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Relationships among *Caliothrips* species (Thysanoptera: Panchaetothripinae) with one new species from Mexico

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Abstract

Caliothrips chiapas **sp.n.** is described from Mexico, breeding on the leaves but not in the flowers of *Tithonia tubiformis* [Asteraceae]. Patterns of tergal sculpture and wing colour exhibited by the 23 species now recognised in this genus are discussed and illustrated.

Key words: tergite sculpture, fore wing colour pattern, host relationships

Introduction

Judging from the available published literature, the genus *Caliothrips* might appear to be one of the better known groups of Thripidae. However, closer examination of this literature reveals a lack of information concerning the plants on which these thrips breed, and no discussion of relationships among the species in the genus. Membership of the genus within the subfamily Panchaetothripinae is readily determined, with all the species sharing the following character states: head and pronotum with reticulate sculpture and complex markings within each reticle; head with lateral margins almost parallel-sided; head with no strong transverse ridge across vertex (Fig. 6); hind coxae with coiled internal apodeme (Bhatti 2006). The genus occurs throughout the tropics and sub-tropics, and currently comprises 22 described species. In describing here a new species of *Caliothrips* from Mexico, careful observations were made on its host-plant association, leading to the conclusion that it is leaf-feeding and is not associated with flowers. The fore wing colour and tergal sculpture of this new species fall outside the choices offered in the key by Wilson (1975) to the 18 members of the genus then known, also the key to 10 Nearctic species by Nakahara (1991). Variation in these two characters was used by Wilson to distinguish the species and thus infer relationships. A second objective here is to discuss the variation in these characters among the described species and to consider their phylogenetic significance. Faure (1962) and Wilson (1975) provide many illustrations of structural characters for species in this genus, and full nomenclatural details are provided by ThripsWiki (2017).

Biological observations

The new species described below was first collected while sampling for thrips in "Canton Texcaltic", municipality of Frontera Hidalgo, Chiapas, in March 2014 (Map 1). The collecting site was a pineapple field surrounded by many herbaceous plants. During general thrips collecting on these plants, about 20 adult *Caliothrips* were taken from the Asteraceae plant "girasolillo" (little sunflower), *Tithonia tubiformis* (Fig. 1), but not from any other plants. In order to confirm this host association, individuals of this plant species at the same site were targeted again in March 2017. More than 70 adults and 20 larvae of *Caliothrips* were taken from this plant, but none from other plants in the vicinity. Thus this thrips species is well established at that site, and appears to have a close association with this plant species. However, *Caliothrips* species are usually associated with leaves, so a further attempt was made to try to determine the feeding and breeding site of the thrips. For this purpose, 40 flowers of *T.*

