Pictorial identification key for species of Sarcophagidae (Diptera) of potential forensic importance in southern Brazil

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ABSTRACT. Pictorial identification key for species of Sarcophagidae (Diptera) of potential forensic importance in southern Brazil. Species of the subfamily Sarcophaginae are important to forensic entomology due to their necrophagous habits. This contribution presents a pictorial key for the identification of 22 Sarcophaginae species in 10 genera that are commonly found in southern Brazil. Photographs of the main structures used in species identification, mainly from the male terminalia, are provided.

KEYWORDS. Flesh flies; medico-legal entomology; morphology, taxonomy.

RESUMO. Chave pictórica para a identificação das espécies de Sarcophagidae (Diptera) de potencial importância forense do sul do Brasil. Espécies da subfamília Sarcophaginae são importantes para a entomologia forense devido ao seu hábito necrófago. Este trabalho apresenta uma chave pictórica para a identificação de 22 espécies de Sarcophaginae de 10 gêneros encontradas na região sul do Brasil. São fornecidas fotografias dos principais estruturas das espécies, principalmente da terminália masculina.

PALAVRAS-CHAVE. Entomologia médico-legal; morfologia; sarcofagídeos, taxonomia.

The widely distributed Sarcophagidae includes approximately 2510 extant species, most from warm climates. Three subfamilies have been recognized: Miltogramminae, Paramacronychiinae and Sarcophaginae. The latter is the most diverse, and includes species that are important to forensics (Pape 1996).

Sarcophaginae larvae feed on excrements and decomposing organic matter (Byrd & Castner 2001), including carcasses and corpses. Additionally, some species are mechanical vectors of pathogens or are known to cause myiasis in vertebrates (Zumpt 1965).

Despite their importance, species in Sarcophaginae are difficult to separate based on external characters, and can only be successfully identified after careful analysis of the male genitalia (de Carvalho & Mello-Patiu 2008). Their external morphology is either too uniform or vary too much, being generally useless for identification purposes.

Sarcophagidae have been found on animal carcasses throughout the decomposition process, being slightly less ubiquitous only during the advanced stages of decomposition (Barros *et al.* 2008).

Experiments using animal carcasses have proved important to forensics because they provide data on the local insect fauna relevant to the decomposition process (Barbosa *et al.* 2010). Undeniably, forensic entomology can only be applied in areas where the composition and biology of the insect fauna at different stages of carrion decomposition are already known.

Medicolegal forensic entomology is able to provide relevant and important data during a criminal investigation, such as whether a corpse has been moved or not (Anderson 2005), or whether the victim was a drug user or had been poisoned (Introna *et al.* 2001). It can also reveal instances of negligence towards incapacitated people or animals (Benecke & Lessing 2001; Benecke *et al.* 2004; Anderson & Huitson 2004). Most importantly, however, forensic entomology can help determine the amount of time a victim has been exposed to the environment, facilitating the estimate of the post-mortem interval (PMI) (Oliveira-Costa & Mello-Patiu 2004; Pujol-Luz *et al.* 2006).

This work presents an identification key to the species of Sarcophagidae found in the municipality of Curitiba, state of Paraná, southern Brazil. In order to facilitate the use of the key by criminal investigators and researchers in general who are not taxonomists, the main features of the male terminalia are illustrated through photographs.

MATERIAL AND METHODS

Specimens were collected in a "capão" with approximately five acres, located in Curitiba-PR (25°25'S and 49°14'W) at the campus of the Centro Politécnico, Universidade Federal do Paraná. The area is a remnant of mixed ombrophilous forest with three well-defined strata, moderately humid soil, and low elevations. The soil has a high percentage of clay, hindering the absorption of water from the rain. It is also acidic due to the large amount of ferns and poor in boron, due to the presence of *Baccharis trimera* ("carqueja"), characterizing the vegetation as pioneer (Mise *et al.* 2007).

We used a 25 kg domestic pig carrion (*Sus scrofa* Linnaeus) in our experiment. The animal was killed by a wound in the heart, and immediately placed in a suspended cage (2 m high) to avoid destruction by large necrophagous animals. We then covered the cage with a trap made of white translucent nylon fabric reaching about 50 cm from the ground to allow insects to enter from underneath. Adult insects that visited the carrion were collected from July 21, 2009 to October 16, 2009 (when adult stages were no longer found). The flies were caught with the help of lethal vials containing ethyl acetate. After collecting, we sorted and mounted the specimens and exposed the male terminalia with the help of entomological pins (Lopes 1973).

In the key we have adopted the terminology of Cumming & Wood (2009) for the external and genital morphologies, and Silva & Mello-Patiu (2010) for some phallic structures characteristic of Sarcophagidae. The general classification and geographic distribution of species follow Pape (1996). Photographs were taken with a Leica DFC 500 digital camera and an Auto-Montage Pro Digital Imaging System (Syncropy), using a Leica MZ16 stereomicroscope.

