

RESEARCH

Fruit Flies of the Genus *Anastrepha* (Diptera: Tephritidae) From Some Localities of Paraguay: New Records, Checklist, and Illustrated Key

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ABSTRACT. This study deals with fruit flies of the genus *Anastrepha* Schiner (Diptera: Tephritidae) collected in McPhail traps in the municipalities of Concepción, Belén, Horqueta, Loreto (state of Concepción) and Santa Rosa (state of Misiones), Paraguay. In total, 17 species were captured, 9 of which are new records for Paraguay. All morphological characters used for species identification are illustrated.

RESUMEN. Se estudió las especies de moscas de las frutas del género *Anastrepha* Schiner (Diptera: Tephritidae), colectadas en trampas tipo McPhail en las localidades de Concepción, Belén, Horqueta (Departamento de Concepción) y Santa Rosa (Departamento de Misiones). En total fueron capturadas 17 especies, de las cuales nueve especies corresponden a nuevos registros para el Paraguay. Todos los caracteres morfológicos para la identificación de las especies fueron ilustrados.

Key Words: diversity, McPhail traps, survey, occurrence, identification

Taxonomic studies involving species of *Anastrepha* Schiner (Diptera: Tephritidae) occurring in Paraguay have been carried out, and all them were based exclusively on small numbers of specimens deposited in museums. The first was by Hendel (1914), who described *Anastrepha macrura* Hendel and *Anastrepha punctata* Hendel, based on specimens collected in San Bernardino, state of Cordillera, Paraguay. Two decades after, Greene (1934) identified five species based exclusively on external morphology, including the species described by Hendel (loc. cit.). Later, Stone (1942) identified a further five species by using female terminalia, thereby showing that specimens identified by Greene (1934) as *Anastrepha parallela* (Wiedemann) actually were *Anastrepha elegans* Blanchard. Norrbom (1991, 1998) identified other species, for an eventual total of 10 (Norrbom 2004). In addition, two monographs (Recalde 1995, Gurrieri 2011) and one MSc dissertation (Arias 2010) were produced. However, identifications of species recorded by Recalde (1995) in his monograph are unreliable, as they were not based on examination of the female terminalia. Gurrieri (2011) recorded *Anastrepha distincta* Greene and *Anastrepha pseudoparallela* (Loew) for the first time in Paraguay and Arias (2010) listed 17 species, which are being formally published herein.

Therefore, this is the first taxonomic study based on species of *Anastrepha* surveyed in five municipalities in Paraguay. This contribution provides a checklist and an illustrated key to contribute to further research on fruit flies belonging to this genus in Paraguay.

Materials and Methods

This study was based in part on fruit flies sampled in the program “Moscas de las Frutas” of the “Servicio Nacional de Calidad y Sanidad Vegetal y de Semillas (SENAVE)”. Specimens were collected in McPhail-type traps baited with hydrolyzed protein in the municipalities of Concepción, state of Concepción (23° 22'S, 57° 16'W, average temperature 25°C, and annual pluvial precipitation around 1,300 mm) and Santa Rosa, state of Misiones (26° 56'S, 56° 52'W, average temperature 23°C and annual pluvial precipitation around 1,600 mm), respectively, in the northern and southern parts of the Oriental region of

Paraguay (Fig. 1), from May 2008 to 2009. These municipalities are about 600 km apart each other. In Concepción, McPhail-type traps were hung at 1.20 m above the ground level in plantation of *Cucurbita pepo* (L.) (zucchini). In Santa Rosa, traps were hung in apical third of trees such as *Averrhoa carambolae* (L.) (star fruit), *Citrus maxima* (Burm.) Merr. (pummelo), and *Carica papaya* (papaya). These surveys of fruit flies were carried out to detect the occurrence of *Anastrepha grandis* (Macquart). A few samples from the municipalities of Belén, Horqueta, and Loreto, state of Concepción, were also studied.

Species identification was based only on females. The illustrated key includes all 21 species known from Paraguay, i.e., *Anastrepha* species captured in these surveys and the species previously recorded for Paraguay. The wings, mesonotum, and abdomen were observed through a stereomicroscope; images were taken with a digital camera and transferred to a computer. The aculei and teeth of the eversible membrane were photographed with a scanning electron microscope (Uramoto and Zucchi 2010). Further information on the species included in the key is found in Norrbom et al. (2012).

Voucher specimens are deposited at the Departamento de Entomología e Acarología, Escola Superior de Agricultura Luiz de Queiroz (ESALQ), Piracicaba, São Paulo, Brazil, and at the Museu de Entomologia del Facultad de Ciencias Agrarias, San Lorenzo, Paraguay.

Results

In total 5,795 fruit flies of the genus *Anastrepha* were collected (2,700 males and 3,095 females) in Concepción and Misiones. Based on females, 17 species were identified, belonging to 10 *Anastrepha* species groups, namely *daciformis*, *dentata*, *fraterculus*, *grandis*, *mucronota*, *pseudoparallela*, *punctata*, *serpentina*, *spatulata*, and *striata*, and one unplaced species, according to the classification proposed by Norrbom et al. (2012). The *fraterculus* (four species) and *spatulata* (three species) groups were the largest; however, most groups were represented by a single species (Table 1). The most common species was *Anastrepha fraterculus* (Wiedemann), totaling ~71% of the specimens

collected. The abundance of some species was quite different in both municipalities. For example, *Anastrepha sororcula* Zucchi was the second most prevalent species in Concepción, but few specimens were collected in Misiones, where *A. punctata* was the most common species. Most species showed frequencies below 2% (Fig. 2).

