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Scirtothrips species (Thysanoptera: Thripidae) described from *Mangifera indica* (Anacardiaceae) in Mexico

Laurence Mound^{1,*} and Mark Hoddle²

Abstract

A series of 15 species described from specimens collected from the leaves of mango trees at a single site in Mexico are newly placed as synonyms of the California citrus thrips, *Scirtothrips citri* (Moulton) (Thysanoptera: Thripidae). These species were originally discriminated based on differences in the precise placement of setae in the median area of the pronotum, and this chaetotaxy is here recognized as variable within populations of this thrips from various sites in California and Mexico. Preliminary results from molecular analysis of 2 genes, *CO1* and *28S-D2*, indicate that there is variation at the molecular level between populations of *S. citri*. However, this variation is not sufficient to support new species designations, and no consistent morphological divergence between these populations was detected.

Key Words: new synonyms; *Scirtothrips citri*; quarantine

Resumen

Una serie de 15 especies descritas de especímenes recolectadas sobre hojas de árboles de mango en un solo sitio en México han sido recientemente colocadas como sinónimos del trips de los cítricos de California, *Scirtothrips citri* (Moulton) (Thysanoptera: Thripidae). Estas especies fueron discriminadas originalmente basado en las diferencias en la colocación precisa de las setas en la zona media del pronoto y esta chaetotaxia está aquí reconocida como variable dentro de las poblaciones de este trips de varios sitios en California y México. Los resultados preliminares de análisis molecular de 2 genes, *CO1* y *28S-D2*, indican que hay una variación en el nivel molecular entre las poblaciones de *S. citri*. Sin embargo, esta variación no es suficiente para soportar las nuevas designaciones de especies, y no se detectó ninguna divergencia morfológica consistente entre estas poblaciones.

Palabras Clave: nuevas sinónimos; *Scirtothrips citri*; cuarentena

In Mexico, from the young leaves of mango, *Mangifera indica* L. (Anacardiaceae), Johansen & Mojica-Guzman (1999) described 18 species in the genus *Scirtothrips* Hood (Thysanoptera: Thripidae). Each of these 18 species was described from specimens that had been collected in association with at least 1 of the other species; 15 of them came from the same locality; and 11 of these new species were described from specimens collected at that locality on the same day (Table 1). The authors of these new species made no comment on this remarkable ecological scenario—a suite of temporally co-existing congeneric species sharing the same resource. Moreover, no-one in Mexico has subsequently re-examined this remarkable sympatric association of species. However, in addition to the ecological and evolutionary interest of this putative species swarm on young mango leaves, the reported situation of high species diversity on young mango leaves is of economic significance, because such an extensive group of species in a genus noted for economically important pests could be expected to trigger quarantine restrictions for an export crop.

Mound & zur Strassen (2001) expressed doubts about the validity of such a large number of apparently indigenous species known only from this non-indigenous tree crop. These doubts were re-enforced when Hoddle et al. (2008a) demonstrated that several species described in the same paper by Johansen & Mojica-Guzman (1999), but from avocado, *Persea americana* Miller (Lauraceae), are actually variants of *Scirtothrips perseae* Nakahara, a pest of avocados in California, and native to Mexico and Guatemala. The objective here is to

re-consider the validity of the 15 species of *Scirtothrips* described by Johansen & Mojica-Guzman (1999) that were collected from mango at a single locality (El Guaco, Michoacan State, Mexico).

Materials and Methods

We re-assessed the morphological character states used by Johansen & Mojica-Guzman (1999) to distinguish species of *Scirtothrips* from mango in Mexico. We compared these published data with variation we observed within populations of *Scirtothrips citri* (Moulton) at Riverside, California, and Chiapas, Mexico, and also on paratypic specimens loaned by R. M. Johansen (Universidad Nacional Autónoma de México). DNA was extracted from 4 *Scirtothrips* specimens collected from mango flowers at Chiapas, Mexico, and data from 2 genes, *CO1* and *28S-D2*, were compared with published data on *S. citri* from California (USA) and Oaxaca (Mexico).

Results and Discussion

MORPHOLOGICAL DATA

In assessing the morphological diversity of a sample of thrips, the appropriate null hypothesis would be that all *Scirtothrips* specimens

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Table 1. *Scirtothrips* species described from mango at a single site in Mexico (El Guaco, Sierra Madre del Sur, Michoacan).

