The Japanese species, *L. pasanii*, has the tube 10 times as long as its basal width, scarcely three times as long as the head in females, and even shorter in males, and although the pos-

Table 1. Checklist of *Leeuwenia* species

Species	Date: page	Original genus	Locality	Host plant
aculeatrix Karny	1923: 370		Vietnam	*Eugenia* – Myrtaceae
ananthakrishnani Varatharajan & Sen	2000: 169		India	
angulata Bianchi	1952: 388		New Caledonia	
arbastoae Reyes	1994: 429		Philippines	
ardisiae Priesner	1949: 113	*Mametiella*	Mauritius	*Ardisia* – Myrsinaceae
caelatrix Karny	1923: 368		India	*Eugenia* – Myrtaceae
convergens Hood	1918: 149		Australia	
coriacea Bagnall	1912: 216	*Panurothrips*	India	*Eugenia* – Myrtaceae
crocodilus Karny	1922: 25	*Hoodiella*	Sumatra	
diospyrae sp. n.			Queensland	*Diospyros* – Ebenaceae
eugeniae Bagnall	1924: 640		India	*Eugenia* – Myrtaceae
fimbriatrix Priesner	1929: 447		Philippines	
flavicornata Zhang *et al*.	1993: 12		Yunan	
gladiatrix Karny	1912: 161		Java	*Eugenia* – Myrtaceae
indica Bagnall	1914: 377		Burma	
karnyi Fulmek	1924: 9	*Hystricothripoides*	Sumatra	*Eugenia* – Myrtaceae
karnyiana Priesner	1929: 448		India	*Eugenia* – Myrtaceae
karnyi Ramakrishna	1925: 791		India	
ramakrishnae Ananthakrishnan	1970: 51		India	
maculans Priesner & Seshadri	1953: 406		India	*Elettaria* – Zingiberaceae
pasanii Mukaigawa	1912: 481	*Cryptothrips*	Japan	*Castanopsis* – Fagaceae
polyosmae sp. n.			New South Wales	*Polyosma* – Grossulariaceae
pugnatrix Priesner	1935: 373		Taiwan	
scolopiae sp. n.			Queensland	*Scolopia* – Flacourtiaceae
seriatrix Karny	1921: 278		Java	*Eugenia* – Myrtaceae
spinosus Moulton	1944: 299		Fiji	
fijiensis Moulton	1944: 299		Fiji	
taiwanensis Takahashi	1936: 451		Taiwan	
tetrastigmae sp. n.			New South Wales	Tetrastigma – Vitaceae
vorax Ananthakrishnan	1970: 53		India	*Eugenia* – Myrtaceae

tocular setae are well developed in females they are commonly absent in males. In contrast, two species, *L. arbastoae* from the Philippines and *L. crocodilus* from Sumatra, have the head exceptionally long with long postocular setae.

No host plant associations are recorded for 11 of the described species, and nine species are recorded from *Eugenia*. The remaining seven species are recorded as breeding on species of plants in seven unrelated genera: *Ardisia* (Myrsinaceae), *Castanopsis* (Fagaceae), *Diospyros* (Ebenaceae), *Elatteria* (Zingiberaceae), *Polyosma* (Grossulariaceae), *Scolopia* (Flacourtiaceae), and *Tetrastigma* (Vitaceae). Three of the four Australian species described here have been found forming colonies on the under surface of leaves, causing the attacked leaf to form a small pouch within which the colony shelters. The upper surface of such a leaf usually bears distinctive circular brown markings, presumably resulting from feeding damage caused by the thrips. The new species described from *Polyosma* was found within young leaves that were folded longitudinally, but which bore many translucent pustules on the external (lower) surface. The host plant of *L. convergens* is not known.

Key to Australian species of *Leeuwenia*

1 Fore tarsus with prominent lateral tooth in female; tube 4.0 times as long as basal width, 1.5 times as long as head in female……*polyosmae* sp. n.

– Fore tarsus without a prominent lateral tooth, sometimes with a small tooth-like swelling on inner ventrolateral margin; tube at least 6.0 times as long as basal width, usually at least 2.0 times as long as head…. 2

2 Antennal segment III at least 3.5 times as long as maximum width; head at least 1.6 times as long as width across compound eyes; pelta without sculpture close to posterior margin…… 3

– Antennal segment III less than 3.0 times as long as maximum width; head less than 1.5 times as long as width across eyes; pelta with reticulation extending to posterior margin at least medially …… 4

3 All femora and tibiae clear yellow; pronotal epimeral setae 1.0 times as long as dorsal width of a compound eye; pronotal anteroangulars setae acute, approximately 0.5 times as long as width of antennal segment I …… *tetrastigmae* sp. n.