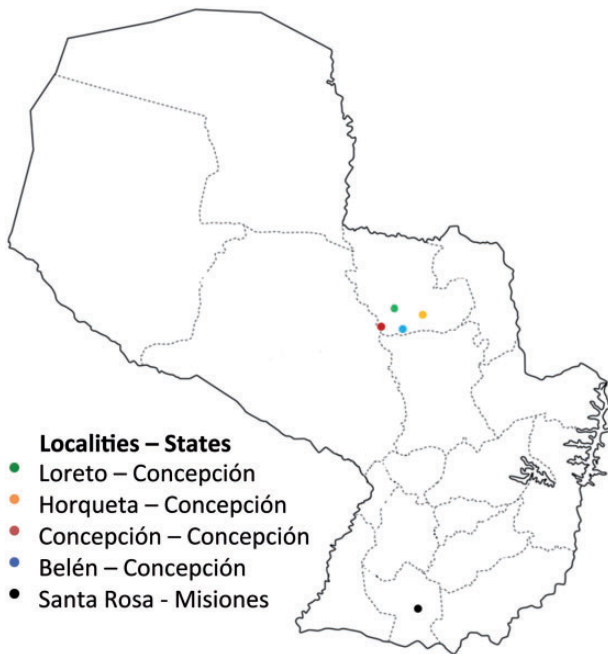


Fig. 1. Localities where *Anastrepha* species were captured.

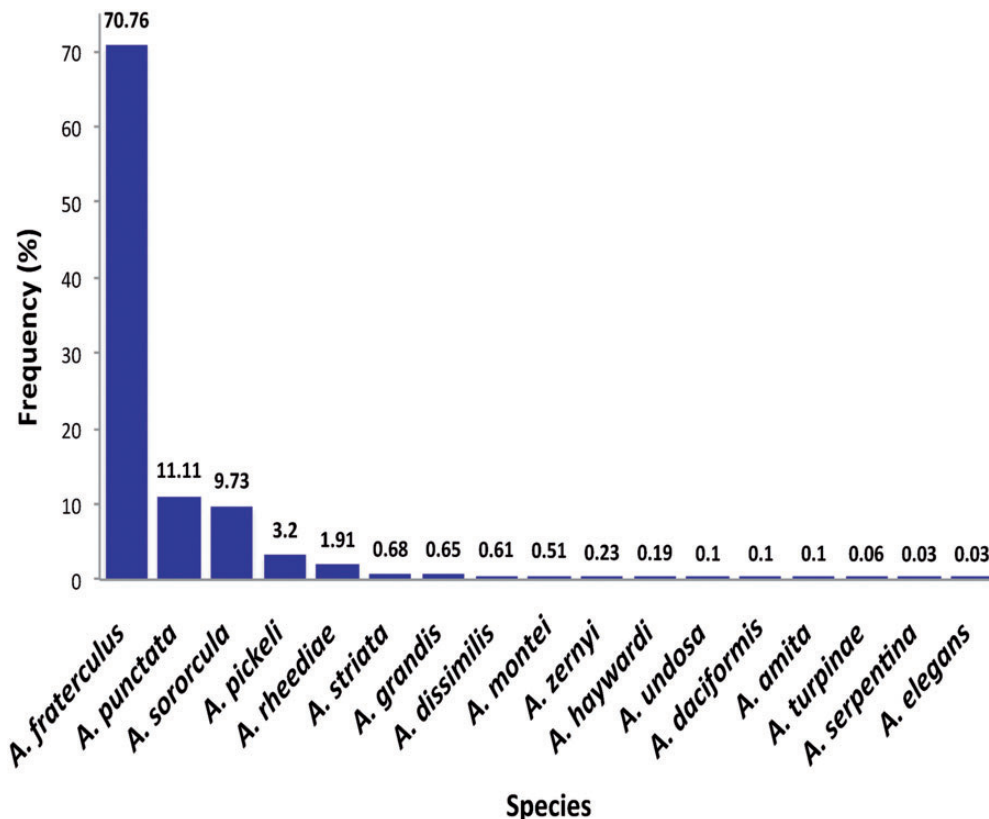


Fig. 2. Frequencies of species of *Anastrepha* (females) captured in McPhail-type traps in the municipalities of Concepción (state of Concepción) and Santa Rosa (state of Misiones), Paraguay, from May 2008 to 2009.

Discussion

The study of species of *Anastrepha* in Paraguay has been neglected. In the last seven decades, taxonomic studies on *Anastrepha* fruit flies have advanced little in Paraguay. No research on fruit flies and host plant associations has been conducted in the country.

Intensive surveys with traps have been carried out by the SENAIVE, but specimens have not been preserved properly or deposited in museum collections. Here, based on part of the specimens surveyed by SENAIVE, 17 species are identified, of which 9 are new records

Table 1. Species of *Anastrepha* in samples collected from May 2008 to 2009 by SENAIVE

Species groups	<i>Anastrepha</i> species	States
<i>daciformis</i>	<i>A. daciformis</i> Bezzi	2
	<i>A. zernyi</i> Lima*	2
	<i>A. amita</i> Zucchi*	2
	<i>A. fraterculus</i> (Wied.)	1, 2
	<i>A. sororcula</i> Zucchi	1, 2
<i>grandis</i>	<i>A. turpinae</i> Stone*	1
	<i>A. grandis</i> (Macquart)	2
	<i>A. mucronota</i>	2
<i>pseudoparallela</i>	<i>A. undosa</i> Stone	1
	<i>A. dissimilis</i> Stone*	1, 2
	<i>A. punctata</i> Hendel	1, 2
	<i>A. serpentina</i> (Wied.)*	1
	<i>A. haywardi</i> Blanchard*	1
<i>striata</i>	<i>A. montei</i> Lima	1
	<i>A. pickeli</i> Lima*	1
	<i>A. striata</i> Schiner*	1, 2
Not assigned to a species group	<i>A. rheediae</i> Stone*	1, 2

*New records for Paraguay; 1, Concepción; 2, Misiones.