Species	Dates of collection (all except one in 1998)		Type series
	holotype	paratypes	
<i>admangiferaffinis</i> ^a	9.iii.1998	10.ii.; 25.ii.; 24.iii.	40 ♀
<i>apatzinganensis</i>	9.iii.1998	10.ii.; 15.vii.	3 ♀ 1 ♂
<i>danieltelizi</i> ^a	9.iii.1998	10.ii.; 24.iii.; 15.vii.	18 ♀ 5 ♂
<i>dieterenkerlini</i> ^a	24.iii.1998	10.ii.; 25.ii.	5 ♀
<i>hectorgonzalezi</i>	10.ii.1998	25.ii.	3 ♀
<i>mangiferaffinis</i> ^a	21.v.1997	10.ii.; 25.ii.; 9.iii.; 24.iii.; 15.vii.	34 ♀
<i>mangoaffinis</i> ^a	9.iii.1998	24.iii.	3 ♀
<i>mangofrequentis</i> ^a	9.iii.1998	10.ii.; 25.ii.; 24.iii.; 15.vii.	25 ♀ 1 ♂
<i>mangoifestans</i> ^a	9.iii.1998	24.iii.	5 ♀
<i>mangomolestus</i> ^a	9.iii.1998	24.iii.	4 ♀
<i>mangorum</i> ^a	9.iii.1998	24.iii.; 15.vii.	11 ♀ 4 ♂
<i>mangonoxius</i>	10.iii.1998	10.ii.	6 ♀
<i>martingonzalezi</i>	24.iii.1998		1 ♀
<i>novomangorum</i>	25.ii.1998	10.ii.; 9.iii.	3 ♀
<i>willihennigi</i> ^a	10.ii.1998	9.iii.	2 ♀

^aParatype studied iii.2016.

collected together on a single host plant at the same time represent a single species. To falsify such a null hypothesis, and to conclude that multiple species were temporally sympatric on young mango leaves, several lines of supporting evidence would be expected. Such evidence might include reliable and replicable measures of morphological (and molecular) variation to distinguish between species, possible changes in species composition over time, and behavioral, ecological, and mating compatibility studies. In contrast to such an analytical approach to distinguish co-existing species, Johansen & Mojica-Guzman (1999) relied almost exclusively on slight differences in the distribution of setae located medially on the pronotum (Figs. 1–8). The number and distribution of setae on the median area of the pronotum are known to be variable within some *Scirtothrips* species, as well as in some other Thripidae (O'Donnell & Mound 2016). Moreover, there was an unstated, and unsupported, implication by Johansen & Mojica-Guzman (1999) that no variation in the patterns they recorded occurred among specimens within each of their named segregates. The authors classified the particular pronotal setae that they studied into the following 3 groups:

1. *Anteromarginal setae*: There are 2 pairs of such setae in the *Scirtothrips* considered here. These setae vary in their precise position: on or distant from the anterior margin, and bilateral asymmetry is frequent, with 1 or more setae absent (Figs. 1–13).
2. *Sub-antemarginal setae*: This group of setae was not clearly defined from the 3rd group of setae (see below) in the illustrations presented by Johansen & Mojica-Guzman (1999). They stated that there are no sub-antemarginal setae in *mangofrequentis* (Fig. 6), just 1 in *mangiferaffinis* (Fig. 7), whereas *mangoifestans* (Fig. 8) was described as having 5 such setae.
3. *Median transverse row of setae*: This was stated to be continuous or with a median gap in the *citri* group of 14 species (Figs. 1–2), but with 1 median seta displaced posteriorly in the *danieltelizi* group of 4 species (Figs. 3–4), and 2 median setae displaced posteriorly in the *mangofrequentis* group of 11 species (Figs. 6–8).

Two further characters were used by the authors to distinguish *Scirtothrips* species on mangoes. The first was the relative length of ocellar setae pair I on the head, and the second was the precise position of ocellar setae pair III in relation to the “ocellar triangle.”