– Mid and hind femora as brown as body, mid and hind tibiae brown at base but yellow in distal two thirds; pronotal epimerals setae 1.2 times as long as dorsal width of a compound eye; pronotal anteroangulars setae weakly capitate, length equals width of antennal segment I ……*convergens* Hood

4 Pronotal epimeral setae capitate, slightly longer than dorsal width of compound eye; prosternal basantra not developed; metanotum with 2 major setae but no minor setae; tergites III-VIII with posteroangular setae

capitate; tube 6.0–6.5 times as long as basal width, 1.5 times as long as head in females……*diospyri* sp. n.

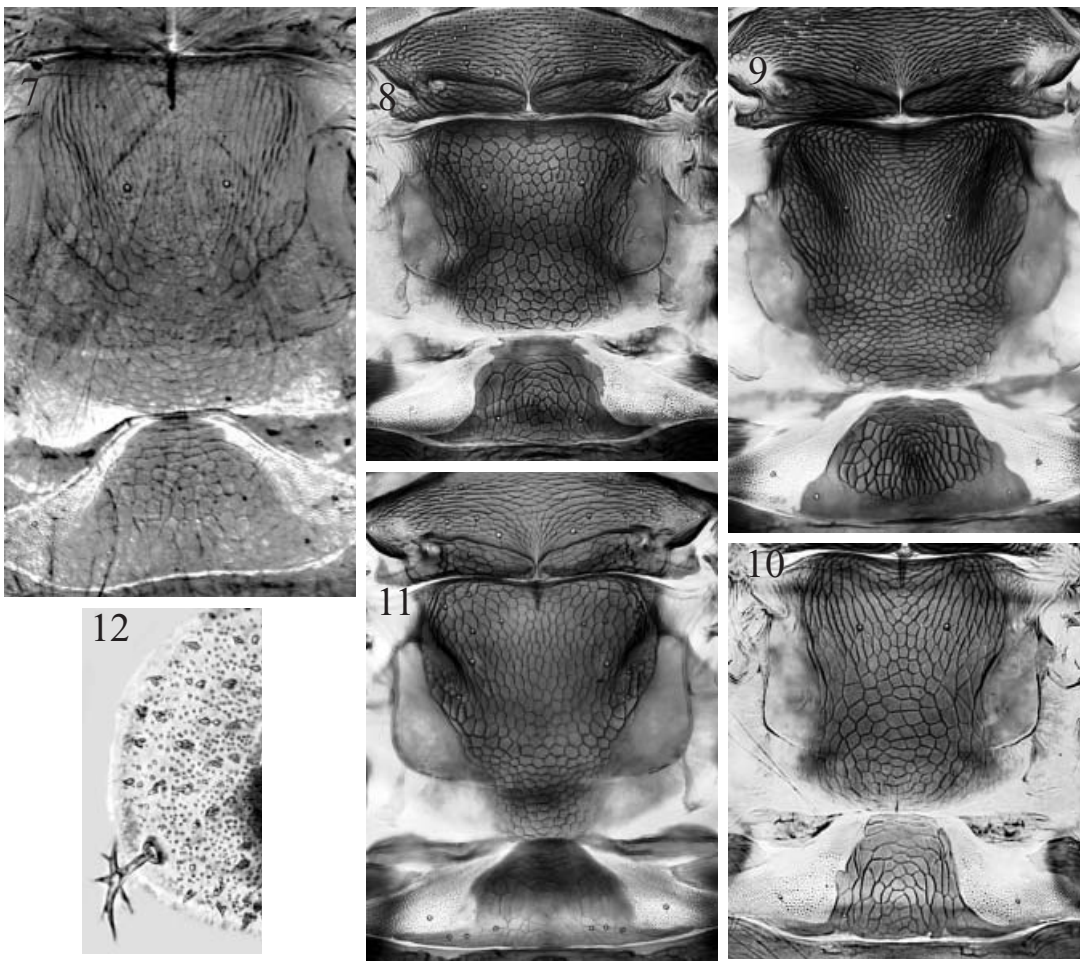
– Pronotal epimeral setae bluntly pointed, scarcely half dorsal width of compound eye; prosternal basantra well developed; metanotum with 2 major setae, also 6–8 minor discal setae anterolaterally and 2 pairs posterolateral to major setae; tergites III-VIII with posteroangular setae stout but acute; tube approximately 9.0 times as long as basal width, 3.0 times as long as head in females…… *scolopiae* sp. n.