The experiment was authorized by the "Comitê de Ética em Experimentação Animal (CEEA)", biological sciences branch, Universidade Federal do Paraná, process number 23075.083831/2009–87.

RESULTS

We identified all adult males into 22 species belonging to 10 different genera (Tab. I). According to the distributional records of Ferreira (1979), Pape (1996) and Moura *et al.* (1997, 2005) (Tab. I), some species found by us represent new records for the state of Paraná.

Figure 1 is a general sketch of the male terminalia showing the main structures used in species identification. The terminalia of each species and other morphological characters used in the key are detailed in figures 2–47, as indicated in the key.

Key to the identification of the species of Sarcophagidae that occur in Curitiba (adult males)

1. Arista with short plumosity restricted to the basal half of the arista length (Fig. 2) 2
1'. Arista with long plumosity reaching beyond the basal half of the arista length (Fig. 3) 3

2. Head mostly silver microtomentose (Fig. 4); epandrium yellowish brown, syntergosternite 7+8 dark brown, subshiny, cerci brown with dark apex and scarce pillosity (Fig. 5). Neotropical – Argentina, Bolivia, Brazil (Ceará, Minas Gerais, Paraná, Rio Grande do Sul, São Paulo) ... . *Microcerella halli* (Engel)

Table I. Species of Sarcophaginae (Diptera, Sarcophagidae) collected from a domestic pig carrion in Curitiba, Paraná, Brazil, from July, 2009 to October, 2009, compared with other records for the state of Paraná (boldface = new records).

Species	Ferreira (1979)	Pape (1996)	Moura *et al.* (1997)	Moura *et al.* (2005)
***Boettcheria aurifera* Lopes, 1950**	_	_	_	_
Helicobia aurescens (Townsend, 1927)	X	_	_	X
***Microcerella analis* (Townsend, 1927)**	_	_	_	_
Microcerella halli (Engel, 1931)	X	_	_	X
***Nephochaetopteryx cyaneiventris* Lopes, 1936**	_	_	_	_
***Oxysarcodexia admixta* (Lopes, 1933)**	_	_	_	_
Oxysarcodexia culmiforceps Dodge, 1966	X	X	_	_
***Oxysarcodexia parva* Lopes, 1946**	_	_	_	_
Oxysarcodexia paulistanensis (Mattos, 1919)	X	X	X	X
Oxysarcodexia riograndensis Lopes, 1946	X	_	_	_
Oxysarcodexia thornax (Wiedemann, 1830)	X	X	_	_
***Oxysarcodexia xanthosoma* (Aldrich, 1916)**	_	_	_	_
***Peckia (Euboettcheria) australis* (Fabricius, 1805)**	_	_	_	_
Peckia (Euboettcheria) collusor (Curran & Walley, 1934)	_	X	_	_
Peckia (Euboettcheria) florencioi (Mattos, 1919)	X	_	_	_
***Peckia (Pattonella) intermutans* (Walker, 1861)**	_	_	_	_
Peckia (Pattonella) resona (Lopes, 1935)	X	_	X	X
Sarcodexia lambens (Wiedemann, 1830)	X	_	_	X
Sarcophaga (Bercaea) africa (Wiedemann, 1824)	X	_	_	_
***Sarcophaga (Lipoptilocnema) lanei* (Townsend, 1934)**	_	_	_	_
***Titanogrypa (Sarconeiva) fimbriata* (Aldrich, 1916)**	_	_	_	_
***Udamopyga percita* (Lopes, 1938)**	_	_	_	–