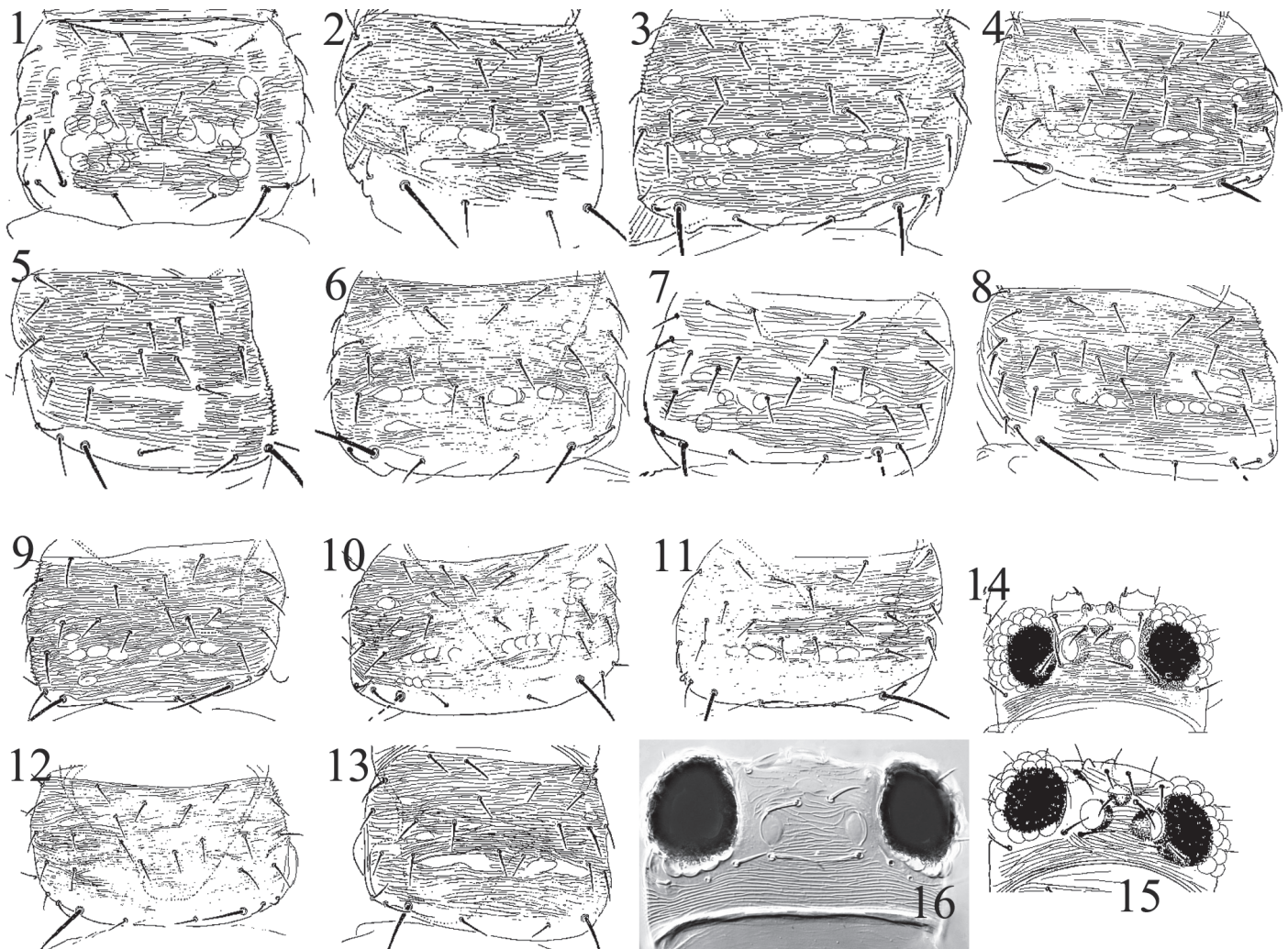
Ocellar setae pair I arise in front of the 1st ocellus on the downward sloping anterior margin of the head, and thus in well-prepared slide-mounted specimens these setae are never orientated in a suitably horizontal state for their length to be measured accurately (unless the head is flattened by crushing under the cover slip). Because these setae project vertically, their length in undamaged specimens cannot be measured with sufficient precision for use as an effective species discriminant. Ocellar setae pair III were categorized by the authors as either “within” or “on anterior margins of” the ocellar triangle. However, such a distinction is not clear because the “anterior margin of the triangle” can be interpreted as being the tangent on the outer margins of the ocelli, or on their inner margins, or as being a line joining the mid points of the ocelli (see Fig. 5 in Retana & Mound 1995). Ocellar setae pair III are stated to be on the margins of the triangle in *dieterenkerlini* (Fig. 14) but within the triangle in *mangorum* (Fig. 15), although the illustrations provided fail to show a clear distinction. Moreover, these 2 setae are commonly positioned asymmetrically in undamaged mounted specimens (Fig. 16). Thus, neither of these ocellar setae characters provides an unequivocal state for distinguishing species among mango-inhabiting *Scirtothrips*. These characters are not considered further as reliable morphological traits to distinguish species, although in some other genera of Thripidae they can be suitable as species discriminants.