Leeuwenia convergens Hood

Material studied. ***Queensland.*** Paratype female, Nelson [Gordonvale], swept, 1913, in U.S. National Museum, Washington.

Description. ***Female. Colour.*** Antennal segments III-VII yellow, VIII faintly shaded; fore femora yellowish at apex, mid and hind femora brown; fore tibiae yellow, mid and hind tibiae yellow in distal two-thirds; forewing pale. ***Structure.*** Head elongate (Fig. 1), 2.0 times as long as width across eyes, constricted behind eyes, vertex with 4 setae emerging from large pores in transverse row, also 2 longitudinal rows of smaller setae between eyes, cheeks almost parallel, without tubercles. Antennal segment III approximately 5 times as long as apical width, sense cones long. Pronotum weakly reticulate, anteroangular setae approximately as long as width of antennal segment I, midlateral setae approximately 0.5 as long as aa setae, epimeral setae stout and 1.2 times as long as dorsal width of a compound eye; metanotum with 2 major but no minor setae, with short longitudinal lines anteromedially but reticulate on posterior half. Abdomen with pelta similar to *L. tetrastigmae* but with sculpture extended a little more toward posterior margin; tergites III-VIII with posteroangular setae blunt to capitate; posterior pair of wing retaining setae on tergites not flattened; S1 and S2 on tergite IX small, approximately 0.5 times width of tube base and equal to pronotal aa setae; tube at least 13 times as long as basal width.

Comments. The transverse row of four setae on the head of this species has not been observed in any other described member of this genus (Fig. 1), but it remains known only from two females collected near Cairns without host-plant data.