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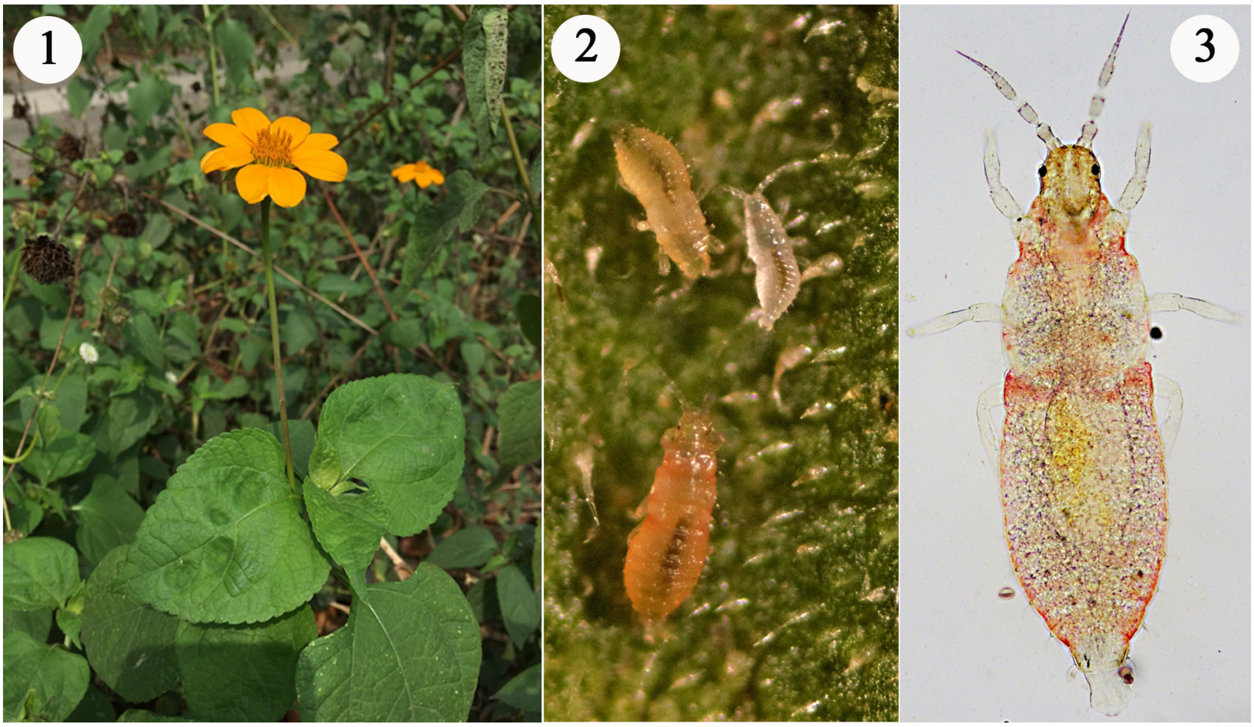
tubiformis were removed with scissors and placed in a plastic bag to extract the thrips in the laboratory. Then the leaves of the same plants where shaken against a plastic tray, and any thrips found were placed into vials containing 70% ethanol using a camel-hair brush. Leaves where then removed from the plant and taken to the laboratory to be placed in Petri dishes (dia = 14 cm) to observe any emergence of thrips larvae. Thrips started to emerge from leaves the following day, and within a few days we noticed several dozen larvae, all of which belonged to the genus *Caliothrips* (Figs 2, 3). The flower samples were processed in the laboratory by rinsing the contents of the bag with 70% ethanol, and the thrips mounted onto slides. No specimens of *Caliothrips* were found in any of the flowers, but amongst the several hundred adult thrips that were extracted we identified eight species, and noted the presence of many larvae. There were four species of *Frankliniella* (*brunnea*, *cephalica*, *gossypiana*, *insularis*), also *Microcephalothrips abdominalis*, together with a few Phlaeothripidae specimens representing *Haplothrips gowdeyi*, *Karnyothrips texensis*, and a *Leptothrips* species. The spatial and biological separation between the thrips in the flowers and the single species on the leaves was remarkable. These observations further emphasise the lack of useful biological information in many published thrips "host records" (Mound 2013). To understand the host relationships of a thrips species it is essential to do more than simply beat adults from a plant. Two adult females of *Caliothrips phaseoli* were also taken from the *Tithonia* leaves.



FIGURES 1–3. *Caliothrips chiapas* **sp.n.** host-plant and immatures. **(1)** *Tithonia tubiformis*. **(2)** *C. chiapas* larvae on leaf. **(3)** *C. chiapas* slide-mounted second instar larva.

Caliothrips chiapas **sp.n.**

Female macroptera: Dark brown, tarsi yellow also base and apex of all tibiae; antennae brown with segments III–V yellow on basal half and III–IV with apical neck pale (Fig. 10); fore wings deeply shaded (Fig. 4), with small, sub-basal, oval pale area between veinal setae II and III, a transverse paler band between second vein setae I and III, and a brighter and large pale transverse band sub-apically that is usually longer than the apical dark area; veinal setae dark brown, but one seta pale on median and also sub-apical pale bands; clavus uniformly dark. The extent of the pale bands, and the colour intensity of the basal dark area on the fore wing, vary among the type series.