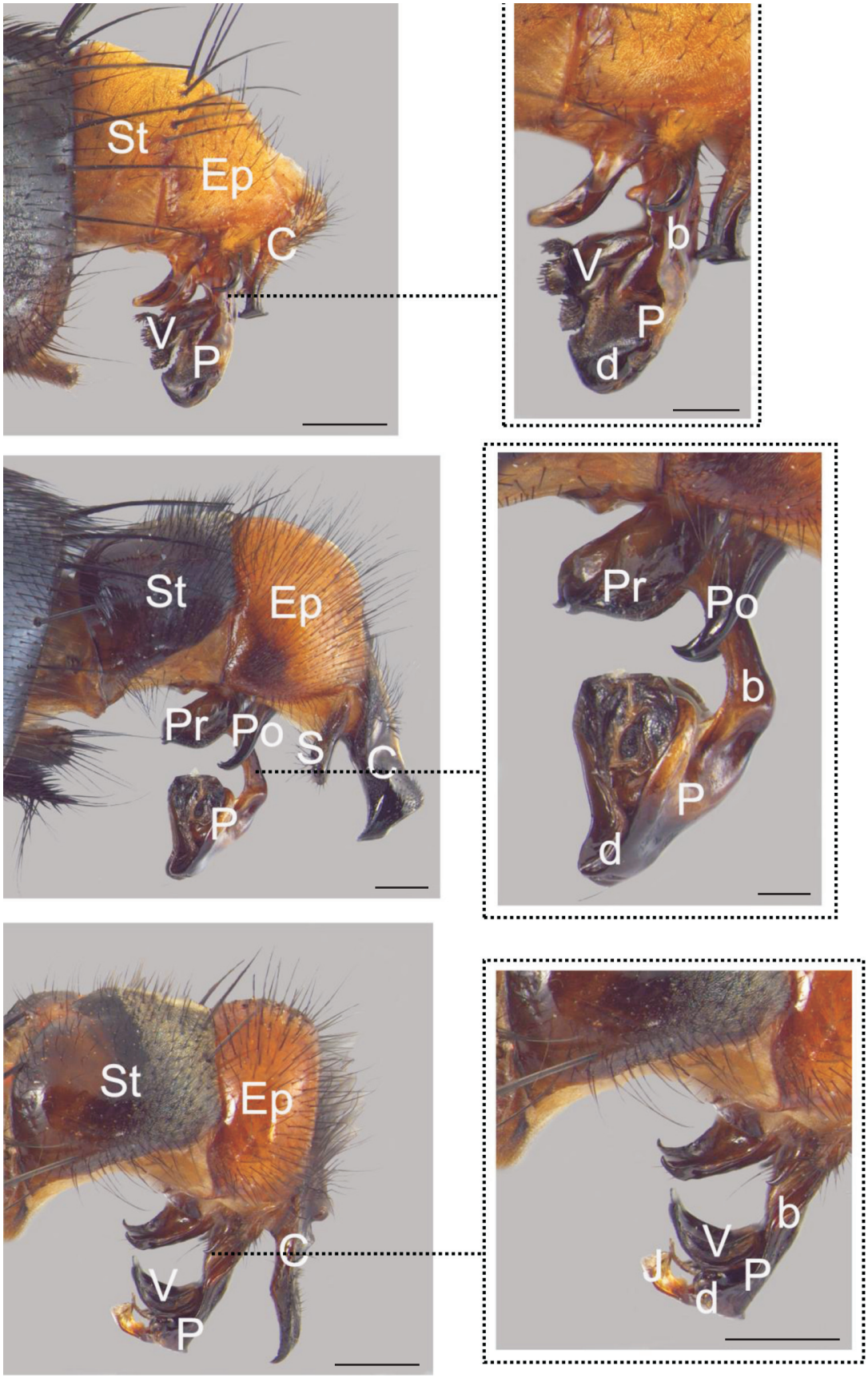
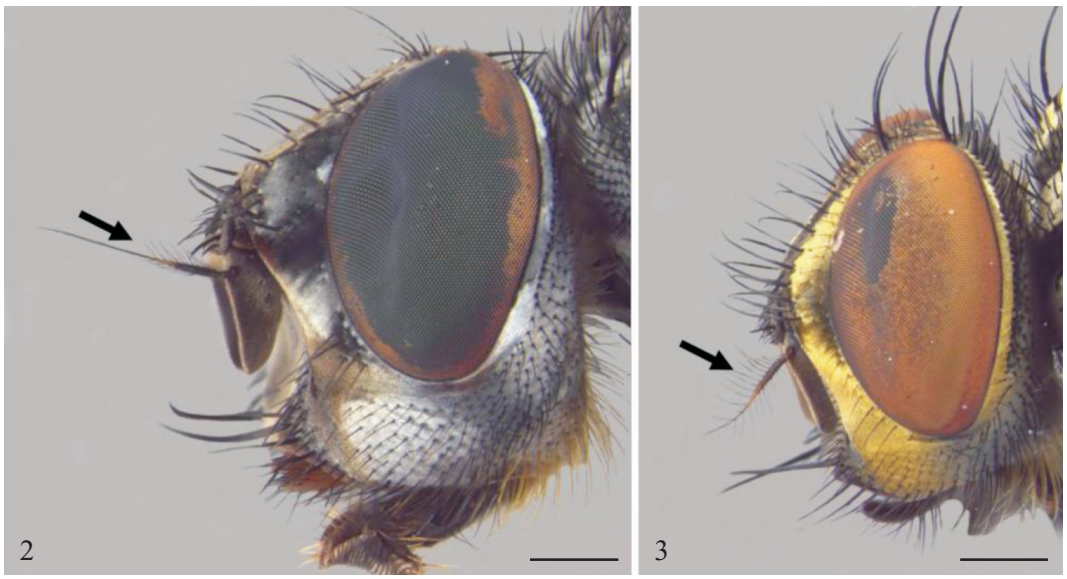


Fig. 1. Genital structures of *Oxysarcodexia*, *Peckia* and *Sarcophaga*, respectively. Abbreviations: b- basiphallus; d: distiphallus; C: cercus; Ep: epandrium; J: juxta; P: Phallus; Po: postgonite; Pr: pregonite; St: syntergosternite 7+8; V: vesica. Scale: 0.5 mm.