Table 2. Checklist of the species of *Anastrepha* in Paraguay, with collection localities

<i>Anastrepha</i> species	Municipalities	Geographic coordinates	States	References
<i>A. amita</i> Zucchi	Santa Rosa	26°52' S, 56°51' W	Misiones	
<i>A. barbiellini</i> Lima*	—		—	Norrbom (2004)
<i>A. daciformis</i> Bezzi	San Bernardino	25°16' S, 57°19' W	Cordillera	Norrbom (1998)
	Asunción	25°18' S, 57°38' W	Central	Norrbom (2004)
	Santa Rosa	26°52' S, 56°51' W	Misiones	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. dissimilis</i> Stone	Concepción	23°24' S, 57°26' W	Concepción	
	Horqueta	23°20' S, 57°03' W	Concepción	
	Loreto	23°16' S, 57°19' W	Concepción	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
	Santa Rosa	26°52' S, 56°51' W	Misiones	
<i>A. distincta</i> Greene*	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. elegans</i> Blanchard	San Bernardino	25°16' S, 57°19' W	Cordillera	Stone (1942), Norrbom (2004)
	Santa Rosa	26°52' S, 56°51' W	Misiones	
<i>A. fraterculus</i> (Wied.)	Belén	23°27' S, 57°15' W	Concepción	Stone (1942)
	Concepción	23°24' S, 57°26' W	Concepción	Stone (1942)
	Horqueta	23°20' S, 57°03' W	Concepción	Stone (1942)
	Santa Rosa	26°52' S, 56°51' W	Misiones	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. grandis</i> (Macquart)	Puerto Bertoni	25°39' S, 54°35' W	Alto Paraná	Norrbom (2004)
	Horqueta	23°20' S, 57°03' W	Concepción	Norrbom (2004)
	San Bernardino	25°16' S, 57°19' W	Cordillera	Greene (1934)
	Villarica	25°45' S, 56°26' W	Guairá	Norrbom (1991, 2004)
	Bella Vista	27°03' S, 55°33' W	Itapúa	Norrbom (1991, 2004)
	Hohenau	27°05' S, 55°45' W	Itapúa	Norrbom (1991, 2004)
	Santa Rosa	26°52' S, 56°51' W	Misiones	
<i>A. haywardi</i> Blanchard	Concepción	23°24' S, 57°26' W	Concepción	
<i>A. macrura</i> Hendel*	San Bernardino	25°16' S, 57°19' W	Cordillera	Hendel (1914), Greene (1934), Norrbom (1998, 2004)
<i>A. montei</i> Lima	San Bernardino	25°16' S, 57°19' W	Cordillera	Stone (1942), Norrbom (2004)
	Concepción	23°24' S, 57°26' W	Concepción	
	Horqueta	23°20' S, 57°03' W	Concepción	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. pickeli</i> Lima	Concepción	23°24' S, 57°26' W	Concepción	
	Horqueta	23°20' S, 57°03' W	Concepción	
	Loreto	23°16' S, 57°19' W	Concepción	
<i>A. pseudoparallela</i> (Loew)*	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. punctata</i> Hendel	Concepción	23°24' S, 57°26' W	Concepción	Greene (1934), Stone (1942)
	San Bernardino	25°16' S, 57°19' W	Cordillera	Hendel (1914), Norrbom (2004)
<i>A. rheediae</i> Stone	Concepción	23°24' S, 57°26' W	Concepción	
	Santa Rosa	26°52' S, 56°51' W	Misiones	
<i>A. serpentina</i> (Wied.)	Concepción	23°24' S, 57°26' W	Concepción	
<i>A. sororcula</i> Zucchi	—		—	Norrbom (2004)
	Concepción	23°24' S, 57°26' W	Concepción	
	Horqueta	23°20' S, 57°03' W	Concepción	
	Santa Rosa	26°52' S, 56°51' W	Misiones	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. striata</i> Schiner	Concepción	23°24' S, 57°26' W	Concepción	
	Santa Rosa	26°52' S, 56°51' W	Misiones	
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. turpinae</i> Stone	Concepción	23°24' S, 57°26' W	Concepción	
<i>A. undosa</i> Stone	Concepción	23°24' S, 57°26' W	Concepción	Norrbom (2004)
	San Lorenzo	25°20' S, 57°31' W	Central	Gurrieri (2011)
<i>A. zernyi</i> Lima	Santa Rosa	26°52' S, 56°51' W	Misiones	

*Species not captured during this survey;—Localities not mentioned.

in Paraguay (Table 1). Five species, namely *Anastrepha dissimilis* Stone, *A. fraterculus*, *A. punctata*, *Anastrepha rheediae* Stone, and *Anastrepha striata* Schiner were trapped in Concepción as well as in Misiones. *A. rheediae* was previously misidentified as *Anastrepha nascentimentoi* Zucchi (Arias 2010). Four species—*Anastrepha barbiellini* Lima, *A. distincta*, *A. macrura*, and *A. pseudoparallela*—previously recorded in Paraguay were not recovered in this study.

