

Species of *Frankliniella* Trybom (Thysanoptera: Thripidae) from the Asian-Pacific Area

Chin-Ling Wang*, Feng-Chyi Lin, Yi-Chung Chiu, and Hsien-Tzung Shih

Applied Zoology Division, Taiwan Agricultural Research Institute, 189 Chung-Cheng Road, Wufeng, Taichung 413, Taiwan

(Accepted May 11, 2010)

Chin-Ling Wang, Feng-Chyi Lin, Yi-Chung Chiu, and Hsien-Tzung Shih (2010) Species of *Frankliniella* Trybom (Thysanoptera: Thripidae) from the Asian-Pacific area. *Zoological Studies* 49(6): 824-838. Fifteen species of the genus *Frankliniella* have been recorded from the Asian-Pacific area including China, Japan, Korea, Taiwan, Thailand, the Philippines, India, Hawaii, Australia, and New Zealand. These are *F. cephalica* (Crawford), *F. fusca* (Hinds), *F. gilva* Lee and Woo, *F. hemerocallis* Crawford, *F. insularis* (Franklin), *F. intonsa* (Trybom), *F. invasor* Sakimura, *F. lantanae* Mound et al., *F. lilivora* Kurosawa, *F. minuta* (Moulton), *F. occidentalis* (Pergande), *F. schultzei* (Trybom), *F. tenuicornis* (Uzel), *F. williamsi* Hood, and *F. zizaniophila* Han and Zhang. A key is provided to these species, together with a brief diagnosis, host plant list, and distribution for each one. <http://zoolstud.sinica.edu.tw/Journals/49.6/824.pdf>

Key words: Thysanoptera, Thripidae, *Frankliniella*, Review, Asia-Pacific.

The genus *Frankliniella* was erected by Karny in 1910 in the form of a footnote, and the type species, *Thrips intonsa* Trybom, was subsequently designated by Hood (1914). Moulton (1948) provided a key to the 148 species he recognized, although this was based in part on information from publications. He divided this large genus into 3 groups, the Minuta, Intonsa, and Tritici-Cephalica groups, and distinguished them basically according to the lengths of the major setae, and the shape of the pedicel on the 3rd antennal segment. Furthermore, he recognized 3 series within the Intonsa group (Intonsa, Insularis, and Tenuicornis), and 2 series within the Tritici-Cephalica group (Tritici and Cephalica).

Sakimura and O'Neill (1979) redefined the genus *Frankliniella* Karny based on the pattern of abdominal ctenidia and associated setae. The redefined genus included species that were previously misplaced or unrecognized. Those authors then revised the Minuta group

of 25 species, of which 11 had previously been described.

Jacot-Guillarmod (1974) listed 144 valid *Frankliniella* species in a world catalogue, and Nakahara (1997) added 159 species to this list. Most of those (151 species) were native to the Americas (Nakahara 1997), with many being Neotropical (Mound and Marullo 1996). Mound (2010) updated the member species of *Frankliniella* to 230 on a website of checklist of world thrips.

In this paper, an identification key based on female character states is presented that includes 15 species of *Frankliniella* recorded from the area between China, India, Hawaii, and New Zealand. The distributions of these species indicated here are cited from Nakahara (1997) unless otherwise stated. Distributions of these species among the countries considered here are given in table 1. To facilitate identification of *Frankliniella* in this area, closely related species were compared, and differences are summarized under "Remarks".

*To whom correspondence and reprint requests should be addressed. Fax: 886-4-23317600. E-mail: clwang@tari.gov.tw

MATERIALS AND METHODS

This paper is based on specimens and the published literature. Characteristics of females were used for species diagnosis and an identification key. Specimens examined were from the authors' collections deposited at the Taiwan Agricultural Research Institute (TARI), Taichung, Taiwan, or borrowed from other institutes.

Origins of the slides are shown with the following abbreviations: CSIRO, Australian National Insect Collection, CSIRO Entomology, Canberra, Australia; TARI, Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan; USNM, Smithsonian Institution, National Museum of Natural History, Washington, DC, USA; and YPPS, Yokohama Plant Protection Station, Yokohama, Kanagawa, Japan.

Table 1. Distribution of *Frankliniella* species in the Asian-Pacific area

Species	Taiwan (Wang 2000 2002)	China (Han 1997)	Japan (Nakahara and Hilburn 1989, Masumota and Okajima 2004)	Korea (Woo 1974, Chou et al. 2001)	The Philippines (Reyes 1994)
<i>cephalica</i>	+		+		
<i>fusca</i>					
<i>gilva</i>				+	
<i>hemerocallis</i>			+		
<i>intonsa</i>	+	+	+	+	+
<i>insularis</i>					
<i>invasor</i>					
<i>lantanae</i>					
<i>lilivora</i>			+	+	
<i>minuta</i>					
<i>occidentalis</i>		+	+	+	+ ^a
<i>schultzei</i>	+				+
<i>tenuicornis</i>		+	+	+	
<i>williamsi</i>	+				+
<i>zizaniophila</i>		+			

Species	Thailand (Bansiddhi and Poonchaisri 1991)	India (Anan. and Sen 1980, Bhatti 1992)	Hawaii (Sakimura 1972)	Australia (Mound 1996, Mound and Houston 1987)	New Zealand (Mound and Walker 1982)
<i>cephalica</i>					
<i>fusca</i>			+		
<i>gilva</i>					
<i>hemerocallis</i>			+		
<i>intonsa</i>	+	+			
<i>insularis</i>		+?			
<i>invasor</i>			+		
<i>lantanae</i>				+	
<i>lilivora</i>					
<i>minuta</i>			+		
<i>occidentalis</i>	+ ^a		+	+	+
<i>schultzei</i>		+	+	+	
<i>tenuicornis</i>					
<i>williamsi</i>	+		+	+	
<i>zizaniophila</i>					

^a*occidentalis* from Thailand and the Philippines was by interception records of Taiwan. Other intercepted Southeast Asian countries included Indonesia, Malaysia, Singapore, and Vietnam.

Frankliniella Karny

Frankliniella Karny 1910: 46.

Type species: Thrips intonsa Trybom, 1914.

Diagnosis: Wings usually present, rarely apterous. Antennae usually 8-segmented, segments III and IV each with a forked sense cone. Head usually wider than long, ocellar setae I present, setae III (interocellar setae) variable in position, 4 or 5 pairs of postocular setae. Pronotum with 2 pairs of long setae on anterior margin (anteromarginal and anteroangulars), and 2 pairs of long posteroangulars; posterior margin with longer submedian pair of setae. Metanotal median setae arising at anterior margin of this sclerite. Macropterous, with complete rows of setae on both 1st and 2nd veins. Tarsi 2-segmented. Abdominal tergite II with 3 lateral marginal setae, a 4th seta on extreme anterior angle of pleurotergite; tergites V (rarely IV)-VIII with paired lateral ctenidia, on VIII anterolateral to spiracles; sternite I with 3 small anteromedian setae; sternites III-VII without discal setae. Male smaller than female and usually lighter in color, sternites III-VII with glandular areas which vary in size and form.

Frankliniella cephalica (DL Crawford) (Figs. 1, 2)

Euthrips cephalicus DL Crawford 1910: 153.
Frankliniella cephalica Karny 1912: 335.

Specimens examined: TAIWAN, Pingtung: 11 ♀♀, Kenting, grass, 20 Aug. 2000; 6 ♀♀, seashore of Kenting, *Cascuta australis*, 20 Aug. 2000; 3 ♀♀, Nanjen Lake, Kenting, *Mikania cordata*, 20 June 2001; 1 ♀, Nanjen Lake, Kenting, *Miscanthus transmorrisonensis*, 22 June 2001 (TARI); JAPAN: 2 ♀♀, 1 ♂, Ryukyu Is., *Bidens pilosa* (Compositae), 20 June 2008, coll. S. Kimura, det. M. Masumoto (YPPS).

