Thrips (Thysanoptera) Species Associated with Developing Citrus Flowers in Florida and A Key to Adult Terebrantian Females[1]

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ABSTRACT Citrus groves in Florida were sampled during February and March 1991 to determine the occurrence, frequency and distribution of thrips including *Thrips palmi* Karny in open flowers of citrus. *Frankliniella bispinosa* (Morgan) was the dominant species accounting for 65% of identified specimens from St. Lucie, Palm Beach, Hendry, Lee and DeSoto counties. *Frankliniella kelliae* Sakimura was the second most abundant species comprising 34% of 2,067 slide-mounted specimens subsampled from collections. *Frankliniella kelliae* was found for the first time in St. Lucie and Indian River counties and this species was the most abundant thrips collected from citrus flowers in Indian River and Dade counties. Five species of thrips including *Frankliniella occidentalis* (Pergande), *T. orientalis* (Bagnall), *T. palmi* and *Adraneothrips pallidus* (Watson) were collected for the first time in February and March 1991 on citrus flowers along with *F. insularis* (Franklin) reported previously. A single adult female, *T. palmi*, was collected from a 'Tahiti' lime flower sample in Dade County. The predaceous thrips, *Aleurodothrips fasciapennis* (Franklin), was collected for the first time from flowers in a mixed block of citrus varieties in Dade County. A key to the species of adult female terebrantian thrips found on citrus flowers and floral buds in Florida is provided.

KEY WORDS Insecta, Thysanoptera, Terebrantia, *Frankliniella, Thrips, Adraneothrips, Aleurodothrips, Pseudothrips, Scolothrips, Aeolothrips.*

Citrus production in Florida has gradually shifted southward since the tree killing freezes of December 1983 and January 1985. Some citrus production remains as far north as Pasco, Lake, Orange and Brevard counties in north central Florida. Ornamental and vegetable farms are frequently found in this northern area and extend south into Dade, Collier and Lee counties where they are intermixed with citrus groves in various localized areas. An array of intensively cultivated plant species is grown in close proximity over this 300 mile north-south axis within Florida. Some thrips species found on citrus flowers are also found on other crops; therefore, continuous vigil must be maintained to identify potentially destructive indigenous and exotic thrips pests moving between these plant species during flowering or vegetative growth cycles.

Large numbers of adult and immature thrips were collected from citrus flowers and developing floral buds in groves throughout Florida between 1986 and 1990. *Frankliniella bispinosa* (Morgan) was the dominant species accounting for

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92% of collected specimens from Dade to Volusia counties (Childers et al. 1990). A second survey for thrips on citrus flowers was initiated in February and March 1991 because *Thrips palmi* Karny, a serious pest of various vegetable crops, was found in Dade County in close proximity of citrus groves. *Thrips palmi* was previously reported on *Citrus medica* L. and an unidentified orange tree in Indonesia (Ruhendi and Litsinger 1979). The objectives of this study were to update our knowledge of thrips species present on citrus and to develop a key to separate the terebrantian adult females collected thus far.

Materials and Methods

Twenty-two citrus grove sites in Indian River, St. Lucie, Martin, Palm Beach, Dade, Hendry, Lee and DeSoto counties were surveyed for thrips associated with citrus flowers during February and March 1991. Citrus species sampled included: sweet orange, *Citrus sinensis* (L.) Osbeck, including the varieties 'Valencia', 'Pineapple' and 'Hamlin'; 'Tahiti' lime, *C. aurantifolia* Swingle; 'Bearss' lemon, *C. limon* Burmann, 'Mineola' tangelo, *C. reticulata* Blanco × *C. paradisi* Macfadyen; and 'Marsh' grapefruit, *C. paradisi* Macfadyen.

A sample of 100 open flowers was collected from each of five to eight trees at each site during the bloom period in February or March. The locations of sample trees at each site were selected at random and the number of locations per site varied from one to five depending on the size of the grove. The flowers were picked and immediately dropped into a one pint capacity jar partially filled with a solution of 70% ethyl alcohol.

Thrips species were separated from citrus flowers in each sample using a stereomicroscope. When fewer than 40 adult thrips were collected, all individuals in the sample were mounted separately on microscopic slides using Hoyer's media and identified with a compound microscope. Otherwise, a minimum subsample of 40 adult thrips per replicated sample was randomly collected and slide-mounted individually for identification to species. Accurate identification of thrips to species requires microscopic slide preparation, especially for the genus *Frankliniella.* Processing subsamples was the only realistic means of handling large numbers of these insects. The number of each identified thrips species was converted to a percentage of the total identified thrips collected per grove site for each citrus variety.

Voucher specimens were deposited in the Division of Plant Industry, Gainesville, Florida and University of Georgia arthropod collection in Griffin, GA.

Explanation of the taxonomic characters used in the key to separate adult female thrips can be found in the general papers on Thysanoptera by Stannard (1968) and Palmer et al. (1989).

Results and Discussion

Previous survey results yielded 13 species of thrips from developing buds and flowers of citrus in Florida (Childers et al. 1990). Five additional species of thrips (*Frankliniella occidentalis* (Pergande), *Thrips orientalis* (Bagnall), *T. palmi*

Karny, *Adraneothrips pallidus* (Watson) and *Aleurodothrips fasciapennis* (Franklin)) were identified from 2,067 slide-mounted specimens subsampled from citrus flowers during February and March 1991 (Table 1).

Frankliniella bispinosa. This thrips was the dominant species collected from all groves except the Sexton site in Indian River County and seven of eight grove sites in Dade County. Only the Calusa 'Tahiti' lime grove in Dade County had more *F. bispinosa* specimens than any other species (Tables 1 and 2). A higher percentage of citrus groves in Dade County was sampled for thrips during 1991 compared with the grove sites sampled during 1986-90 (Childers et al. 1990). This is indicated by the lower frequencies of *F. bispinosa* identified from lime, tangelo and grapefruit grove sites during 1991. Virtually all citrus production in Dade County consists of 'Tahiti' lime.

Frankliniella bispinosa was consistently the dominant species collected from vegetables in Collier, Hendry, Lee, DeSoto and Manatee counties between 1986 and 1990 (Frantz and Mellinger 1990). They reported collecting *F. bispinosa* from February through December on over 33 species of cultivated and non-cultivated plants. Lanza (1991) found *F. bispinosa* heavily infesting snapdragon, *Antirrhinum majus* L., plants in Pinellas County during March and flowers of black-eyed peas, *Vigna unguiculata* (L.) Walpers in Manatee County during September (Runnals 1991). In addition, *F. bispinosa* was the dominant species collected from palmetto (Sabal sp.) flowers and anthers on 23 and 24 April 1990 from several sites in the Immokalee vicinity in Lee County (Childers, unpublished data). The occurrence of *F. bispinosa* on such a diverse group of plants throughout the year in Florida demonstrates their adaptability and potential economic importance on many crops.