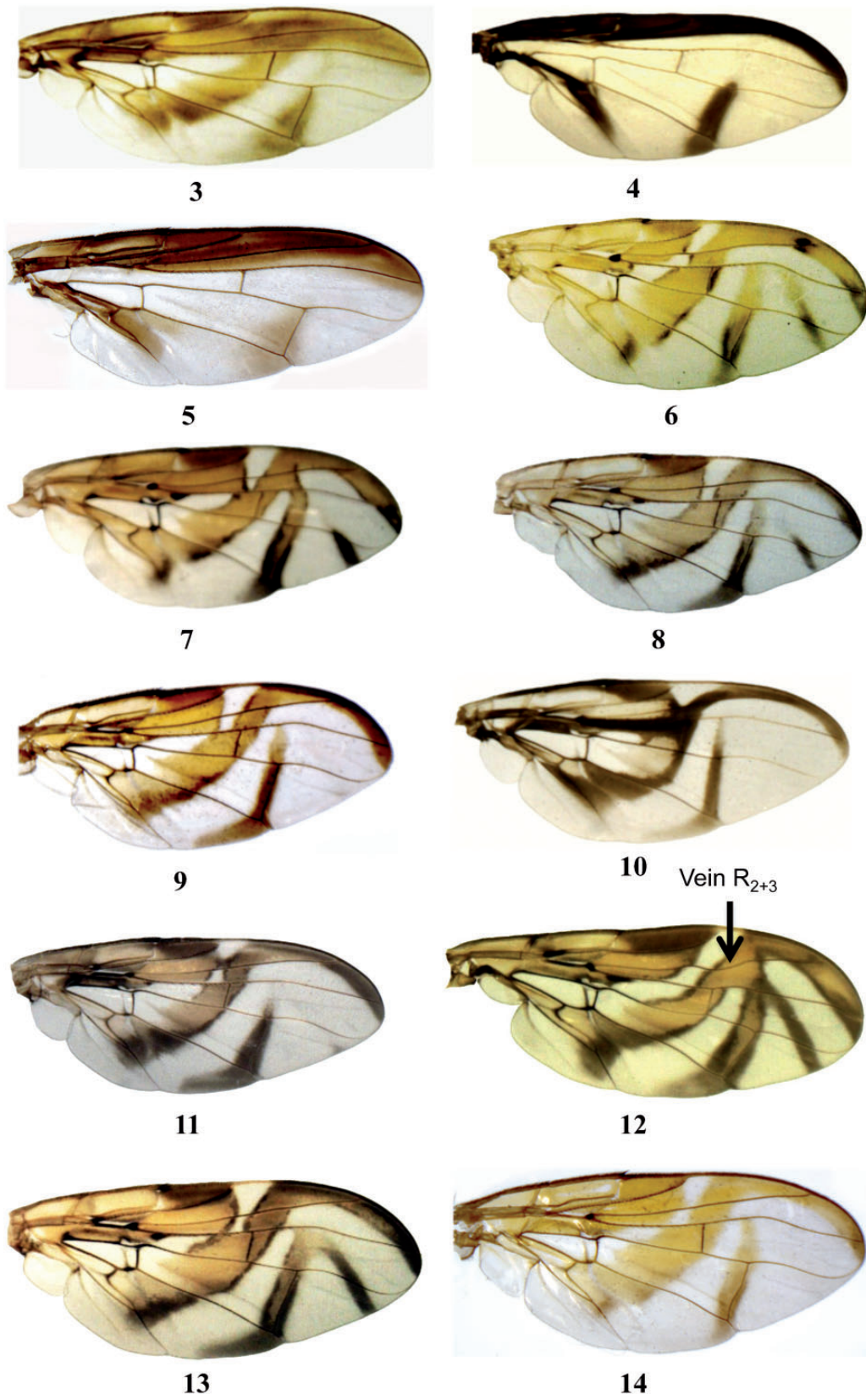
Including the species from SENAIVE surveys studied here and those from literature data, 21 species are known in Paraguay. Certainly, more species will be found when surveys can be conducted throughout Paraguay.

Some *Anastrepha* species of economic and/or quarantine importance such as *A. fraterculus*, *A. grandis*, *A. sororcula*, and *A. striata* occur in Paraguay (Table 2). However, an intriguing point is that *Anastrepha obliqua* (Macquart), a quite common and broadly distributed species in the Americas, has not yet been detected. The record of