Figs. 2–3. Head, lateral view. 1, *Microcerella halli*; 2, *Peckia* (*Euboettcheria*) *australis*. Scale: 0.5 mm.

Figs. 4–5. Head and male terminalia of *Microcerella halli*, lateral view. Scale: 0.5 mm.

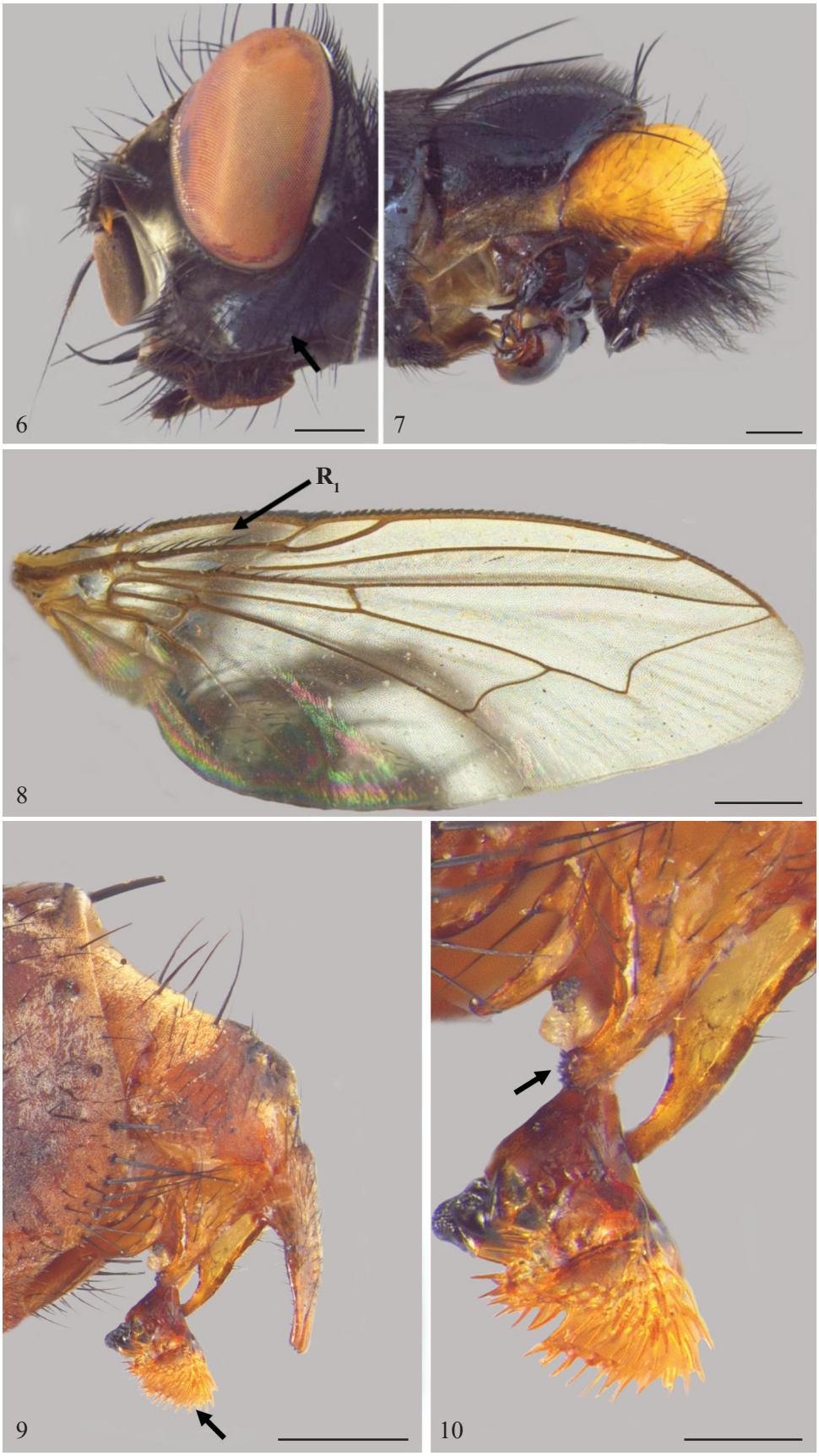
2'. Head mostly black with few microtomentose areas (Fig. 6); epandrium yellowish, syntergosternite 7+8 shiny black, cerci black with pillosity dense and long (Fig. 7). Neotropical – Brazil (Espiríto Santo, Minas Gerais, Paraná, Rio de Janeiro, Santa Catarina, São Paulo) .... *Microcerella analis* (Townsend)