Frankliniella insularis. All 10 of the identified specimens of *F. insularis* were collected from citrus flowers in Dade County (Tables 1 and 2). This species has been consistently found in low numbers on citrus flowers with a maximum of three specimens recorded from a 100 flower sample of 'Tahiti' lime at the P-155 grove in Homestead.

Frankliniella kelliae. This species was the second most abundant thrips collected from citrus flowers during February and March 1991 (Tables 1 and 2). Seven of eight grove sites in Dade County and one grapefruit grove in Indian River County had higher frequencies of *F. kelliae* than any other thrips species. New records of *F. kelliae* from Indian River and St. Lucie counties were obtained 12 and 13 February 1991. *Frankliniella kelliae* is restricted to the east coast and southern citrus growing areas in Florida. Frantz and Mellinger (1990) reported this species from chrysanthemum (= *Dendranthema* sp.), confederate jasmine, jasmine, pepper and tomato during March, April and May.

Frankliniella occidentalis. This species, first identified in Florida from pumpkin at the Epcot Center in Lake Buena Vista on 16 January 1982 (Denmark 1986), has spread throughout the state from a wide array of plants (Frantz and Mellinger 1990). Four adult females were collected from a 'Valencia' orange grove in Palm Beach County, one adult female from a 'Mineola' tangelo in Dade County and one adult female from a 'Hamlin' orange grove in DeSoto County during 1991 (Tables 1 and 2). These are the first records of *F. occidentalis* on citrus flowers in Florida. The earliest records of this species found in citrus groves are from sticky trap collections taken during 1990 at a 'navel' orange grove south of LaBelle in Hendry County (Childers, unpublished data).

Table 1. Frequencies of thrips species identified by grove site and county during February-March 1991.

County	Site	Citrus variety	Thrips species*									
			N	1	2	3	4	5	6	7	8	9
St. Lucie	Olson	'Marsh' grapefruit	128	100%	0	0	0	0	0	0	0	0
	Gentile	'Marsh' grapefruit	35	80%	20%	0	0	0	0	0	0	0
	Girl Scout	'Valencia' orange	134	90%	10%	0	0	0	0	0	0	0
	Brown	'Pineapple' orange	42	100%	0	0	0	0	0	0	0	0
Indian River	Sexton	'Marsh' grapefruit	29	45%	55%	0	0	0	0	0	0	0
Palm Beach	Land O Sun	'Valencia' orange	71	83%	11%	0	6%	0	0	0	0	0
		'Bearss' lemon	14	71%	29%	0	0	0	0	0	0	0
	Crossman	'Marsh' grapefruit	42	67%	33%	0	0	0	0	0	0	0
Dade	Sunshine 40	'Tahiti' lime	169	3%	96%	<1%	0	0	0	<1%	0	0
	Calusa	'Tahiti' lime	181	62%	38%	0	0	0	0	0	0	0
	Krome West	'Tahiti' lime	31	32%	65%	3%	0	0	0	0	0	0
	P-155	'Tahiti' lime	200	25%	72%	2%	0	0	<1%	0	0	0
	Jemada East	'Tahiti' lime	124	12%	80%	1%	0	3%	0	0	0	4%
	Sunshine 80	'Tahiti' lime	115	17%	83%	0	0	0	0	0	0	0
	McGill Elmore	'Mineola' tangelo	40	10%	88%	0	2%	0	0	0	0	0
	McGill Elmore	Mixed citrus	18	11%	72%	11%	0	0	0	0	6%	0
	McGill Elmore	Lemon	12	84%	8%	8%	0	0	0	0	0	0
Hendry	U. S. Sugar	'Hamlin' orange	400	100%	0	0	0	0	0	0	0	0
	Jebco	'Hamlin' orange	50	98%	2%	0	0	0	0	0	0	0
Lee	Green	'Valencia' orange	17	100%	0	0	0	0	0	0	0	0
DeSoto	Murphy	'Hamlin' orange	215	99%	0	0	<1%	0	0	0	0	0

* 1 = *Frankliniella bispinosa,* 2 = *F. kelliae,* 3 = *F. insularis,* 4 = *F. occidentalis,* 5 = *Thrips orientalis,* 6 = *T. palmi,* 7 = *Adraneothrips pallidus,* 8 = *Aleurodothrips fasciapennis,* 9 = Tubuliferan species.

Table 2. Species composition of thrips collected from flowers and developing buds of different citrus species in Florida, February through March, 1991.

Thrips species	N	Lime	Lemon	Orange	Tangelo	Grapefruit	Other*
			Thripidae				
Frankliniella bispinosa (Morgan)	1,337	213	20	901	4	197	2
	65%	26%	77%	97%	10%	84%	11%
Frankliniella kelliae Sakimura	702	589	5	23	35	37	13
	34%	72%	19%	2%	88%	16%	72%
Frankliniella insularis (Franklin)	10	7	1	0	0	0	2
	<1%	<1%	4%				11%
Frankliniella occidentalis (Pergande)	6	0	0	5	1	0	0
	<1%			<1%	<1%		
Thrips palmi Karny	1	1	0	0	0	0	0
	<1%	<1%					
Thrips orientalis (Bagnall)	4	4	0	0	0	0	0
	<1%	<1%					
			Phlaeothripidae				
Adraneothrips pallidus (Watson)	1	1	0	0	0	0	0
	<1%	<1%					
Aleurodothrips fasciapennis (Franklin)†	1	0	0	0	0	0	1
	<1%						6%
Tubulifera spp.	5	5	0	0	0	0	0
	<1%	<1%					
Total	2,067	820	26	929	40	234	18

* Mixed citrus.
† Predaceous thrips.

Frankliniella occidentalis was the dominant thrips identified from citrus flower samples in the Rio Grande Valley area of Texas during 1992 (J. V. French, Texas A&I Univ., Weslaco, personal communication). This species occurs on citrus in California where rind blemish injury has been reported on grapefruit, 'navel' orange and lemon (Jeppson 1989).

