SYNONOMY OF FIVE *SCIRTOTHRIPS* SPECIES (THYSANOPTERA: THRIPIDAE) DESCRIBED FROM AVOCADOS (*PERSEA AMERICANA*) IN MEXICO

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ABSTRACT

The holotypes of *Scirtothrips aguacatae*, *S. kupandae*, *S. manihotifloris*, *S. tacambarensis*, and *S. uruapaniensis* were examined and compared with specimens of *Scirtothrips perseae* from Mexico, Guatemala, and California. The chaetotaxy of the pronotum and head of each of these 5 holotypes was found to fall within the range observed on specimens identified as *S. perseae* based DNA analyses and subsequent slide mounting and morphological examination of the body surface of specimens from which analyzed DNA was extracted. As a result of morphological examination and complementary DNA analyses, these 5 species are considered synonyms of *S. perseae*. This synonomy should reduce potential quarantine disputes over avocado imports from Mexico that could arise from concerns raised over the large number of *Scirtothrips* species previously considered as pests of avocados in Mexico that might inadvertently accompany imports.

Key Words: biosecurity, California, Mexico, *Persea americana*, *Scirtothrips* species, synonomy, quarantine

RESUMEN

Los holotipos de *Scirtothrips aguacatae*, *S. kupandae*, *S. manihotifloris*, *S. tacambarensis* y *S. uruapaniensis* fueron examinados y comparados con especimenes de *Scirtothrips perseae* de Mexico, Guatemala y California. Se encontró que la quetotaxia del pronoto y cabeza de cada uno de los 5 holotipos estaba entre el rango observado en especimenes identificados de *S. perseae* basado en el análisis de ADN y la subsecuente examinación morfológica de la superficie del cuerpo de los especimenes montados en placas de vidrio que fueron usados para dicho análisis de ADN. Como resultado de la examinación morfológica y los análisis de ADN complementarios, se considera que estas 5 especies son sinónimos de *S. perseae*. Esta sinónimia debe reducir las disputas potenciales de cuarantena de aguacates importados de Mexico que pueden presentarse por la preocupación de un alto número de especies de *Scirtothrips* considerados anteriormente como plagas de aguacate que pueden acompañar involuntariamente los aguacates importados de Mexico.

The genus *Scirtothrips* Shull 1909 (Thysanoptera: Thripidae) consists of very small active insects typically less than 1.5 mm in length and often pale yellow in color. Typically, these thrips breed and feed on young foliage but can occasionally be found in flowers (Hoddle & Mound 2003). Often large populations of a single species are taken from a single host plant, and it is very uncommon to find a mixture of several *Scirtothrips* species co-inhabiting a single host plant. This economically important genus includes several species that are serious pests of unrelated annual and perennial fruits, vegetables, and ornamental crops. Moreover, some of these species have demonstrated a high invasion potential, and are a serious quarantine concern for many countries (Mound & Palmer 1981; Hoddle & Mound 2003).

The genus *Scirtothrips* includes around 100 described species, and 32 of these were described primarily from avocados *Persea americana* Miller (Lauraceae) and mangos *Mangifera indica* L. (Anacardiaceae) in Mexico (Johansen & Mojica-Guzmán 1998). Species in this genus are difficult to identify because morphological characteristics (e.g., number and arrangement of pronotal setae) are highly variable within species, even among members of populations collected at the same time from the same host plant (Hoddle & Mound 2003). Additionally, many species have been described from distorted, uncleared specimens, and the resultant iridescence from body contents obscures important details on the body surface that are needed for species identification. To fully appreciate intra- and interspecific morphological variation in *Scirtothrips*, it is essential to remove the body contents so that important character states, such as surface sculpturing, distribution patterns of microtrichia and small setae, can be seen readily. Consequently, excellent slide mounted material is needed for taxonomic identification of *Scirtothrips* species.

