



***Liothrips* species (Thysanoptera, Phlaeothripinae) from leaf-galls on *Piper* species in Southeast Asia and Australia**

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Abstract

Variation in colour and structure is re-considered amongst 19 species of *Liothrips* collected from leaf-galls on *Piper* vines in Asia. *Gynaikothrips crassipes* Karny, *Liothrips aemulans* Priesner, and *Liothrips baccati* Priesner are considered **new synonyms** of *Liothrips chavicae* (Zimmermann). *Gynaikothrips karnyi* Bagnall is considered a **new synonym** of *Liothrips mirabilis* (Schmutz). *Gynaikothrips kuwanai* Moulton and *Liothrips reynvaanae* Priesner are considered **new synonyms** of *Liothrips pallipes* (Karny). Doubts are expressed about the significance of several further described species, and an identification key is provided to nine putative species. Despite the number of *Liothrips* species described from *Piper*, there is little evidence of thrips radiation on this plant genus, and the two most common species of the genus on *Piper* are probably not closely related.

Key words: inter- and intra-population variation, new synonyms, host specificity

Introduction

The genus *Liothrips*, with almost 280 species worldwide currently listed (ThripsWiki 2020), is the most species-rich genus in the Order Thysanoptera. Species of this genus are found widely around the world, but with most species in tropical and subtropical countries. From Europe seven species of *Liothrips* are listed (Vierbergen 2017), and 30 from North America (Stannard 1957). From India 55 species are listed (Tyagi & Kumar 2016), although less than 20 from Brazil (Monteiro & Lima 2011) and less than 10 from the whole of Africa (ThripsWiki 2020). The genus appears to be particularly diverse in tropical Asia, and Priesner (1968) recognized in an unillustrated key about 85 *Liothrips* species from the Oriental Region. Of these species, 54 were newly described, mainly from Java and Sumatra. Unfortunately, over the past 50 years there has been no further study of these species, although Okajima (2006) provided a key to 24 *Liothrips* species from Japan, of which 12 were newly described. The objective of the present study is to consider, and to provide an identification tool to, the various species of *Liothrips* that have been described from species of *Piper* vines [Piperaceae], as listed by Ananthakrishnan and Raman (1989). Commercial crops of these vines are commonly infested by leaf-rolling species of *Liothrips*, and there are recurrent requests to identify such pest thrips. Because of this limited objective, species of *Liothrips* described from other plant genera are not considered, nor those described without host associations. For example, in describing *L. ater*, *L. cecidii* and *L. flavescens*, the authors (Ananthakrishnan & Jagadish 1969) provided comparisons only between their three new species, and they provided no host data nor mentioned any previously described species with similarly coloured yellow hind tibiae. Judging from the descriptions, *L. cecidii* needs to be compared with *mirabilis*, and the other two with *L. pallipes*, both of which are considered below as gall-inducing species on *Piper* vines.

Material and methods

The observations and taxonomic conclusions recorded here are based on a re-examination of the original Karny and Priesner slides at the Senckenberg Museum, Frankfurt (SMF), together with recent samples from *Piper* vines

in Australia and Southeast Asia. The original slides (Fig. 1) were studied at Frankfurt using a Wild microscope with Bright Field and Phase Contrast illumination, and slides from the recent samples were taken to Frankfurt for direct comparisons with the type specimens. At Canberra, the recent slides were studied under Bright Field and Differential Interference Contrast illumination using a Leica DM2500 microscope. Images (Figs 3–11) were produced with this microscope using Automontage software and processed through Photoshop. An indication of the specimens studied is given under each species.