Diagnosis: Female macroptera. Body yellow, some individuals with brownish head and thorax, major setae dark; antennal segment I yellow, II and III yellow with brown distal 1/2, IV brown with yellow basal 1/3, V yellow with brown distal end, VI-VIII brown. Antennal segment II with 2 stout dorsal distal setae each situated on a projection, III with a sharp-ridged pedicel ring. Ocellar setae III situated on edge of ocellar triangle, postocular setae i-iii about same length, setae iv longer, about 2/3 length of ocellar setae III. Metanotum with paired campaniform sensilla. Posterior comb on

tergite VIII with a few teeth on lateral, lacking in middle.

Host plants: *Cascuta australis*, *Mikania cordata*, *Miscanthus transmorrisonensis* (Taiwan), *Bidens pilosa* flower, *Ipomoea batatas* (L.) (Masumoto and Okajima 2004) *indica*, *Ligustrum arboretum*, and a wide range of flowers (Mound and Marullo 1996).

Distribution: Taiwan (new record), Japan (Masumoto and Okajima 2004); Bermuda, Caribbean islands, Central America, Mexico, USA.

Remarks: This is a species with quite-obvious characteristics. The protrusion of antennal segment II easily distinguishes it from other species in the Asian-Pacific area. It occurs in large numbers on weeds. There is no report of damage to crops.

Frankliniella fusca (Hinds) (Figs. 3, 9)

Euthrips fuscus Hinds 1902: 154.
Frankliniella fusca Karny 1912: 332.

Specimens examined: 1 ♀, US: Illinois,



Fig. 1. Projections on antennal segment II of *Frankliniella cephalica*.

sweeping grass, 25 June 1994; 1 ♀, Illinois, white clover flower, 27 June 1994; 1 ♂, Maryland, composite, 5 Nov. 1991 (USNM).

Diagnosis: Female macroptera. Body dark brown to pale brown, but never yellow, head and thorax usually lighter than abdomen; antennal segments brown with lighter basal segments. Ocellar setae III arising on margins, or a little outside of ocellar triangle; all postocular setae small. Posteromarginal comb on tergite VIII reduced on lateral and lacking in middle.

Brachyptera: Both sexes with brachypterous individuals, wings reduced to pads. Thorax sometimes yellow to light yellowish-brown. Ocelli reduced in size or absent.

Host plants: *Tradescantia*, *Gladioli*, tobacco, peanuts (Stannard 1968), *Narcissus* flowers (Sakimura 1972).

Distribution: Canada, Martinique, Mexico, the Netherlands, Puerto Rico, USA (including Hawaii).

Remarks: This species is a vector of Tomato Spotted Wilt Virus (TSWV). Moreover, it is an important pest of several crops such as tobacco and peanuts in the eastern US.

***Frankliniella gilva* Lee and Woo**

Frankliniella gilva Lee and Woo 2002: 200-204.

Diagnosis: Female macroptera. Body uniformly pale yellow; antennal segments I-V yellow; forewing not shaded; head between eyes prominently prolonged; ocellar setae III well developed and inserted just out of ocellar triangle; pronotum disc almost smooth without median setae; without mesosternal spinula; posterior comb on abdominal tergite VIII complete but almost without teeth on broad and triangular bases.

Host plants: On leaves of Gramineous plants including *Miscanthus sinensis* Andersson.

Distribution: Korea.

Remarks: This species is closely related to *F. tenuicornis*, as both species have a prolonged head. The latter can be easily distinguished from the former by the dark brown body, and presence of mesosternal spinula.

***Frankliniella hemerocallis* Crawford**

(Fig. 15)

Frankliniella hemerocallis JC Crawford 1948: 83.

Specimens examined: 1 ♀ paratype, US: Wisconsin: Lake Geneva, *Hemerocallis*, 7 June

1944 (USNM).

Diagnosis: Female macroptera. Body dark brown; antennal segments III and IV and basal 1/2 of V yellow. Ocellar setae III long, arising on margin of ocellar triangle; all postocular setae short, pair iv no longer than diameter of hind ocellus. One pair of short setae between anteromarginal major setae. Metanotum without campaniform sensilla. Posteromargin of tergite VIII with complete row of teeth from triangular base, a few teeth in middle very short or absent from triangular bases. Tergite X constricted posteriorly.

Host plants: *Hemerocallis* (day-lilies) (Sakimura 1972).

Distribution: Bermuda, Costa Rica, Japan, USA (including Hawaii).

Remarks: It is close to *F. intonsa*, as both have seasonal body color variations. The arrangement and shape of the posteromarginal comb on tergite VIII can be used to distinguish these species, as indicated in the key.

***Frankliniella insularis* (Franklin)**

(Figs. 4, 22)

Frankliniella insularis Karny 1912: 334.

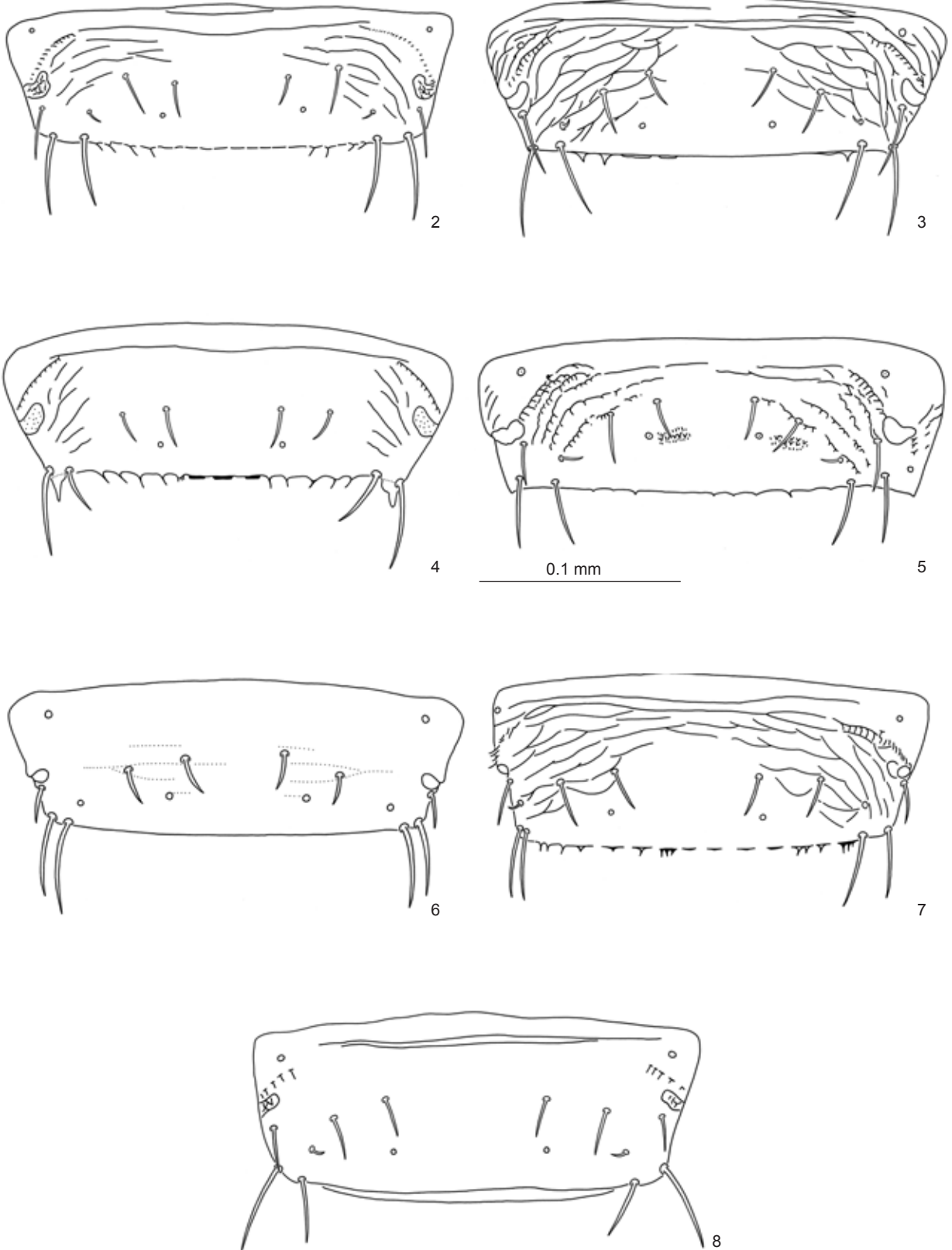
Specimens examined: 2 ♀ ♀, US: Florida: Panama City, *Castilla elastica*, May 2000 (CSIRO).