TAXON DISCRIMINATION

Johansen & Mojica-Guzman (1999) distinguished a group of 30 *Scirtothrips* species from Mexico as belonging to a “*citri* group,” and this included the 15 species from mango listed in Table 1. Of these 15 species, 3 were further placed amongst 14 species designated as a “*citri* assemblage,” 9 were listed amongst the 11 species of a “*mangofrequentis* assemblage,” and 3 were listed amongst the 4 species of the “*danieltelizi* assemblage.” Subsequently, flaws in this classification became evident, because 5 of the 14 species in the “*citri* assemblage” were recognized as synonyms of *S. perseae* (Hoddle et al. 2008a). This species, the avocado thrips, has dark tergal antecostal ridges and the males have drepanae on the 9th tergite, in contrast to the uniformly pale *citri* in which males do not have drepanae. Males (where known) of all the nominal species considered here in association with mango leaves do not have drepanae. However, 1 species, *chamelaensis*, listed as a member of the “*mangofrequentis* assemblage,” is clearly unrelated to the “*citri* group” because the male has drepanae on tergite IX.

The members of the “*citri* assemblage” were distinguished by the presence on the pronotum of a “median transverse setae row forming a straight line, either continuous or with a median gap,” and 3 species from mango were said to share this character state with *citri*. Two of them, *apatzinganensis* (Fig. 9) and *martingonzalezi* (Fig. 10), were considered to have “a gap at middle” in this setal row, in contrast to *mangonoxius* (Fig. 2) that was stated to have the setal row “regularly continuous,” as claimed also for *citri* itself (Fig. 1). The “*danieltelizi* assemblage” and the “*mangofrequentis* assemblage” were distinguished from the “*citri* assemblage” solely because the median transverse setal row has either 1 (Fig. 3) or 2 (Fig. 8) setae displaced to the posterior. However, the original illustrations, reprinted here, provide no clear support for these statements. A simpler interpretation of the situation would be that the precise positions and number of setae on the pronotal disc are not constant between individuals.

The setae designated as a sub-antemarginal row were stated by Johansen & Mojica-Guzman (1999) to be lacking in *mangofrequentis* (Fig. 6) and *novomangorum* (Fig. 11), but present in *mangoifestans* (Fig. 8), *dieterenkerlini* (Fig. 12), and *mangorum* (Fig. 13). In the illustrations provided, such a row of setae cannot be recognized unambigu-



Figs. 1–16. *Scirtothrips pronota* (1–15, copied from Johansen & Mojica-Guzman 1999). 1, *citri*; 2, *mangonoxius*; 3, *danieltelizi*; 4, *mangoaffinis*; 5, *willihennigi*; 6, *mangofrequentis*; 7, *mangiferaffinis*; 8, *mangoinfestans*; 9, *apatzinganensis*; 10, *martingonzalezi*; 11, *novomangorum*; 12, *dieterenkerlini*; 13, *mangorum*; 14, *dieterenkerlini*; 15, *mangorum*; 16, *citri*.