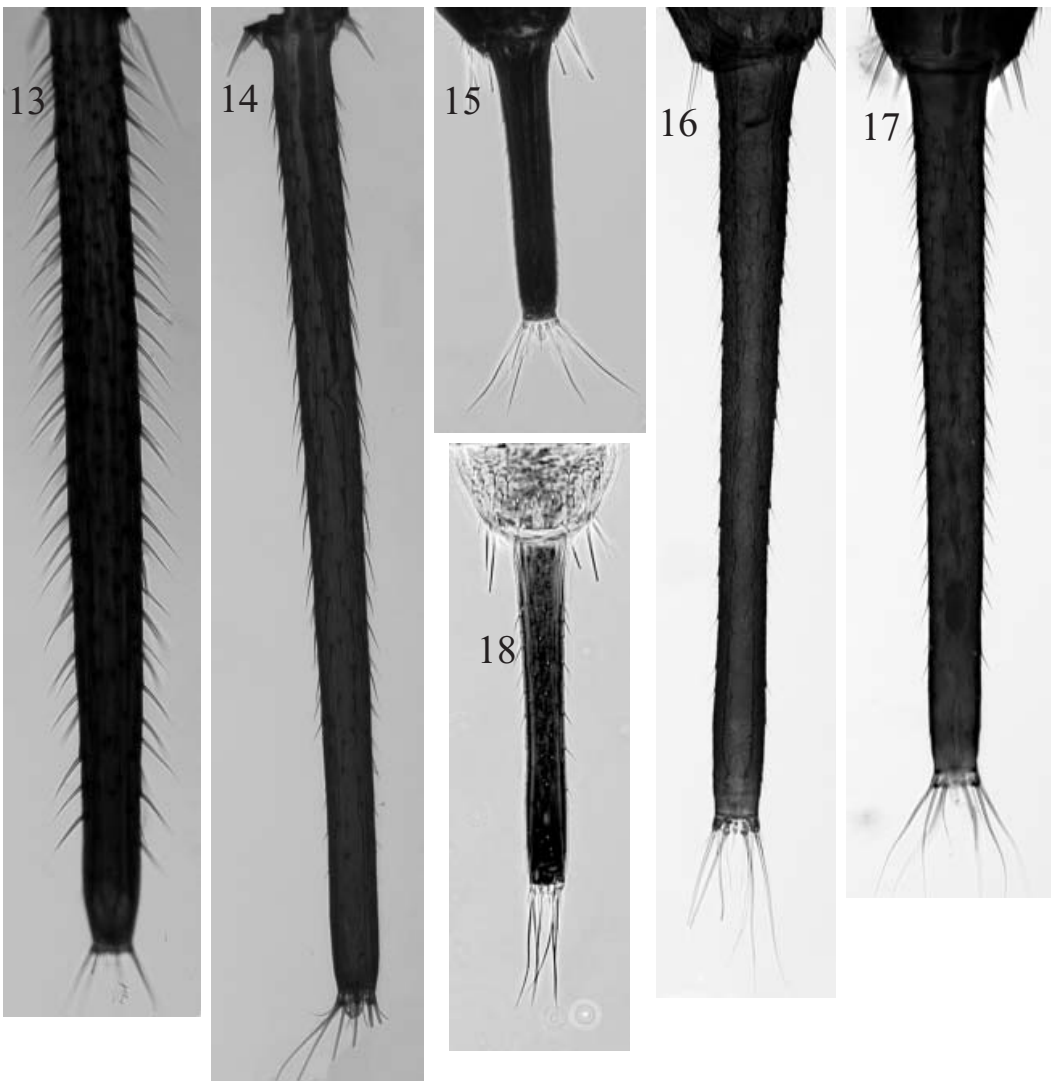


Figs 7–12. *Leeuwenia* spp. (**7–11**) metanotum and pelta: (**7**) *L. convergens*; (**8**) *L. diospyri*; (**9**) *L. tetrastigmae*; (**10**) *L. polyosmae*; (**11**) *L. scolopiae*; (**12**) *L. scolopiae* larva II, margin of third tergite.

Leeuwenia diospyri sp. n.

Types. ***New South Wales.*** Holotype female, Lorien, 3 km north of Lansdowne near Taree, from curled leaf gall on *Diospyros pentamera* (Ebenaceae), 29.vi.2002, Geoff. Williams. Paratypes: 7 females, 6 males, in colony with the holotype.

Description. ***Female. Colour.*** Body largely brown, anterior margin of head paler, abdominal segments VIII-IX also base of tube commonly yellowish; all tarsi yellow, fore tibiae, mid and hind tibiae dark brown with apical 0.2–0.3 yellow, mid and hind femora dark brown; forewing brownish grey with surface strongly granulate; antennal segments I–II brown, III–VIII yellow. ***Structure.*** Head approximately 1.4–1.5 times as long as width across compound eyes, reticulate between eyes, tuberculate-reticulate on posterior half (Fig. 2); 2 irregular longitudinal rows of fine setae extending back from ocelli, scattered similar setae on posterior half of head; maxillary stylets not deeply retracted and approximately one-fifth of head width apart, mouth cone broadly rounded. Antennal segment III less than 3 times as long as apical width, sense cones not elongate, 1 on III, 2 on IV; segment VIII short with base broad. Pronotum with epimeral setae capitate, slightly longer than dorsal width of compound eye, midlateral and anteroangular setae similar; pronotal reticulations with internal markings, epimeral sutures complete. Mesonotum medially with 2 pairs of prominent setae; metanotum with 2 major setae but no minor setae (Fig. 8), reticulation longitudinal medially but equiangular on posterior half. Prosternal basantra not developed, ferna transverse, mesopraesternum transverse and complete medially although slightly eroded. Forewing with two capitate subbasal setae, as long as width of antennal segment II; surface of wing coarsely granulate. Abdomen with pelta sculptured close to posterior margin, posterior angles prolonged laterally (Fig. 8); tergite II sculpture not divided into anterior and posterior areas by antecostal ridge, wing-retaining setae on II–VII slender and sigmoid, III–VIII with posteroan-



Figs 13–18. Tubes of *Leeuwenia* spp. (**13**) *L. gladiatrix*; (**14**) *L. karnyiana*; (**15**) *L. polyosmae*; (**16**) *L. scolopiae*; (**17**) *L. tetrastigmae*; (**18**) *L. diospyri*.

gular setae capitate, also tergite IX setae S1 and S2; tube approximately 6.5 times as long as basal width, margins with few setae (Fig. 18); anal setae short.

Male. Similar to female but smaller.

Immature instars. Larvae and pupae yellow with median longitudinal bright-red markings; larva II with major setae on head and pronotum short and broadly capitate with long fringed apices, pronotal surface with minute tubercles.

