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A photo-based key of thrips (Thysanoptera) associated with horticultural crops in Florida

Jeffrey D. Cluever[1] *and Hugh A. Smith*[1,*]

Abstract

A dichotomous key is presented to aid in the identification of adult and larval stages of 20 thrips species commonly associated with horticultural crops in Florida.

Key Words: morphology; systematics; taxonomy; IPM guide; identification

Resumen

Se presenta una clave dicotómica para ayudar en la identificación de los adultos y los estadios larvales de 20 especies de trips, comúnmente asociadas con cultivos hortícolas en la Florida.

Palabras Clave: morfología; sistemática; taxonomía; guia MIP; identificación

The insect order Thysanoptera consists of approximately 5,800 described species in 2 suborders and 9 families (Diffie et al. 2008). The suborder Tubulifera consists of 1 family, Phlaeothripidae, with 3,500 species (Morse & Hoddle 2006; Tipping 2008). The suborder Terebrantia consists of 8 families: Thripidae (about 1,970 species), Aeolothripidae (about 190 species), Heterothripidae (about 70 species), Melanthripidae (about 65 species), Merothripidae (15 species), Stenurothripidae (6 species), Fauriellidae (5 species), and Uzelothripidae (1 species). Thrips are 1 to 4 mm in length, have fringe-like wings (unless wings are lacking), and have asymmetrical mouthparts, with only the left mandible developed. Thrips in the suborder Terebrantia have a conical 10th abdominal segment and a saw-like ovipositor, whereas thrips in the suborder Tubulifera have a tube-like 10th abdominal segment and chute-like ovipositor that lacks teeth (Stannard 1968; Tipping 2008; Mehle & Tredan 2012).

Thrips display holometabolous development. Terebrantian females use their saw-like ovipositor to make a slit in the plant foliage so their eggs may be deposited within the plant tissue. After hatching, thrips in this suborder pass through 2 larval stages and 2 pupal stages (prepupa and pupa) before reaching maturity (Stannard 1968; Morse & Hoddle 2006; Tipping 2008). Tubuliferan females oviposit onto the surface of plant foliage. After hatching, thrips in the Tubulifera suborder pass through 2 larval and 3 pupal stages (primipupa, prepupa, and pupa) before reaching maturity. Larval stages are found on the host whereas pupal stages are usually passed in the soil. Late in the 2nd larval instar, the thrips usually drops to the ground where it pupates and remains there until emergence of the adult (Stannard 1968; Broadbent et al. 2003; Morse & Hoddle 2006).

Thrips impact agriculture globally. Many thrips are polyphagous, attacking agronomic, horticultural, and ornamental crops (Morse & Hoddle 2006). Thrips cause damage directly to plants by feeding and through oviposition. Fifteen thrips species transmit tospoviruses, of which thrips are the only known vector (Rotenberg et al. 2015). Thrips have also been implicated in the transmission of viruses in the genera *Ilarvirus*, *Carmovirus*, *Sobemovirus*, and *Machlomovirus* (Hull 2002; Jones 2005; Plant Health Australia and Nursery & Garden Industry Australia 2011; Cabanas et al. 2013).

Twenty species of thrips are known to occur commonly in Florida horticultural crops (Table 1). Of these, 8 species transmit tospoviruses: *Frankliniella bispinosa* (Morgan), *Frankliniella cephalica* (Crawford DL), *Frankliniella fusca* (Hinds), *Frankliniella occidentalis* (Pergande), *Frankliniella schultzei* (Trybom), *Scirtothrips dorsalis* Hood, *Thrips palmi* Karny, and *Thrips tabaci* Lindeman (Rotenberg et al. 2015). In Florida, thrips feeding damage has been associated with post-bloom fruit drop in citrus, fruit bronzing in strawberry, leaf distortion in pepper and other crops, and stippling in tomato (Frantz & Mellinger 1990; Childers 1999; Dŏgramaci et al. 2011; Smith & Whidden 2014). Viruses in Florida transmitted by thrips include *Tomato spotted wilt virus* (TSWV), *Tomato chlorotic spot virus* (TCSV), *Iris necrotic spot virus* (INSV), and *Groundnut ringspot virus* (GRSV) (Baker et al. 2007; Webster et al. 2011, 2015). Thrips species in Florida that have quarantine status elsewhere include *F. occidentalis*, *Thrips hawaiiensis* (Morgan), *T. palmi*, and *S. dorsalis* (Mehle & Tredan 2012; EPPO 2015).

Florida possesses heavily trafficked ports-of-entry that are globally important for commerce and tourism, providing opportunities for the introduction of thrips and other invasive species. The state's temperate panhandle, subtropical mid-peninsula, and tropical southern peninsula provide a range of habitats suitable for numerous thrips species. Of the over 5,800 described species, only about 1% are considered serious pests (Morse & Hoddle 2006) and only 15 species worldwide are implicated in tospovirus transmission (Morse & Hoddle 2006; Riley et al. 2011; Rotenberg et al. 2015). As of 2008, over 275 species of thrips are recorded in Florida (Diffie et al. 2008) but less than 1% are considered serious pests, and of those only the 20 species treated here are commonly encountered. Thrips species vary in the ability to inflict crop damage, transmit viruses, and develop resistance to insecticides, all of

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Table 1. Thrips pests of horticultural crops in Florida, arranged by family and subfamily.

Family	Subfamily	Genus	Species
Phlaeothripidae	Phlaeothripinae	*Haplothrips*	*gowdeyi* (Franklin)
			graminis Hood
Thripidae	Panchaetothripinae	*Caliothrips*	*phaseoli* (Hood)
	Thripinae	*Anaphothrips*	*obscurus* (Müller)
		Frankliniella	*bispinosa* (Morgan)
			cephalica (Crawford DL)
			fusca (Hinds)
			insularis (Franklin)
			occidentalis (Pergande)
			schultzei (Trybom)
			tritici (Fitch)
		Microcephalothrips	*abdominalis* (Crawford DL)
		Scirtothrips	*dorsalis* Hood
		Scolothrips	*pallidus* (Beach)
			sexmaculatus (Pergande)
		Thrips	*australis* (Bagnall)
			florum Schmutz
			hawaiiensis (Morgan)
			palmi Karny
			tabaci Lindeman

which influence the threat they present and their quarantine status (Wijkamp et al. 1995; Avila et al. 2006; Morse & Hoddle 2006; Frantz & Mellinger 2009).

In Florida, thrips are primary pests of tomato (Funderburk 2009), pepper (Frantz & Mellinger 2009), blueberries (Rhodes et al. 2012), and strawberries (Cluever et al. 2016), and several species in the herein presented key also attack ornamental plants in Florida. In suitable conditions, thrips populations can reach high densities and cause damage to a broad range of horticultural crops.

Materials and Methods

As with all pests, proper identification of thrips is the first step in developing a response to an infestation, and the digital micrograph key provided here was developed to facilitate and enhance the ability of both taxonomists and non-specialists to identify thrips associated with horticultural crops in Florida (see Table 1 for species list). The key is compiled from the following published and unpublished sources: Watson (1923), Stannard (1968), Nakahara (1995), S. Nakahara (Systemic Entomology Laboratory, Agricultural Research Service, US Department of Agriculture unpublished key to some species of 2nd stage Terebrantia larvae), Vierbergen et al. (2010), Mound (2011), Hoddle et al. (2012), and Thomas Skarlinsky (United States Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine, Miami, Florida; unpublished).

Most thrips must be slide mounted to be identified to species. During the mounting of thrips, it is important to spread the wings and orient the thrips so that it is dorsal side up when the slide mounting is completed (Lyle Buss, University of Florida, Entomology and Nematology Department, Gainesville, Florida; personal communication). Either Hoyer's mounting medium (Schofield 1985) or CMC-10 (Masters Company, Inc., Wood Dale, Illinois) can be used to produce a temporary mount of adult thrips. However, because Hoyer's mounting medium contains chloral hydrate, for which a Drug Enforcement Administration permit is required, it is not commercially available and must be made in the laboratory. Canada balsam is used for a permanent mount (Hoddle et al. 2012). For larvae, Hoyer's mounting medium should be used, and the mounted slides should be placed on a hotplate (about 45 °C) overnight (Thomas Skarlinsky, personal communication).

A common method for slide mounting is to: 1. place a cover slip on a standard microscope slide (slide A); 2. place a drop of mounting medium onto the coverslip; 3. place the specimen ventral side up into the media; 4. use a micropin to position the antennae, to spread the forewings to form a right angle to the body, and to position the hind wings to a 45-degree angle from the body; 5. gently press another a standard microscope slide (slide B) onto the cover slip; 6. gently lift slide B from slide A; and 7. allow drying for 24 to 48 h for CMC-10 mounts or place on a hot plate overnight for Hoyer's mounts (Lyle Buss, personal communication; Thomas Skarlinsky, personal communication).