Diagnosis: Female macroptera. Body dark brown; antennal segment III and basal 1/2 of IV and V yellow; forewing brown with transparent base. Ocellar setae III arising on outer margin of ocellar triangle; postocular setae iv long, about 1/2 of ocellar setae III. Metanotum with paired campaniform sensilla. Posteromarginal comb on tergite VIII with 2 or 3 teeth missing medially.

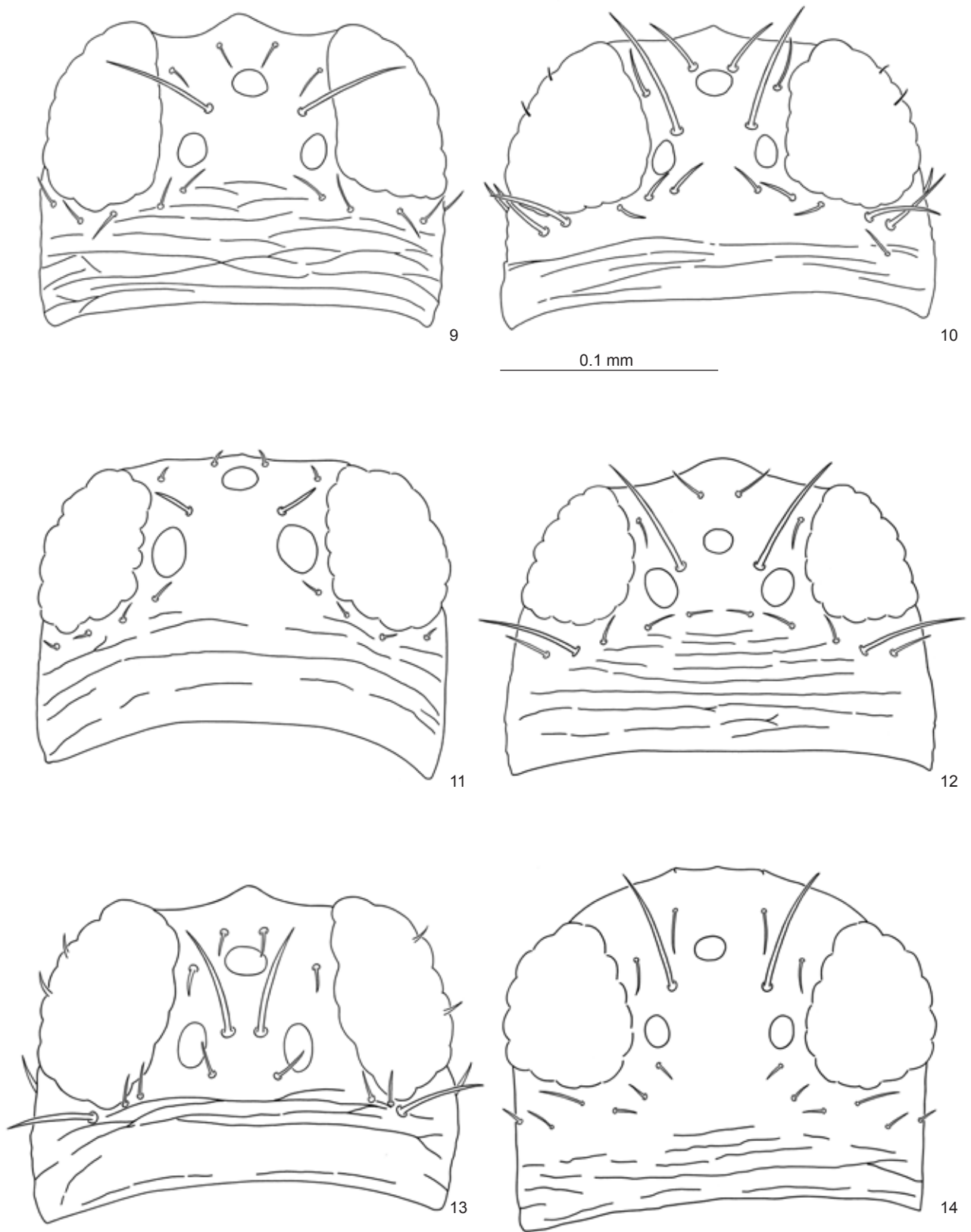
Host plants: *Lupinus*, *Convolvulus*, Compositae, and *Rhamnus*, also less important leguminous crops, *Cajanus*, and *Pachyrhizus* (Mound and Marullo 1996).

Distribution: Argentina, Bermuda, Brazil, Caribbean islands, Colombia, Central, America, Guyana, Mexico, Peru, Trinidad, the USA, Venezuela, India (Ananthakrishnan and Sen, 1980), Fiji, Singapore (Mound 2009, pers. comm.).

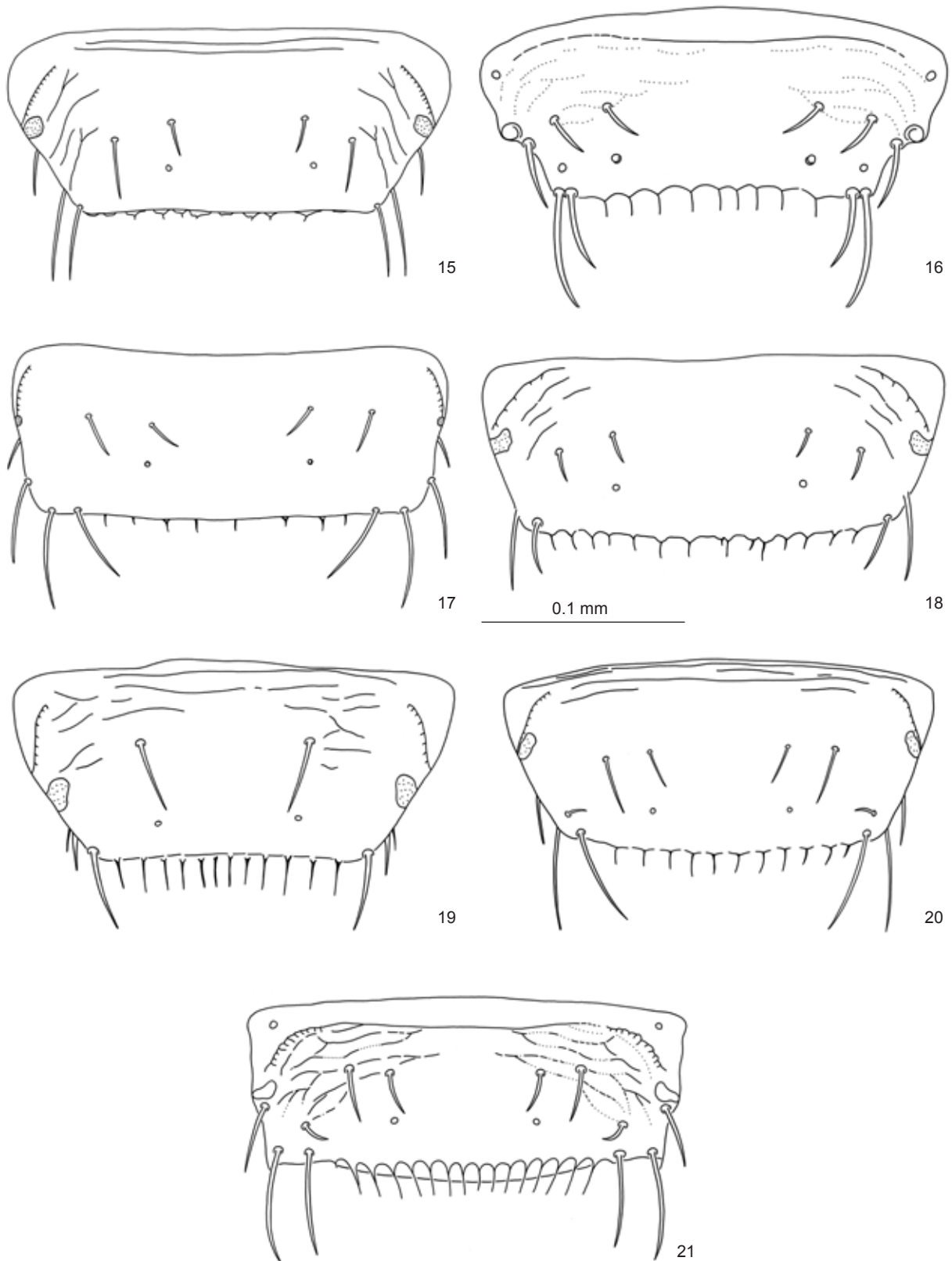
Remarks: Similar to *F. unicolor*, the existence of this species in India may be uncertain. It was listed from India by Ananthakrishnan in publications in both 1954 and 1980, and in the latter publication was included in a key with a comparatively detailed description. However, this species is also distributed in Fiji (in the Australian National Insect Collection, Canberra, Mound 2009, pers. comm.).