Low frequency collection records of *F. occidentalis,* compared to those of *F. bispinosa,* were obtained on cucumber, tomato and pepper from Collier, Hendry and Lee counties between 1986 and 1990 (Frantz and Mellinger 1990). *Frankliniella occidentalis* is a known vector of tomato spotted wilt virus and the ability of this species to compete with *F. bispinosa* on citrus is unknown.

Thrips orientalis. Four adult males were collected from a 100 flower sample of 'Tahiti' lime in Dade county on 14 February (Tables 1 and 2). This thrips has been reported from Indonesia, India, China, Hawaii and Malaya on *Morinda tomentosa* Roth., *Jasminum, Gardenia, Jasminum mesnyi* Hance and *Jasminum* sp. (Jacot-Guillarmod 1975). *Thrips orientalis* also occurs in Guam and the Virgin Islands of St. Croix and St. Thomas. Additional host plants include *J. azoricum* L., *J. fluminense* Velloso, *J. multiflorum* Andrews, and *J. sambac* (L.) Aiton (S. Nakahara, USDA, SEL, Beltsville, MD, personal communication). This thrips was one of eight species inhabiting soybean, *Glycine max* (L.) Merrill, in Java (Miyazaki et al. 1984).

Thrips palmi. One adult female was collected from 'Tahiti' lime at the P-155 site in Homestead on 14 February (Tables 1 and 2). This species was first described from tobacco plants in Medan, Sumatra in 1925 and subsequently reported from many host plants from the Orient, Guam and Hawaii (Sakimura et al. 1986). *Thrips palmi* has been reported as a polyphagous feeder with larvae and adults feeding on leaves, stems, flowers and fruits from a wide host range. *Thrips palmi* was first reported in Japan in 1978 and became a serious pest of cucumber, eggplant and sweet pepper on both greenhouse and field grown plants (Kawai 1990). In 1982, *T. palmi* was first discovered in Hawaii and subsequently collected on watermelon, cucumber, cantaloupe, egg plant, Chinese spinach, various bean species or varieties, lettuce and cheese weed (Johnson 1986). *Thrips palmi* caused serious injury to peppers by feeding on the leaves, stems, flowers and developing fruits in Puerto Rico in November 1986 (Pantoja et al. 1988).

Thrips palmi Karny was first collected from flowers of *Bidens pilosa* L. in the Homestead vicinity on 21 December 1990 by Galen Frantz (Glades Crop Care, Jupiter, FL, personal communication) and is currently known as far north as Apopka in Orange county (H. A. Denmark, Fla. Dept. Agric. and Cons. Serv., DPI, Gainesville, personal communication). *Thrips palmi* has been collected from flowers of both okra, *Abelmoschus esculentus* (L.) Moench, in Dade County and pepper, *Capsicum annuum* L., in Collier, Martin and Palm Beach counties (Galen Frantz, personal communication; Allingham 1991; Johnson 1991). Heavy infestations of *T. palmi* have been reported on the leaves of both yellow wax beans, *Phaseolus vulgaris* L., and passion fruit, *Passiflora edulis* Sims, in Dade County (Mead 1991).

Japan, Hawaii and Puerto Rico do not have a significant amount of citrus grown in close proximity to vegetable and ornamental production areas compared with the situation that exists in Florida. However, results of this survey show that *T. palmi* is not a problem on citrus flowers at this time.

Adraneothrips pallidus. One adult female was collected from a 'Tahiti' lime flower sample in Dade County on 14 February (Tables 1 and 2). This tubuliferan species was collected from cynipid galls in pigeon plums from Miami and described as *Gastrothrips pallidus* by Watson (1924). It is known only from Miami, Florida where it was collected from dead fallen leaves of avocado (S. Nakahara, personal communication).

Aleurodothrips fasciapennis. One adult female was collected from a mixed stand of unidentified citrus trees in an abandoned grove in Dade County on 14 February (Tables 1 and 2). *Aleurodothrips fasciapennis* has been previously reported only from citrus leaf samples in Florida (Childers et al. 1990). This predaceous thrips has been found in association with various scale insects by Medina-Gaud (1961). Beshear (1975) reported *A. fasciapennis* as a predator of the oleander scale, *Aspidiotus nerii* Bouché. *Aleurodothrips fasciapennis* was the primary biological agent that resulted in suppression of red scale, *Aonidiella aurantii* (Maskell), on citrus in China during 1983 (G. A. C. Beattie, Dept. Agriculture, Rydalmere, NSW, Australia, personal communication).

Agricultural production is a 12-month process in Florida with a continuous cycle of various cultivated plants being grown and harvested. Some require 8 to 15 months to produce a crop (i.e., citrus) while others are relatively short (i.e., certain vegetables and ornamentals). Many thrips species have wide host ranges. As more data are obtained on their distributions, seasonal occurrence, host plants and associated injuries for the different commodities, it becomes evident that certain species (i.e., *Frankliniella bispinosa, F. kelliae* and *F. occidentalis*) pose significant economic problems to Florida agriculture. Shifts in the frequencies of thrips species may occur and questions must be addressed concerning their economic importance. Considerable diversity of thrips species exists and many species remain undescribed in such economically important genera as *Frankliniella, Thrips* and *Scirtothrips.* Further research is needed to improve our understanding of this important group of insects.

Key to Adult Female Terebrantian Thrips Found on Citrus Flowers and Floral Buds in Florida

1 Last abdominal segment tubelike; female without sawlike ovipositor (Fig. 1).....Tubulifera..Phlaeothripidae

Last abdominal segment rarely tubelike; female with sawlike ovipositor (Fig. 2).....Terebrantia..2

2(1) Antennae nine segmented with an elongate sensoria placed longitudinally on segments 3 and 4 (Fig. 3); forewings broad and rounded at tips (Fig. 4).....Aeolothripidae

Forewings with a dark longitudinal band in posterior 1/2 extending from base to tips (Fig. 4).....*Aeolothrips vittipennis* Hood*

Antennae seven, eight or nine segmented with sensoria protruding as forked or simple sense cones (Figs. 6 and 7); forewings generally narrower and usually pointed at tips (Figs. 14 and 16B) .....Thripidae..3

3(2) Antennae nine segmented (Fig. 10); pronotum with one pair of posteroangular setae (Fig. 11) .....*Pseudothrips inequalis* (Beach)

Antennae seven or eight segmented (Figs. 8 and 9); pronotum with two pairs of posteroangular setae (Figs. 16A and 17A).....4