3. Vein R1 setose dorsally (Fig. 8) 4
3'. Vein R1 bare dorsally 6

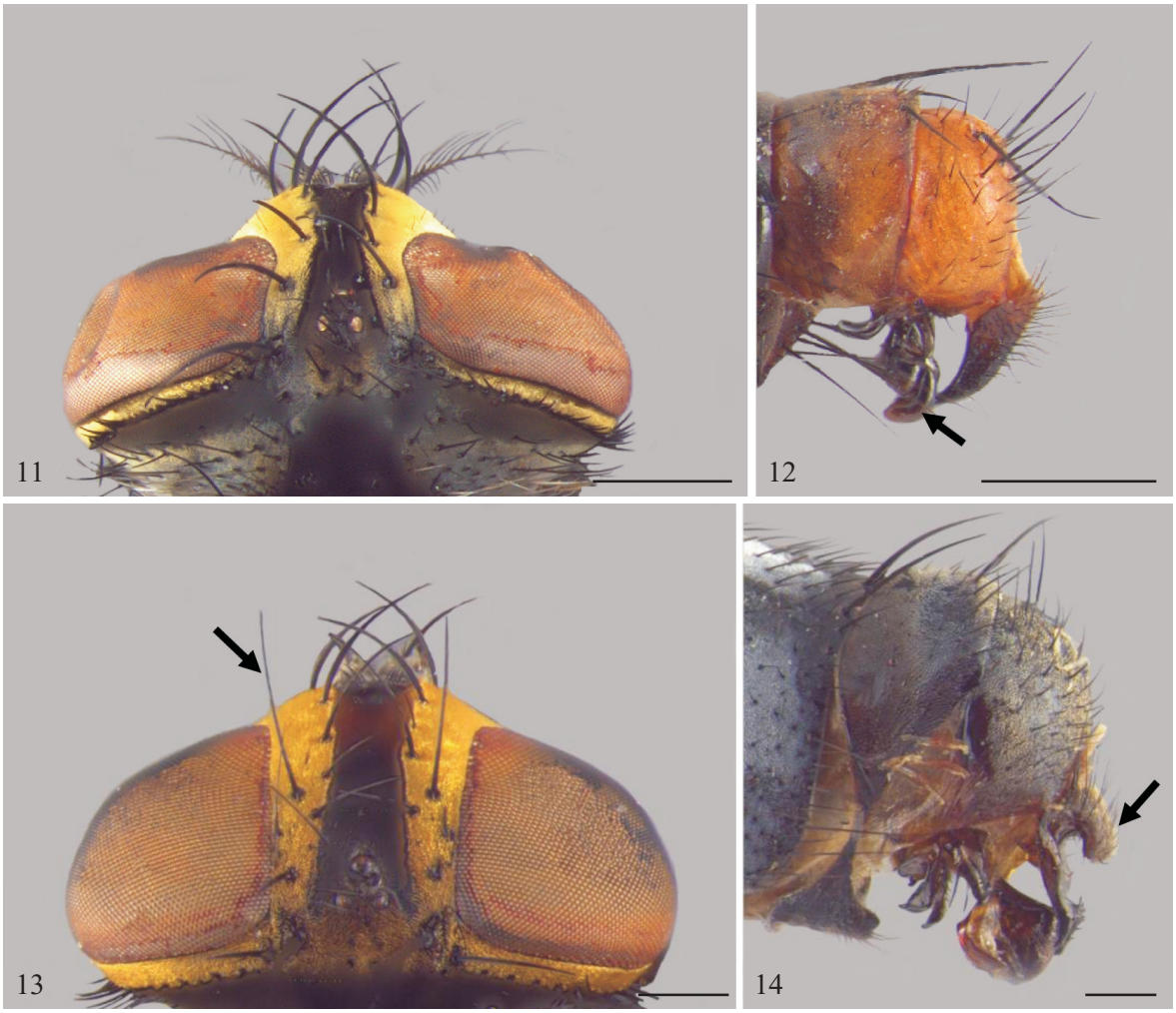
4. Body more than 10 mm long; phallus with apex membranous and conspicuously spiny (Fig. 9), surstylus with apex slender and covered with spines (Fig. 10). Neotropical – Argentina (Salta), Brazil (Bahia, Paraná, Rio de Janeiro, Santa Catarina), Dominica, Dominican Republic, Jamaica, Mexico (Jalisco), Peru .... *Titanogrypa* (*Sarconeiva*) *fimbriata* (Aldrich)

4'. Body less than 10 mm long; phallus with apex sclerotized and without spines, apex of surstylus without spines 5

5. Proclinate fronto-orbital setae absent (Fig. 11); terminalia reddish-brown, cercus dorsally straight and without apical spines, distiphallus round and reniform (Fig. 12). Neotropical – Argentina (Catamarca, Corrientes, Misiones), Brazil (Paraná, Rio de Janeiro, São Paulo) .... *Helicobia aurescens* (Townsend)



Figs. 6–10. 6–7, Head and male terminalia of *Microcerella analis*, lateral view. 8, Wing of *Helicobia aurescens*, dorsal view. 9–10, Terminalia of *Titanogrypa (Sarconeiva) fimbriata*, lateral view. Scale: 0.5 mm.