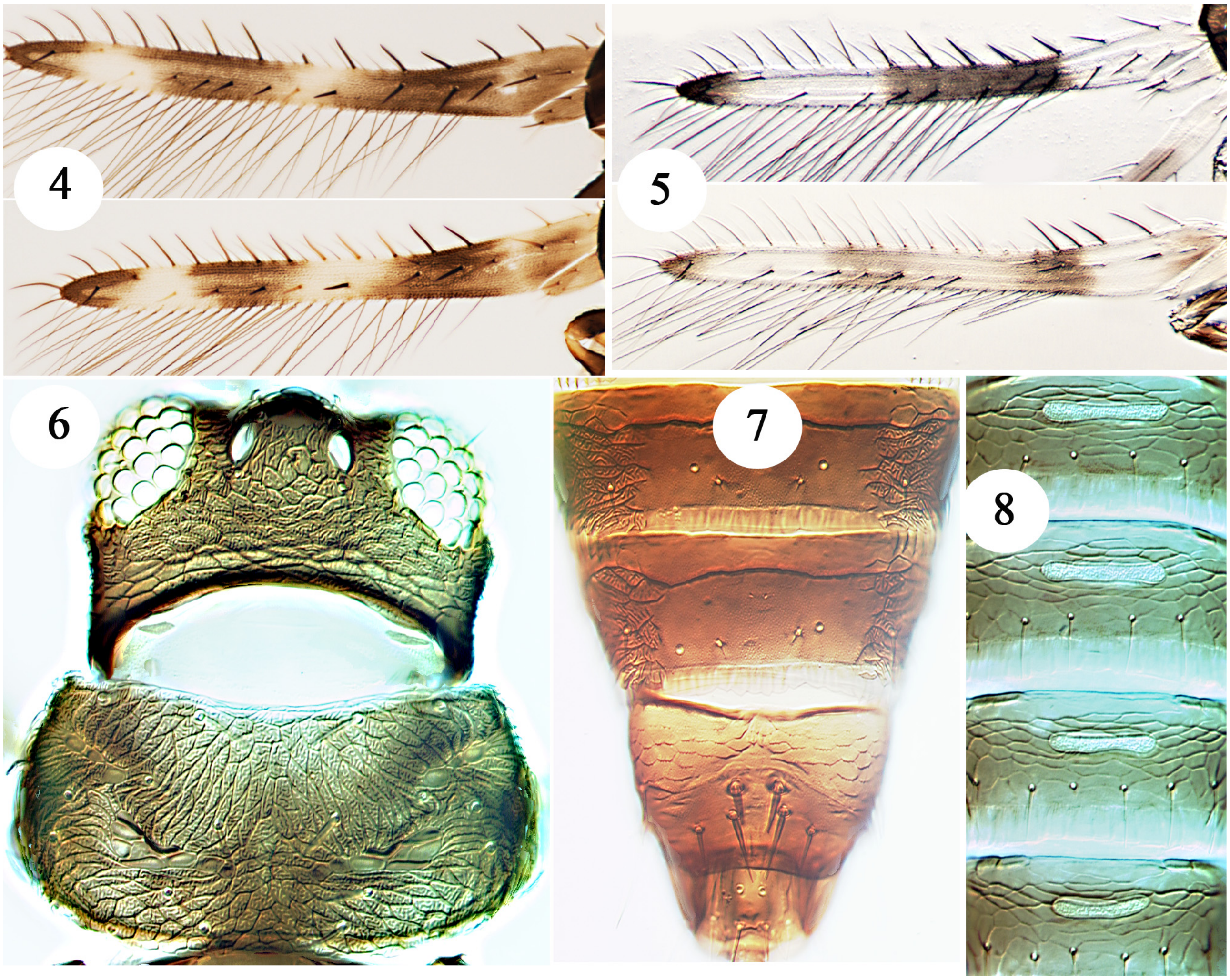
Antennae 8-segmented, III–IV each with an apical neck (Fig. 10) and stout forked sense cone, IV with one simple sense cone dorsally extending to mid-point of V; segment VI with simple dorsal sense cone extending beyond mid-point of VIII. Head typical of genus, reticulations with many internal markings (Fig. 6). Pronotal reticulations longitudinally elongate on anterior median third, but equiangular on posterior third. Metanotum longitudinally reticulate with many internal markings. Fore wing costa with about 17 setae (Fig. 4), setae IV–VI particularly stout; first vein with 5 setae basally (IV–V stout) and one seta near wing apex; second vein with 6 (or 7) setae of which two are pale. Tergites I–II with small area of reticulation medially, but remaining tergites with no sculpture medially; tergite II lateral thirds with narrow transverse striations, on III–V these striations become progressively more reticulate and this varies among individuals (Fig. 9), VI–VII with reticulate sculpture laterally; posterior margin of tergites with broad craspedum that is toothed laterally; X with median split on distal third. Sternites with broad craspedum, II–VII with 3 pairs of marginal setae, pair III usually arising in front of margin.