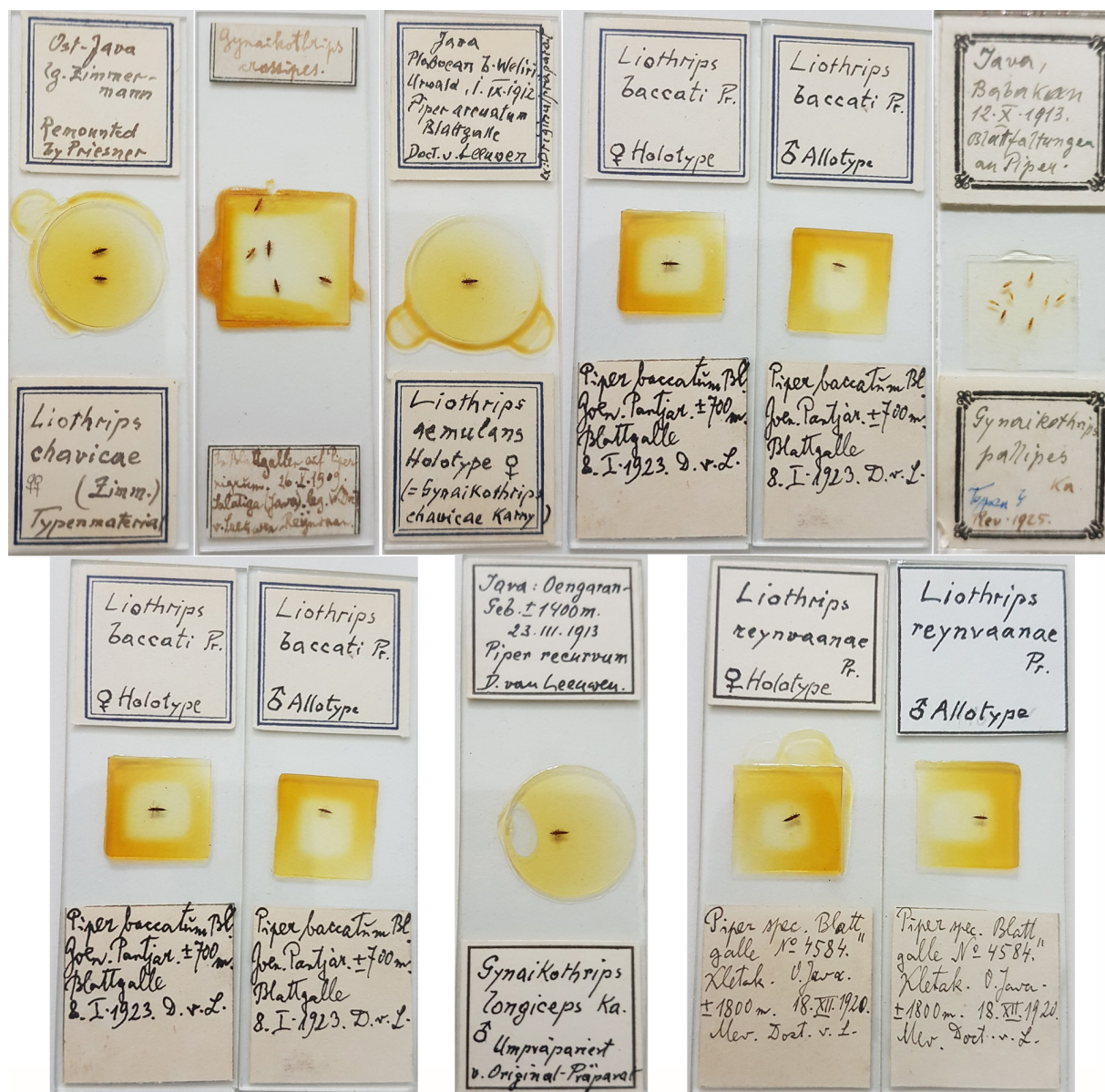


FIGURE 1. Labels of *Liothrips* type specimen slides (Senckenberg Museum)

Original slide material

The studies on *Liothrips* by Priesner (1968) were based on slide-mounted specimens that had been prepared by Karny in the early 1920's when he was employed in Java. Karny was interested in Orthoptera, and he considered that the mouth cone of thrips would provide the most interesting character states for species discrimination. He therefore slide-mounted almost all the specimens of *Liothrips* ventral side uppermost. Moreover, little effort was given to spreading the appendages of specimens, their body contents were not digested and cleared to facilitate light transmission, and as a result many characters cannot be seen that are now considered important for species discrimination. Working with these specimens, Priesner (1968) distinguished species largely on the basis of colour, particularly of the fore wings, antennae and legs.