For descriptions of new *Scirtothrips* species a reasonable series of cleared specimens is needed to assess intraspecific variation before meaningful and useful comparisons across species groups can be successfully attempted (Hoddle & Mound 2003; Mound & zur Strassen 2001). Superior specimen preparation is especially important to ensure accuracy and high quality detail for descriptions of new pest species from economically important crops like avocados and mangos in order to minimize the chances of inaccurate determination of new species. This is important because importing countries may impose unnecessary quarantine restrictions to minimize the risk of acquiring new pest species that have been inaccurately determined and described from poorly prepared specimens. Quarantine blockades of this kind are reasonable and should be expected. However, disputes may be unnecessary if the described species at the center of quarantine arguments have poor taxonomic accuracy and low biological validity.

Scirtothrips perseae Nakahara is the primary thrips pest of avocados in California U.S.A., causing millions of dollars ($US) in crop loses and increased management costs annually (Hoddle et al. 2003). At time of discovery in California in 1996, this pest was an undescribed species and its country of origin unknown. Subsequent detailed study of morphology and comparison to known *Scirtothrips* species in North and Central America resulted in the determination that this was a new species, which led to the description and naming of this pest as *S. perseae* (Nakahara 1997).

Because of the severe economic impact *S. perseae* has had on Californian avocado production, exploration for this pest was undertaken in neighbouring countries with avocado industries. The objectives were to determine the home range of this pest, to prospect for natural enemies, and to collect material for DNA analyses to determine species limits and to more accurately pinpoint the area of origin of this pest within the delineated home range. The morphological examination of approximately 800 slide-mounted specimens, collected during surveys in Mexico and Guatemala, revealed that *S. perseae* is native to high altitude areas in these 2 countries, and appears to be extremely host specific. It has been found only in California, Mexico, and Guatemala, and the only known breeding host is *P. americana*, the avocado. Using DNA techniques, a molecular key to pest species of *Scirtothrips* was developed (Rugman-Jones et al. 2006), microsatellites for *S. perseae* were characterized (Rugman-Jones et al. 2005), and results of microsatellite and mitochondrial DNA analyses have indicated that the area of origin for the source population that invaded California was most likely Coatepec-Harinas in Mexico (Rugman-Jones et al. 2007). Complementary DNA analyses of 2 gene regions (COI and D2) have indicated that widely separated and isolated populations of *Scirtothrips* collected from avocados throughout Mexico and Guatemala represent just the 1 species, *S. perseae* (Rugman-Jones et al. 2007).

In the light of these findings, the description by Johansen & Mojica-Guzmán (1998) of 5 species of *Scirtothrips* from avocados (*S. aguacatae*, *S. kupandae*, *S. manihotifloris*, *S. tacambarensis*, and *S. uruapaniensis*) is perplexing. With the recent legalization of fresh avocado imports into California from Mexico the risk of quarantine disputes between the U.S.A. and Mexico over pest species is likely to increase. Consequently, the high number of putative native *Scirtothrips* species infesting avocados described by Johansen & Mojica-Guzmán (1998) could possibly cause quarantine concerns for countries importing fresh Mexican avocados.

Johansen & Mojica-Guzmán (1998) separated the 5 species indicated above on the basis of differences in the arrangement of setae on the pronotum. These 5 species were included within a "*citri*-assemblage" of 14 species of which 11 were described as new species. Membership in this "*citri*-assemblage" was based on the median setae on the pronotum arising in "a straight line, either continuous or with a median gap". This condition was contrasted with these setae arising "with 1-2 posterior displaced setae". Mound & zur Strassen (2001) pointed out that the number and position of the median setae on the pronotum was variable among specimens of *S. perseae* from California, and suggested that the validity of several of the species described from Mexico needed further substantiation. The purpose of this paper is to report new observations on the original specimens of the 5 *Scirtothrips* species described from avocados in Mexico, and to consider the biological reality of these species.

Materials and Methods

Material Examined

Scirtothrips aguacatae Johansen and Mojica-Guzmán: holotype female, Mexico, Michoacán, Tacámbaro, May 16, 1991, in flowers of *Manihot aesculifolia*.