Figs. 2-8. Abdominal tergite VIII with incomplete (or lacking) posteromarginal comb: **2.** *Frankliniella cephalica*, **3.** *F. fusca*, **4.** *F. insularis*, **5.** *F. lilivora*, **6.** *F. schultzei*, **7.** *F. tenuicornis*, **8.** *F. zizaniophila*.



Figs. 9-14. Head: 9. *Frankliniella fusca*, 10. *F. intonsa*, 11. *F. minuta*, 12. *F. occidentalis*, 13. *F. schultzei*, 14. *F. tenuicornis*.



Figs. 15-21. Abdominal tergite VIII with complete posteromarginal comb: **15.** *Frankliniella hemerocallis*, **16.** *F. intonsa*, **17.** *F. invasor*, **18.** *F. lantanae*, **19.** *F. minuta*, **20.** *F. occidentalis*, **21.** *F. williamsi*.

***Frankliniella intonsa* (Trybom)**

(Figs. 10, 16, 24, 28)

Thrips intonsa Trybom 1895: 188.*Frankliniella intonsa*: Karny 1912: 336.

Specimens examined: This is a common species in Taiwan, found on flowers of various plants, and occasionally causes damage. About 200 females and males were examined; R. Takahashi's slides kept at TARI include: 20 ♀♀ on 2 slides, sugarcane, Jan. 1930 (coll. Yanagihara); 30 ♀♀, 1 ♂ on 2 slides, Tainan, citrus, May 1933 (coll. Oshima).

Diagnosis: Female macroptera. Body color varied, head and thorax grayish-brown with brown abdomen; or head and thorax brown with grayish-brown abdomen; or head, thorax, and abdomen all

brown or all yellowish. Antennal segments I and II brown, III yellow, IV and V with yellow basal part and brown distal part, VI-VIII brown. Ocellar setae III situated on inner margin of ocellar triangle; postocular setae pair iv about 2/3 length of ocellar setae III. Metanotum without campaniform sensilla. Tergite VIII with a complete posteromarginal comb, microtrichia short and arising from triangular base.

Host plants: Highly polyphagous species, host plants include cucurbits, legumes, lettuce, onion, corn, and various floricultural crops.

Distribution: Asia: Bangladesh, China, India, Israel, Japan, Korea, Malaysia, Mongolia, Pakistan, the Philippines, Taiwan, Thailand, Turkey; Europe: Russia; North America: Canada, the USA.

Remarks: *Frankliniella intonsa* is a pest species, found on flowers of various herbs and woody plants. This species causes damage to plant tissues both by feeding and laying eggs into plant surface cells. The surface injury on newly formed fruits may enlarge as the fruits grow and eventually become significant brown scars. This species is widely distributed in the Asian-Pacific area. Its occurrence and feeding habits are similar to those of *F. occidentalis*.

Characteristics for separating *F. intonsa* from *F. occidentalis* are 1) the length of antennal segment VIII is twice the length of segment VII in the latter species; 2) pronotum with 2 small setae between the anteromarginal major setae in the former species, but usually 4 (rarely fewer) setae in the latter species; 3) metanotal campaniform sensilla absent in the former species but present in the latter species; and 4) postocellar setae iv shorter than ocellar setae III in the former species but about the same length in the latter species. The lengths of postocular and ocellar setae III are sometimes not easy to determine with specimens on slides.

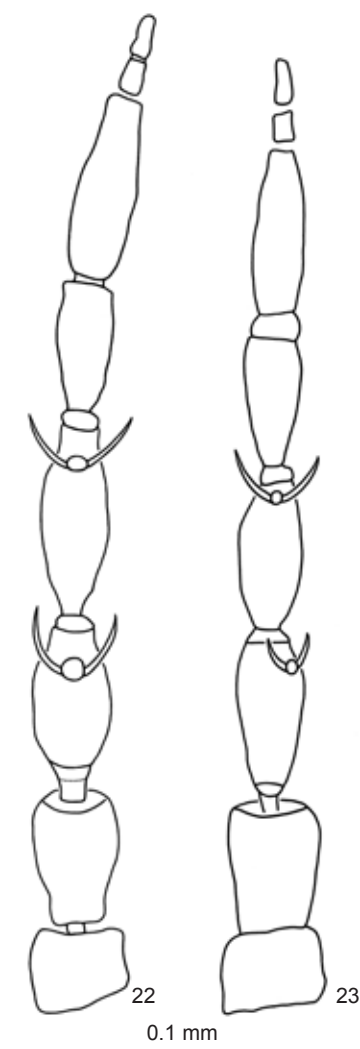
***Frankliniella invasor* Sakimura**

(Figs. 17, 25, 30)

Frankliniella invasor Sakimura 1972: 263.

Specimens examined: 1 paratype ♀ (#4675-1), US: Hawaii: Kahuku, Oahu, flower of *Leucaena glauca*, 27 Sept. 1966 (USNM).

Diagnosis: Female macroptera. Body and legs yellow, abdomen with grayish-brown shading in band along antecostal ridge of tergites I-VIII, forming brown spots laterally; major setae brown; antennal segment I pale, II-IV yellow, grayish-brown on distal 3/4 of II, distal 1/3 of III, distal 3/4



Figs. 22-23. Antennal segments III-V normal: 22. *Frankliniella insularis*, 23. *F. williamsi*.

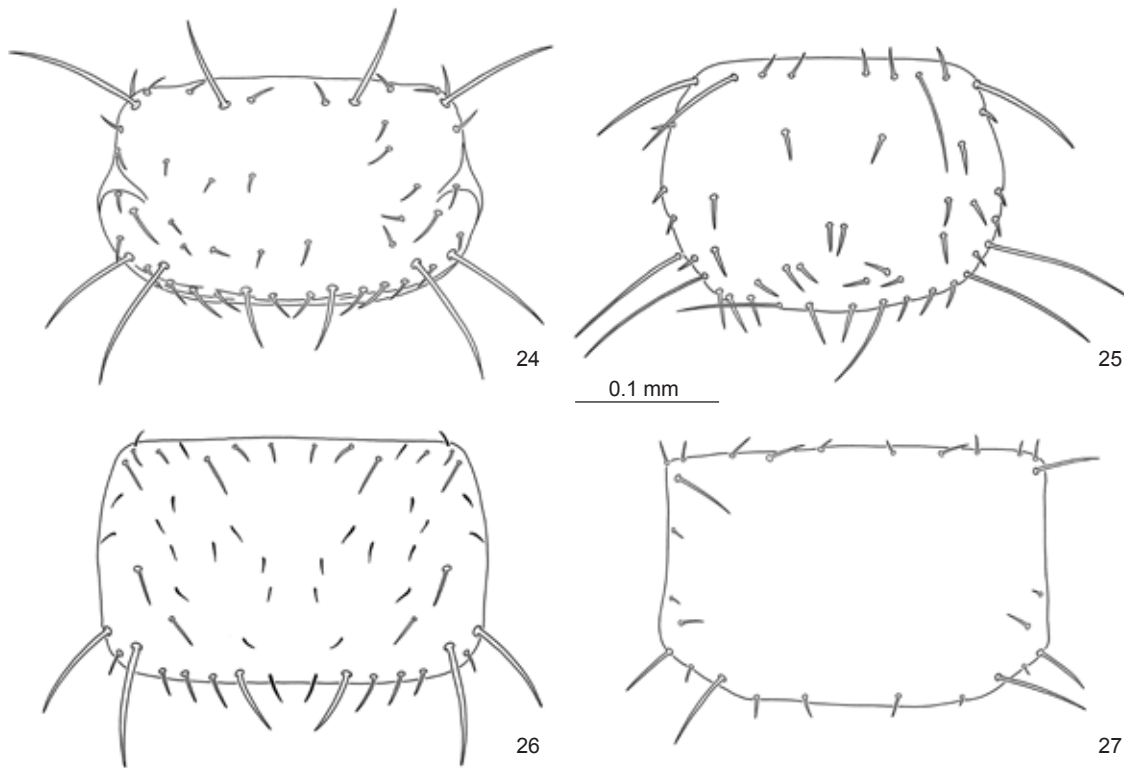
of IV, segment V yellow between brownish IV and VI, VI-VIII brown. Antennal segment II slender, 2.0-2.3 times as long as wide, pedicel of antennal segment III with sharp-edged ring. Ocellar setae III situated at edge of ocellar triangle; postocular setae iv longer, about 3/4 of length of ocellar setae III. Posteromarginal comb on tergite VIII short and fine, sparse but complete; absent in male.