4(3) Pronotum with well-developed anteromarginal, anteroangular and posteroangular setae (Figs. 17A and 18A); antennae eight segmented 7

Pronotum with only posteroangular setae well-developed; antennae seven or eight segmented.....5

5(4) Body entirely yellow; forewings light yellow; abdominal sternites without accessory setae .....*Thrips palmi* Karny

Body brown; forewings brown; abdominal sternites 3-5 with accessory setae.....6

6(5) Forewings with three distal setae on forevein (Fig. 16B); metanotum sculptured longitudinally, slightly reticulated medially, median setae at anterior margin (Fig. 12); antennae usually eight segmented .....*Thrips hawaiiensis* (Morgan)

Forewings with almost complete row of setae on forevein (Fig. 14); metanotum completely polygonally reticulated, reticles with short marks, median setae posterior of anterior margin (Fig. 13); antennae seven segmented .....*Thrips orientalis* (Bagnall)

7(4) Pronotum with six pairs of exceptionally long setae (Fig. 15); body completely pale yellow; forewing clear with small basal, subbasal and submedial brown spots .....*Scolothrips pallidus* (Beach)*

Pronotum with four pairs of long setae (Fig. 17A); other characters various.....8

8(7) Forewing brown with pale base; body dark brown, legs brown except tarsi and foretibiae yellow .....*Frankliniella insularis* (Franklin)

Forewings clear; body completely yellow, predominantly yellow with brown patches or submarginal oval spots on abdomen, or more extensively brown 9

9(8) Posteromarginal comb on abdominal tergite 8 complete (Fig. 17B) 10

Posteromarginal comb on abdominal tergite 8 incomplete (Fig. 20B) 12

10(9) Posteromarginal comb on abdominal tergite 8 close-set, about as long as median setae on sclerite; body completely yellow ..... *Frankliniella williamsi* Hood

Posteromarginal comb on abdominal tergite 8 sparse, distinctly shorter than median setae on sclerite (Fig. 17B); body color various 11

11(10) Pedicel of antennal segment 3 mushroom-shaped (Fig. 18C); body yellow usually with submarginal oval brown spots on abdomen (Fig. 18B) ..... *Frankliniella kelliae* Sakimura

Pedicel of antennal segment 3 straight (Fig. 17C); body yellow with brown patches or spots on abdomen or more extensively brown ..... *Frankliniella occidentalis* (Pergande)

12(9) Pedicel of antennal segment 3 with distal and basal parts equally diverging forming a mushroom-shaped angulation; pair of dorsal setae on antennal segment 2 not enlarged nor on projections (Fig. 19C) ..... *Frankliniella tritici* (Fitch)

Pedicel of antennal segment 3 with distinct angulation; pair of dorsal setae on antennal segment 2 enlarged on projections (Figs. 20C and 21C) 13

13(12) Pedicel of antennal segment 3 strongly angulated, 12 to 14 μm wide with distal and basal parts of angulation diverging inward (Fig. 20C) ..... *Frankliniella bispinosa* (Morgan)

Pedicel of antennal segment 3 with smaller angulation, usually 7 to 10 μm wide, the distal surface of the angulation flat but basal part diverging (Fig. 21C) ..... *Frankliniella cephalica* (Crawford)

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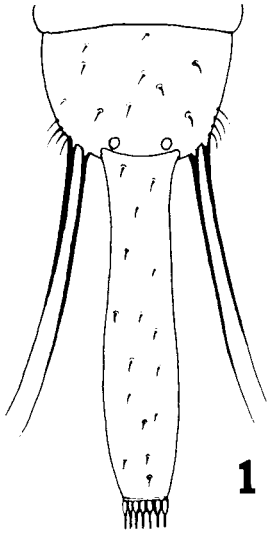
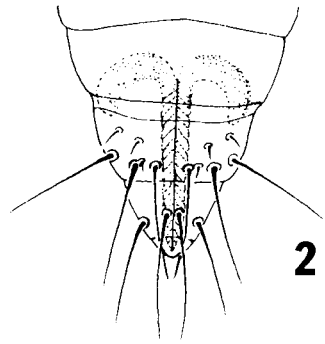
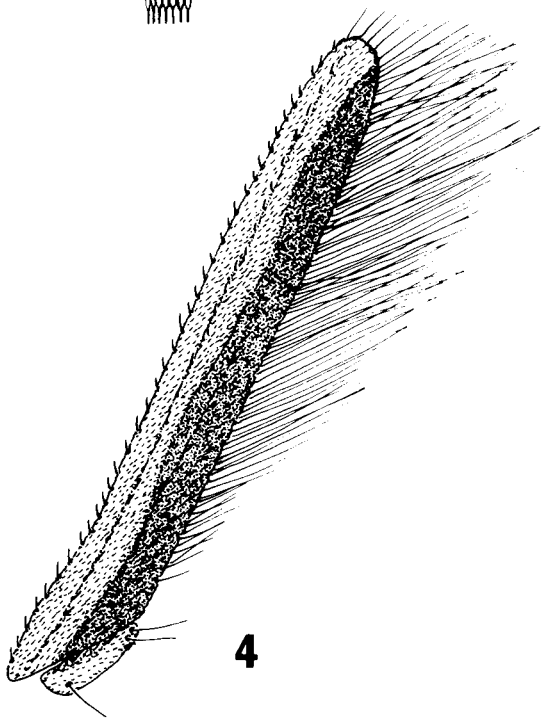
*Predaceous species included to show example of morphological structure.







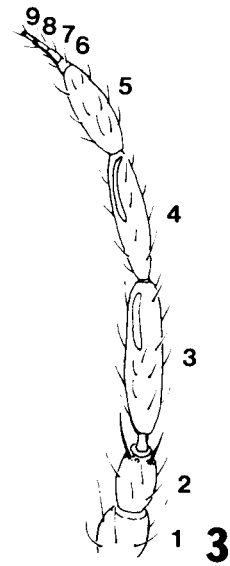


Fig. 1. Tubulifera segments 9-10.
Fig. 2. Terebrantia segments 8-10.
Fig. 3. *Aeolothrips vittipennis* antenna with sensoria.
Fig. 4. *Aeolothrips vittipennis* forewing.