The samples studied by Priesner included few specimens of each putative taxon, and so no estimate was possible of intraspecific variation in colours, nor of setal lengths and their association with body size. Of the 54 new species in the 1968 paper, 11 were each based on single specimens, 13 were each based on two specimens, and a further 15 were based on less than five specimens. Decisions in many of the key couplets are often subjective and based on weakly defined character states. Even structural character states such as the form of setal apices are not necessarily reliable, because they are dependent on the type of microscope used and may be altered by different methods of slide-preparation. Setae, for which the apices are considered “pointed” under a Bright-field Microscope, such as that used by Priesner, can be resolved under Differential Interference Contrast (Nomarski) illumination as clearly blunt or even slightly expanded. Although the key was a remarkable effort in assessing and introducing a highly complex group of species, it is essentially archival rather than a functional identification tool. An obvious weakness is that about 25% of the included species emerge in the key at two or more couplets.

Structural and biological diversity

There have been no attempts to study intra-specific variation within Asian *Liothrips* species, although intra-specific variation has been discussed for some Neotropical species (Mound & Pereyra 2008; Mound *et al.* 2010). It appears from the 1968 key that the taxonomic decisions by Priesner involved accepting any slight difference in wing colour or setal lengths as representing a species difference. But the thrips within any single gall are known in some (but not all) species to be the progeny of a single female (Crespi *et al.* 2004) and can thus be expected to exhibit little variation. Thrips in other galls on the same tree will be slightly different genetically, and so may differ in appearance. Moreover, some galls grow faster and larger than others, and thus presumably provide a more beneficial physiological environment for a developing thrips, and this is likely to be reflected in structural and colour variation among resultant adults. To provide a suitable level of species predictability, taxonomic studies on gall thrips need to be based on a well-planned scheme of population sampling, with the objective of recording variation within and between individual populations.

Some *Liothrips* species induce leaf galls of various types, including simple leaf-rolls and emergent nail-galls, but a few species in the genus are invaders of galls induced by other thrips. For example, as indicated by Okajima (2006), *L. piperinus* invades galls on unrelated plant species that are induced by a *Liothrips* species and also those induced by a *Leeuwenia* species. Moreover, the present author has found *L. takahashii* invading galls induced by *Gynaikothrips* species on *Ficus* leaves in Australia, Taiwan and Costa Rica. However, nothing else is known of the biology of these invading species. They are probably not predators, but are likely to be phytophagous kleptoparasites, or even true inquiline that do not disrupt the colony of their galling host species.

Host associations

The species of *Liothrips* are known to feed on the leaves of higher plants, but recognizing true host-associations is difficult, and optimally needs to be based on multiple records and the presence of larvae. The monograph by Priesner (1968) provided collection data for each of the species discussed, indicating that these specimens came from 30 different plant species representing about 24 different plant families. However, Priesner did not comment on the pattern of host associations, with 16 *Liothrips* species taken only on species of *Piper*, five taken only from *Schlefflera* [Araliaceae], five from *Fagraea* [Gentianaceae], and six from *Elatostemma* [Urticaceae]. Studies on thrips of this genus in other parts of the world (Stannard 1968; Okajima 2006; Mound *et al.* 2018) indicate that many *Liothrips* species have limited, or even specific, host associations. When multiple congeneric species are found on a single plant genus a major evolutionary question arises as to whether those thrips species represent an independent clade on each of these plant genera, or if there has been multiple host-switching between plant genera during radiation within *Liothrips* genus.