Host plants: Found on flowers of *Leucaena glauca*, *Gardenia jasminoides* (Sakimura 1972),

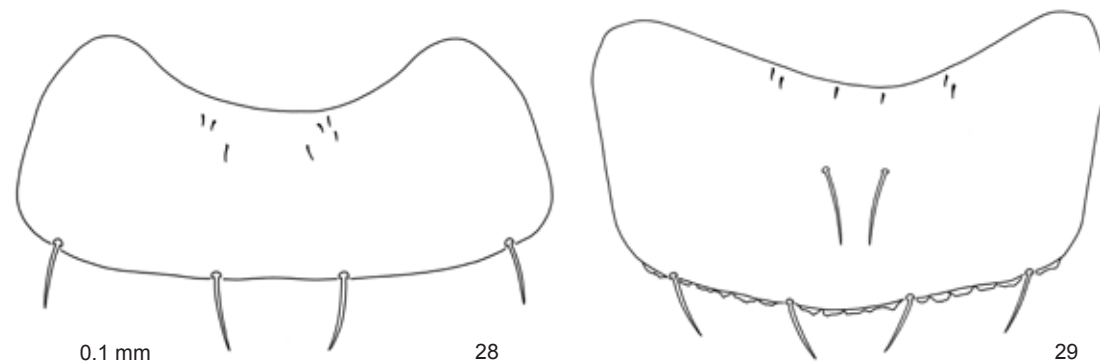
Casearia corymbosa, *Allophylus occidentalis*, coffee, *Rubus fruticosus*, *Musa*, *Lawsonia alba*, *Schwartzia simplex*, *Pseudobombax*, avocado leaves, and bananas (Mound and Marullo 1996).

Distribution: Hawaii, St. Vincent, Trinidad, Costa Rica, Guatemala, Panama, Puerto Rico.

Remarks: Sakimura (1972) described this species with 1 pair of pores (= campaniform sensilla) on metascutum, but these were not clear on the specimen observed by the present authors.



Figs. 24-27. Pronotum: 24. *Frankliniella intonsa*, 25. *F. invasor*, 26. *F. lantanae*, 27. *F. zizaniophila*.



Figs. 28-29. Abdominal sternite II: 28. *Frankliniella intonsa*, 29. *F. williamsi*.

***Frankliniella lantanae* Mound, Nakahara and Day**
(Figs. 18, 26, 32)

Frankliniella lantanae Mound et al. 2005: 279.

Specimens examined: 2 ♀♀, AUSTRALIA: Queensland, *Lantana* leaves, Mar. 2000 (CSIRO).

Diagnosis: Female macroptera. Body color varying from yellow to largely yellow with light-brown markings on fore coxae and metanotum, and laterally on mesonotum, and tergites I-VI; antennal segments I and II yellow, III-V light brown at apex, VI-VIII light brown. Antennal segments III and IV unusually short, less than 1/2 length of segment VI. Ocellar setae III arising on margins of ocellar triangle; all postocular setae small. Pronotum with anteromarginal and anteroangular major setae scarcely larger than discal setae, median posteromarginal setae i, ii, iii, and v short, iv longer; metanotum with campaniform sensilla, 1 or both sensilla sometimes modified to produce a seta; forewing unusually short. Posteromarginal comb on tergite VIII complete. Female aptera. Both sexes with apterous individuals: color similar to macroptera; ocelli not developed; median pair of setae arising well behind anterior margin.

Host plants: *Lantana*.

Distribution: Australia.

Remarks: This species, together with *F. lilivora* and *F. minuta*, is characterized by short and rounded antennal segments. However, the short anteromarginal pronotal setae make it possible to distinguish *F. lantanae* from the other 2 species. In addition, their feeding habits greatly differ: *F. lantanae* is a leaf feeder, *F. minuta* stays on

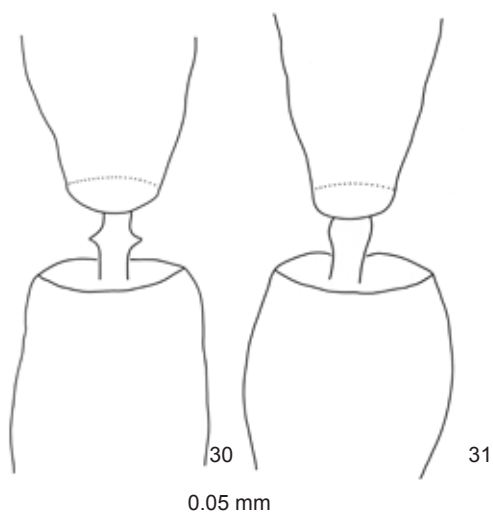
flowers as a pollen feeder, while *F. lilivora* feeds on lily bulbs.

***Frankliniella lilivora* Kurosawa**
(Fig. 5)

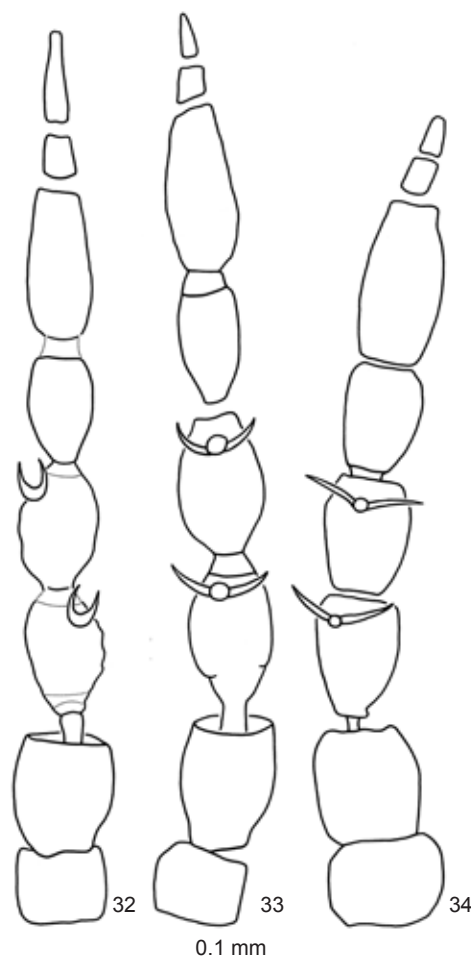
Frankliniella lilivora Kurosawa 1937: 269.

Specimens examined: 1 ♀, JAPAN: Yokohama, *Lilium* bulb, 10 Apr. 1940; 1 ♀, JAPAN: Kagoshima-ken, 3 Sept. 1968, *Lilium* bulb; 1 ♀, JAPAN, *Lilium* bulb, 25 Sept. 1968 (USNM).