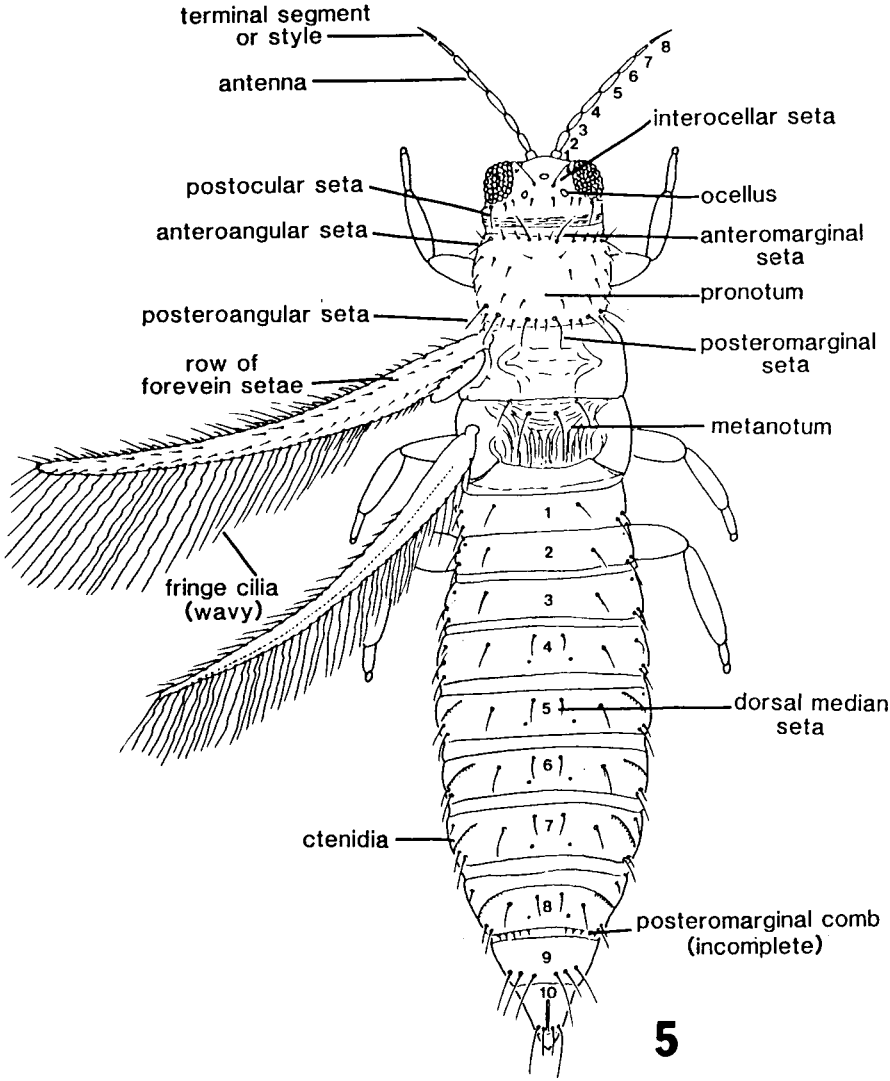


Fig. 5. Morphological characters of Thripidae.

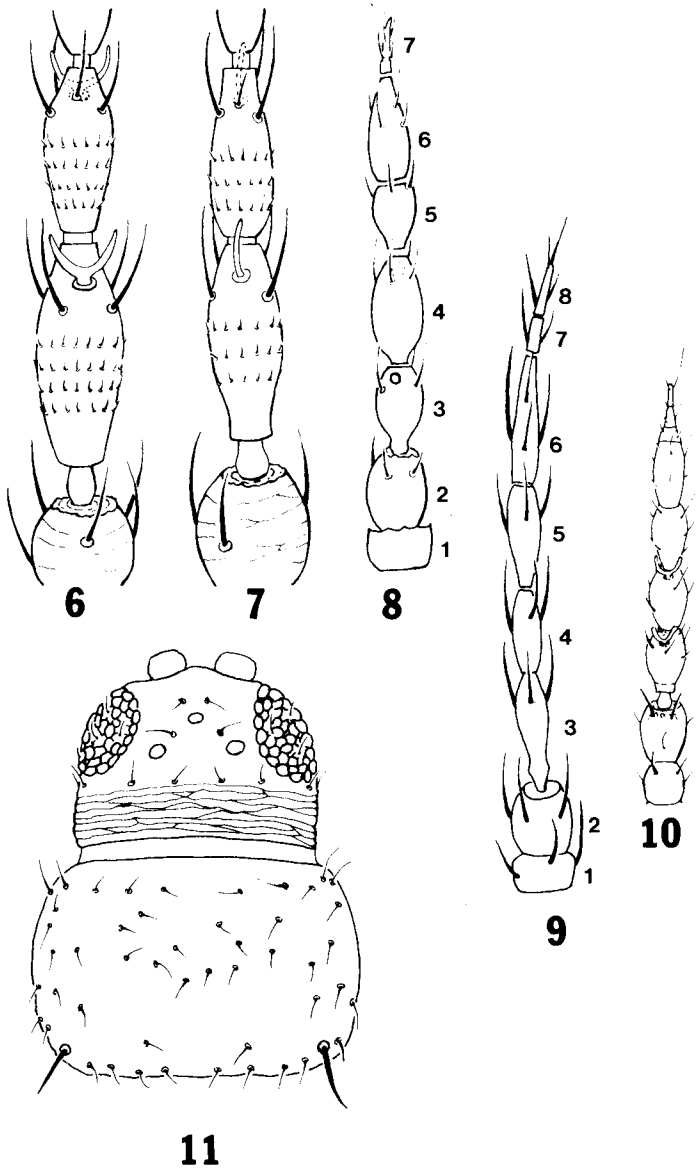
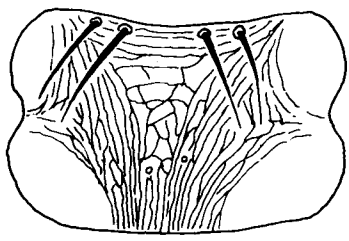


Fig. 6. Thripidae antenna, forked sense cones.
Fig. 7. Thripidae antenna, simple sense cone.
Fig. 8. *Thrips* sp. antenna.
Fig. 9. Thripidae antenna.
Fig. 10. *Pseudothrips inequalis* antenna.
Fig. 11. *Pseudothrips inequalis* head and pronotum.