A Key to Common Thrips Pests of Crops in Florida

1. — Wings (brachypterous or macropterous) or wing buds present 2

1'. — Wings or wing buds absent . . . . . Larva, 24

2. (1) Wings not fully formed, appear tube-like (Fig. 1a,b) 3

2'. — Wings fully formed, with setae present . . . . . Adult, 4

3. (2) Antennae straight, projecting forward (Fig. 1a) . . . . . Prepupa

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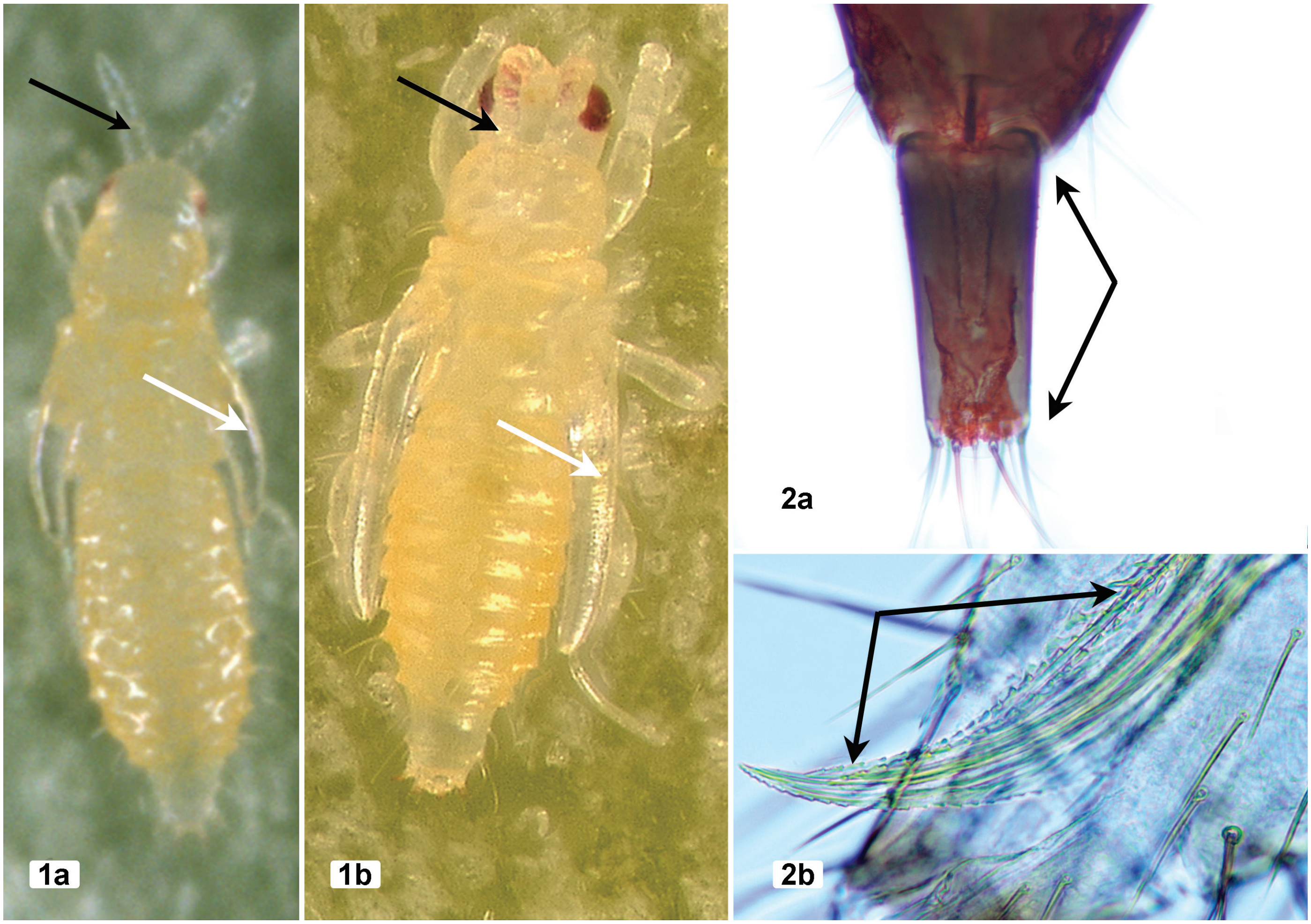

Figs. 1 and 2. Plate I: Distinguishing between life stages and suborders. **1a.** Wing pads present (white arrow); antennae projecting forward (black arrow) (prepupa). Photograph by Lyle Buss, University of Florida. **1b.** Wing pads present (white arrow); antennae curved back over head (black arrow) (pupa). Photograph by Lyle Buss, University of Florida. **2a.** Tubular abdominal segment X (black arrows) (adult Phlaeothripidae). **2b.** Conical abdominal segment X (black arrows); saw-like ovipositor present on females (adult Terebrantia).

3'. — Antennae curved back over head (Fig. 1b) . . . . Pupa

4. (2') Abdominal segment X tubular (Fig. 2a) . . . . Tubulifera: *Haplothrips*, 5

4'. — Abdominal segment X conical; female with saw-like ovipositor (Fig. 2b) . . . . Terebrantia, 6

5. (4) Antennal segment III with 2 sensoria . . . . *Haplothrips gowdeyi* (Franklin)

5'. — Antennal segment III with 1 sensorium . . . . *Haplothrips graminis* Hood

6. (4') If ctenidia are present on abdominal tergites V–VII; ctenidium on tergite VIII anterior to spiracle (Fig. 3a); anterior margin of prothorax with major setae (Fig. 4a); antennae 8-segmented (Fig. 5b) 7

6'. — If ctenidia are present on abdominal tergites V–VII, ctenidium on tergite VIII posterior to spiracle (Fig. 3b); anterior margin of prothorax lacking major setae (Fig. 4b); antennae 7-, 8-, or 9-segmented (Fig. 5a–c) 15

7. (6) Ctenidia on abdominal tergites absent (Fig. 3c); forewing patterned with dark, elliptical dots (Fig. 6d); major setae on veins of forewing longer than width of wing (Fig. 7c) 8

7'. — Ctenidia on abdominal tergites present (Fig. 3a); forewing dark, clear or patterned but lacking dark, elliptical dots (Fig. 6a–c); major setae on veins of forewing not longer than width of wing (Fig. 7a,b) 9

8. (7) Body pale in color, abdomen lacking brown markings; basal-most dot on forewing small and elliptical (Fig. 6d) . . . . *Scolothrips pallidus* (Beach)

8'. — Body with brown markings; basal-most dot on clavus large (not figured) . . . . *Scolothrips sexmaculatus* (Pergande)

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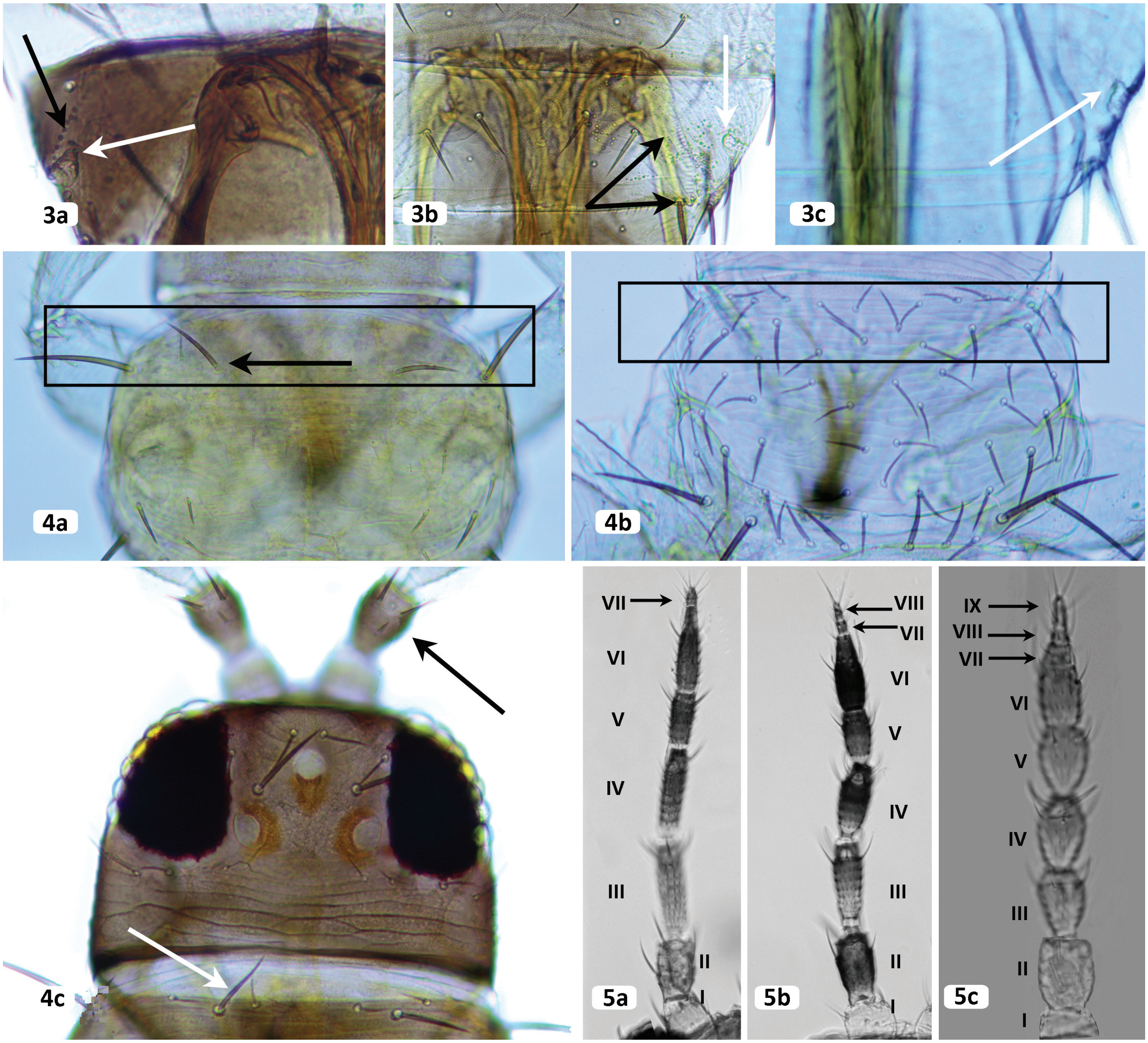