The species level taxonomy of *Piper* is complex, with between 1000 and 2000 species-level names being available. Clearly there is a possibility that *Liothrips* may have diversified in association with this complex of plant species, but there is limited evidence for any specific association between particular *Liothrips* species and particular *Piper* species. For example, Priesner (1968) recorded *L. pallipes* from the following species of *Piper*: *betle*, *nigrum*,

refractum and *sarmentosum*. Moreover, he recorded *L. kuwanai* (here considered a synonym of *pallipes*) from *Piper futokadsura*, *muricatum* and *recurvum*, and Okajima (2006) recorded this thrips from *Piper kadzura*. In the absence of specifically targeted field studies, the approach adopted here is essentially pragmatic, and species have been placed as synonyms where the published discriminating character states seem equally likely to be related to body size or colour variation. Although the identification key below distinguishes nine species of *Liothrips* from leaf-galls on *Piper* vines, the available evidence supporting recognition of more than two of these is weak. Some of the nominal species in this key are likely to be no more than size and colour variants of the two common species, *chavicae* and *pallipes*.

Key to *Liothrips* species on *Piper*

1. Mid and hind tibiae yellow. 2
- Mid and hind tibiae brown with apices more or less yellow 4
2. Antennal segments VII–VIII as uniformly pale as V–VI; pronotal and postocular setae finely acute and dark; Sri Lanka *mirabilis*
- Antennal segments VII–VIII darker than V–VI. 3
3. Antennal segments VII–VIII uniformly dark; fore wing paler in basal third; but shaded medially with weak longitudinal line [mesopresternum broadly complete medially Fig. 9]; Southeast Asia to northern Australia. *pallipes*
- Antennal segment VII pale on basal half; fore wing uniformly shaded with dark median longitudinal line; southern India *tibialis*
4. Antennal segments III–VIII uniformly pale yellow; postocular and some pronotal setae with apices finely acute . . . *acuminatus*
- At least VIII shaded; postocular setae bluntly pointed to weakly capitate (Figs 2, 3). 5
5. Fore wings almost uniformly pale, or with very weak median line *retrofracti*
- Fore wings shaded or with strong median dark line. 6
6. Maxillary stylets close together medially [sense cones on antennal segments III & IV almost 0.5 as long as the segments; mesopresternum complete medially]; Taiwan, southern Japan, northern Australia *piperinus*
- Maxillary stylets about one third of head width apart (Fig. 2). 7
7. Antennal segments weakly shaded, at least VI distinctly shaded *confusus* group
- Antennal segments III–V uniformly pale, VI usually pale but sometimes very weakly shaded 8
8. Sense cones on antennal segments III–IV about 0.5 as long as their segment; head long, about 1.5 times as long as width across cheeks; Java *longiceps*
- Sense cones shorter and stouter; head less than 1.3 times as long as width across cheeks [mesopresternum reduced to two lateral triangles that are often prolonged medially Fig. 8]; Malaysia to northern Australia *chavicae*

Liothrips acuminatus Priesner

Liothrips acuminatus Priesner, 1968: 219

This species was described from one male and an unspecified number of females taken in leaf galls of an unidentified *Piper* species in west Java, Salak Mountains, 26.x.1921 (1 male, 4 female types in SMF). It is distinguished from most specimens of *Liothrips* from *Piper* by the postocular setae that were stated to be finely acute and 120 microns long. Moreover, although antennal segments VII–VIII are as pale as III–VI, the fore tibiae are slightly shaded. However, none of these character states are unique, and there is little evidence that *acuminatus* is a different species from the widespread species *chavicae*.

Liothrips chavicae (Zimmermann)

(Figs 2, 3, 6, 8, 10)

Mesothrips chavicae Zimmermann 1900: 14.