Diagnosis: Female macroptera. Body yellow, major setae yellow; antennal segment I same color as head, remaining segments brown, except for yellow basal 1/4 of segment III. Ocellar setae III situated on margin of ocellar triangle; postocular setae iv long, over 3/4 length of ocellar setae III. Antennal segments I-V short and rounded. Abdominal tergite VIII without regular comb on posterior margin.



Figs. 30-31. Base of segments III: 30. *Frankliniella invasor*, 31. *F. occidentalis*.



Figs. 32-34. Antennal segments III-V short and rounded: 32. *Frankliniella lantanae*, 33. *F. minuta*, 34. *F. zizaniophila*.

Host plants: Lily bulbs (Kurosawa 1937).

Distribution: China, Japan, Korea.

***Frankliniella minuta* (Moulton)**

(Figs. 11, 19, 33)

Euthrips minutus Moulton 1907: 56.

Frankliniella minuta Karny 1912: 335.

Specimens examined: 1 ♀, USA: Hawaii: Ewa Beach, flower of *Verbesina encelioides*, 9 Dec. 1976 (USNM).

Diagnosis: Female macroptera. Body brown to dark brown; antennal segments all brown or sometimes III paler; forewing and legs brown. Antennal segments III and IV unusually short, less than 1/2 length of segment VI. Ocellar setae III short, about same length as 1 hind ocellus, arising on margin of ocellar triangle; postocular setae short. Pronotum posteromarginal setae I, III, and V short, ii and iv longer; middle of metanotum with weak reticulations, without campaniform sensilla. Posteromarginal comb on tergite VIII with long, slender microtrichia.

Host plants: Compositae flowers, *Verbesina encelioides* (Sakimura 1972), *Senecio* flowers, *Calea* flowers, *V. turbaiensis* flowers (Mound and Marullo 1996).

Distribution: Costa Rica, Guatemala, Mexico, Panama, Peru, the USA (including Hawaii).

Remarks: According to Moulton (1948), this species is the representative species of a group with minute interocellar setae, postocular setae, and pronotal setae. However, the posterior comb on tergite VIII is slender and long. The length of the setae and shape of the antennal segments distinguish this species from others.

***Frankliniella occidentalis* (Pergande)**

(Figs. 12, 20, 31)

Euthrips occidentalis Pergande 1895: 392.

Frankliniella occidentalis Karny 1912: 335.

Specimens examined: 1 ♀, 1 ♂, NEW ZEALAND, 20 Feb. 1979 (CSIRO); 5 ♀♀, 3 ♂♂, JAPAN: Shizuoka, 23 Mar. 2003; 30 ♀♀, 3 ♂♂, USA: California, flowers of various plants, 9 Aug. 1991, coll. C. L. Wang (TARI).

Diagnosis: Female macroptera. Body color varied, from brown to yellow; yellow form with brown patches on abdomen; antennal segment I yellow, II yellowish-brown, III-V yellow with brown distal end, VI-VIII brown. Antennal segment VIII twice length of VII. Ocellar setae III long, situated

on inner margin of ocellar triangle; postocular setae iv same length as ocellar setae III. Two to 4 pairs of median anteromarginal setae, metanotum with paired campaniform sensilla, occasionally without such sensilla. Posteromarginal comb on tergite VIII complete.

Host plants: Highly polyphagous, recorded on at least 244 species of 62 families (CABI, IPPO 1992).

Distribution: Asia: Israel, Japan, South Korea, China, Indonesia, Malaysia, the Philippines, Singapore, Thailand, Vietnam (footnote of Table 1); North America: Canada, the USA (including Hawaii); Central America: Costa Rica, Guatemala, Mexico, Caribbean islands, Dominican Republic, Martinique, Puerto Rico; South America: Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela; Europe and Africa: Canary Is., Kenya, South Africa; Australia; New Zealand.

Remarks: *Frankliniella occidentalis* (western flower thrips; WFT) is the most serious pest species in this genus worldwide. WFT originated from the western US, but is now widely distributed throughout the world (Kirk and Terry 2003). It is a pest on various agricultural crops, and is an important vector of tospoviruses (Peters et al. 1996). At least TSWV, tomato chlorotic spot virus (TCSV), groundnut ringspot virus (GRSV), and impatiens necrotic spot virus (INSV) were proven to be transmitted by these thrips. These viruses are recognized as limiting factors in the production of a large number of horticultural crops.

***Frankliniella schultzei* (Trybom)**

(Figs. 6, 13)

Physopus schultzei Trybom 1910: 151.

Euthrips gossypii Shiraki 1912: 56.

Frankliniella schultzei Karny 1912: 334.

Frankliniella sulphurea Schmutz 1913: 1018-1019.

Specimens examined: Dark form: 1 ♀, 4 ♂♂, TAIWAN: Taichung: Wufeng, *Ipomoea aquatica*, Oct. 1990; 1 ♀, Wufeng, *Zea mays*; 1 ♀, Wufeng, *Ipomoea nil*, Sept. 1990; Light form: 3 ♀♀, Taichung, *Thunbergia erecta*, Apr. 1990 (TARI).

Diagnosis: Female macroptera. Light form: body color light, antennal segments I-V grayish-white, end of segments III-V grayish-brown, segments VI-VIII brown, legs same color as body, wings white, transparent. Dark form: body color brown; antennae brown, base of segments III and IV yellow. Ocellar setae III arising close together between hind ocelli; postocular setae iv as long as distance between hind ocelli. Metanotum

without campaniform sensilla. Tergite VIII without posteromarginal comb, at most with a few microtrichia at each side of posterior margin.

Host plants: Flowers of legumes (Sakimura 1972), chrysanthemum, gladiolus (Mound and Marullo 1996), *Ipomoea reptans*, *I. carica*, *Allamanda cathartica*, *Zea mays*, *Salvia farinacea*, *Zephyranthes candida*, *Thunbergia erecta* (Wang 2000).

Distribution: Asia: Bangladesh, India, Indonesia, Israel, Iran, Iraq, Malaysia, Pakistan, the Philippines, Sri Lanka, Taiwan, Thailand, Yemen; Africa: Cameroon, Canary Is., Cape Verde Is., Chad, Egypt, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Mauritius, Morocco, Namibia, Nigeria, Senegal, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire, Zimbabwe; Europe: Italy, the Netherlands; Australia; Pacific area: Johnston I., Kiribati, Mariana Is., Papua New Guinea, Tahiti; Caribbean islands: Dominican Republic, Haiti, Jamaica, Puerto Rico, St. Thomas, Tortola; South America: Argentina, Brazil, Chile, Colombia, Guyana, Paraguay, Surinam, Uruguay, Venezuela; the USA (including Hawaii).

Remarks: There are individuals with light and dark body color, and these have been considered different species. The pale type is often treated as the species *F. sulphurea*. These names are currently listed as synonyms. The dark form was proven to be a valid vector of tospovirus which causes serious diseases on cucurbits.

***Frankliniella tenuicornis* (Uzel)**

(Figs. 7, 14)

Physopus tenuicornis Uzel 1895: 99.

Frankliniella tenuicornis Karny 1912: 334.

Specimens examined: 1 ♀, USA: Utah, *Zea mays*, 31 May 1938; 1 ♂, Minnesota, corn, 18 July 1956 (USNM).

Diagnosis: Female macroptera. Body brown; antennal segments I grayish-brown, II brown, III and IV yellow with light brown distal of IV, V-VIII brown with light basal of V. Head slightly prolonged in front of eyes, cheeks nearly straight and parallel; ocellar setae III long; all postocular setae short. Metanotum without campaniform sensilla. Tergite IV-VIII with lateral ctenidia (usually V-VIII of this genus); posteromargin of tergites VI and VII with row of scalloping; posteromarginal comb of tergite VIII not developed in middle, reduced to scalloping or basal small teeth.

Host plants: Corn, cattail, grasses (Stannard

1968), cereals (Jacot-Guillarmod 1974), tomato, onion (Han 1997).

Distribution: Asia: China, Israel, Japan, Mongolia, Turkey, Uzbekistan; Europe; Russia; Africa: Libya; North America: Canada, the USA.