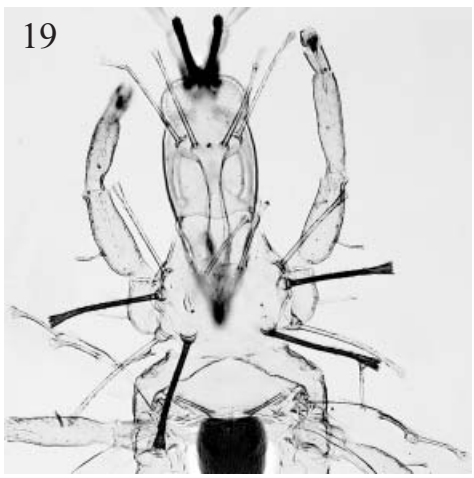
Measurements (holotype female in µm)**.** Body length 2850. Head: length 300; width across cheeks 240. Pronotum: length 175; median width 320; major setae: aa 45; ml 55; pa 80. Forewing length 970; subbasal setae 35, 45, 55. Tergite IX setae S1 75; S2 90. Tube: length 450; basal width 70. Antennal segments III-VIII length 80, 75, 72, 68, 55, 35.

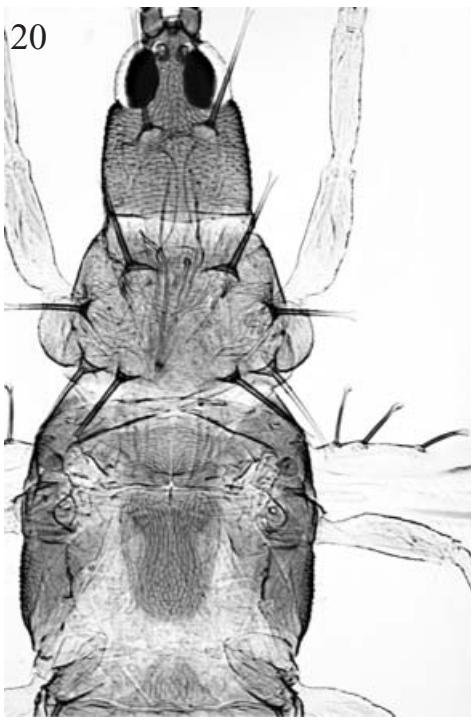
Comments. Although a member of *Leeuwenia* in its general appearance, this species has the tube shorter than any other described species, apart from *L. polyosmae* sp. n. described below. The antennal segments are also short, as are the postocular setae, but the pronotum bears three pairs of elongate major setae. An undescribed species that has been studied from Vanuatu, without host data, is similar in sculpture and with granulate forewings but with no elongate pronotal setae. A further similar undescribed species has been seen from Wau, Papua New Guinea, but with the tube more than 3.0 times as long as the head. Geoff Williams, who collected this new species in rainforest near Taree in eastern Australia, indicated that the specimen of *Diospyros pentamera* on which the thrips colony was found was the only specimen of that tree species recorded in the locality.

Leeuwenia polyosmae sp. n.

Types. ***Queensland.*** Holotype female, Mt Glorious near Brisbane, from leaf gall on *Polyosma cunninghamii* (Grossulariaceae), 11.vii.2002, LAM 4173. Paratype: 1 female, with the holotype in colony of larvae.

Description. ***Female. Colour.*** Body largely brown; all tarsi yellow, also distal half of fore tibiae and extreme apices of mid and hind tibiae; forewing brownish grey with surface strongly granulate; antennal segments I–II brown, III–VIII yellow. ***Structure.*** Head approximately 1.4–1.5 times as long as width across compound eyes, reticulate between eyes, tuberculate-reticulate on posterior half (Fig. 3); 2 irregular longitudinal rows of fine setae extending back from ocelli, scattered similar setae on posterior half of head; maxillary stylets wide apart and low in head, mouth cone broadly rounded. Antennal segment III approximately 2 times as long as apical width, sense cones not elongate, 1 on III, 2 on IV; segment VIII short with base broad. Pronotum with epimeral setae weakly capitate, approximately as long as dorsal width of compound eye; anteroangular setae no larger than discal setae but midlaterals slightly larger; pronotal reticulations without internal markings, epimeral sutures complete. Mesonotum medially with 1 pair of large and 1 pair of minor setae; metanotum with 2 major setae but no minor setae, reticulation mainly equiangular medially (Fig. 10). Prosternal basantra not developed, ferna transverse, mesopraesternum transverse and complete medially. Fore tarsus with recurved tooth on inner margin, length less than half of tarsal width. Forewing with two acute sub-