Measurements (holotype female in microns): Body length 1050. Head, length 60; width 135. Pronotum, length 80; width 180. Fore wing length 650. Tergite IX setae length, S1 45; S2 70. Antennal segments III–VIII length 40, 38, 35, 25, 10, 25.

Male macroptera: Body smaller, colour similar to female, but fore wing paler at base and median pale area slightly larger and paler. Sculpture on tergal lateral thirds similarly grading on II–VII from linear transverse to reticulate. Tergite IX with 3 pairs of dorsal setae, antero-median pair stout and thorn-like (Fig. 7). Sternites III–VII each with transverse pore plate (Fig. 8).

Specimens studied. Holotype female, **MEXICO**, Chiapas State, Frontera Hidalgo, Canton Texcaltic, 4.iv.2014 (F. Infante) in United States National Museum, Washington.

Paratypes: 28 females 18 males taken from same locality and plant as holotype; paratypes deposited in the entomological collection of ECOSUR (Tapachula, Chiapas, Mexico), also in USNM, Washington, The Natural History Museum, London, The Senckenberg Museum, Frankfurt, and the Australian National Insect Collection, Canberra.



FIGURES 4–8. *Caliothrips* species. **(4)** *C. chiapas*, wing colour variants; **(5)** *C. phaseoli*, wing colour variants; **(6)** *C. chiapas*, head & pronotum; **(7)** *C. chiapas*, male tergites VII–X; **(8)** *C. chiapas*, male sternites IV–VII.