Remarks: This species with a somewhat protruding head and parallel cheeks has a comparatively square head. Moulton (1948) placed this species in a series of the *Intonsa* group. *Frankliniella lilivora* belongs to the same series. These 2 species can be separated by the former having longer antennal segments, while those of the latter being short and rounded. Because its host plants are mainly food crops, it is regarded as a pest in some areas. Most cases; however, are not serious.

***Frankliniella williamsi* Hood**

(Figs. 21, 23, 29)

Frankliniella williamsi Hood 1915: 19.

Specimens examined: 30 ♀♀, TAIWAN: Taichung, *Zea mays*, Nov. 1989; 4 ♀♀, 1 ♂, Wufeng, TARI, *Zea mays*, Sept. 1990 (TARI).

Diagnosis: Female macroptera. Body uniformly yellow; antennal segments I-V yellow, grayish on distal ends of II-V, basal 1/2 of segment VI yellow and distal 1/2 brown, segments VII and VIII brown. Ocellar setae III short; postocular setae iv almost as long as ocellar setae III. Metanotum with paired campaniform sensilla. Posteromarginal comb on tergite VIII complete, microtrichia long and regular; sternite II usually with 1 or 2 discal setae, about same length as posteromarginal setae.

Host plants: *Zea mays*, Gramineae (Mound and Marullo 1996), *Ipomoea reptans*, *Ageratum conyzoides* (Wang 2000 2002), *Callistephu chinensis*, *Sorghum vulgare*, *Panicum purpurascens*, *Asclepias tuberosa* (Jacot-Guillarmod 1974).

Distribution: Asia: the Philippines, Taiwan, Thailand; Central America: Guatemala, Honduras, Mexico; Caribbean islands: Cuba, Dominican Republic, Guadeloupe, Jamaica, Puerto Rico, Trinidad; South America: Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela; the USA (including Hawaii); Australia; New Guinea.

Remarks: *Frankliniella williamsi* is an occasional pest of maize, when its population increases during suitable weather. The thrips crowd on leaves of young plants and cause leaf curling, discoloration, and even wilting.

Frankliniella zizaniophila Han and Zhang
(Figs. 8, 27, 34)

Frankliniella zizaniophila Han and Zhang 1982: 210.

Specimens examined: 1 ♀ paratype #3935-2698, CHINA: Hubei, *Zizania caduciflora*, 1978 (USNM).

Diagnosis: Female macroptera. Body brown; antennae brown, segments III and IV and base of VI yellow, III lighter than other segments. Antennal segments I-V stout and short; ocellar setae III long; postocular setae short. Pronotum lacking discal setae, only 2 pairs of median posteromarginal setae; metanotum with paired campaniform sensilla. Tergite VIII without posteromarginal comb.

Host plants: *Zizania caduciflora*.

Distribution: China.

Remarks: Nakahara (1997) examined this species and wrote "This species is atypical in having only 2 pairs of pronotal posteromarginal setae and 2 pairs of postocular setae in the head". There are 2 pairs of postocular setae in the drawings with the original description (Han and Zhang 1982), while there are 4 pairs of such setae in drawings published by Han (1997). The author also found 4 pairs of postocular setae in 1 paratype borrowed from the USNM. It is possible that Han's specimens varied in the number of the postocular setae.

Key to species of *Frankliniella* in the Asian-Pacific area (Excluding *F. salicis* and *F. unicolor*)

1. Apterous or brachypterous2
 - Macropterous3
2. Apterous*lantanae* (part)
 - Brachypterous.....*fusca* (part)
3. Antennal segment II with 2 stout distal setae, each on a projection (Fig. 1).....*cephalica*
 - Antennal segment II normal without such stout setae4
4. Posteromarginal comb on abdominal tergite VIII completely lacking, or only a few microtrichia present laterally5
 - Posteromarginal comb on abdominal tergite VIII present....6
5. Ocellar setae III situated on margin of ocellar triangle, between anterior and posterior ocelli.....*zizaniophila*
 - Ocellar setae III situated inside triangle, between hind ocelli (Fig. 13)*schultzei*
6. Antennal segments III and IV short and rounded, < 1/2 length of VI (Figs. 32-34)7
 - Antennal segments III and IV longer, over 2/3 length of VI (Figs. 22, 23).....9
7. Major setae minute, ocellar setae III no longer than diameter of hind ocellus (Fig. 11).....*minuta*
 - Ocellar setae III longer than twice diameter of hind ocellus8

8. Anterior margin of pronotum without elongated setae*lantanae* (part)
 - Anterior margin of pronotum with elongated setae*livivora*
9. Posteromarginal comb on abdominal tergite VIII complete (Figs. 15-21)10
 - Posteromarginal comb on abdominal tergite VIII present only laterally, middle teeth lacking or reduced to scalloping or basal triangles, never with sharp-ended microtrichia (Figs. 2-8)15
10. Body color yellow or light yellow11
 - Body color brown, or yellow but at least with brown central patches or lateral spots on tergites II-VII12
11. Teeth of posterior comb on tergite VIII long and sharp*williamsi*
 - Posterior comb on tergite VIII with only a triangular base*gilva*
12. Antennal segment III with sharp-ridged basal ring (Fig. 30), color of antennal segment V light, much lighter than segment IV.....*invasor*
 - Basal ring of antennal segment III rounded (Fig. 31), color of antennal segment V darker or similar to IV.....13
13. Pronotum with 2-4 pairs of median anteromarginal setae, postocular setae iv as long as ocular setae III (Fig. 12)*occidentalis*
 - Pronotum with 1 pair of median anteromarginal setae (Fig. 24), postocular setae iv much shorter than ocular setae III (Fig. 10)14
14. Posteromarginal comb on tergite VIII with irregular teeth (Fig. 15).....*hemerocallis*
 - Posteromarginal comb on tergite VIII with even, regular teeth (Fig. 16)*intonsa*
15. Postocular setae i-iv short and subequal in length, much shorter than ocellar setae III (Fig. 9).....*fusca* (part)
 - Postocular setae i-iii short, setae iv longer, about 1/2 of ocellar setae III or longer (Fig. 13).....16
16. Metanotum with campaniform sensilla.....*insularis*
 - Metanotum without campaniform sensilla.....*tenuicornis*

DISCUSSION

Frankliniella salicis Moulton was described in 1948 with the holotype female collected by Takahashi on *Salix* plants at Kannonzan, Taiwan. There is no other collection record of this species. Nakahara (1997) examined the holotype deposited in the California Academy of Science and placed it as a synonym of *F. tritici* (Fitch) which is distributed only in the Americas. It is reasonable to doubt that there was a mistake in labeling the specimen in Moulton's collection, and this species is not considered in this paper.

Frankliniella unicolor Morgan was reported from India by Ananthkrishnan (1954). However, this species was not included in the same author's list of Indian Thysanoptera published in 1980. It is probably a correction of the former record. Bhatti in his *Catalogue of Indian Terebrantia* (1992) cited Ananthkrishnan's record of *F. unicolor*, but doubted the existence of this species (J.S. Bhatti,

pers. comm., 2009). Other than India, *F. unicolor* is recorded only from the US (Nakahara 1997), therefore it is not included here as an Indian or Asian-Pacific species.

Jacot-Guillarmod (1974) wrote in the catalogue that *F. hemerocallis* was intercepted from Japan. The distribution of it in Japan was thereafter cited by several authors. However, Masumoto and Okajima (2004) mentioned only *F. intonsa*, *F. tenuicornis*, *F. lilivora*, and *F. cephalica* in a paper on Japanese *Frankliniella*, and it seems that no specimen was found in Japan.

Intraspecific variations in this genus make identification among species confusing. Even for individuals of the same species, the body color and size, and the presence or absence of wings vary by geographic location, population, host plant, and season. These less-stable traits should be coupled to other distinctive features to make the identification more reliable.

Some not so obvious characteristics should be avoided as primary identification features. For example, on poorly mounted slides, there will be difficulties in examining and determining the shape and structure of the pedicel of antennal segment III. Also, the number of teeth on the comb of tergite VIII will vary, but the presence or lack of a complete array can be expected with certainty. This is an important basis for classification using our key.