Gynaikothrips crassipes Karny, 1912: 137 **syn.n.**

Liothrips aemulans Priesner, 1968: 228 **syn.n.**

Liothrips baccati Priesner, 1968: 236 **syn.n.**

Zimmerman described this species as occurring in large numbers at Buitenzorg (= Bogor, Java) in October 1900 in rolled leaf margins of *Chavica densa* (= *Piper betle*) (5 female, 4 male syntypes in SMF). The fore wings of the type

specimens were stated by Priesner (1968) to be “hyaline, with slight yellowish hue, a longitudinal shade only very faint”. These specimens seem likely to have faded during storage in alcohol prior to being slide mounted. The syntypes of *crassipes* were collected from *Piper nigrum* in central Java, 26.v.1909, and distinguished from *chavicae* by Priesner (1968) because the fore wings are “infumated for all their length with conspicuous and broad longitudinal stripe”. Priesner further described *aemulans* from two females taken on *Piper arcuatum* in central Java, 1.ix.1912, and distinguished this species as having the fore wings “slightly infumated with faint longitudinal stripe”. He also stated “Antennae yellow on joints 3-6, joint 6 may be slightly infumated, joints 7-8 dark.” The fourth species listed above, *baccati*, was described from four females and one male, taken in Java [near Bogor] on *Piper baccatum*, 8.i.1923, and distinguished because the width of antennal segment III was “no more than 34 microns” in contrast to 36-40 microns that was claimed for related species. The fore wings were stated to be “slightly shaded, but with conspicuous dark longitudinal stripe,” and the apical half of antennal segment VI was stated to be “very slightly infumated”. The original specimens of each of these nominal species have been studied and compared with the variation found within single samples from *Piper* leaves in Australia.

This species is interpreted as having antennal segments III–V clear yellow. However, VIII is consistently light grey/brown, with VII varying from completely shaded to largely pale, and although VI is generally pale the apex is also very slightly shaded in a few specimens. There is no evidence that this colour variation represents different species as it has been observed within single populations. Similarly, within a single sample from *Piper novaehollandiae* in northern New South Wales, Australia, the form of antennal segment III varies, with the maximum width ranging from 30 to 38 microns. The fore wing is pale sub-basally and on the apical third, but the median area of the wing is variably shaded and with a darker median line, and the margins also are usually distinctly shaded. The mesopre-sternum is never complete medially (Fig. 8) but the lateral triangles sometimes extend medially as a thin line, the metanotum medially is less closely striate than in *L. pallipes* (Figs 6, 7), and the pelta is irregularly triangular with the apex variably weakly truncate (Fig. 6). The postocular, pronotal and fore wing sub-basal setae are very dark, and tergite IX setae S1 are slightly longer than the tube (Fig. 10). This species differs from *L. pallipes* in each of these character states as well as in the colour of the mid and hind tibiae, and the range of differences suggests that the two species are not closely related. Apart from the type specimens of the four nominal species, specimens of both sexes have been studied and identified as *chavicae* (in ANIC) from northern Australia (Noosa, Babinda, Redlynch, Cairns, Cape Tribulation); Malaysia (Bangi), and Timor Leste.