Figs 19,20. Leeuweniini head and thorax:
(**19**) *Neohoodiella jennibeardae*;
(**20**) *Kochummania excelsa.*

basal setae, as long as width of antennal segment II; surface of wing coarsely granulate. Abdomen with pelta sculptured close to posterior margin, posterior angles prolonged laterally (Fig. 10); tergite II sculpture not divided into anterior and posterior areas by antecostal ridge, wing-retaining setae on II-VII slender and sigmoid, III–VIII with posteroangular setae weakly capitate, also tergite IX setae S1 and S2; tube approximately 5.0 times as long as basal width, margins with few setae (Fig. 15); anal setae short.

Immature instars. Larvae and pupae yellow with short median longitudinal bright-red marking; major setae long and slender with apices capitate on head and pronotum of instar II, but finely acute on pupae.

Measurements (holotype female in µm)**.** Body length 2700. Head: length 280; width across cheeks 235. Pronotum: length 200; median width 320; major setae: aa 32; ml 35; pa 50. Forewing length 1050; subbasal setae 20, 25, 30. Tergite IX setae S1 75; S2 95. Tube: length 400; basal width 80. Antennal segments III-VIII length 70, 55, 55, 55, 40, 35.

Comments. The only other described species of *Leeuwenia* with a distinct fore tarsal tooth is from Fiji (Table 1), but that has the tube much longer, 7–12 times as long as its basal width. *Leeuwenia polyosmae* is otherwise similar to *L. diospyri* described above, but with the tube even shorter and bearing few setae. Two galls were found, each with one female and a few larvae. These galls were quite unlike any other known to be produced by members of *Leeuwenia* or any other thrips. Each was formed from a longitudinally folded leaf of which the external surface was covered with many translucent pustules up to 2 mm in diameter.

Leeuwenia scolopiae sp. n.

Types. ***Queensland.*** Holotype female, 80 km south of Brisbane, O'Reilly's, Lamington National Park, from curled leaf gall on *Scolopia braunii* (Flacourtiaceae), 10.vii.2002, LAM 4171. Paratypes: 8 females, 5 males, taken with holotype and immatures; 4 females and immatures from second leaf at same locality (LAM 4178); 32 females, 12 males, 50 km south of Brisbane, Mt Tamborine, with larvae from curled leaves of *Scolopia braunii*, 21.iii.1968, LAM 580.

Description. ***Female. Colour.*** Body largely brown; all tarsi yellow, also fore tibiae; fore femora yellow in distal half; mid and hind femora brown, mid and hind tibiae diffuse brownish yellow; forewing deeply shaded with a paler area near apex, surface coarsely granulate; antennal segments I brown, II yellow distally, III–VII yellow, VIII light brown. ***Structure.*** Head approximately 1.4 times as long as width across compound eyes, broad near base; reticulate between eyes, irregularly tuberculate on posterior half (Fig. 4); 2 irregular longitudinal rows of fine setae extending back from ocelli, many similar setae scattered posterolaterally on head; mouth cone broadly rounded. Antennal segment III almost 3 times as long as apical width, sense cones not elongate, 1 on III, 2 on IV; segment VIII short with base broad. Pronotum with epimeral setae stout but bluntly acute, scarcely half dorsal width of compound eye, remaining major setae not developed; pronotal reticulations with faint internal markings, epimeral sutures usually incomplete. Metanotum with 2 major setae, also 6–8 minor discal setae anterolaterally and 2 pairs posterolateral to major setae (Fig. 11); reticulation slightly elongate medially but equiangular on posterior half. Prosternal basantra well-developed and bearing approximately 5 setae, ferna transverse, mesopraesternum transverse and complete medially. Forewing subbasal setae acute, very short, 0.5 of width of antennal segment II; surface very coarsely granulate. Abdomen with pelta sculptured close to posterior margin, posterior angles prolonged laterally (Fig. 11); tergite II sculpture divided into anterior and posterior areas by strong W-shaped antecostal ridge, wing-retaining setae on II–VII slender and sigmoid, III-VIII with posteroangular setae stout but sharply pointed, also tergite IX setae S1 and S2; tube approximately 9 times as long as basal width, margins with many setae (Fig. 16); anal setae short.