Figs. 3–5. Plate II: Ctenidial position, pronotal setae, and antennae of common genera. **3a.** Ctenidium (black arrow) anterior to spiracle (white arrow) on abdominal segment VIII (adult *Frankliniella*). **3b.** Ctenidium (black arrows) posterior to spiracle (white arrow) on abdominal segment VIII (adult *Thrips* and *Microcephalothrips*). **3c.** Ctenidium absent on abdominal segment VIII (white arrow indicates spiracle) (adult *Scolothrips*). **4a.** Major setae (black arrow) present on anterior margin of pronotum (adult *Frankliniella* and *Scolothrips*, setae are much longer than 1.3 times the diameter of antennal segment II). **4b.** Major setae absent on anterior margin of pronotum (other species). **4c.** Setae on anterior margin of pronotum (white arrow) shorter than 1.3 times the diameter of antennal segment II (black arrow) (adult *Frankliniella fusca*). **5a.** 7-Segmented antenna (adult *Thrips* and *Microcephalothrips*). **5b.** 8-segmented antenna (adult *Frankliniella*, *Caliothrips, Anaphothrips*, and some *Thrips*). **5c.** 9-segmented antenna (adult *Anaphothrips*).

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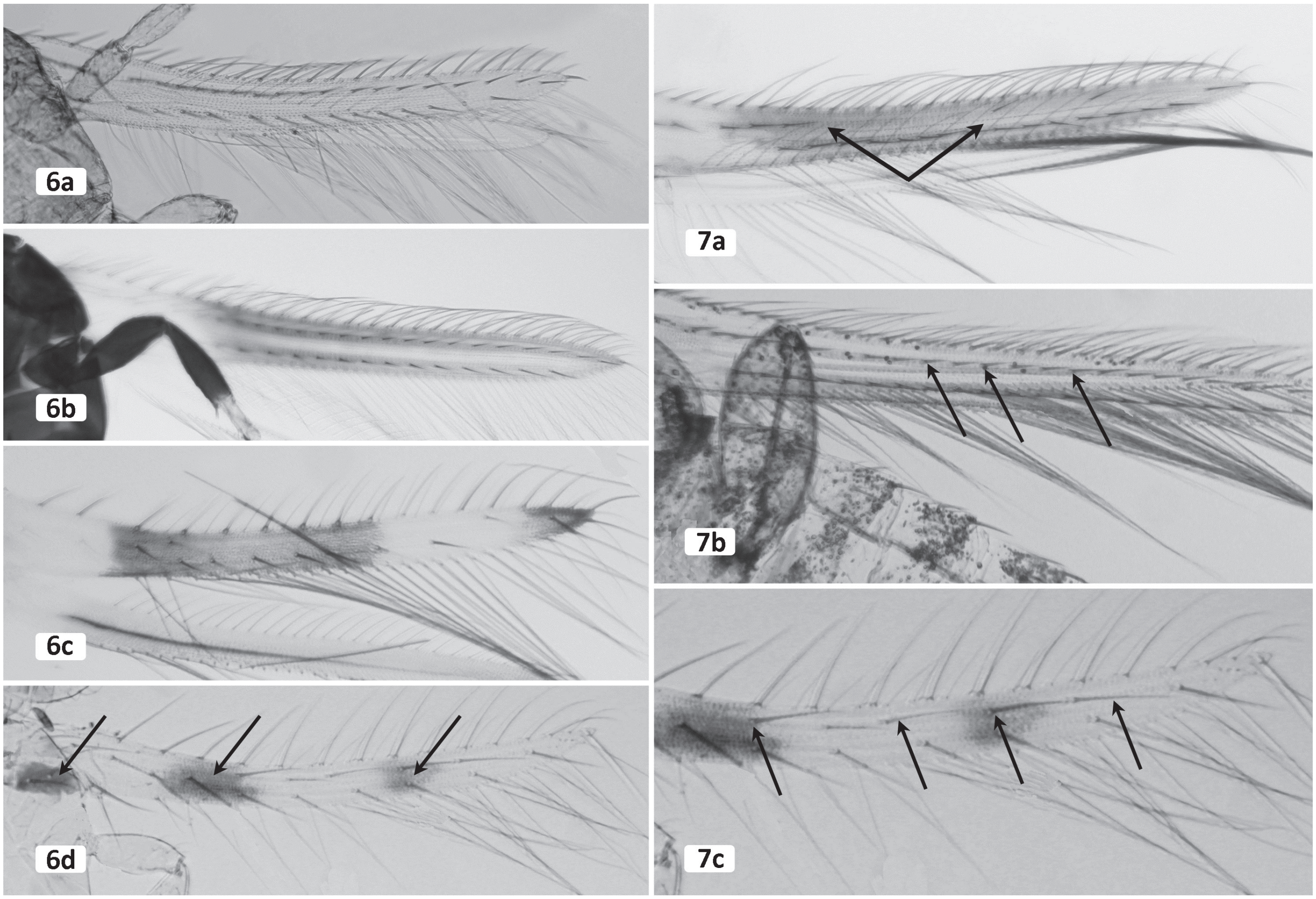

Figs. 6 and 7. Plate III: Forewing features. **6a.** Forewing clear (*Frankliniella occidentalis*). **6b.** Forewing pale at base, infuscated beyond and with indistinct dark band in middle third of wing (*Frankliniella insularis*). **6c.** Forewing pale at base, with distinct transverse band in forewing (*Caliothrips phaseoli*). **6d.** Forewing pattern consists of 3 dark dots (black arrows) (adult *Scolothrips pallidus*). **7a.** Setae (black arrows) on 1st vein of forewing (anterior row) spaced apart, with wide gaps; forewing setae shorter than width of wing (adult all other species). **7b.** Setae (black arrows) on 1st vein of forewing (anterior row) evenly spaced, without wide gaps; forewing setae shorter than width of wing (adult *Thrips australis*, *Frankliniella* spp.). **7c.** Forewing setae (black arrows) longer than width of wing (adult *Scolothrips*).

9. (7') Pedicel of antennal segment III either strongly convex or forming a flange (Fig. 8b–d) 10

9'. — Pedicel of antennal segment III neither strongly convex, nor forming a flange (Fig. 8a) 12

10. (9) Pedicel of antennal segment III strongly convex but not forming flange (Fig. 8b); setae arising from antennal segment II gracile, evenly tapered, not forming heavy, stout spines (Fig. 9b) . . . . *Frankliniella tritici* (Fitch)

10'. — Pedicel of antennal segment III forming flange (Fig. 8c,d); setae arising from antennal segment II basally with slightly convex margins, forming robust spines (Fig. 9a) 11

11. (10') Apical section of flange on antennal segment III curved in lateral view (Fig. 8c) . . . . *Frankliniella bispinosa* (Morgan)

11'. — Apical section of flange on antennal segment III with straight margins in lateral view (Fig. 8d); basal section of flange on antennal segment III cup-shaped . . . . *Frankliniella cephalica* (Crawford DL)

12. (9') Ocellar III setae pair arising at a level slightly posterior to the anterior margin of posterior ocelli (Fig. 10a) and metanotal campaniform sensilla lacking (Fig. 11a) . . . . *Frankliniella schultzei* (Trybom)

12'. — Ocellar III setae pair arising at a level of, or anterior to, anterior margin of posterior ocelli (Fig. 10a,c) and metanotal campaniform sensilla present (Fig. 11b) 13