Figs. 11–14. 11–12, Head (dorsal view) and terminalia (lateral view) of *Helicobia aurescens*. 13–14, Head (dorsal view) and terminalia (lateral view) of *Nephochaetopteryx cyaniventris*. Scale: 0.5 mm.

5'. Proclinate fronto-orbital setae present, two (Fig. 13); terminalia dark-brown, cercus dorsally folded posteriorly, bearing apical spines, distiphallus enlarged and not reniform (Fig. 14). Neotropical – Brazil (Paraná, São Paulo) ..... *Nephochaetopteryx cyaneiventris* Lopes

6. Mid femur with posteroventral ctenidium (Fig. 15) 7
6'. Mid femur without posteroventral ctenidium 13

7. Cercus cuneiform; syntergosternite 7+8 and tergite 5 uniformly colored, vesica of phallus variously shaped 8
7'. Cercus not cuneiform; syntergosternite 7+8 with a dorsal spot of intense golden microtomentum, and tergite 5 with a lateral one (Figs 16, 17); vesica of phallus with a translucent membrane. Neotropical – Argentina, Brazil (Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo), Paraguay .... *Oxysarcodexia culmiforceps* Dodge

8. Vesica concave with two lateral lobes bearing spines, apex of distiphallus three times wider than basiphallus (Figs. 18, 19). Argentina (Misiones), Brazil (Goiás, Mato Grosso, Minas Gerais, Paraná, Rio de Janeiro, Santa Catarina, São Paulo) ..... *Oxysarcodexia admixta* (Lopes)

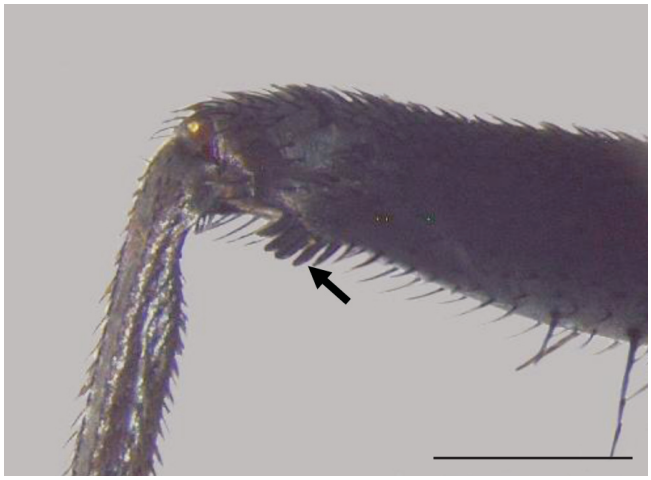


Fig. 15. Mid femur of *Oxysarcodexia admixta*, posterior view. Scale: 0.5 mm.

Figs. 16–19. 16–17, Terminalia and adult male of *Oxysarcodexia culmiforceps*, lateral view. 18–19, Terminalia of *Oxysarcodexia admixta*, lateral view. Scale: 0.5 mm.