Male. Similar to female but smaller.

Immatures. Larvae and pupae with extensive red pigment; larvae with legs, head and terminal abdominal segments brown; thorax and anterior abdominal segments of larva II with surface coarsely spiculate (Fig. 12), major setae short with apex produced into radiating spines.

Measurements (holotype female in µm)**.** Body length 4100. Head: length 380; maximum width across cheeks 310; Pronotum: length 270; median width 450; major setae: aa 32; ml 32; pa 50. Forewing length 1500; subbasal setae 30, 30, 32. Tergite IX setae S1 50; S2 90. Tube: length 1100; basal width 120. Antennal segments III-VIII length 105, 95, 95, 90, 70, 40.

Comments. The head shape in this species is similar to that of *L. convergens* but rather shorter. It appears to be unusual amongst species in this genus in having well-developed basantral sclerites on the prosternum. The metanotum is also unusual in bearing two setae posterolateral to the median pair of setae. Colonies of this species are striking due to the bright red colour of the larvae, and the red and brown markings induced on the distorted leaf. The aposematic colour and the remarkable branched and thorn-like setae of the larvae (Fig. 12) may be involved in inhibiting bird predation.

Leeuwenia tetrastigmae sp. n.

Types. ***Queensland.*** Holotype female, Brisbane, Mt Nebo, from distorted leaf of *Tetrastigma nitens* (Vitaceae), 11.vii.2002, LAM 4174. Paratypes: 2 females, 1 male, taken with holotype; 1 female, Many Peaks, Bulburin State Forest, swept, 5.iv.1972. ***New South Wales.*** 1 female, 3 km north of Lansdowne, Lorien, swept, 29.xi.2001.

Description. ***Female. Colour.*** Body brown; all femora, tibiae and tarsi yellow; forewing pale, surface weakly granulate near base; antennal segment I brown, II yellow distally, III–VI yellow, VII–VIII with light brown markings. ***Structure.*** Head approximately 1.6 times as long as width across compound eyes, slightly broader near base; irregularly reticulate between eyes, weakly tuberculate on posterior half (Fig. 5); 2 irregular longitudinal rows of fine setae extending back from ocelli, many similar setae scattered posterolaterally on head; mouth cone broadly rounded. Antennal segment III approximately

3.5 times as long as apical width, sense cones not elongate, 1 on III, 2 on IV; segment VIII short with base slightly narrowed. Pronotum with epimeral setae stout with apex blunt to capitate, as long as dorsal width of a compound eye, remaining major setae not developed; pronotal reticulations without internal markings, epimeral sutures incomplete. Metanotum with 2 major setae, also 0–5 minor discal setae anterolaterally (Fig. 9); reticulation mainly equiangular medially but longitudinal laterally. Prosternal basantra not developed, ferna transverse, mesopraesternum transverse and complete medially. Forewing subbasal setae acute, very short, 0.5 of width of antennal segment II; surface coarsely granulate around subbasal setae. Abdomen with pelta D-shaped, without lateral wings, almost without sculpture on a transverse band close to posterior margin (Fig. 9); tergite II sculpture weakly divided into anterior and posterior areas by W-shaped antecostal ridge, wing-retaining setae on II–VII slender and sigmoid (almost straight on VII), III–VIII with posteroangular setae blunt to capitate also tergite IX setae S1 and S2; tube approximately 9 times as long as basal width in female, but 7.5 in male, margins with many setae (Fig. 17); anal setae short.

Male. Similar to female but smaller.

Immatures. Pupae with much red pigment in posterior half of abdomen, anterior half of body yellow.

Measurements (holotype female in μm)**.** Body length 4550. Head: length 400; maximum width 280. Pronotum: length 230; median width 450; major setae: aa 35; ml 32; pa 70. Forewing length 1600; subbasal setae 30, 30, 32. Tergite IX setae S1 75; S2 80. Tube: length 1000; basal width 120. Antennal segments III–VIII length 150, 115, 115, 95, 70, 40.

Comments. Although this species has slender antennae similar to those of *L. convergens,* the legs are uniformly yellow, and the head has the setae on the vertex more generally distributed without a transverse row of four dominant setae. The host plant is an invasive vine that is widespread in the eastern rainforests of Australia. One galled leaf of this plant taken at the type locality contained many pupae of *L. tetrastigmae* together with adults and larvae of an undescribed species of *Teuchothrips* Hood.

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