13. (12') Tergite VIII posterior margin with comb of microtrichia weakly developed (Fig. 12d); pronotal antemarginal setae shorter than 1.3 times the diameter of antennal segment II (Fig. 4c); individuals macropterous or brachypterous (Fig. 13a) . . . . . . *Frankliniella fusca* (Hinds)

13'. — Tergite VIII posterior margin with comb of microtrichia well developed (Fig. 12a–c); pronotal antemarginal setae longer than 1.3 times the diameter of antennal segment II; individuals macropterous, never brachypterous 14

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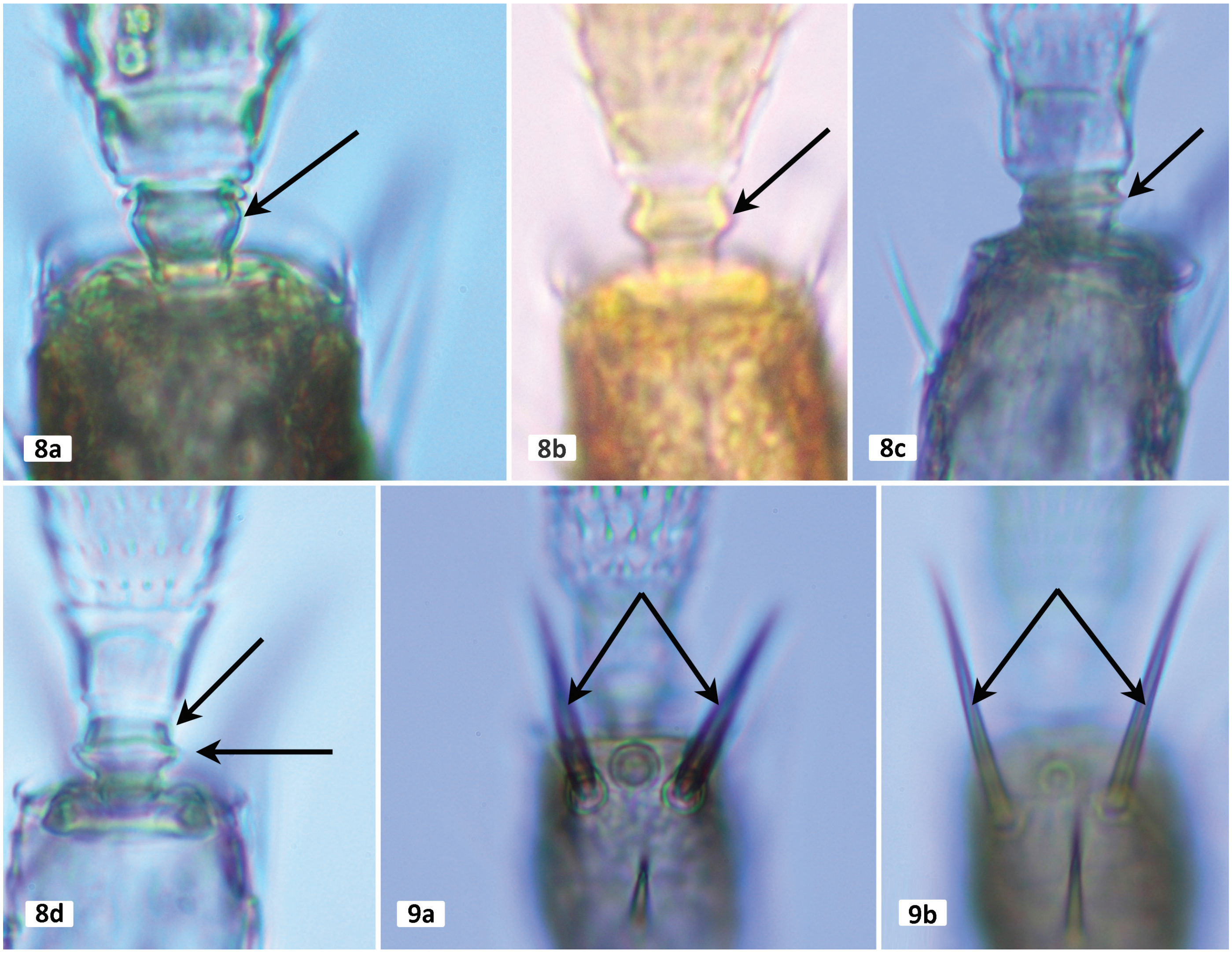

Figs. 8 and 9. Plate IV: Features around antennal segment II. **8a.** Antennal segment III pedicel gently curved outward (convex; black arrow) but not strongly convex (adult *Frankliniella occidentalis*). **8b.** Antennal segment III pedicel strongly curved outward (convex; black arrow), appearing angular (adult *Frankliniella tritici*). **8c.** Antennal segment III pedicel forming flange (black arrow), pedicel margins concave distal and proximal to flange (adult *Frankliniella bispinosa*). **8d.** Antennal segment III pedicel forming flange (black arrows), pedicel margins distal to flange with straight sides (margins not concave) (adult *Frankliniella cephalica*). **9a**. Setae (black arrows) on antennal segment II forming thick, heavy spines, profile fusiform, but strongly tapered to apex (adult *Frankliniella bispinosa*). **9b.** Setae (black arrows) on antennal segment II slender, tapered evenly from base to apex (other adult *Frankliniella* spp.).

14. (13') Forewing pale (Fig. 6a); body color ranging from yellow to brown, the widespread strain is yellow with a dark, longitudinal stripe running down the center; ocellar III setae arising slightly anterior to anterior margin of posterior ocelli, setal bases near margins of ocellar triangle (Fig. 10b); microtrichial comb on tergite VIII continuous, not interrupted medially (Fig. 12a) .... *Frankliniella occidentalis* (Pergande)

14'. — Forewing dark with base sharply paler (Fig. 6b); body color brown; ocellar III setae arising well outside the ocellar triangle; microtrichial comb on tergite VIII interrupted medially (Fig. 12b) .... *Frankliniella insularis* (Franklin)

15. (6') Lateral margins of abdominal tergites IV–VI with microtrichia, rows of microtrichia closely spaced (Fig. 14a); cilia of forewing fringe straight (Fig. 15a); ocellar III setae arising between posterior ocelli, contained within ocellar triangle (Fig. 10c) .... *Scirtothrips dorsalis* Hood

15'. — Lateral margins of abdominal tergites VI–VI lacking closely spaced rows of microtrichia; cilia of forewing fringe wavy (Fig. 15b); ocellar III setae not arising within the ocellar triangle 16

16. (15') Abdominal tergites V–VIII lacking paired ctenidia laterally; antennae 8- or 9-segmented (Fig. 5b,c) 17

16'. — Abdominal tergites V–VIII with paired with ctenidia laterally; antennae 7- or 8-segmented (Fig. 5a,b) 19

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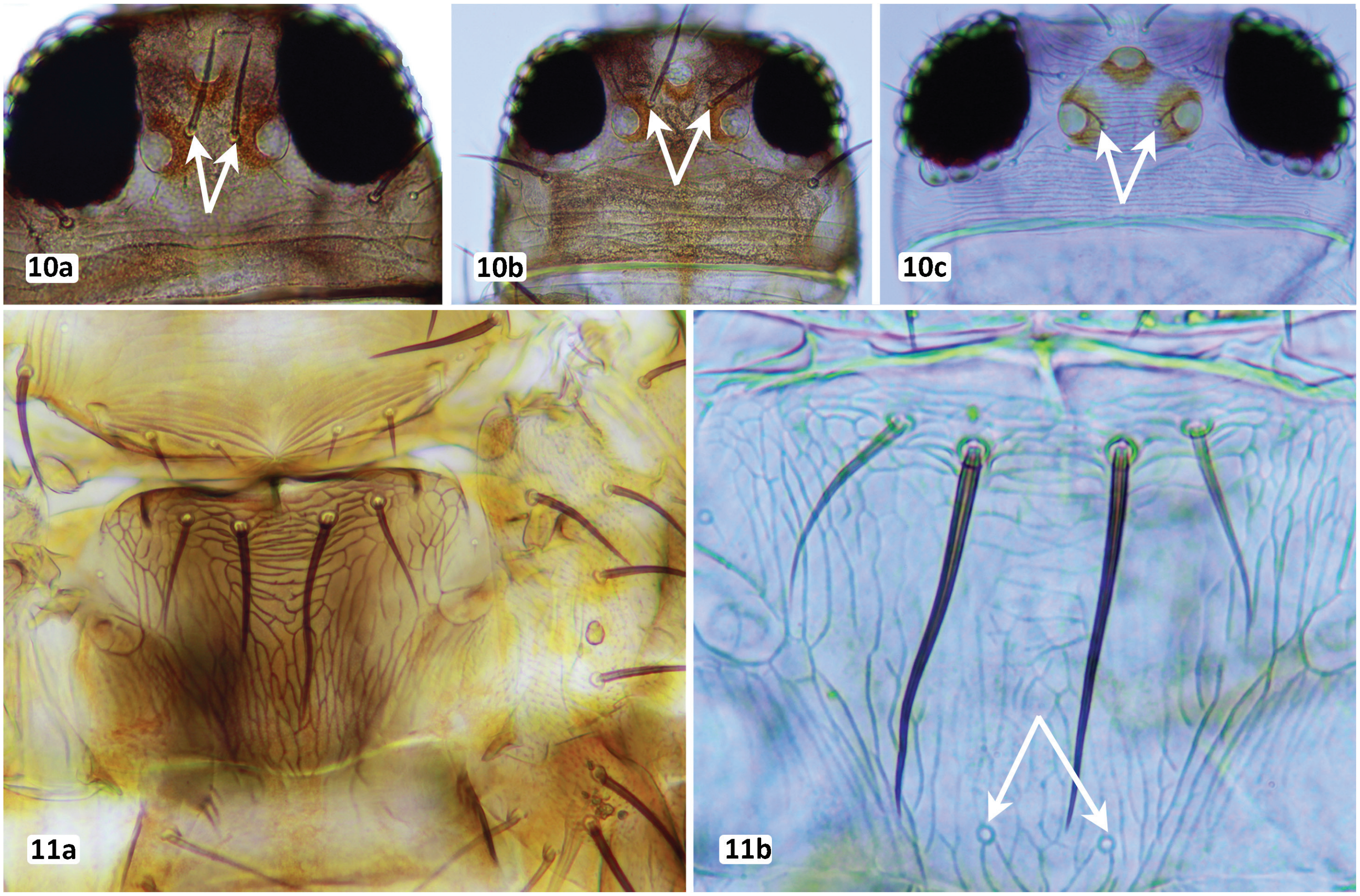