8'. Vesica very well developed and not shaped as above... 9

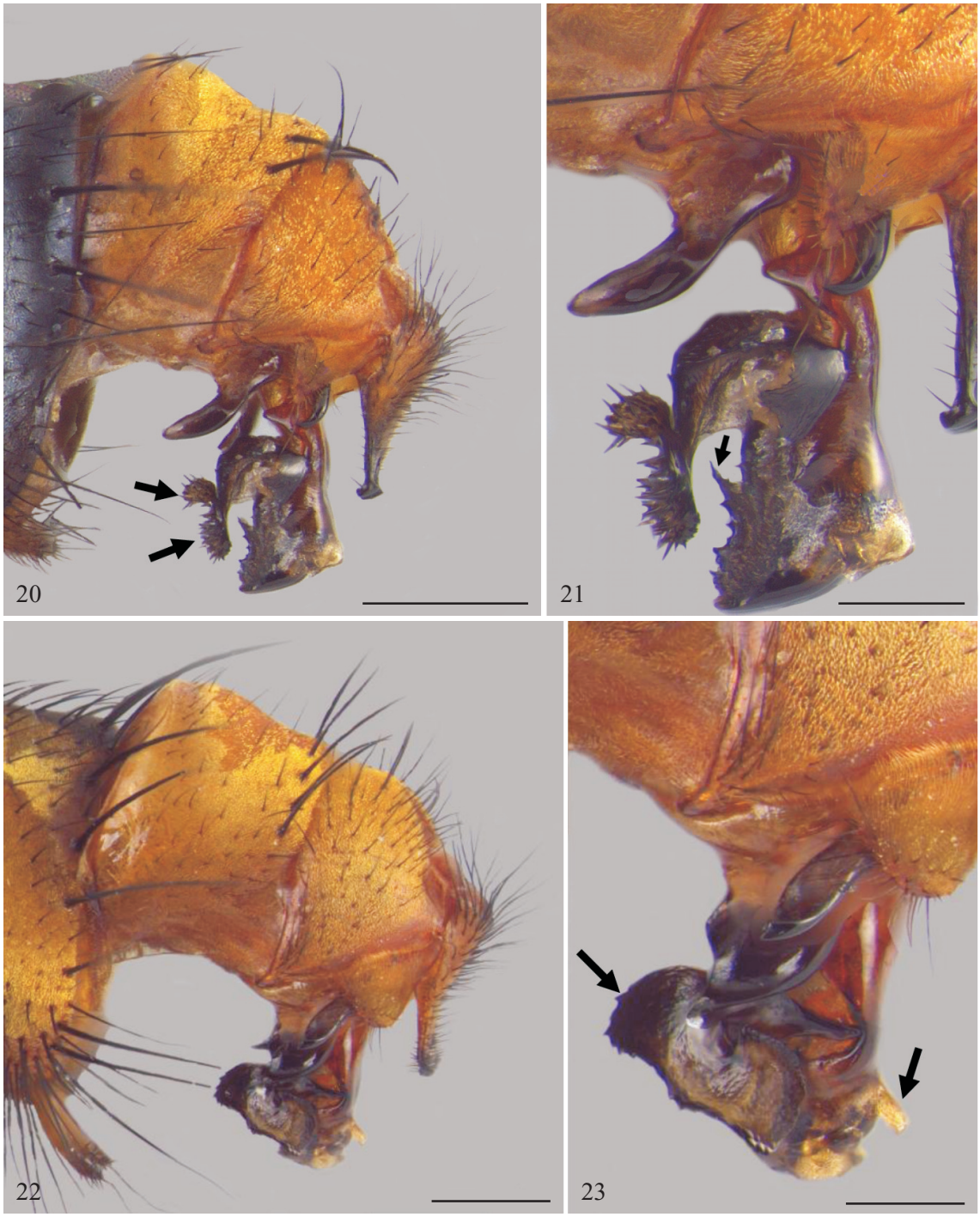
9. Vesica in lateral view with two lobes bearing apical spines, anterior margin of distiphallus serrated, with the uppermost projection longer than the others (Figs. 20, 21). Neotropical – Argentina (Jujuy), Brazil (Paraná, Rio de Janeiro, Rio Grande do Sul, São Paulo) .... *Oxysarcodexia riograndensis* Lopes

9'. Vesica and anterior margin of distiphallus not as above...10

10. Phallus with digitiform projection on the posterior portion of distiphallus, vesica with a large laminar portion and with margin serrated (Figs. 22, 23). Neotropical – Argentina (Catamarca, Jujuy, Misiones), Bolivia, Brazil (Amazonas, Ceará, Espírito Santo, Goiás, Mato Grosso, Minas Gerais, Pará, Paraíba, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo), Ecuador, Guyana, Paraguay, Peru) .... *Oxysarcodexia thornax* (Wiedemann)

10'. Phallus without digitiform projection on the posterior portion of distiphallus, vesica variously shaped 11

11. Cercus in lateral view with apex abruptly expanded, vesica with apical round lobes (Figs. 24, 25). Neotropical – Argentina (Jujuy, Misiones), Brazil (Ceará, Mato Grosso, Minas Gerais, Paraná, Rio de Janeiro, São Paulo) .... *Oxysarcodexia parva* Lopes



Figs. 20–23. 20–21, Terminalia of *Oxysarcodexia riograndensis*, lateral view. 22–23, Terminalia of *Oxysarcodexia thornax*, lateral view. Scale: 0.5 mm.

11'. Cercus without apex abruptly expanded, vesica with terminal lobes variously shaped 12

12. Vesica in lateral view with three lobes bearing apical spines (Figs. 26, 27). Neotropical – Argentina (Buenos Aires, Córdoba, Entre Ríos), Brazil (Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, São Paulo), Chile (Santiago) ..... *Oxysarcodexia paulistanensis* (Mattos)

12'. Vesica in lateral view with two lobes, upper lobe shaped as a long spiny ribbon (Figs. 28, 29). Neotropical – Argentina (Misiones), Brazil (Amazonas, Ceará, Espirito Santo, Mato Grosso, Minas Gerais, Pará, Paraná, Rio de Janeiro, São Paulo), Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Mexico (Jalisco, Veracruz), Panama, Peru ..... *Oxysarcodexia xanthosoma* (Aldrich)

13. Mid tibia with long median anterior seta that extends beyond apex of tibia (Fig. 30); apex of cercus truncated,

Figs. 24–27. 24–25, Terminalia of *Oxysarcodexia parva*, lateral view. 26–27, Terminalia of *Oxysarcodexia paulistanensis*, lateral view. Scale: 0.5 mm.

phallus small and bifid in frontal view (Fig. 31). Neotropical – Argentina (Misiones, Tucumán), Bahamas (Grand Bahamas, New Providence), Bolivia, Brazil (Ceará, Mato Grosso, Paraná, Rio de Janeiro, Santa Catarina, São Paulo), Chile (Tarapacá), Colombia, Costa Rica, Cuba, El Salvador, Guyana, Haiti, Jamaica, Mexico (Jalisco, Nuevo León, Tamaulipas), Panama, Paraguay, Peru, Puerto Rico, St. Vincent, Trinidad & Tobago (Tobago) ..... *Sarcodexia lambens* (Wiedemann)