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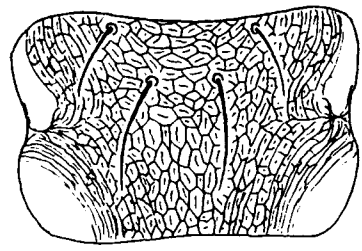

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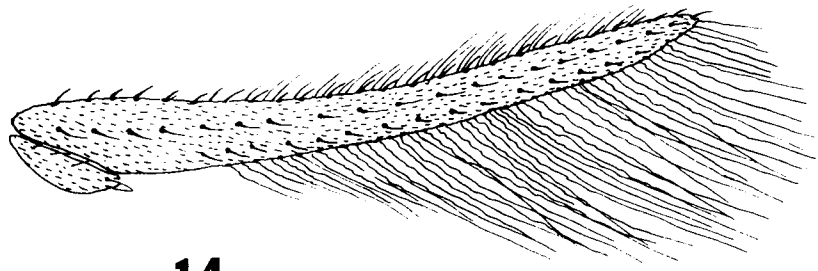

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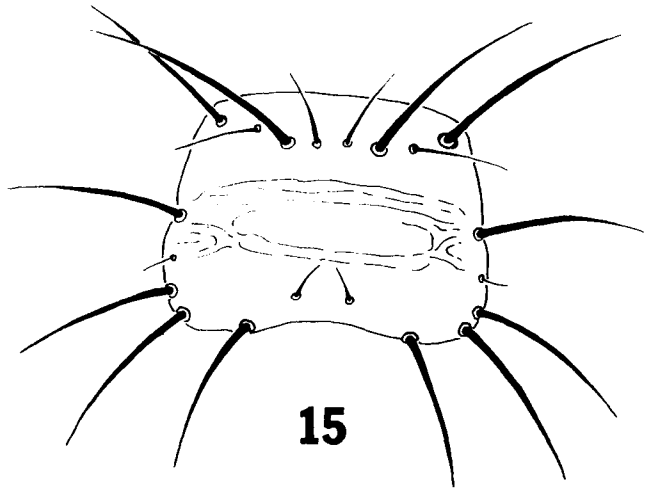

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Fig. 12. *Thrips hawaiiensis* metanotum.
Fig. 13. *Thrips orientalis* metanotum.
Fig. 14. *Thrips orientalis* forewing.
Fig. 15. *Scolothrips pallidus* pronotum.

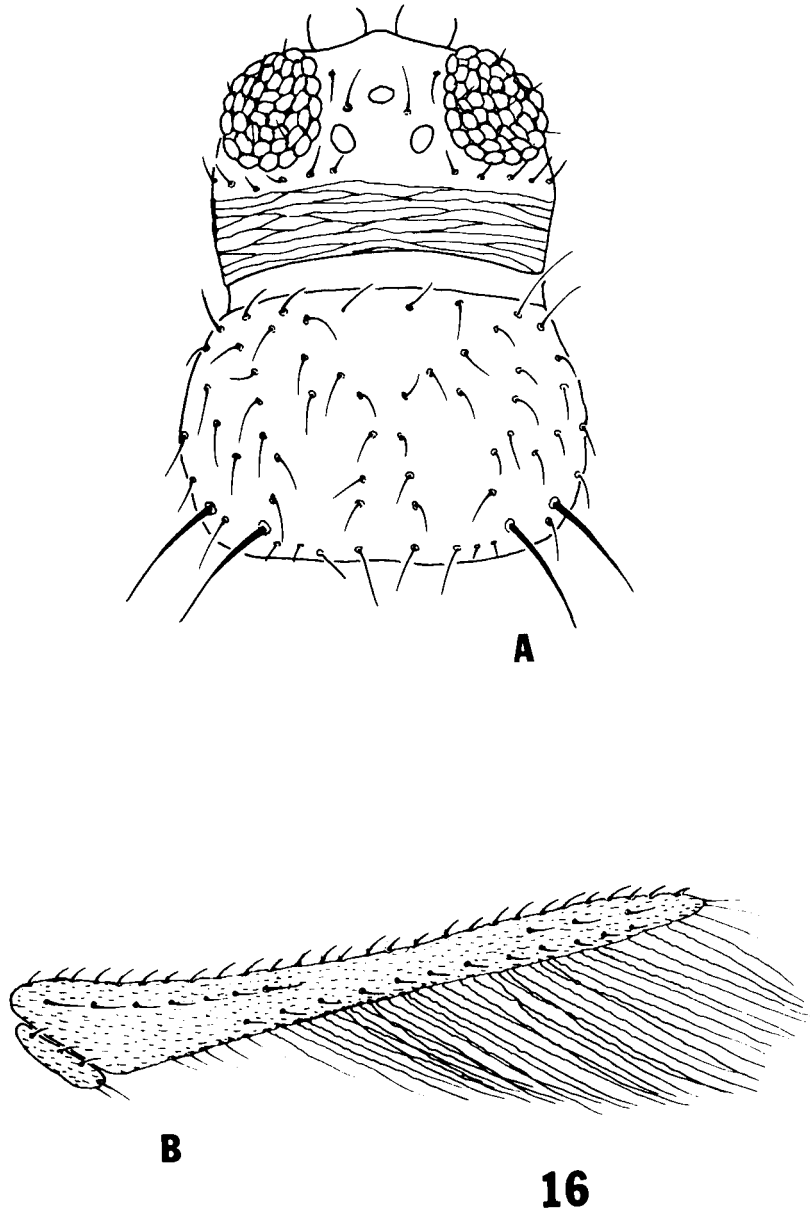

Fig. 16. *Thrips palmi*; A) head and pronotum, B) forewing.