Figs. 10 and 11. Plate V: Features around the ocellar triangle and the metanotum **10a.** Ocellar III setae arising at a level essentially between anterior margin of the posterior ocelli, setal bases close together (white arrows) (adult *Frankliniella schultzei*). **10b.** Ocellar III setae arising at the level of the anterior margin of posterior ocelli, setal bases widely separated (white arrows) (other *Frankliniella*). **10c.** Ocellar III setae arising between posterior ocelli (white arrows) (adult *Scirtothrips dorsalis*). **11a.** Metanotal campaniform sensilla absent (adult *Frankliniella schultzei* and *Thrips tabaci*). **11b.** Metanotal campaniform sensilla present (white arrows) (adult other *Frankliniella* and *Thrips palmi*).

17. (16) At least 2 major posteroangular setae on the prothorax . . . . *Chaetanaphothrips* sp.

17′. — Posteroangular setae lacking 18

18. (17′) Body dark brown in color; scale-like sculpture on lateral thirds of abdominal tergites (Fig. 16); forewing transversely banded (Fig. 6c); tergite VIII posterior margin lacking comb of microtrichia (Fig. 12e); antennae 8-segmented (Fig. 5b) . . . . *Caliothrips phaseoli* (Hood)

18′. — Body color with varying shades of yellow and brown; forewing uniformly pale (Fig. 6a); tergite VIII posterior margin with comb of long, hair-like microtrichia (Fig. 12c); antennae 8- or 9-segmented (Fig. 5b,c) . . . . *Anaphothrips obscurus* (Müller)

19. (16′) Tergites III–VIII with craspedum toothed or fringed (Fig. 17); pronotum trapezoidal, wider at the posterior margin than the anterior; antennae 7-segmented (Fig. 5a) . . . . *Microcephalothrips abdominalis* (Crawford DL)

19′. — Tergites III–VIII lacking craspedum; pronotum transverse; antennae 7- or 8-segmented (Fig. 5a,b) 20

20. (19′) Metanotum with median pair of setae arising near anterior margin (Fig. 18a); antennae 7- or 8-segmented (Fig. 5a,b) 21

20′. — Metanotum with median pair of setae arising posterior to anterior margin (Fig. 18b); antennae 7-segmented (Fig. 5a) 22

21. (20) Forewing clavus with apical setae longer than subapical setae (Fig. 13b) . . . . *Thrips hawaiiensis* (Morgan)

21′. — Forewing clavus with subapical setae longer than apical setae . . . . *Thrips florum* Schmutz

22. (20′) Abdominal sternites with numerous discal setae in addition to posteromarginal setae (Fig. 19a); row of setae on 1st vein of forewing with spaces between setal bases subequal to length of each seta (Fig. 7b) . . . . *Thrips australi*s (Bagnall)

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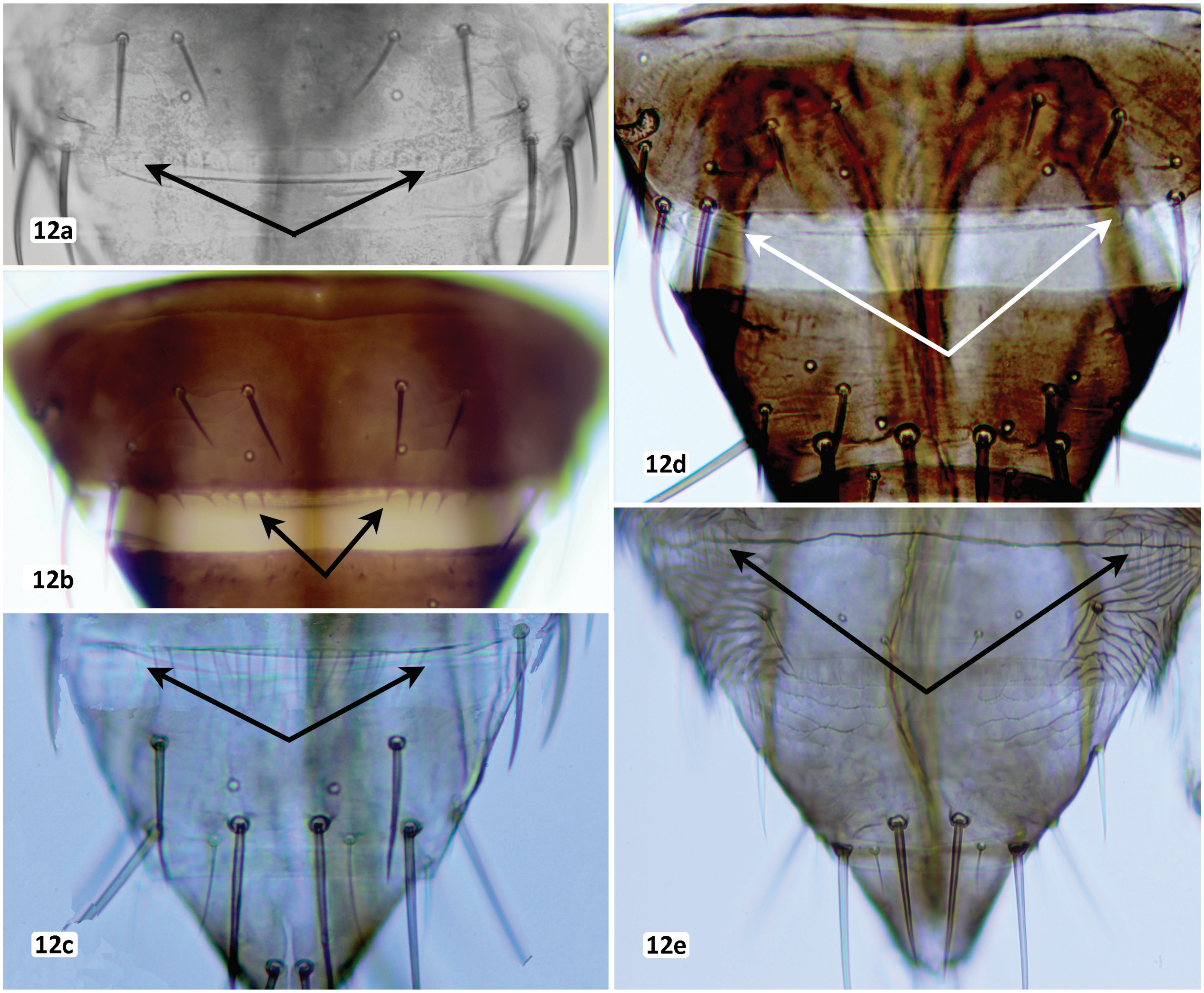

Fig. 12. Plate VI: Comb of microtrichia on Tergite VIII. **12a.** Comb on abdominal segment VIII posterior margin present and uninterrupted (black arrows) (adult *Frankliniella occidentalis*). **12b.** Comb on abdominal segment VIII posterior margin present but interrupted medially (black arrows) (adult *Frankliniella insularis*). **12c.** Comb on abdominal segment VIII posterior margin present (black arrows) (adult *Anaphothrips obscurus*). **12d**. Comb on abdominal segment VIII posterior margin weakly developed (white arrows) (adult *Frankliniella fusca*). **12e.** Comb on abdominal segment VIII absent (black arrows) (adult *Caliothrips phaseoli*).