Scirtothrips kupandae Johansen and Mojica-Guzmán: holotype female, Mexico, Michoacán, Tacámbaro, May 16, 1991, in flowers of *Manihot aesculifolia*.

Scirtothrips manihotifloris Johansen and Mojica-Guzmán: holotype female, Mexico, Michoacán, Tacámbaro, May 16, 1991, in flowers of *Manihot aesculifolia*.

Scirtothrips tacambarensis Johansen and Mojica-Guzmán: holotype female, Mexico, Michoacán, Tacámbaro, May 16, 1991, in flowers of *Manihot aesculifolia*.

Scirtothrips uruapaniensis Johansen and Mojica-Guzmán: holotype female, Mexico, Micho-

acán, km 7 on road Uruapan-Nuevo San Juan Parangaricutiro, Sep 1-4, 1992, from young foliage of *P. americana*.

Paratypes of these 5 species have not been reexamined, but most of the paratypes were collected from *P. americana* (Johansen & Mojica-Guzmán 1998).

In addition to these holotypes, the following slide mounted specimens of *S. perseae* have been studied: California 292; Mexico 361; Guatemala 411 (Hoddle et al. 2002; Rugman-Jones et al. 2007). The exoskeletons of specimens of *S. perseae* collected from California, Mexico, and Guatemala from which DNA had been extracted and analyzed were subsequently mounted onto slides for morphological examination following methods outlined by Rugman-Jones et al. (2006, 2007). The pronotum of the holotypes of *S. agucatae*, *S. kupandae*, *S. manihotifloris*, *S. tacambarensis*, and *S. uruapaniensis* were digitally photographed with a Zeis Axioskop microscope at 400x magnification and the images compiled with automontage software (Syncroscopy, Synoptic, U.K.) (Fig. 1A-E). Photography and image compilation was repeated for 4 specimens of *Scirtothrips* collected from avocados in Uruapan, Mexico, from which DNA was extracted, analyzed, and confirmed as being from *S. perseae*. The resultant cadavers from DNA extraction were cleared in NaOH, and subjected to a dehydrating ethanol series and clove oil before mounting in balsam on glass slides (Mound & Marullo 1996 for details on slide mounting thrips). The photographs of *S. perseae* (Fig. 2A-D) are used here for comparison to the 5 holotype species described from Mexico (Fig. 1A-E).

Results and Discussion

It is important to note that the holotypes of the first 4 of these new *Scirtothrips* species, *S. aguacatae*, *S. kupandae*, *S. manihotifloris*, and *S. tacambarensis*, were collected on the same date, at the same locality, and from the same plant species. As noted previously, it is very unusual to collect more than 2 different species of *Scirtothrips* together on the same plant at the same time. Based on the identification key provided by Johansen & Mojica-Guzmán (1998), the holotypes of *S. aguacatae* and *S. manihotifloris* will key to *S. citri*, in view of the arrangement of pronotal setae (i.e., pronotal median transverse setal row regularly continuous) (Fig. 1A, C) and position of pair III of the ocellar setae (i.e, ocellar setae III arising on the margin of the ocellar triangle). However, *S. citri*, the Californian citrus thrips, does not have the tergal antecostal ridges dark as in these specimens. The variation in position of setae is apparent in the original illustrations provided by Johansen & Mojica-Guzmán (1998). For example, the illustrations of both *S. aguacatae* and *S. manihotifloris* (see original Figs. 18 and 20 of the holotypes in Johansen & Mojica-Guzmán 1998), indicate that 1 ocellar seta is on the margin of the ocellar triangle but the other is within the triangle. The pronotal chaetotaxy of these 2 holotypes falls (see Fig. 18 *S. manihotifloris* and Fig. 20 *S. aguacatae* in Johansen & Mojica-Guzmán 1998) within the range of variation found in specimens of *S. perseae* collected from avocados in California, Guatemala, and Mexico, which have been confirmed as being *S. perseae* by DNA analyses (Fig. 2A-D). Further, comparison of the position of ocellar setae III of these 2 holotypes also show variation that is consistent with *S. perseae* (see original Figs. 10 and 127 for *S. perseae* in Johansen & Mojica-Guzmán 1998). Consequently, there is no reason to consider that *S. aguacatae* and *S. manihotifloris* represent any species other than *S. perseae*.