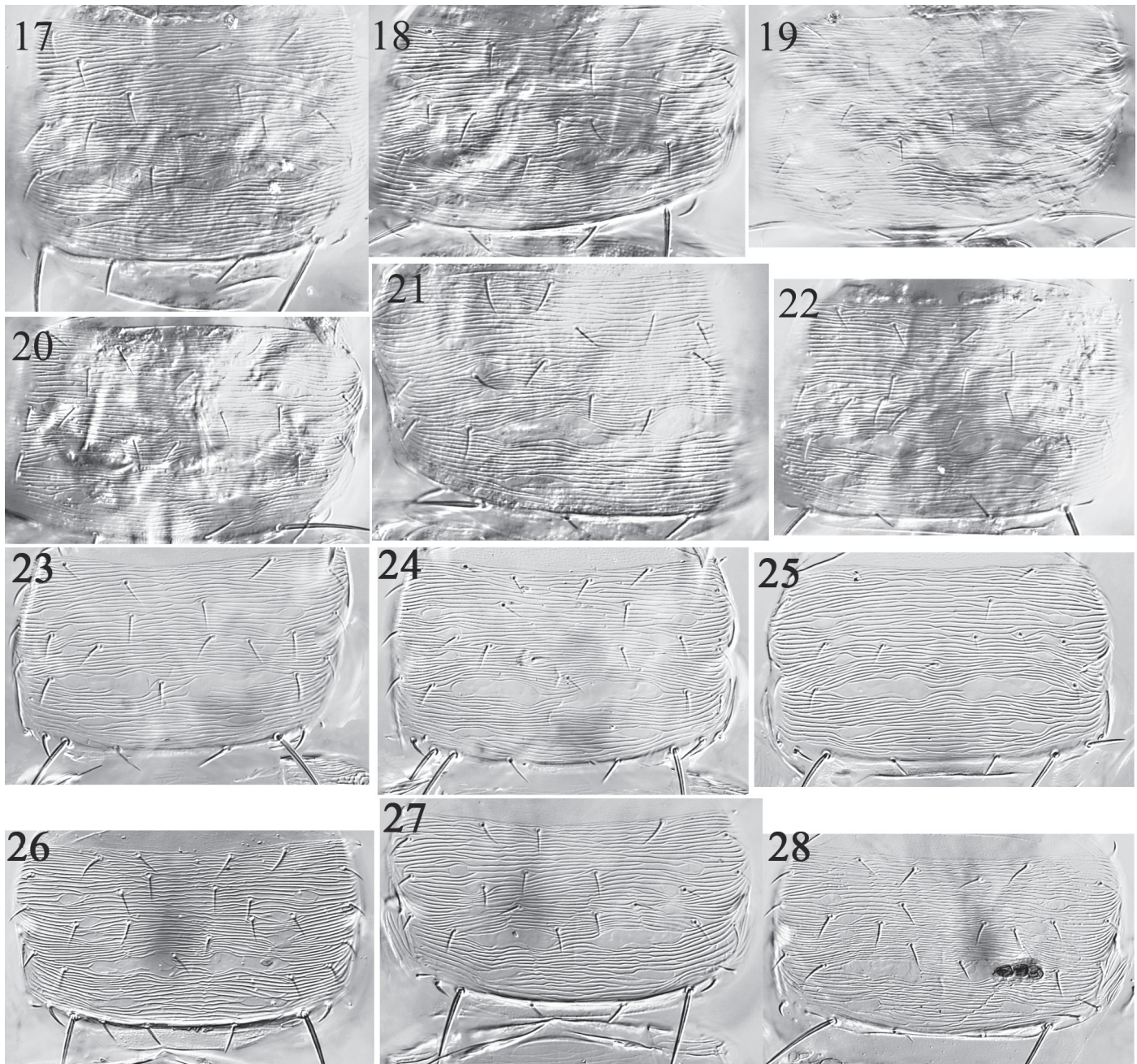
ously, and this character state seems to be largely subjective. The possibility that the discal setae on the pronotum do not have any precise positions was therefore considered. To this end, the pronotal chaetotaxy was examined: on a paratype of each of 10 species (loaned by R. M. Johansen, Universidad Nacional Autónoma de México); on a series of *Scirtothrips* specimens collected from mango at Chiapas, Mexico; and on a series of *S. citri* specimens collected from citrus and mango in California.

DATA FROM PARATYPES

Comparison of the chaetotaxy of the pronota of the available paratypes (Figs. 17–22) with that of the illustrations of the relevant holotypes (Figs. 1–13) indicates that there is general agreement concerning the position of the median 1 or 2 pairs of setae. However, the precise positions of these setae, and the precise positions of the surrounding setae on the median area of the pronotum, are clearly not constant between these paratypes and the illustrated holotypes. This lack of consistency suggests that the arrangement of all the setae on the median area of the pronotum is not rigidly constrained as interpreted by Johansen & Mojica-Guzman (1999), and is therefore not a reliable morphological character for recognizing and separating species.