22'. — Abdominal sternites lacking discal setae, setae present only at posterior margin (Fig. 19b); row of setae on 1st vein with spaces between setal bases much greater than length of each seta (Fig. 7a) 23

23. (22') Metanotal campaniform sensilla absent (Fig. 11a); microtrichia on lateral thirds of tergites IV–VI present on sculpture lines (Fig. 14b) . . . . *Thrips tabaci* Lindeman

23'. — Metanotal campaniform sensilla present (Fig. 11b); microtrichia lacking on lateral thirds of tergites IV–VI . . . . *Thrips palmi* Karny

Key to the Larvae of Common Thrips Pests of Crops in Florida

24. (1') Annulations on antennal segments III and IV absent; microtrichia on antennal segments III and IV absent (Fig. 20a) . . . . Family Phlaeothripidae

24'. — Annulations on antennal segments III and IV present, with microtrichia typically arising from annulations (Fig. 20b) . . . . Family Thripidae, 25

25. (24') Two setae present on each of sternites IV–VIII (Fig. 21a); 12 setae (6 pairs) on pronotum (Fig. 22a) . . . . Stage I Larva

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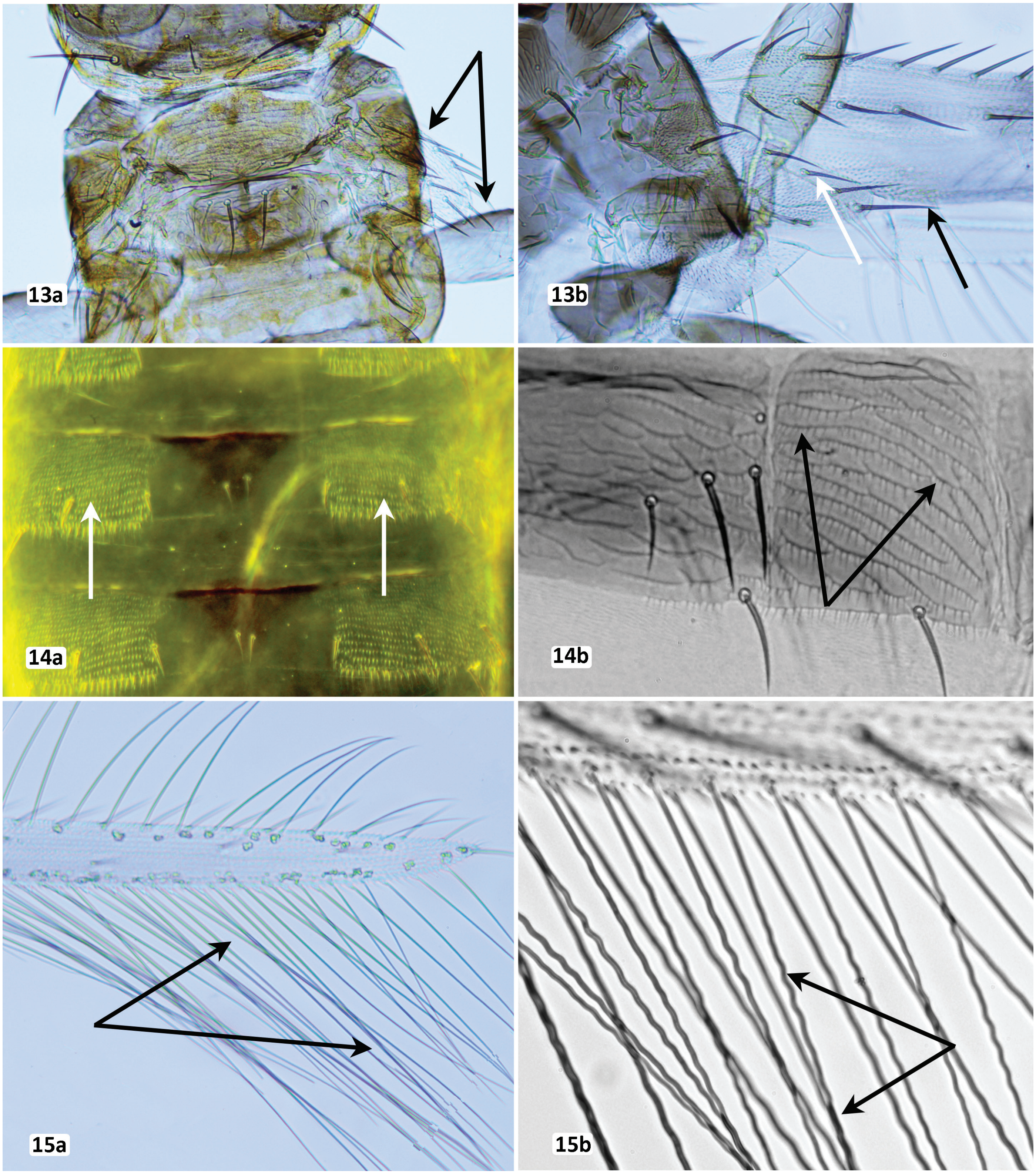

Figs. 13–15. Plate VII: Wing characteristics, microtrichia, and cilia. **3a.** Brachypterous wing (black arrows) (adult *Frankliniella fusca*). **13b.** Apical setae on clavus (black arrow) longer than subapical setae (white arrow) (adult *Thrips hawaiiensis*). **14a**. Microtrichial fields present on lateral thirds of tergites (white arrows) (adult *Scirtothrips dorsalis*). **14b.** Microtrichia present on sculpture lines on the pleurotergites (black arrows) (adult *Thrips tabaci*). **15a.** Fringe of cilia on forewing straight (black arrows) (adult *Scirtothrips dorsalis*). **15b.** Fringe of cilia on forewing wavy (black arrows) (adult other species).

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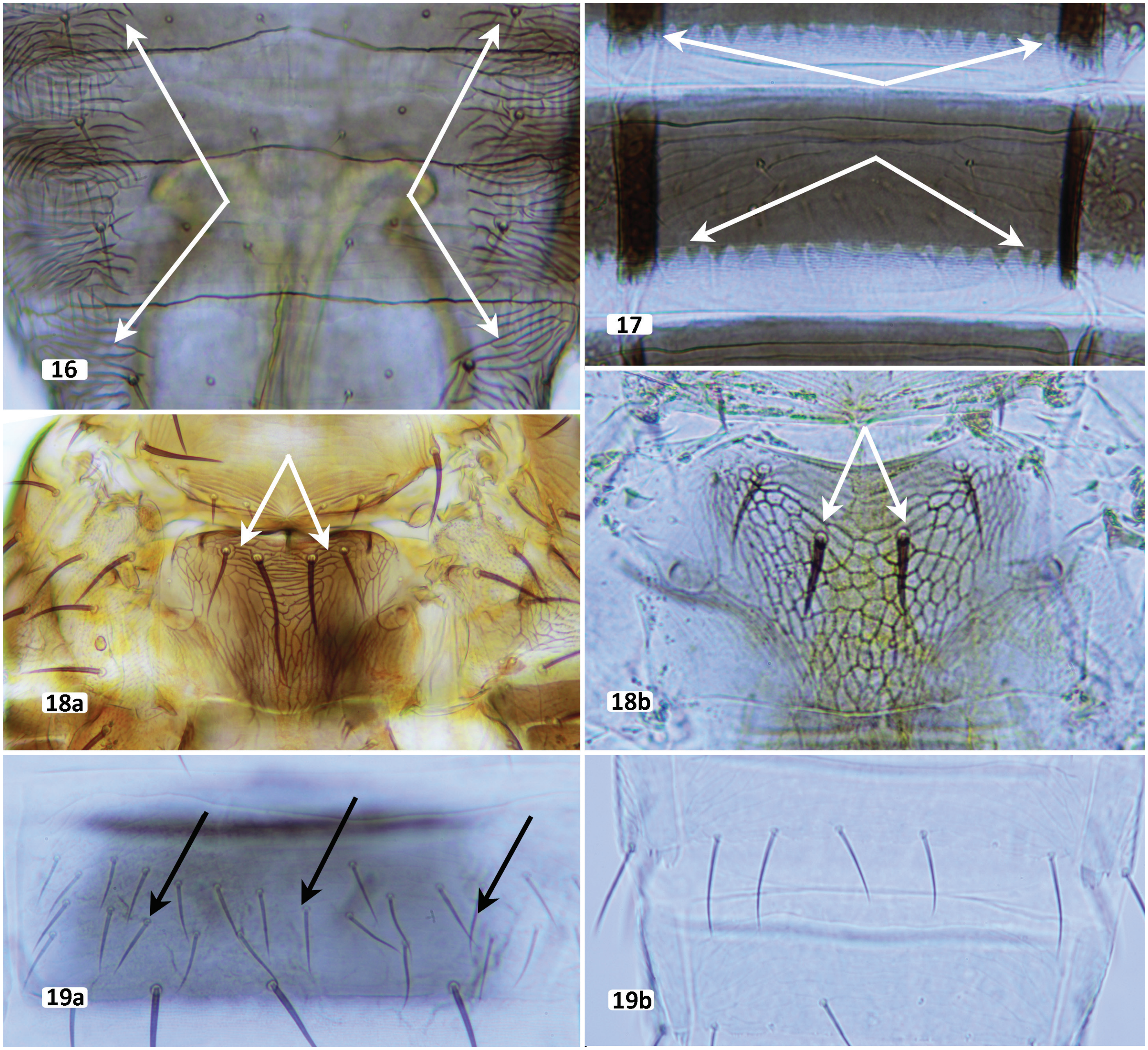