Discussion

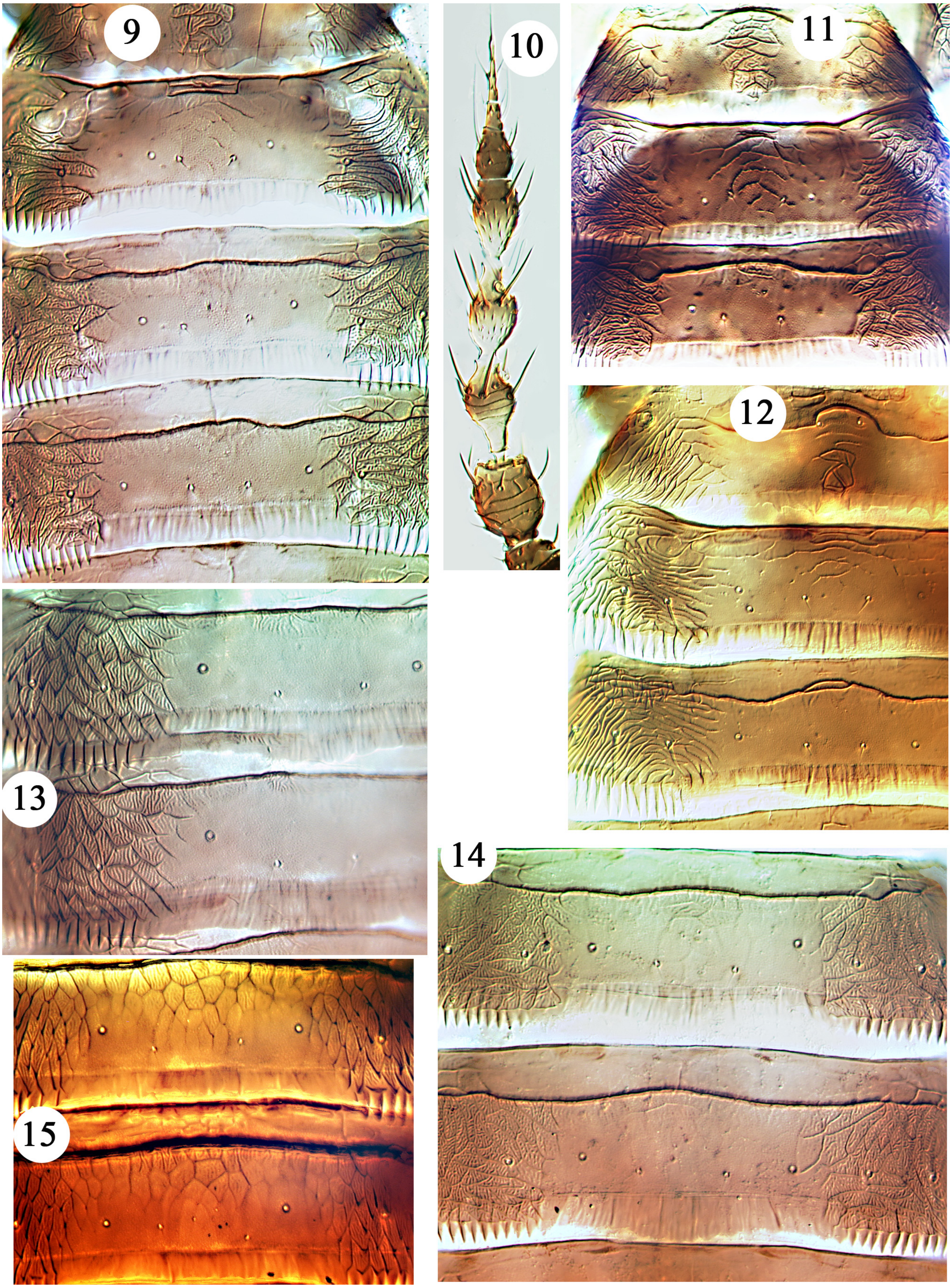
In the key to species provided by Wilson (1975) this new species runs to *quadrifasciatus* (as *graminicola*). However, despite the rather similar tergal sculpture, that Old World species has three extensive pale areas on the fore wing. The only described species in the genus that share with *chiapas* such an extensively dark basal half to the fore wing are *impurus* and *oneillae* from Africa and *masculinus* from Trinidad; two of these have reticulate tergal sculpture, but *oneillae* has striate sculpture with no markings between the striae. There are two New World species that share with *chiapas* a rather similar striate tergal sculpture. The most widespread is *phaseoli*, extending south from western USA through South America. However, *phaseoli* either lacks markings between the striae, or has only a few markings between the anterior striae on each tergite (Fig. 12), and the fore wing basal area is more extensively pale (Fig. 5) with the median pale area sometimes absent. The second species is *multistriatus* from southeastern USA. This has markings between closely spaced tergal striae, but as in *phaseoli* there is an extensive sub-basal pale area on the fore wing, and the median pale area is not developed.