DATA FROM RECENTLY COLLECTED SPECIMENS

The pronotal chaetotaxy of the common pest, the California citrus thrips, *S. citri*, includes with remarkable consistency a longitudinal row of 3 setae on each side of the pronotum close to the extreme lateral margins. Mesad of each of these rows there is usually a 2nd longitudinal row, but of 2 setae (Figs. 23–25). Apart from these 2 groups of setae, the remaining discal setae of *citri* specimens from California appear to be arranged irregularly, and we were not able to detect any clear repeatable patterns. Between the lateral setae, the discal area has 4 to 10 setae, but these do not form 2 recognizable “sub-antero-marginal” or “median transverse” rows. One or both of the anteromarginal setae (Figs. 23–28) is commonly displaced posteriorly (or even entirely absent), and 1 or more of the median discal setae is commonly displaced anteriorly and thus becomes part of a putative “sub-antero-marginal row.” The pronotum of specimens from Chiapas (Figs. 26–28), identified here as *citri*, has essentially the same arrangement of setae as *citri* specimens from California (Figs. 23–25), with the same paired lateral rows but irregular discal chaetotaxy. The available specimens from California tend to have rather fewer median discal setae on the pronotum than specimens from Mexico, and this might be a sampling artifact or a population difference. Certainly, this thrips species seems to exhibit unusual variation in the number of pronotal discal setae.



Figs. 17–28. *Scirtothrips pronota*. 17–22 Paratype females on loan from Johansen: **17**, *danieltelizi*; **18**, *mangoaffinis*; **19**, *willihennigi*; **20**, *mangofrequentis*; **21**, *mangiferaffinis*; **22**, *mangoifestans*. 23–28 Recent slide mounts: **23**, *citri* from citrus at Riverside, California; **24–25**, *citri* from mango at Riverside, California; **26–28**, *citri* from mango at Chiapas, Mexico.

MOLECULAR DATA

Using *S. citri* specimens from citrus in California as a reference point, Hoddle et al. (2008b) identified *Scirtothrips* specimens taken from mango in Oaxaca, Mexico, as *S. citri*, using molecular data from the gene regions *28s-D2* and *CO1*. As part of the present study, DNA was extracted from 4 *Scirtothrips* females collected in Chiapas, southern Mexico, and the same 2 genes were assessed separately and compared with the data published by Hoddle et al. (2008b). Both of the analyzed genes placed these 4 females in the same major clade as *citri*, but with the specimens from Mexico as sister-group to the Californian specimens. Detected differences were not sufficient to declare the existence of different species. This result is not surprising, and more ex-

tensive studies are needed to examine the molecular variation of *citri* populations across the extensive geographic range of this species. Collections and analyses should include material from across the southern USA, from Florida to California, and throughout Mexico (Hoddle et al. 2012).

A similar problem exists with *S. perseae*, where molecular data indicated that a population from Honduras was a sister-group to that pest species (Hoddle et al. 2008b), although no structural differences could be recognized (Mound & Hoddle 2016). Molecular differences have been detected within some other widespread species, including *Frankliniella occidentalis* (Pergande), the western flower thrips (Rugman-Jones et al. 2010). However, such differences at the molecular level are rarely correlated with significant morphological and biologi-

cal differences, and morphospecies concepts remain the only practical approach for separating “pest” vs. “non-pest” variants of the same species. One notable exception to this lack of correlation between molecular and field studies is work on populations of *Scirtothrips dorsalis* Hood in Japan, which demonstrated the existence of crop-specific strains of this pest that were separable using molecular data but not morphologically (Toda et al. 2014).

CONCLUSIONS

We conclude that the data provided by Johansen & Mojica-Guzman (1999) (see Figs. 1–15) do not adequately distinguish the 15 *Scirtothrips* species that they named from mango in Mexico. Similar patterns of pronotal chaetotaxy have been observed between samples of the common pest species, *S. citri*, from different sites and host plants, and across time in California and Mexico (including Baja California, Sonora, and Chiapas). Recognition amongst these specimens of the 3 discrete groups of pronotal setae proposed by Johansen & Mojica-Guzman (1999) has not proved possible. The 2 pairs of “anteromarginal setae” are variable both in presence and position; the row of “sub-antemarginal setae” is not clearly distinguished from either the anteromarginal or the median discal setae; and the “median transverse row of setae” is usually an irregular arrangement of setae rather than a discrete row. Thus, there is no consistent evidence that the arrangement of setae on the median discal area of the pronotum is anything other than random. Further, molecular-based data are not sufficiently different across analyzed specimens to recognize different species, especially without supporting biological data. Therefore, we conclude that there is 1 *Scirtothrips* species, *S. citri*, that exhibits high levels of morphological intraspecific variation and these variants sympatrically inhabit young mango leaves in Mexico.