Figs. 16–19. Plate VIII: Tergal, metanotal and discal characteristics. **16.** Lateral thirds of abdomen greatly reticulated (white arrows) (adult *Caliothrips phaseoli*). **17.** Posterior margin of each tergum with a toothed craspedum (white arrows) (adult *Microcephalothrips abdominalis*). **18a.** Metanotal setae arising at anterior margin (white arrows) (adult *Thrips florum* or *Thrips hawaiiensis*). **18b.** Metanotal setae arising posterior to anterior margin (white arrows) (other adult *Thrips*). **19a.** Discal setae present (black arrows) (adult *Thrips australis*). **19b.** Discal setae absent (adult *Thrips tabaci* or *Thrips palmi*).

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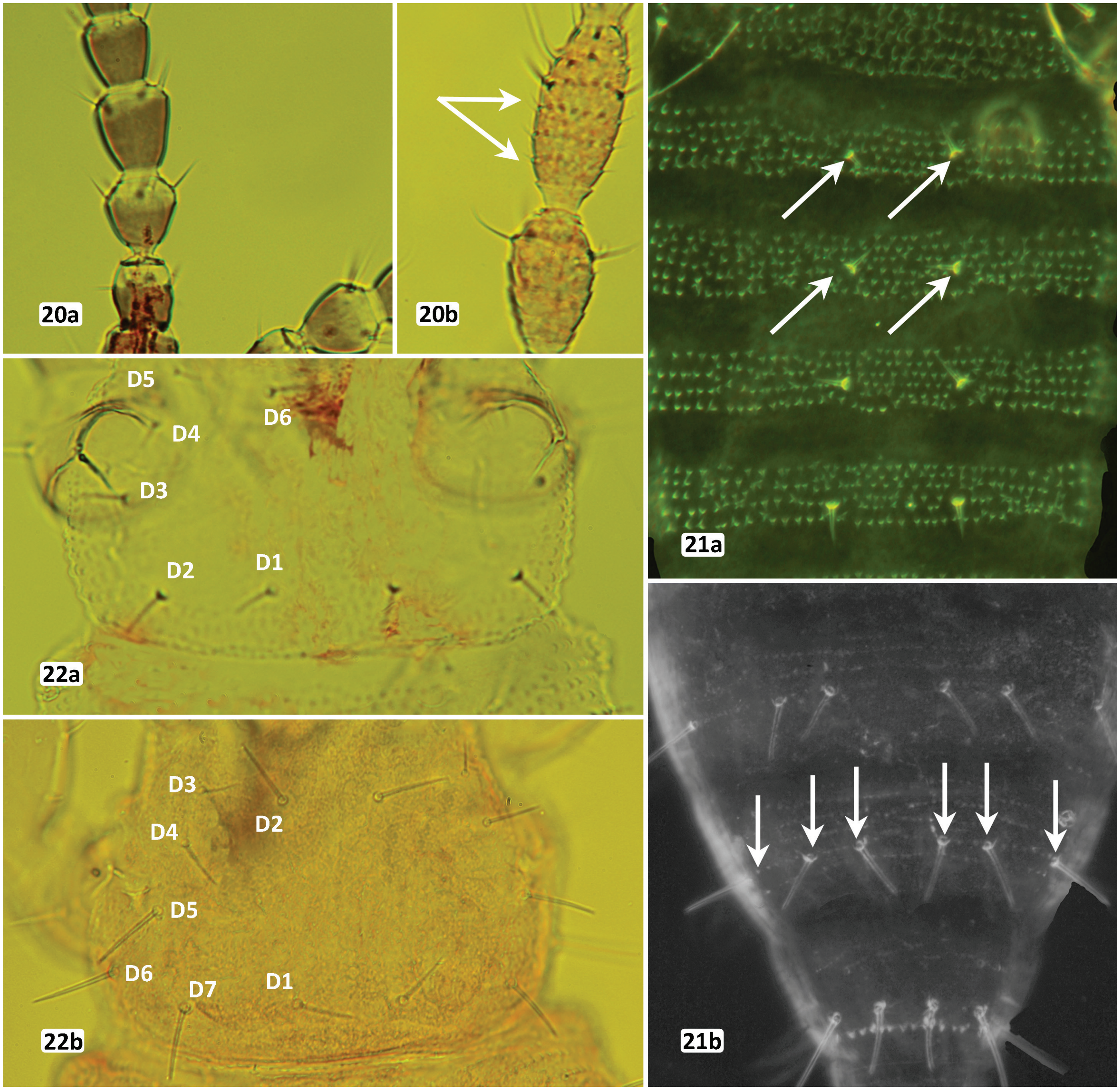

Figs. 20–22. Plate IX: Larval antennal, sternite and pronotal characteristics. **20a.** Antennal segments with smooth margins, lacking annulations (larval Tubulifera: Phlaeothripidae). **20b.** Antennal segments with margins interrupted by annulations, microtrichia arise from these annulations (white arrows) (larval Terebrantia). **21a.** Two setae present on each sternite (white arrows) (larva I). **21b.** Six setae present on each sternite (white arrows) (larva II). **22a.** Twelve setae (6 pairs, D1–D6) on pronotum (Larva I). **22b.** Fourteen setae (7 pairs, D1–D7) on pronotum (Larva II).

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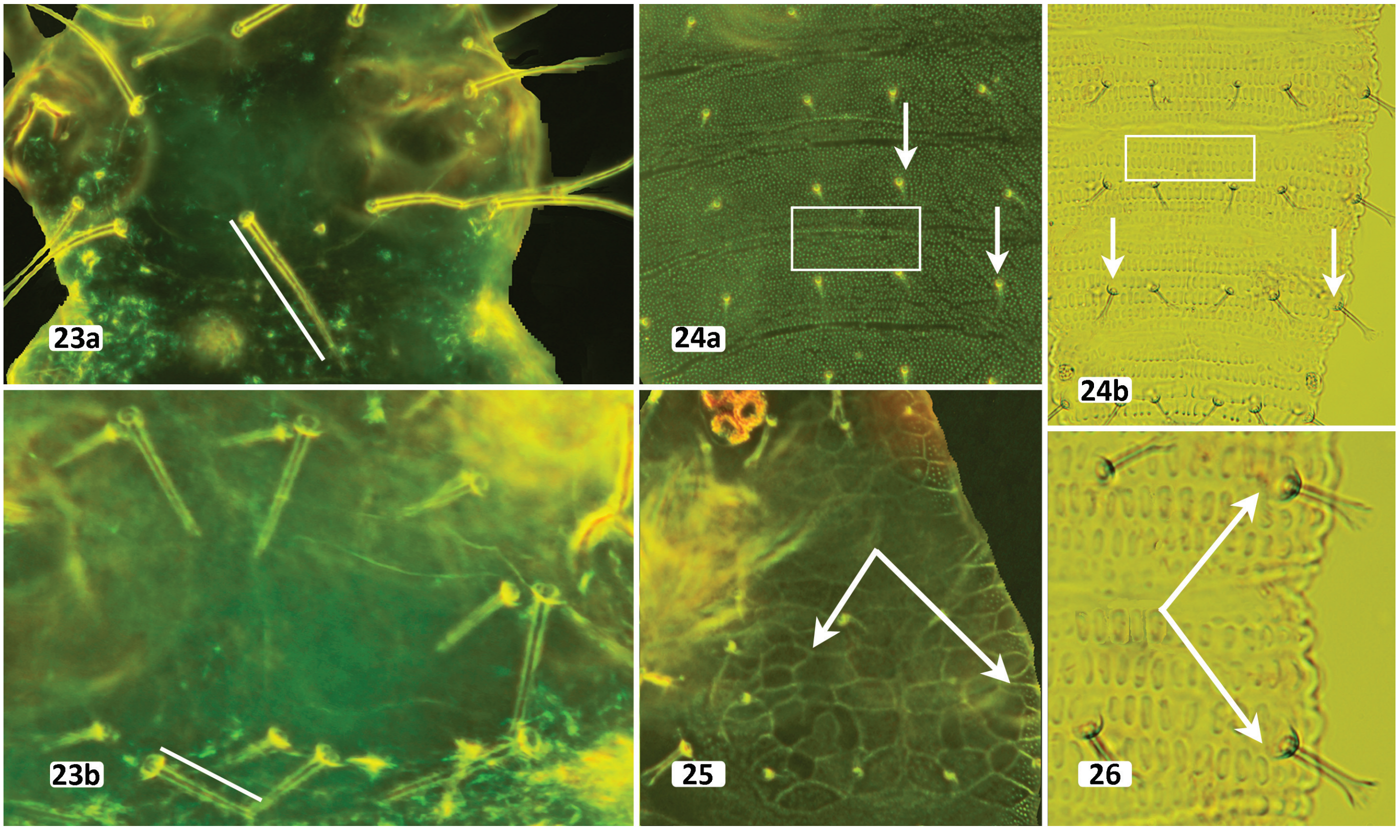