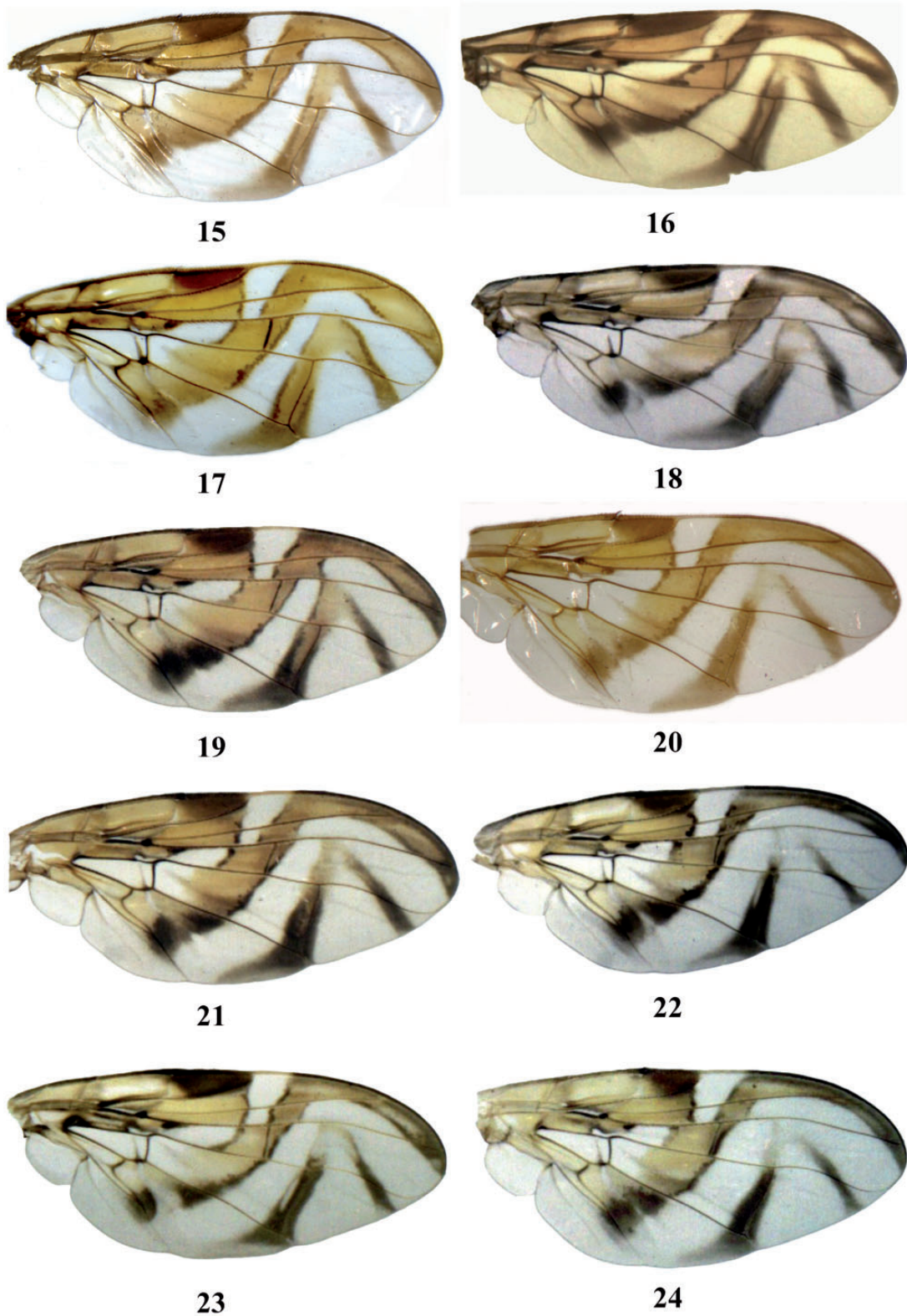
A. grandis in the state of Concepción refers to individuals collected in the 1930s (Norrbom 1993). This species has not been collected in SENAIVE surveys in Concepción in recent years (“N.L.F., unpublished data”).