All specimens that have been studied from Mexico and California on mango and on citrus (including paratypes of 10 species in Table 1) share the essential character states of the California citrus thrips, *S. citri*. These include the uniformly pale color of the body and wings, the transverse striation of the ocellar triangle, the presence of discal microtrichia on the 8th and 9th tergites, and the absence of drepanae in males. Given the unreliability of the published data purporting to characterize the 15 species of *Scirtothrips* from mango in Mexico, and in the absence of any alternative biologically based supporting evidence, these 15 species are here formally placed into synonymy with *S. citri*. This decision has broad economic implications, because *S. citri* is not only widespread in the southern USA, it is highly polyphagous. In California in recent years, this thrips has become a pest of blueberry crops, *Vaccinium* species (Ericaceae) (Haviland et al. 2009), and has been found seriously damaging the young leaves of pistachio trees, *Pistacia vera* L. (Anacardiaceae) (J. Nay & M. Hoddle personal observation).

If taxonomy is to provide a useful service to other biologists, then the data and keys produced need to be tested independently and “ground-truthed,” preferably by reviewers prior to publication (O’Donnell & Mound 2016). The genus *Scirtothrips* is not the only major Thysanoptera genus for which publications emanating from the Universidad Nacional Autónoma de México involve problems in species recognition. Hoddle et al. (2012) pointed out that Johansen (1987) had recognized and described as a second species some of the specimens that came from a single experimental population of the predatory thrips *Leptothrips mali* (Fitch). They further indicated that some of the other *Leptothrips* species described in that 1987 paper were likely to be synonyms as these were based on the presence or absence of minor sense cones on the antennae that seemed liable to variation. Similarly, character state assessments used in Mexico to distinguish a large number of new species in the genus *Frankliniella* (references

in Johansen & Mojica-Guzman 2009) are often at variance with those considered to be valid in this genus by other authors (Nakahara 1997; Cavalleri & Mound 2012). As with the putative *Leptothrips* species, the limited biological evidence available in support of these species suggests that the reported biological diversity of Mexican thrips needs further consideration.

SYNONYMIES

Scirtothrips citri (Moulton)

Euthrips citri Moulton 1909: 119

Scirtothrips admangiferaffinis Johansen & Mojica Guzman, 1999: 34. **Syn.n.**

Scirtothrips apatztinganensis Johansen & Mojica Guzman, 1999: 37. **Syn.n.**

Scirtothrips danieltelizi Johansen & Mojica Guzman, 1999: 44. **Syn.n.**

Scirtothrips dieterenkerlini Johansen & Mojica Guzman, 1999: 44. **Syn.n.**

Scirtothrips hectorgonzalezi Johansen & Mojica Guzman, 1999: 46. **Syn.n.**

Scirtothrips mangiferaffinis Johansen & Mojica Guzman, 1999: 48. **Syn.n.**

Scirtothrips mangoaffinis Johansen & Mojica Guzman, 1999: 49. **Syn.n.**

Scirtothrips mangofrequentis Johansen & Mojica Guzman, 1999: 50. **Syn.n.**

Scirtothrips mangoinfestans Johansen & Mojica Guzman, 1999: 51. **Syn.n.**

Scirtothrips mangomolestus Johansen & Mojica Guzman, 1999: 52. **Syn.n.**

Scirtothrips mangonoxius Johansen & Mojica Guzman, 1999: 54. **Syn.n.**

Scirtothrips mangorum Johansen & Mojica Guzman, 1999: 53. **Syn.n.**

Scirtothrips martingonzalezi Johansen & Mojica Guzman, 1999: 56. **Syn.n.**

Scirtothrips novomangorum Johansen & Mojica Guzman, 1999: 58. **Syn.n.**

Scirtothrips willihennigi Johansen & Mojica Guzman, 1999: 67. **Syn.n.**

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