***Liothrips confusus* group**

Liothrips confusus Priesner, 1968: 227

Liothrips insidiosus Priesner, 1968: 230

Liothrips sarmentosi Priesner, 1968: 231

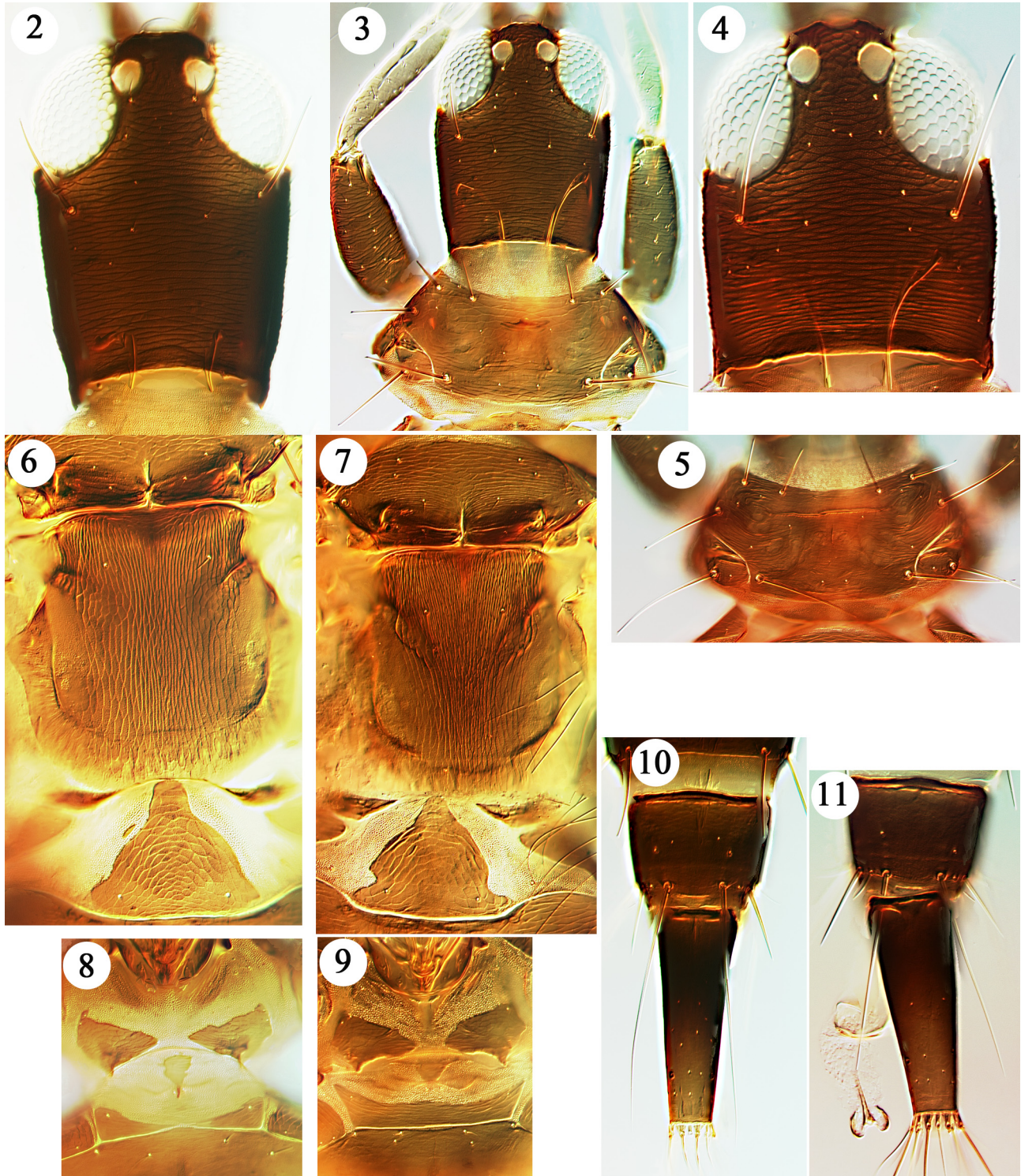
Liothrips fumicornis Priesner, 1968: 232

Liothrips exiguus Priesner, 1968: 234

Liothrips exiguus falsus Priesner, 1968: 235

These species are all weakly differentiated; see for example couplet 32 in Priesner (1968). Priesner described *confusus* from two females and two males collected from *Piper* in Java, 22.vi.1913 (in SMF). He distinguished these specimens from *chavicae*, with which they had previously been identified by Karny, primarily because antennal segments IV–VI are distinctly light brown on the apical third, but also because the tube is only 220 microns long in contrast to the more than 240 microns that he claimed for *chavicae*. In *insidiosus*, described from an unspecified number of both sexes from Java, Bogor, 13.iii.1921 (1 male, 5 females in SMF), the tube is as long as that of *chavicae*, but antennal segment IV is pale, with V–VI shaded apically and segment VI considerably longer (82 vs 66 microns). Priesner stated that *sarmentosi*, described from three females taken from *Piper* at two different sites in Java (1 male, 3 females in SMF), was smaller than *insidiosus*, but the character states given are closely similar to those of *chavicae*, with antennal segments III–V yellow, but apical half of VI as shaded as VII–VIII. Specimens collected from *Piper sarmentosi* on Timor Leste, 18.vii.2000, have been studied (in ANIC) but these are considered to represent *chavicae*. A further one male and two females (in SMF) identified by Karny as *chavicae* and collected from *Piper* in Java, 11.x.1913, were described by Priesner as *fumicornis*, based on the distinctly shaded apices of antennal segments IV–VI. Moreover, these were distinguished from *insidiosus* by the shorter head (260 vs 290