Figs. 23–26. Plate X: Larval cuticular, abdominal and head characteristics. **23a.** Pronotal setae extremely long (white line) (larval *Scolothrips*). **23b.** Pronotal setae not extremely long (white line) (other larval thrips). **24a.** Cuticle of abdomen ornamented with small stipples (white box); dorsal setae small (white arrows) (larval *Scirtothrips dorsalis*). **24b.** Cuticle of abdomen ornamented with oval plaques, forming distinct rows (white box); moderate-sized dorsal setae (white arrows) (larvae other species). **25.** Cuticle of head patterned with irregularly shaped reticulations (white arrows) (larval *Scirtothrips dorsalis*). **26.** Dorsal setae funnel shaped (white arrows) (larval *Chaetanaphothrips*).

25′. — Six setae present on each of sternites IV–VIII (Fig. 21b); 14 (7 pairs) setae present on pronotum (Fig. 22b) . . . . Stage II Larva, 26

26. (25′) Dorsal setae extremely long, length greater than 15 times the diameter of seta socket (Fig. 23a) . . . . *Scolothrips* sp.

26′. — Dorsal setae not extremely long, length less than 10 times the diameter of seta socket (Fig. 23b) 27

27 (26′) Cuticle heavily stippled, appearing shagreen-like (Fig. 24a); cuticle of head heavily reticulated (Fig. 25); dorsal abdominal setae small (Fig. 24a) . . . . *Scirtothrips dorsalis* Hood

27′. — Cuticle not stippled, but with oval plaques (Fig. 24b); head not heavily reticulated; dorsal abdominal setae moderately enlarged (Fig. 24b) 28

28. (27′) Dorsal setae expanded apically (Fig. 26); teeth on posterior margin of tergite IX large, prominent (Fig. 27a) . . . *Chaetanaphothrips* sp.

28′. — Most dorsal setae not greatly expanded apically; teeth on posterior margin of tergite IX small, indistinct (Fig. 27b,c) 29

29. (28′) Sensilla on tergite IX separated by 1.0–1.5 times the space between the D_1 setae . . . . *Thrips* spp.

29′. — Sensilla on tergite IX separated more than 2.0 time the space between the D_1 setae (Fig. 28) . . . . *Frankliniella*, 30

30. (29′) Abdominal tergite setae pointed (Fig. 29a); microtrichia on plaques of tergite VIII well developed (Fig. 30) . . . . *Frankliniella occidentalis* (Pergande)

30′. — Abdominal tergites with blunt setae (Fig. 29b); microtrichia on plaques of tergite VIII well developed or absent 31

31. (30′) Plaques on tergite VIII with well-developed microtrichia (Fig. 30); tergite IX with posteromarginal teeth longer than basal width of D_1 setae (Fig. 27b) . . . . *Frankliniella bispinosa* (Morgan)

31′. — Plaques on tergite VIII lacking well-developed microtrichia; tergite IX with posteromarginal teeth equal to or shorter than basal width of D_1 setae (Fig. 27c) . . . . *Frankliniella schultzei* (Trybom)

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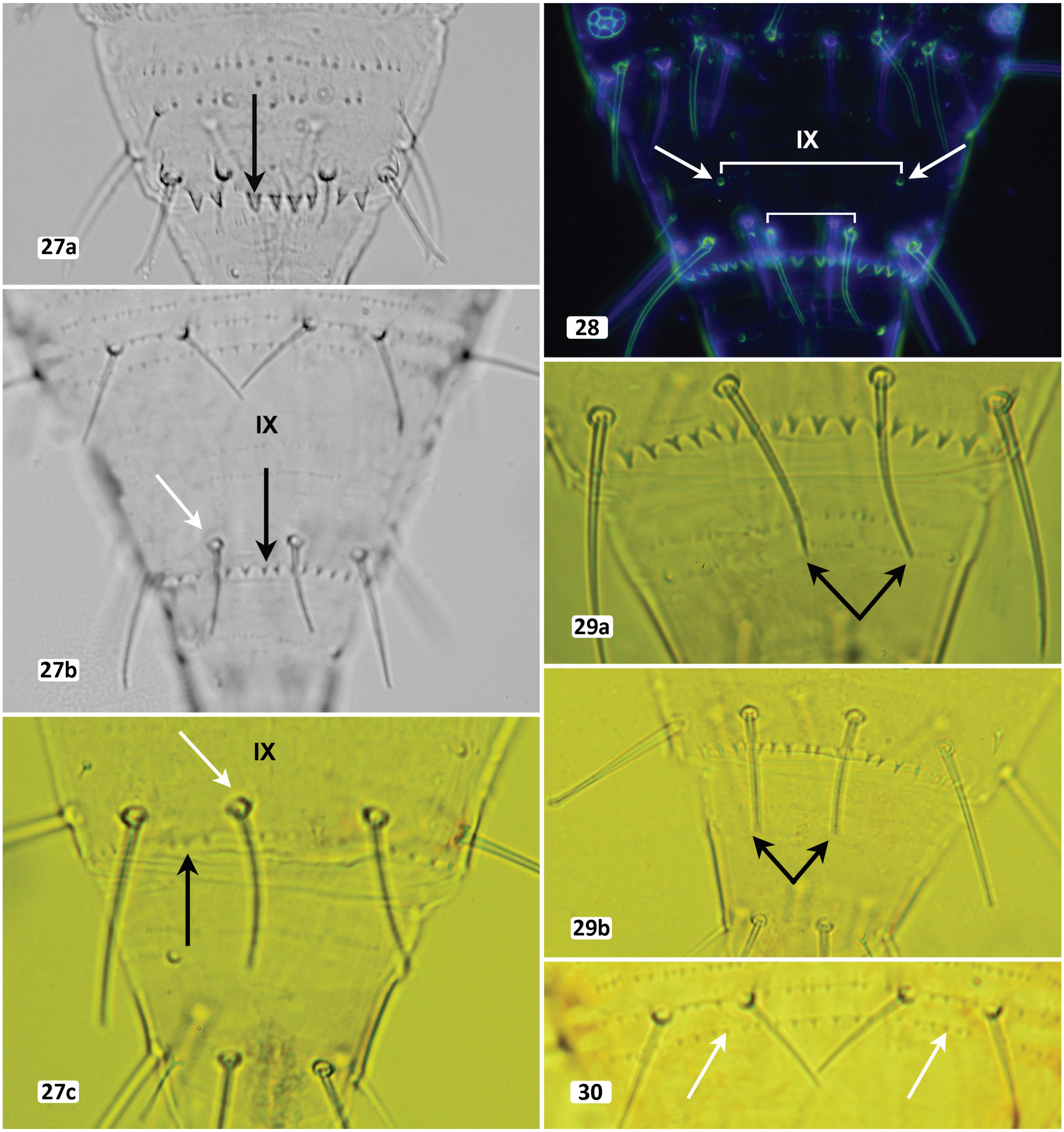

Figs. 27–30. Plate XI: Larval abdominal characteristics. **27a**. Teeth (black arrow) on posterior margin of abdominal segment IX large, prominent (larval *Chaetanaphothrips*). **27b.** Teeth (black arrow) on posterior margin of abdominal segment IX small but longer than basal width of D_1 setae ; base of D_1 seta (white arrow) (larval *Frankliniella bispinosa*). **27c.** Teeth (black arrow) on posterior margin of abdominal segment IX small and equal to or shorter than basal width of D_1 setae; base of D_1 seta (white arrow) (larval *Frankliniella schultzei*). **28.** Campaniform sensilla (white arrows) on abdominal segment IX separated by 2.0 times the distance (long white line) as compared with the distance (short white line) between D_1 setae (larval *Frankliniella*). **29a.** Setae arising from tergites on abdominal segment IX pointed (black arrows) (adult *Frankliniella occidentalis*). **29b.** Setae arising from tergites on abdominal segment IX blunt (black arrows) (adult *Frankliniella bispinosa* or *Frankliniella schultzei*). **30.** Plaques with well-defined microtrichia (white arrows) on abdominal segment VIII (larval *Frankliniella occidentalis* or *Frankliniella bispinosa*).

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