Illustrated Key to Species of *Anastrepha* From Paraguay

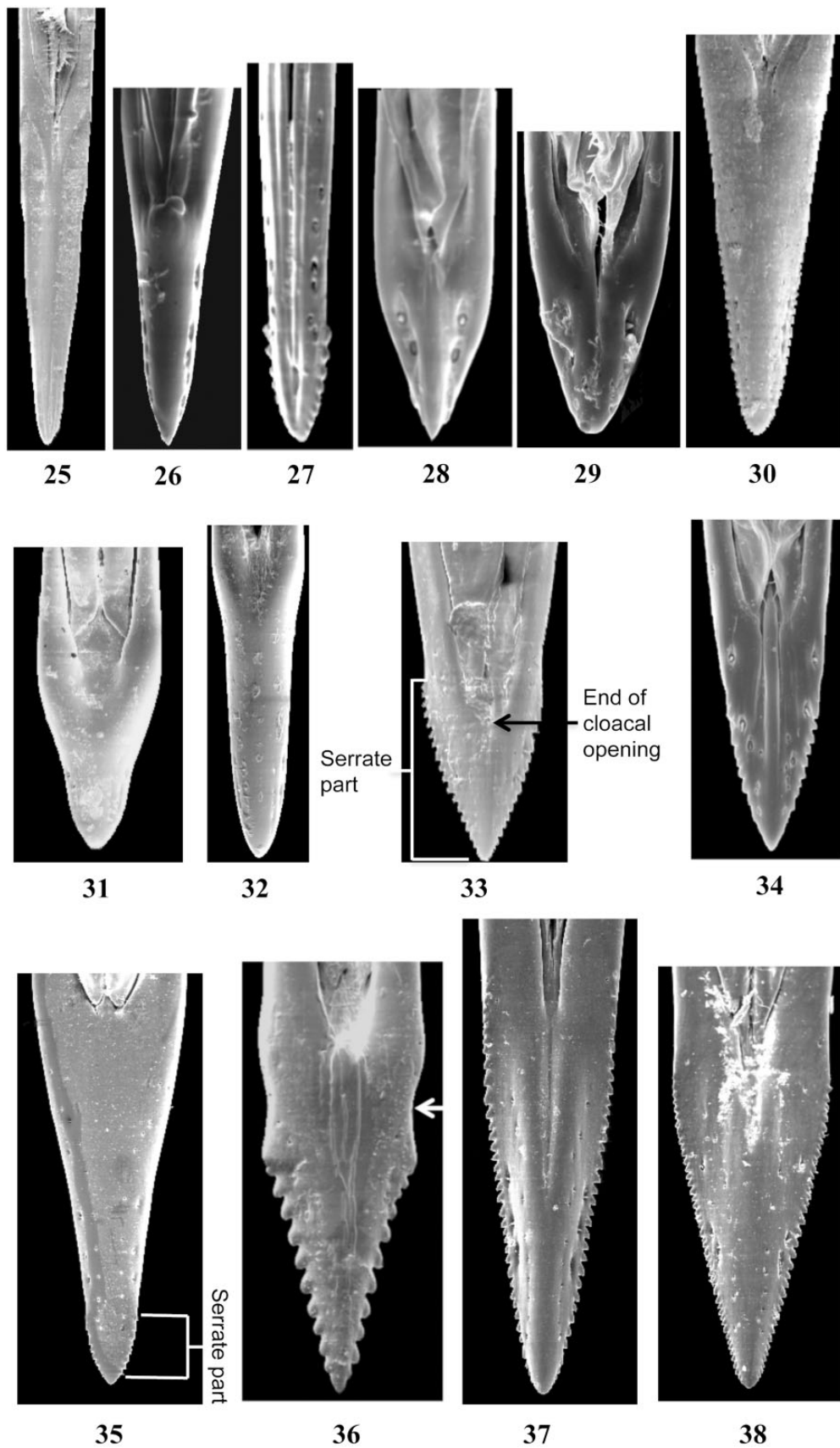
1. Wing without marginal hyaline spot beyond apex of vein R₁ 2
- Wing with marginal hyaline spot beyond apex of vein R₁ 4
2. S-band complete (central part present), scutum with sublateral dark stripes, aculeus more than 6 mm long, tip nonserrate (Figs. 3, 25, and 51)..... *A. grandis* (Macquart)
- S-band incomplete (central part absent)..... 33.
- Cell r₂₊₃ hyaline except apex, V-band (basal arm), brown, pale presutural lateral stripe on scutum complete, abdominal tergite with apical white bands (Figs. 4, 46, and 47).....
- *A. daciformis* Bezzi



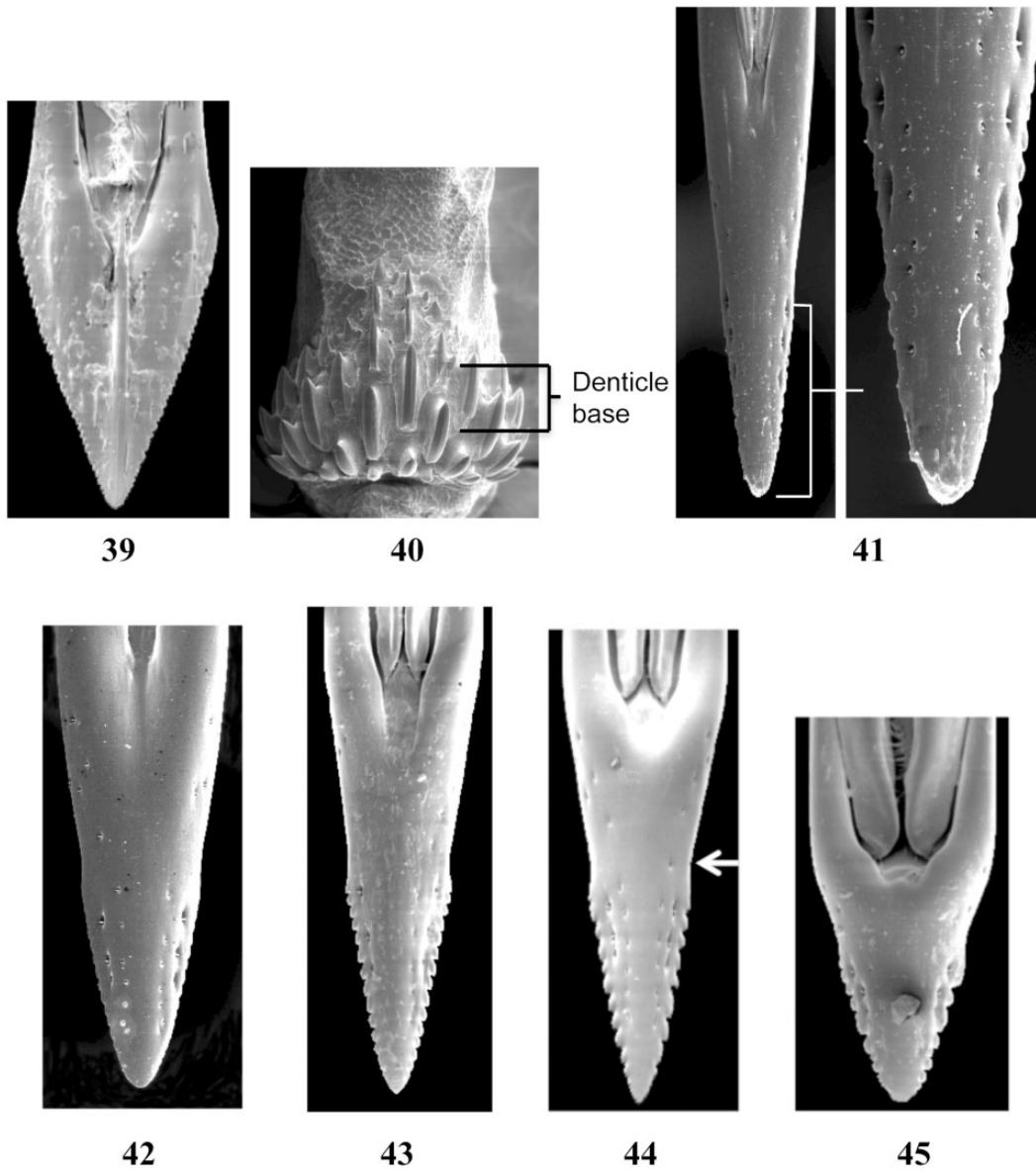
Figs. 3–14. Wings: 3. *A. grandis*, 4. *A. daciformis*, 5. *A. macrura*, 6. *A. punctata*, 7. *A. zernyi*, 8 and 9. *A. montei*, 10. *A. serpentina*, 11. *A. striata*, 12. *A. undosa*, 13. *A. pickeli*, 14. *A. haywardi*.