microns). Finally, *exiguus* was described from two females and five males taken from *Piper* at Penang, 28.ix.1920, and Priesner stated that this sample included the holotype of *sarmentosi*. The subspecies *falsus* was based on one female and one male from *Piper* at Sebesie, Java, 23.iv.1921. These forms were distinguished on the basis of slight difference in shading of the fore wings and distal antennal segments. In addition to the Priesner type specimens, two males and two females of the *confusus*-group have been studied from Vietnam, taken in a leaf-roll gall on *Piper longum*. However, without multiple population samples to investigate variation within and between individual galls, it is impossible to assess the significance of the indicated differences used to distinguish these six taxon names.



FIGURES 2–11. *Liothrips* species. *L. chavicae* 2–3: (2) female head, (3) male head & pronotum. *L. pallipes* 4–5: (4) head, (5) pronotum. Metanotum & pelta 6–7: (6) *L. chavicae*, (7) *L. pallipes*. Mesopresternum 8–9: (8) *L. chavicae*, (9) *L. pallipes*. Tergites IX–X 10–11: (10) *L. chavicae*, (11) *L. pallipes*.

***Liothrips longiceps* (Karny)**

Gynaikothrips longiceps Karny, 1916: 19.

Described apparently from one female taken in central Java on *Piper recurvum*, 23.iii.1913, the presumed holotype has the head unusually elongate, one and a half times as long as wide, and slender (350 x 240 microns). Moreover, the sense cones on antennal segments III and IV are unusually long.

***Liothrips mirabilis* (Schmutz)**

Gynaikothrips mirabilis Schmutz, 1913: 1041

Gynaikothrips karnyi Bagnall, 1914: 28. **syn.n.**

The original description of this species is confusing as it is stated to have been taken by Uzel on the leaves of *Pavetta hispida* [Rubiaceae] and also the rolled leaf margins of a pepper plant, with the collection data Sri Lanka, Peradenya, on 11.ii.1902 and 5.iii.1902. Priesner (1968: 205) studied one specimen from the type series but stated that it was not possible to know from which plant this had come (1 male, 1 female syntypes in SMF). He did not study the original specimens of *karnyi* that were also collected at Peradenya, 21.vii.1913, from *Piper nigrum*. As a result, he placed *karnyi* twice in the key, with the fore wings either hyaline or shaded. If the latter, then based on Bagnall's description *karnyi* had antennae 1.5 times as long as the head in contrast to *mirabilis* antennae 1.8 times as long as the head. These species share the unusual character state of antennal segments VII and VIII as pale as V and VI. Having examined type specimens of both species they are here considered to represent a single species, known only from these type specimens taken in Sri Lanka.

***Liothrips pallipes* (Karny)**

(Figs 4, 5, 7, 9, 11)

Gynaikothrips pallipes Karny, 1913: 110.