Scirtothrips kupandae was distinguished because the pronotum has a wide gap (21.5 mm) in the transverse row of setae, and the pronotum was stated to be "without subanteromarginal setae". However, examination of the holotype has confirmed that the original illustration Fig. 11 of Johansen & Mojica-Guzmán (1998) is correct in showing the presence of 2 subanteromarginal setae (Fig. 1B). No other characters have been observed on this holotype that would distinguish *S. kupandae* from *S. perseae*.

Scirtothrips tacambarensis was distinguished by Johansen & Mojica-Guzmán (1998) because of the presence of 4 setae in the median transverse row on the pronotum, and also the presence of 1 subanteromarginal seta (Fig. 1D). Johansen & Mojica-Guzmán (1998) provide no clear definition or illustration of what constituted either the median row of setae, or the subanteromarginal setae. Further, the precise position of the pronotal setae is highly variable between individual *Scirtothrips* from the same population (Fig. 2A-D). Thus, *S. tacambarensis* can not be distinguished morphologically from *S. perseae*.

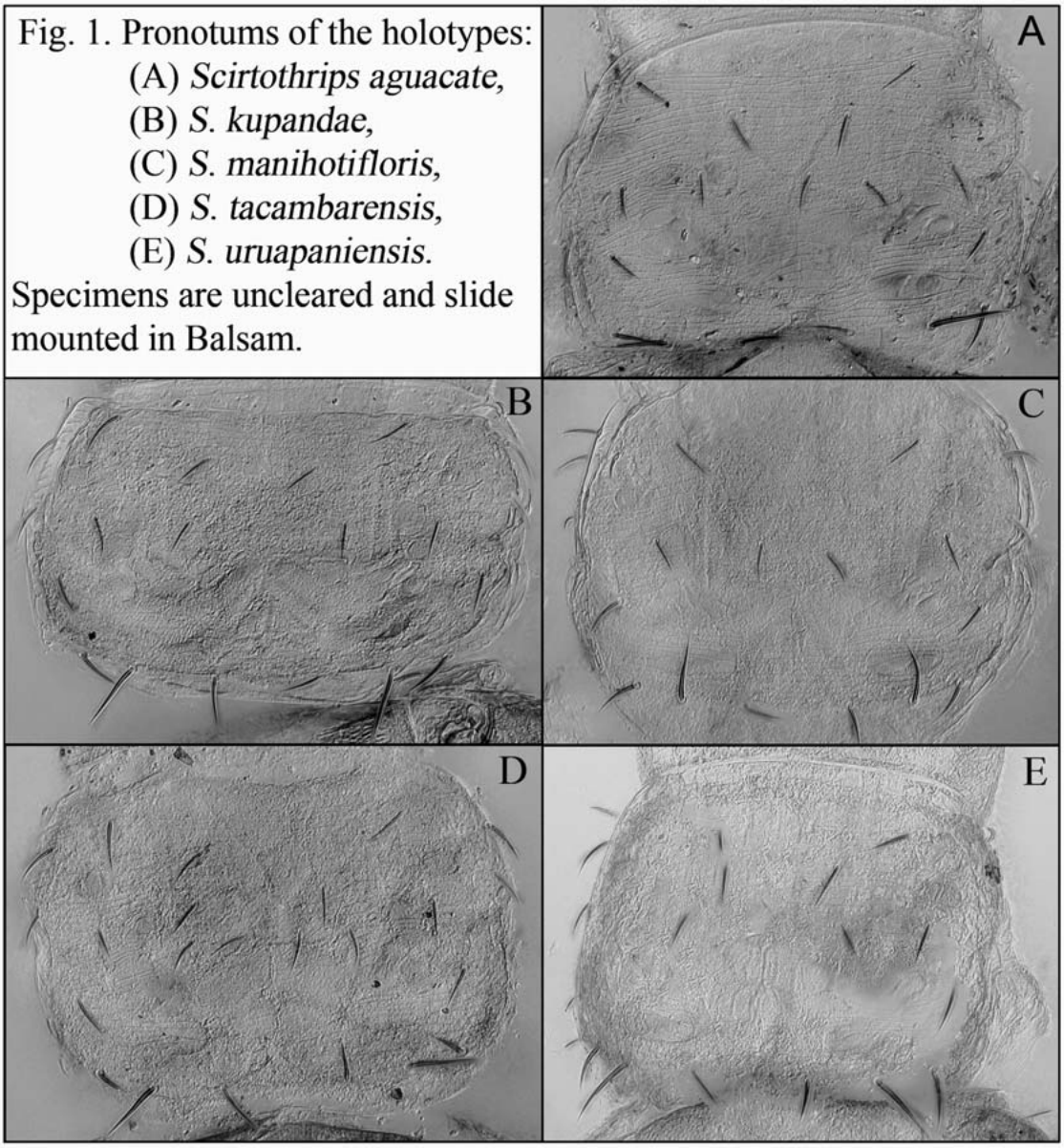
Scirtothrips uruapaniensis was based on 2 specimens, the holotype listed above and a female paratype taken from *Mangifera*. This species was distinguished because there is a broad gap in the transverse row of median setae on the pronotum, that is, there are only 2 setae in this transverse row instead of 4 (Fig. 1E). This interrupted condition of transverse pronotal median setae occurs in specimens of *S. perseae* from populations in Guatemala, California, and Mexico (Fig. 2B), making it impossible to distinguish *S. uruapaniensis* as a species distinct from *S. perseae*.