Figs. 15–24. Wings: 15. *A. barbiellini*, 16. *A. elegans*, 17. *A. pseudoparallela*, 18. *A. dissimilis*, 19. *A. rheediae*, 20. *A. distincta*, 21. *A. amita*, 22. *A. turpiniae*, 23. *A. fraterculus*, 24. *A. sororcula*.

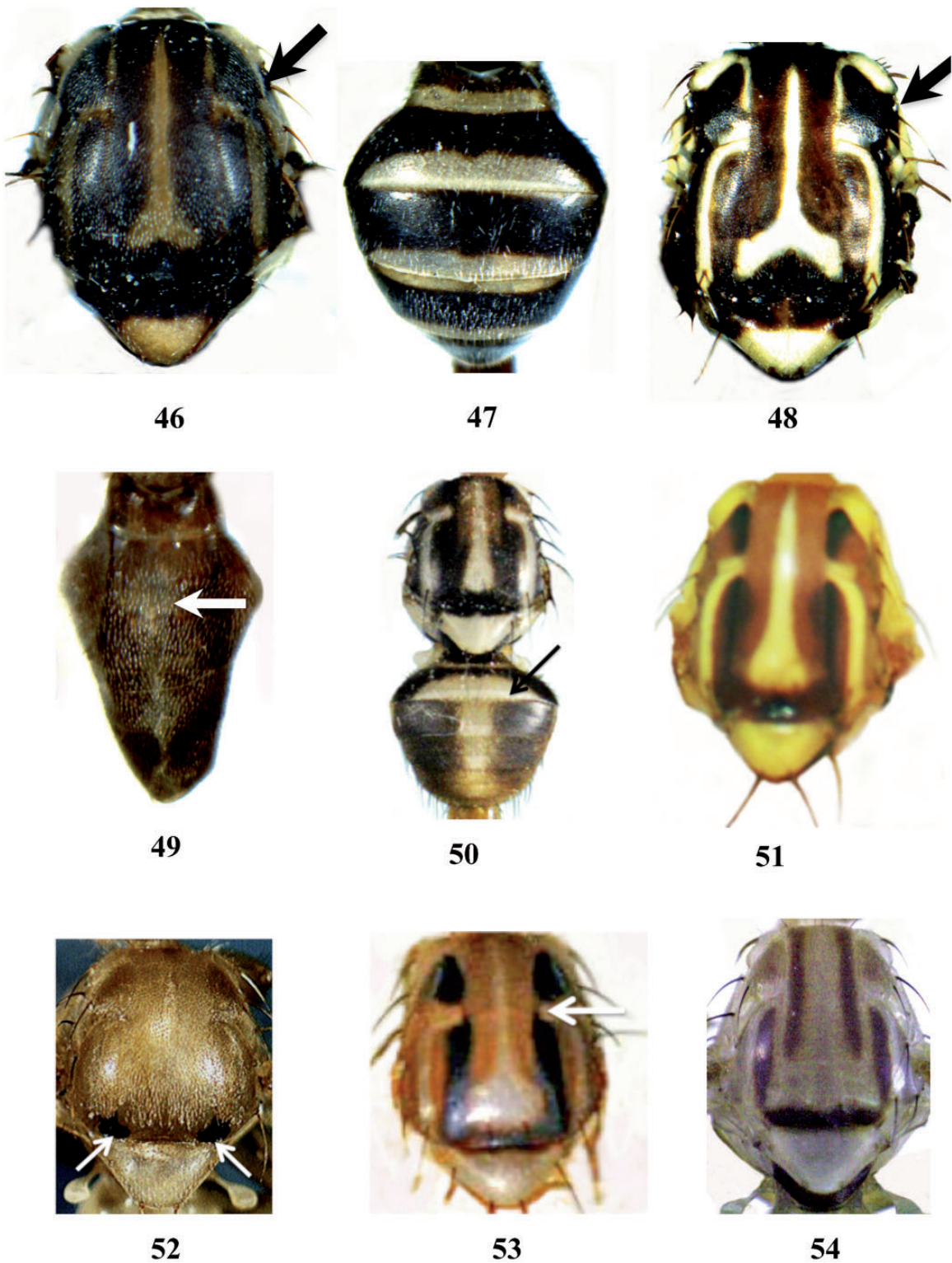


Figs. 25–38. Aculeus tips (scanning electron micrographs): 25. *A. grandis*, 26. *A. punctata*, 27. *A. zernyi*, 28 and 29. *A. montei*, 30. *A. serpentina*, 31. *A. striata*, 32. *A. undosa*, 33. *A. pickeli*, 34. *A. haywardi*, 35. *A. barbiellini*, 36. *A. elegans*, 37. *A. pseudoparallela*, 38. *A. dissimilis*.