Gynaikothrips kuwanai Moulton 1928: 308 **syn.n.**

Liothrips reynvaanae Priesner, 1968: 203 **syn.n.**

Collected originally from *Piper* in Semarang, Java on 20.iii.1912, this species has a distinctive antennal colour, with segments III–VI clear yellow, but VII–VIII uniformly dark. The head length was given in the original description as 270 microns, and the fore wing was stated to be almost uniformly shaded but with a darker median line. Moulton described *kuwanai* from Taiwan, and distinguished it from *pallipes* by the greater body length (2800 vs 2500 microns), with the fore wing having a paler area sub-basally and at apex. There is no evidence that Moulton saw any specimens of *pallipes*, and Priesner (1968) stated that *kuwanai* and *pallipes* can be distinguished only “by the measurements”. However, Okajima (2006) re-described *kuwanai* from various sites in southern Japan and Taiwan, taken in leaf-roll galls on *Piper kadzura*. He provided the following measurements of one female: body length 2380 microns; head length 261; epimeral setae 118–161. Priesner described *reynvaanae* from a single female and an unspecified number of males (1 female, 3 males in SMF), collected in East Java on 18.xii.1920 from a species of *Piper*. He distinguished it from *kuwanai* by the longer pronotal setae (epimerals 172–180 vs 120 microns), and moreover distinguished *pallipes* from *kuwanai* by the shorter head length (208–235 vs 230–260), whereas the head length of *reynvaanae* was given as 320. The head length amongst females from *Piper* leaf galls in northern Queensland, Australia varies from 220 to 270 microns, and the pronotal epimeral setae 135 to 150 microns. As interpreted here, *pallipes* is considered to vary in body size and associated setal lengths. The major setae are weakly capitate, although the lateral abdominal setae vary from bluntly pointed to acute. However, the appearance of the setal tips varies depending on the type of microscope illumination; a postocular seta that is pointed under bright field illumination is clearly blunt or weakly expanded under Differential Interference Contrast illumination. However, the colour of the epimeral and sub-basal wing setae is paler than the pronotal anteroangular setae, and considerably paler than the colour of the major setae of *chavicae*. The fore wing is shaded medially with a weak median dark line, but is paler near the base and apex with

the wing margins broadly shaded. In addition to the yellow mid and hind tibiae, this species differs from *chavicae* in the following character states: metanotum more closely striate on anterior half (Fig. 7); mesopresternum broadly complete medially (Fig. 9); pelta lateral margins sinuate (Fig. 7); tergite IX setae S1 only 0.8–0.9 as long as the tube (Fig. 11). This species has been recorded from the following *Piper* species: *betle*, *canina*, *futokadsura*, *kadzura*, *muricatum*, *nigrum*, *recurvum*, *refractum*, *sarmentosum*. Described from Java, it is recorded from southern Japan and Taiwan (Okajima 2006), from India (Tyagi & Kumar 2016), and specimens have been studied (in ANIC) from Timor Leste, Papua New Guinea (east Sepik Prov.), and Australia (northern Queensland).

***Liothrips piperinus* Priesner**

Liothrips piperinus Priesner, 1935: 361

Priesner described this species from Taiwan, on an unspecified number of females (2 females in SMF) on *Piper* in association with *Liothrips kuwanai*. However, a full re-description together with illustrations is given by Okajima (2006). The antennae are unusually slender with elongate sense cones on III and IV that are almost two-thirds as long as their segment. The maxillary stylets are retracted to the postocular setae and almost touching medially, and the pelta is triangular. This thrips apparently invades leaf-roll galls induced by various Phlaeothripinae on a range of different plants, including *Castanopsis* [Fagaceae], *Elaeocarpus* [Elaeocarpaceae] and *Piper* [Piperaceae]. In addition to Taiwan, Okajima (2006) also records this species from Hainan, as well as Japan (Honshu, Kyushu, Ryukyu Islands).

***Liothrips retrofracti* Priesner**

Liothrips retrofracti Priesner, 1968: 224

This species was described from three samples of both sexes that were collected from *Piper retrofractum* on small islands in the Java Sea (Klein Kombuis and Isle Edam) (1 male, 5 females in SMF). It is closely similar to *chavicae* from which it appears to be distinguished only by the almost completely pale fore wings.

***Liothrips tibialis* Priesner**

Liothrips tibialis Priesner, 1952: 194

Described from one female and one male from the leaves of wild pepper in southern India, Valparai, 24.viii.1945 (in SMF), this species was not compared to *pallipes*. However, it has antennal segment VII pale on the basal half, and the fore wing strongly shaded with a dark median line. Priesner compared it only to another species from India, *flavitibia* Moulton, but that was described as having the apical antennal segments uniformly pale.

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