Acknowledgments: The author is grateful to Dr. L.A. Mound, CSIRO, Australia for all the help he offered and Dr. J.S. Bhatti, Univ. of Delhi, India for his valuable comments. Thanks also go to Dr. D.A. Nickle, National Museum of Natural History, Smithsonian Institution, USA and Dr. M. Masumoto, Yokohama Plant Protection Station, Japan for the loan of specimens.

REFERENCES

- Ananthakrishnan TN. 1954. New and little known Indian Thysanoptera. *J. Zool. Soc. India* **6**: 159-166.
- Ananthakrishnan TN, S Sen. 1980. Taxonomy of Indian Thysanoptera. Zoological Survey India Handbook Series 1. Zool. Survey India, Calcutta, 234 pp.
- Bansiddhi K, S Poonchaisri. 1991. Thrips of vegetables and other commercially important crops in Thailand. *In* NS Talekar, ed. Proc. Regional Consultation Workshop. Bangkok: AVRDC Publication 91, pp. 34-39.
- Bhatti JS. 1992. Catalogue of insects of the order Terebrantia from the Indian subregion. *Zoology (J. Pure Appl. Zool.)* **2**: 205-352.
- CABI, EPPO. 1992. Quarantine pests for Europe: data sheets on quarantine pests for the European Communities and for the European and Mediterranean Plant Protection Organization. Wallingford, UK, CAB International (CABI), pp. 145-150.
- Chou K, JH Lee, JJ Park, JK Kim, KB Uhm. 2001. Analysis of special pattern of *Frankliniella occidentalis* on greenhouse cucumbers using dispersion index and special autocorrelation. *Jpn. J. Appl. Entomol. Zool.* **36**: 25-32.
- Crawford DL. 1910. Thysanoptera of Mexico and the south II. Pomona College J. Entomol. **2**: 153-170.
- Crawford JC. 1948. A new species of *Frankliniella* on *Hemerocallis* (Thysanoptera: Thripidae). *Proc. Entomol. Soc. Wash.* **50**: 83-84.
- Han Y. 1997. Economic insect fauna of China. Academia Sinica, FASC 55 Thysanoptera. Beijing: Science Press, pp. 263-268.
- Han YF, GX Zhang. 1982. Description of *Frankliniella zizaniophila*, sp. nov. *Acta Zootaxon. Sin.* **7**: 210-211.
- Hinds WE. 1902. Contribution to a monograph of the insects of the order Thysanoptera inhabiting North America. *Proc. US Natl. Mus.* **26**: 79-242.
- Hood JD. 1914. On the proper generic names of certain Thysanoptera of economic importance. *Proc. US Natl. Mus.* **16**: 34-44.
- Hood JD. 1915. Descriptions of new American Thysanoptera. *Insector Inscitiae Menstruus* **3**: 1-40.
- Jacot-Guillarmod CF. 1974. Catalogue of the Thysanoptera of the world. *Annals of the Cape Province Museum (Natural History)*. Cape Provincial Museum at Albany Museum, South Africa, pp. 517-976.
- Karny HH. 1910. Neue Thysanopteren der Wiener Gegend. *Mitt. des Naturwiss. Ver. Univ. Wien* **8**: 41-57.
- Karny HH. 1912. Revision der von Serville aufgestellten Thysanopteren-Genera. *Zool. Ann.* **4**: 321-344.
- Kirk WDJ, LI Terry. 2003. The spread of the western flower thrips *Frankliniella occidentalis* (Pergande). *Agric. For. Entomol.* **5**: 301-310.
- Kurosawa M. 1937. Description of four new thrips from Japan. *Jpn. J. Entomol.* **11**: 266-275.
- Lee GS, KS Woo. 2002. A new *Frankliniella* species (Thysanoptera, Thripidae) on Gramineae from Korea. *Insecta Kor.* **19**: 199-204.
- Masumoto M, S Okajima. 2004. A new record of *Frankliniella cephalica* from Japan. *Jpn. J. Appl. Entomol. Zool.* **48**: 225-226.
- Morgan AC. 1925. Six new species of *Frankliniella* and a key to the American species. *Can. Entomol.* **57**: 136-147.
- Moulton D. 1907. A contribution to our bibliography of North American Thysanoptera, with descriptions of new species. USDA, Bureau of Entomol. Tech. Ser. **12**: 39-68.
- Moulton D. 1948. The genus *Frankliniella* Karny, with keys for the determination of species. *Rev. Entomol.* **19**: 55-114.
- Mound LA. 1996. Thysanoptera. *In* A. Wells, eds. Psocoptera, Phthiraptera, Thysanoptera. Zoological Catalogue Australia, vol. 26. Melbourne, Australia. CSIRO Publications, pp. 249-414.
- Mound LA. 2010. Thysanoptera (thrips) of the World – a checklist. Available at <http://www.ento.csiro.au/thysanoptera/worldthrips.html> Accessed 15 Jan. 2010.
- Mound LA, KJ Houston. 1987. An annotated check-list of Thysanoptera from Australia. *British Museum (Natural History)*, London, England. Occasional Papers Systematic Entomology no. 4, 6 pp.
- Mound LA, R Marullo. 1996. The thrips of Central and South

- America: an introduction. Gainesville, FL: Associated Publishers. Mem. Entomology International. Vol. 6: pp. 118-156.
- Mound LA, S Nakahara, MD Day. 2005. *Frankliniella lantanae* sp. n., a polymorphic alien thrips damaging *lantana* leaves in Australia. Aust. J. Entomol. **44**: 279-283.
- Mound LA, AK Walker. 1982. Terebrantia. Fauna of New Zealand no.1, Wellington, NZ: DSIR, 66 pp.
- Nakahara S. 1997. Annotated list of the *Frankliniella* species of the world. Contrib. Entomol. Int. **2**: 355-389.
- Nakahara S, DJ Hilburn. 1989. Annotated checklist of the Thysanoptera of Bermuda. J. NY Entomol. Soc. **97**: 251-260.
- Pergande T. 1895. Observations on certain Thripidae. Ins. Life **7**: 390-395.
- Peters D, I Wijkamp, F van de Watering, R Goldbach. 1996. Vector relations in the transmission and epidemiology of tospoviruses. Acta Hort. **431**: 29-43.
- Reyes CP. 1994. Thysanoptera of the Philippine Islands. Raffles Bull. Zool. **42**: 107-507.
- Sakimura K. 1972. *Frankliniella invasor*, new species, and notes on *F. gardeniae* and the *Frankliniella* spp. in Hawaii. Proc. Hawaii. Entomol. Soc. **21**: 263-270.
- Sakimura K, E O'Neill. 1979. *Frankliniella*, redefinition of genus and revision of *minuta* group species (Thysanoptera: Thripidae). Washington DC: US Department of Agriculture Technical Bulletin 1572, pp. 1-49.
- Shiraki T. 1912. Insect pests of cotton. Spec. Rep. No.5. Agric. Exp. Stn. Gov. Formosa **5**: 65-67.
- Stannard LJ. 1968. The thrips, or Thysanoptera, of Illinois. IL Nat. Hist. Surv. Bull. **29**: 215-552.
- Trybom F. 1895. Iakttagelser om vissa Blasfotingars (Physapoders) uppträdande i grasens blomställningar. Entomol. Tidskr. **16**: 157-194.
- Trybom F. 1910. Physapoda. *IN* Schultze, Zoologische und anthropologische Ergebnisse einer Forschungsreise im weslichen and zentralen Südafrika, (1903-1905). Denkschr. Med.-Naturwiss. Ges. Jena **16**: 147-174.
- Uzel H. 1895. Monographie der Ordnung Thysanoptera. Konigratz, Bohemia, pp. 1-472.
- Wang CL. 2000. Thysanoptera of Taiwan (5). J. Agric. Res. China **49**: 94-120.
- Wang CL. 2002. Thrips of Taiwan: biology and taxonomy. Taichung, Taiwan: Taiwan Agricultural Research Institute Special Publication 99, pp. 193-209.
- Woo KS. 1974. Thysanoptera of Korea. Kor. J. Entomol. **4**: 33-38.