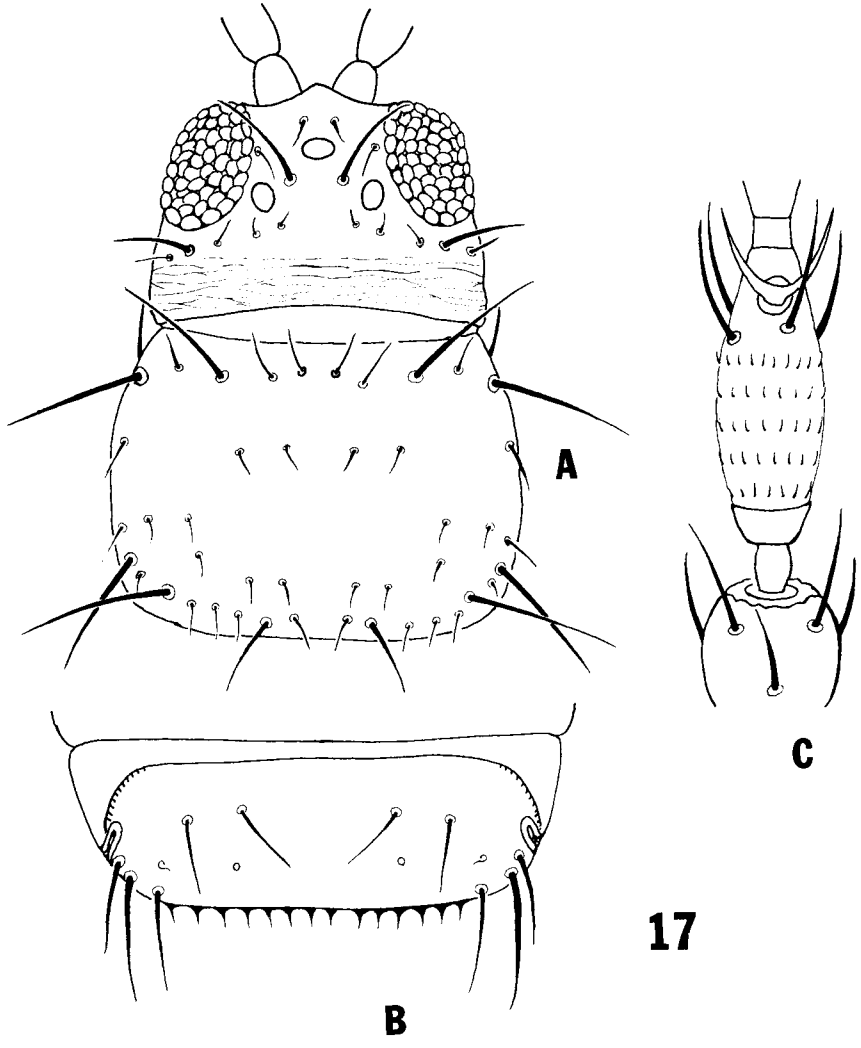

Fig. 17. *Frankliniella occidentalis;* A) head and pronotum, B) tergite 8, C) pedicel third antennal segment.

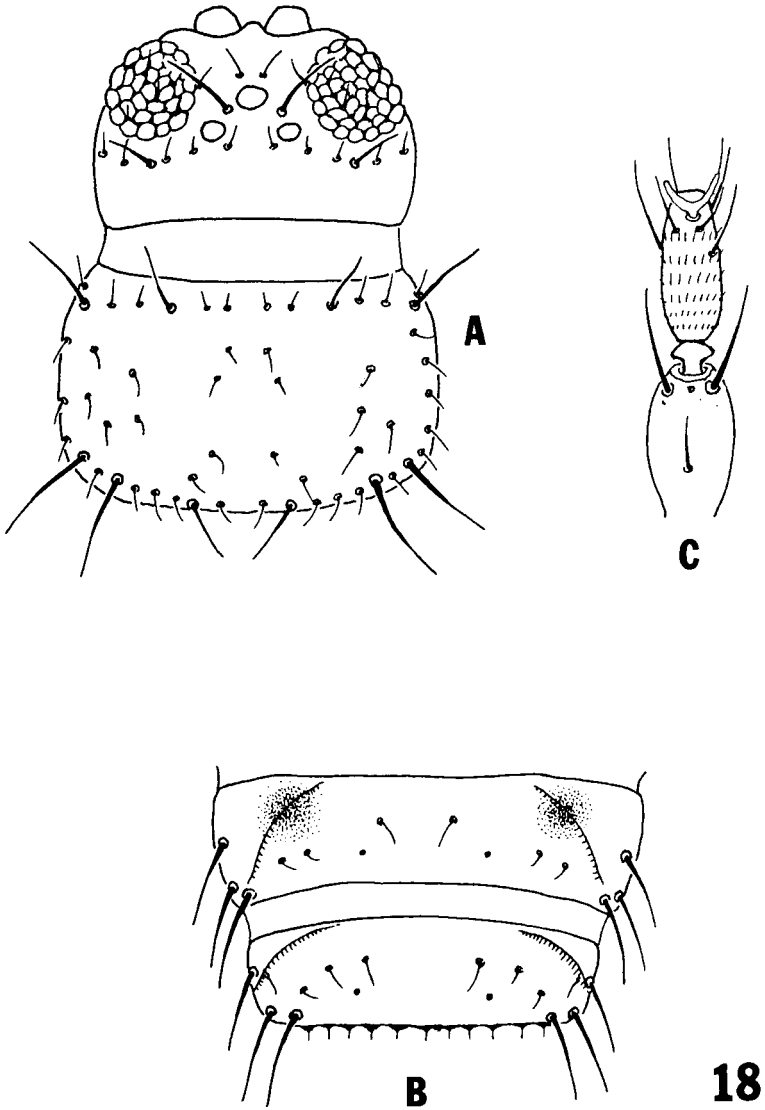

Fig. 18. *Frankliniella kelliae;* A) head and pronotum, B) tergites 7-8, C) pedicel third antennal segment.