It is proposed here that *S. aguacate*, *S. kupandae*, *S. manihotifloris*, *S. tacambarensis*, and *S. uruapaniensis* be synonomized with *S. perseae*.

Scirtothrips perseae Nakahara

Scirtothrips perseae Nakahara, 1997: 189-192

Scirtothrips aguacatae Johansen and Mojica-Guzmán, 1998: 34-36 *syn.n*.



Scirtothrips kupandae Johansen and Mojica-Guzmán, 1998: 47-48 *syn.n.*

Scirtothrips manihotifloris Johansen and Mojica-Guzmán, 1998: 55-56 *syn.n.*

Scirtothrips tacambarensis Johansen and Mojica-Guzmán, 1998: 62-63 *syn.n.*

Scirtothrips uruapaniensis Johansen and Mojica-Guzmán, 1998: 66 *syn.n.*

Conclusions

The lack of significant structural differences between the 5 holotypes of *Scirtothrips* described from Mexico that have been examined for this study, apart from differences that are known to be naturally variable within *S. perseae*, and the fact that each of these Mexican species falls within the known range of structural variation of *S. perseae* as confirmed by DNA analyses, leads to the conclusion that these 5 species associated with avocados are all the same species, *S. perseae*. The formal synonymies listed above must raise further doubts concerning the biological reality of the other "new species" of *Scirtothrips* described in Johansen & Mojica-Guzmán (1998), of which 18 were collected from *Mangifera indica*, a plant not native to Mexico. However, there will be no pressure to consider the validity of those species until