Fore wing colour patterns. In essence, the fore wings of *Caliothrips* species are dark with three white transverse bands—sub-basally, medially, and sub-apically. However, the extent of these pale bands varies between species, and the new species described above has the sub-basal pale band almost completely occluded (Fig. 4), a condition that is shared with only three other species, *impurus*, *masculinus* and *oneillae*. The median pale band is small in this new species (Fig. 4), but in about half of the *Caliothrips* species this median band is weak or not present [*cinctipennis*; *floridensis*, *impurus*; *masculinus*; *multistriatus*; *oneillae*; *sudanensis*; *tongi*]. The median pale band in *phaseoli* is particularly variable, such that even within a single population it may be well-developed or scarcely visible. In contrast, two species [*marginipennis*; *punctipennis*] have the pale bands so extensive that the fore wings are essentially pale with only a small dark marking sub-basally and at the apex. Distal to the sub-apical pale band the fore wing is dark in all described species except *pallidizonata* in which the entire wing apex is pale. However, three particularly closely related species [*luckmanni*; *striatopterus*; *sudanensis*] are remarkable in that the extreme tip is sharply pale distal to the dark area that is terminal in most members of this genus.

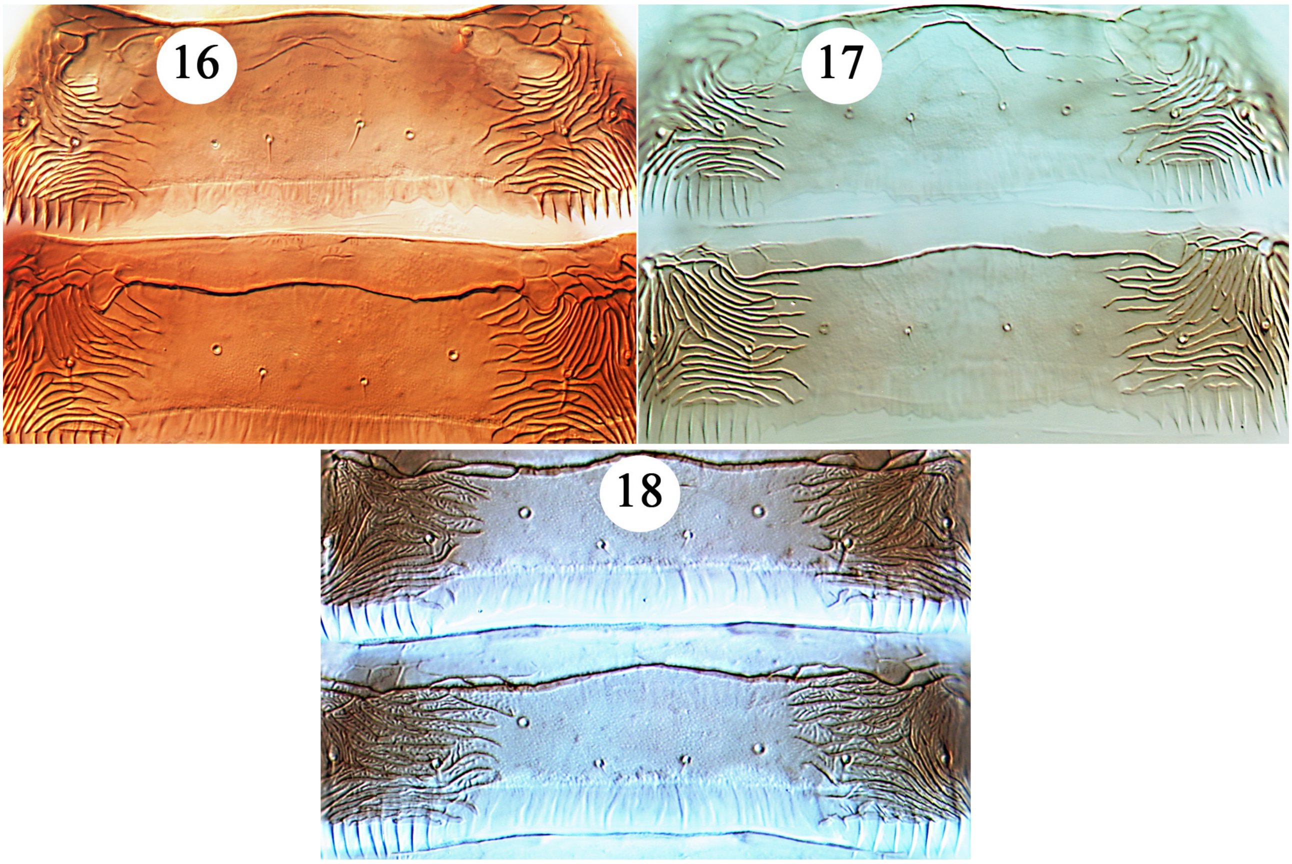
Tergal sculpture variation. The sculpture on the lateral thirds of the abdominal tergites takes the form of equiangular reticles in about half of *Caliothrips* species (Fig. 13), and each such reticle has a pattern of internal sculpture markings. In a few species [*fasciapennis*; *marginipennis*, *pallidizonata*, *tongi*] the reticles are not equiangular but are elongate in a longitudinal direction (Fig. 15). In contrast, about 50% of the species have tergal sculpture in the form of transverse or oblique sub-parallel lines, and complex sculpture markings between the lines are either present (Fig. 18) or absent (Figs 16, 17), depending on the species. However, *phaseoli* has an intermediate condition between presence and absence, with just a few internal markings on the anterolateral striae (Fig. 12). An intermediate condition between reticulation and striation occurs on the tergites of a few species, such as *chiapas* (Figs 9, 11) and also *impurus* (Fig. 14). The condition is sometimes slightly variable in *quadrifasciatus* (Fig. 18), and this presumably resulted in Wilson (1975) placing this species (as *graminicola*) twice in his key.