Figs. 39–45. Aculeus tip and eversible membrane (scanning electron micrographs): 39, 40. *A. rheediae*; Aculeus tips (scanning electron micrographs): 41. *A. distincta*, 42. *A. amita*, 43. *A. turpiniae*, 44. *A. fraterculus*, 45. *A. sororcula*.

- Cell r_{2+3} entirely infuscated, V-band pale and diffuse, pale presutural lateral stripe absent on scutum, abdominal tergites with somewhat T-shaped medial yellow or white area (Figs. 5, 48, and 49) *A. macrura* Hendel
- 4. Aculeus tip 0.02–0.05 mm wide 5
- Aculeus tip more than 0.05 mm wide 7
- 5. Scutum yellowish with two black spots on posterior margin, aculeus 1.5 mm long (Figs. 6, 26, and 52) *A. punctata* Hendel
- Scutum without pair of black spots on posterior margin 6
- 6. All wing bands connected, aculeus more than 2 mm long, tip with fine serrations (Figs. 7 and 27) *Anastrepha zernyi* Lima
- C- and S-bands connected and V-band separated, aculeus <2 mm long, tip nonserrate or with irregular margin (Figs. 8, 9, 28, and 29) *Anastrepha montei* Lima
- 7. Mesonotum brown except for pale stripes, abdomen brown with yellow T-shaped medial mark, wing bands dark brown, V-band without distal arm (Figs. 10, 30, and 50) .. *A. serpentina* (Wiedemann)
- Mesonotum and abdomen predominantly orange 8
- 8. Scutum with dark stripes 9
- Scutum without dark stripes 10
- 9. Scutum with one pair of dark stripes (usually interrupted at transverse suture) merging with a band on posterior margin to form U-shaped mark, C-band, and S-band usually separate V-band, distal arm sometimes faint, vein r_{2+3} not sinuous, aculeus 1.9–2.5 mm long (Figs. 11, 31, and 53) *A. striata* Schiner
- Scutum with two pairs of longitudinal reddish-brown stripes and a band on posterior margin, C-band separate and S- and V-bands united, vein r_{2+3} distinctly sinuous, aculeus more than 4.5 mm long (Figs. 12, 32, and 54) *Anastrepha undosa* Stone
- 10. Mediotergite and/or subscutellum without dark lateral marks 11
- Mediotergite and/or subscutellum with dark lateral marks 16
- 11. Aculeus tip with serrations extending beyond end of cloacal opening, aculeus about 1.5 mm long (Figs. 13 and 33) *Anastrepha pickeli* Lima
- Aculeus tip with serrations not extending beyond end of cloacal opening 12
- 12. V-band without distal arm, aculeus <2.0 mm long, tip with subacute teeth (Figs. 14 and 34) *Anastrepha haywardi* Blanchard
- V-band with distal arm, aculeus more than 2.0 mm long 13



Figs. 46–54. Thorax, abdomen (dorsal): 46 and 47. *A. daciformis*, 48 and 49. *A. macrura*, 50. *A. serpentina*; thorax (dorsal): 51. *A. grandis*, 52. *A. punctata*, 53. *A. striata*, 54. *A. undosa*.

- 13. Aculeus tip with diminutive serrations on apical 0.2 (Figs. 15 and 35) *A. barbiellini* Lima
- Aculeus tip with serrations on more than apical half 14
- 14. Aculeus tip with conspicuous teeth and with constriction at base of serrate part (Figs. 16 and 36) ... *Anastrepha elegans* Blanchard
- Aculeus tip with minute serrations and without constriction at base of serrate part 15
- 15. Serrated part 0.85–1.11 times length of tip, with medium or large serrations, aculeus tip serrations extending onto dorsal side basally (Figs. 17 and 37) *A. pseudoparallela* (Loew)
- Serrated part 0.6–0.8 times length of tip, with fine or medium serrations, aculeus tip serrations not extending onto dorsal side basally (Figs. 18 and 38) *A. dissimilis* Stone

16. Aculeus tip with serrations beyond end of cloacal opening, eversible membrane denticles with large bases, longer than length of denticles (Figs. 19, 39 and 40) *A. rheediae* Stone
 – Aculeus tip with serrations not extending beyond end of cloaca opening, eversible membrane denticles with bases not unusually large..... 17
 17. Aculeus tip with serrations on less than apical half..... 18
 – Aculeus tip with serrations at least on apical half..... 19
 18. Aculeus longer than 2 mm (Figs. 20 and 41)..... *A. distincta* Lima
 – Aculeus <2 mm long (Figs. 21 and 42).. *Anastrepha amita* Zucchi
 19. Aculeus tip with slight constriction at base of serrate part, 0.30–0.36 mm long (Figs. 22 and 43).. *Anastrepha turpiniae* Stone
 – Aculeus tip with distinct constriction at base of serrate part, <0.30 mm long..... 20
 20. Aculeus tip length 0.25–0.29 mm (distinctly longer than wide) (Figs. 23 and 44) *A. fraterculus* (Wiedemann)
 – Aculeus tip length 0.17–0.20 mm (slightly longer than wide) (Figs. 24 and 45)..... *A. sororcula* Zucchi

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