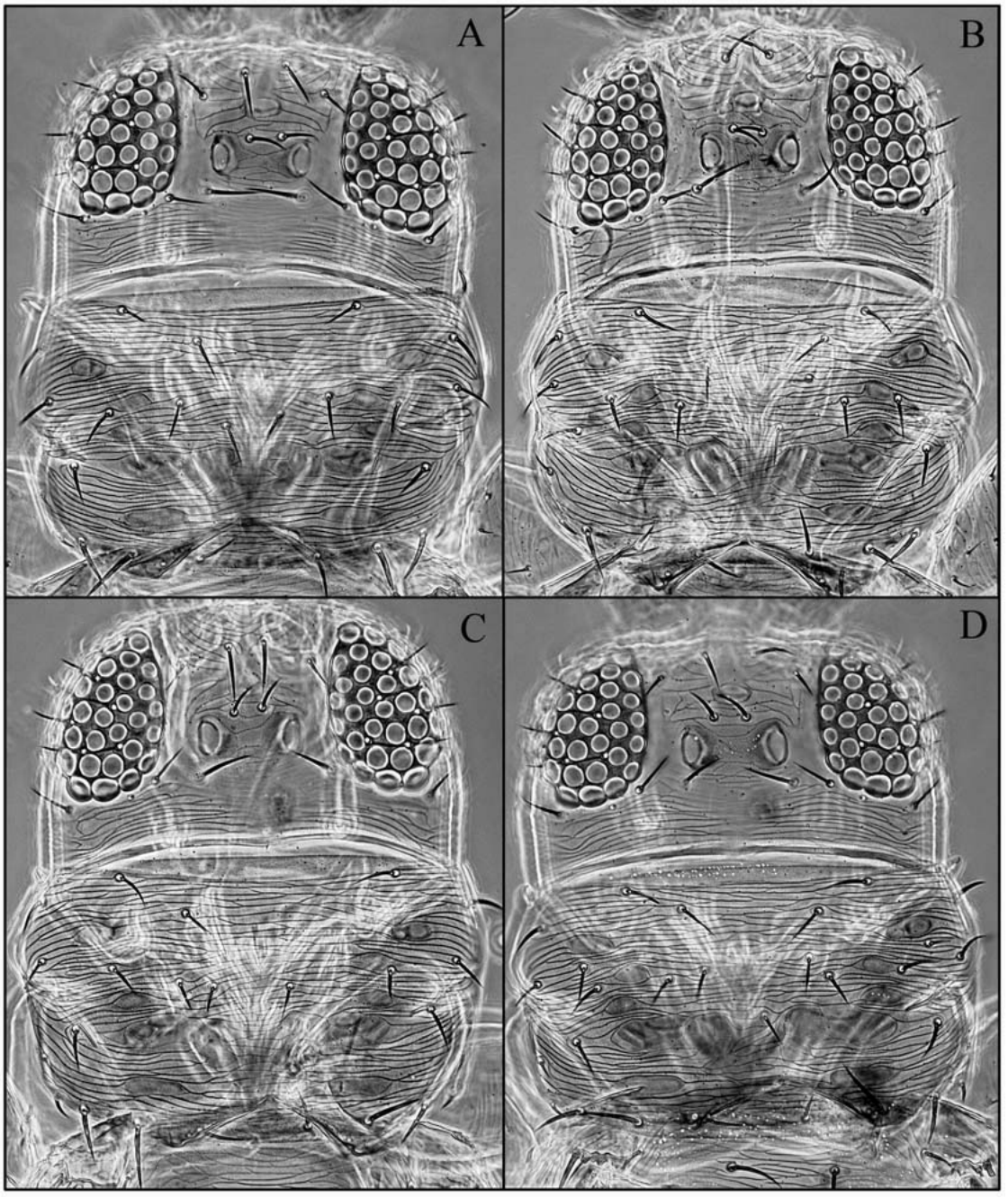


Fig. 2. The head and pronotum of 4 NaOH cleared and balsam mounted *Scirtothrips perseae* females collected from avocados in Uruapan Mexico with species identity confirmed by DNA analyses.

such time as the quarantine service of a potential importing country for Mexican mangos raises concerns over potential risks to biosecurity that could be caused by such a large number of different pest species of *Scirtothrips* contaminating imports.

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