Host relationships. Because so few of the species of *Caliothrips* have been collected with their larvae, or taken repetitively from the same plant species, it is impossible to be certain of their host relationships. However, the available data suggest that some species are primarily associated with leaves of Poaceae [*cinctipennis*; *insularis*; *punctipennis*; *quadrifasciatus*; *striatopterus*]. In contrast, a few appear to be particularly associated with the leaves of Fabaceae [*impurus*; *indicus*; *sudanensis*]. In the Sudan Gezira it was normal to grow cotton crops in rotation with *Dolichos* beans and, possibly as a result of this proximity, *sudanensis* adults commonly attacked seedling cotton (Bagnall & Cameron 1932). Similarly, other species that originally might have been associated with Fabaceae [*fasciatus*; *phaseoli*] also breed on many other plants (Rugman-Jones *et al.* 2012). Moreover, *tongi* has been reported breeding on crops of *Lactuca* [Asteraceae] in Japan (Minoura & Masumoto 2016), although that is not likely to have been its original host. Wilson (1975) stated that *Caliothrips striatus* breeds particularly on the leaves of *Liriodendron* trees [Magnoliaceae], and *C. pallidizonata* was described from a few specimens taken on the moss-like plant, *Selaginella*.

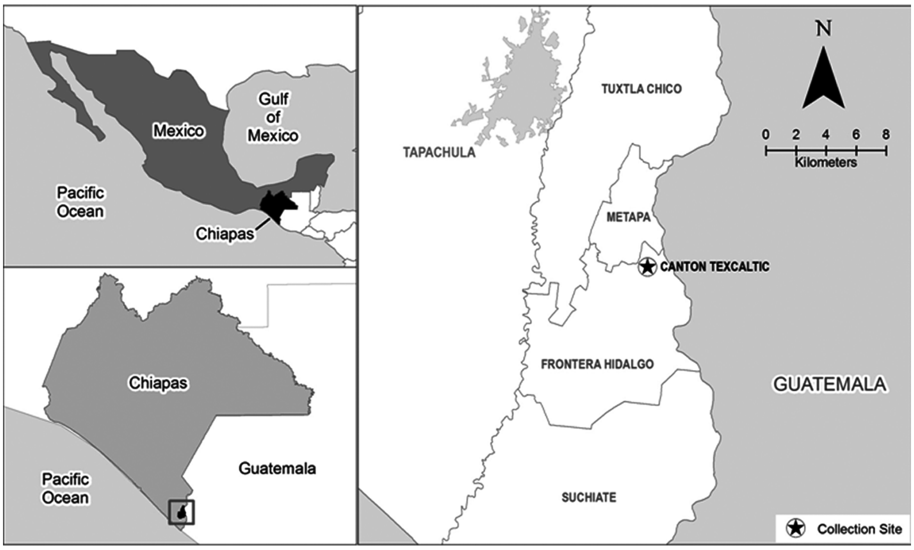
Intra-generic relationships. The objective of the discussions above was to provide a basis for considering relationships between the species of *Caliothrips*. Fore wings with alternating bands of light and dark is a condition that is common and widespread amongst Panchaetothripinae, and from this we assume that the plesiotypic condition of fore wing colour in *Caliothrips* was three pale bands alternating with four dark areas. Fore wings with the apex pale is thus assumed to be a derived condition; it is known in only a few species, all from the Old World



FIGURES 9–15. *Caliothrips* species. **(9)** *C. chiapas*, female tergites I–IV; **(10)** *C. chiapas*, antenna; **(11)** *C. chiapas*, male tergites I–III; **(12)** *C. phaseoli*, female tergites II–IV; **(13)** *C. fasciatus*, female tergites IV–V; **(14)** *C. impurus*, female tergites IV–V; **(15)** *C. tongi*, female tergites IV–V.



FIGURES 16–18. *Caliothrips* species. **(16)** *C. helini*, female tergites II–III; **(17)** *C. striatopterus*, female tergites II–III; **(18)** *C. quadrifasciatus*, female tergites II–III.



MAP 1. Collecting site of *Caliothrips chiapas* **sp.n.**

(*luckmani pallidizonata, sudanensis*). In contrast, the derived condition of an extensively pale fore wing is known only amongst species from the New World (*marginipennis, punctipennis*). The median pale area has been lost in several species on opposite sides of the world, including *impurus* in the Old World and *masculinus* in the New World, and this condition is variable within *phaseoli*. Similarly, species in which the sub-basal pale area has been lost are from widely separated areas (*impurus* from Africa and *masculinus* from Trinidad). Fore wing banding patterns therefore provide little information about relationships within the genus. The distribution of tergal sculpture patterns among the species is equally complex. Equiangular tergal reticulation with markings internal to each reticle is presumably the plesiotypic condition, as this occurs on the head and pronotum of all members of this genus. Striate sculpture on the tergites has apparently developed independently among species from both the Old World (Figs 16, 17) and New World (Figs 9, 12), and markings between the striae have been lost independently in some of these species. Both character states considered here show intermediate conditions; *phaseoli* has the median pale band on the fore wing variably present or absent (Fig. 5), and *chiapas* has the tergal sculpture intermediate between reticulate and striate, depending on the tergite examined (Fig. 9). The lack of correlation between the geographic distributions and morphological characters suggests that considerable homoplasy is involved, and currently it is not possible to deduce clear relationships between the species of *Caliothrips*. However, the genus is ancient, with two species described from fossils in Baltic amber with an age of at least 40 million years. Presumably the sculpture and colour patterns discussed here have diversified independently in individual species isolated in different parts of the world, and molecular data will be needed in order to deduce evolutionary relationships among these various species.

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