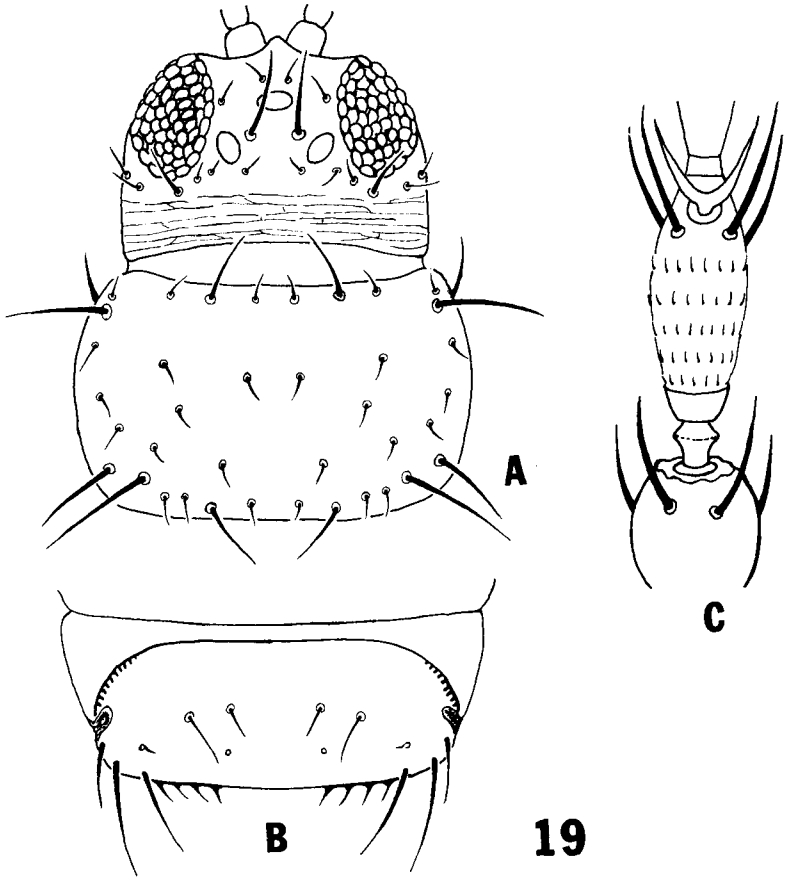

Fig. 19. *Frankliniella tritici;* A) head and pronotum, B) tergite 8, C) pedicel third antennal segment.

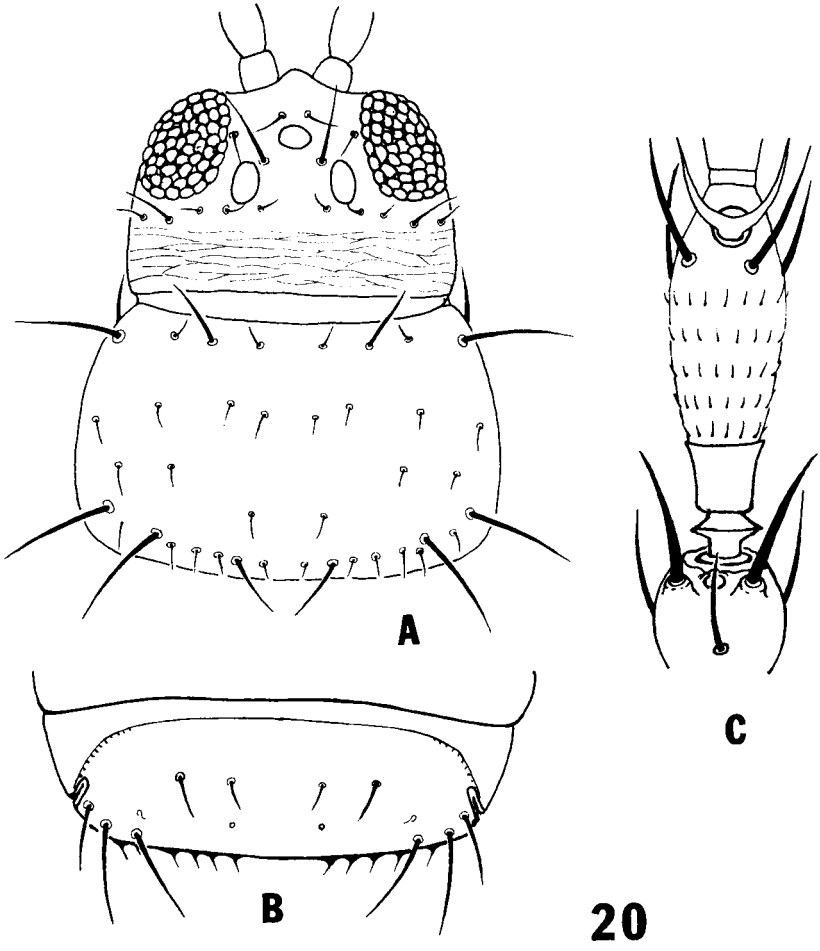

Fig. 20. *Frankliniella bispinosa;* A) head and pronotum, B) tergite 8, C) pedicel third antennal segment.

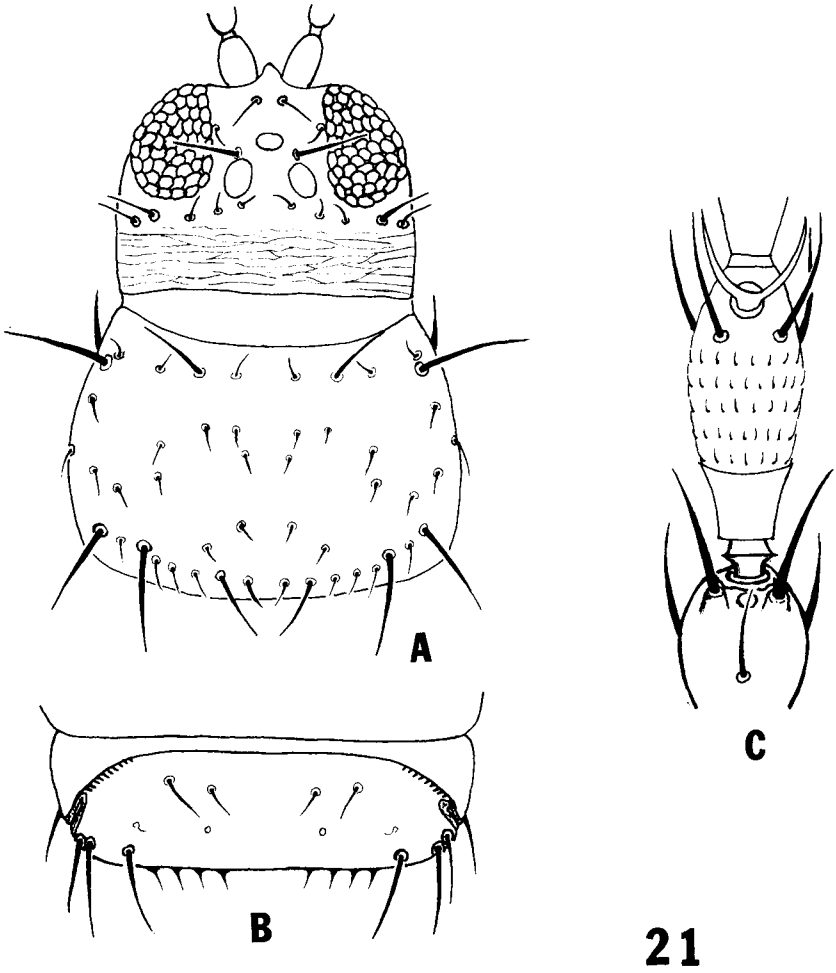

Fig. 21. *Frankliniella cephalica;* A) head and pronotum, B) tergite 8, C) pedicel third antennal segment.

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