13'. Mid tibia without long, median anterior seta extending beyond apex of tibia; apex of cercus generally slender, phallus variable in shape 14

14. R_{4+5} with dorsal setae (Fig. 32); hind trochanter with an anteroventral spine-pad 15

14'. R_{4+5} without dorsal setae; hind trochanter without a spine-pad 16

Figs. 28–31. 28–29, Terminalia of *Oxysarcodexia xanthosoma*, lateral view. 30–31, Mid tibia (posterior view) and terminália (lateral view) of *Sarcodexia lambens*. Scale: 0.5 mm.

Figs. 32. Wing of *Udamopyga percita*, dorsal view. Scale: 0.5 mm.

15. Cercus with a basal tuft of setae, vesica small and simple; postalar wall setose, sternite 5 without posteriorly oriented projection (Fig. 33). Neotropical – Brazil (Paraná, Rio de Janeiro, São Paulo).. *Udamopyga percita* (Lopes)

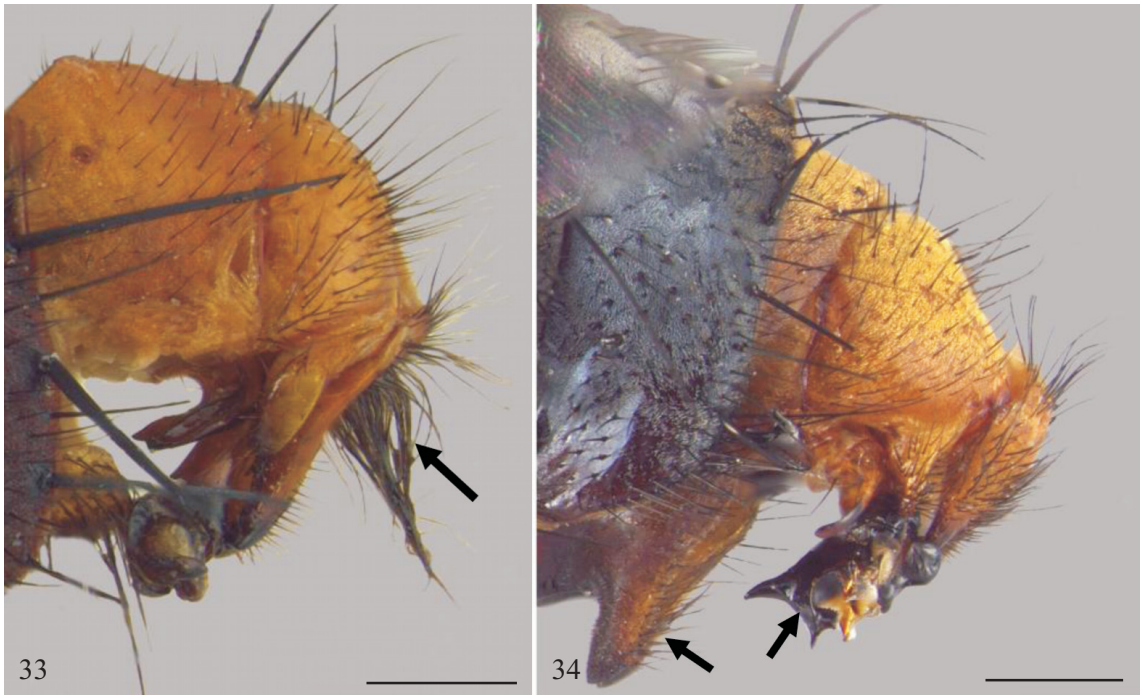
15'. Cercus with setae uniformly distributed (Fig. 34), vesica well developed and conspicuously projected anteriorly; postalar wall naked, sternite 5 with posteriorly oriented projection. Neotropical – Brazil (Paraná, Santa Catarina, São Paulo) ..... *Boettcheria aurifera* Lopes

16. Cercus with upper portion folded posteriorly forming a conspicuously setose projection, apex of distiphallus with posterior rounded and spiny lobe (juxta) (Figs. 35, 36). Neotropical – Argentina (Salta), Brazil (Paraná, Rio Grande do Sul, Santa Catarina, São Paulo) .... *Sarcophaga* (*Lipoptilocnema*) *lanei* (Townsend)

16'. Cercus without upper projection, apex of distiphallus without a spiny juxta as described above 17

17. Phallus with conspicuous juxta and distinctly separated from distiphallus, oriented anteriorly, vesica slightly concave (Fig. 37), gena silver microtomentose (Fig. 38). Neotropical – Argentina (Buenos Aires), Brazil (Paraná, Rio de Janeiro, Rio Grande do Sul), Costa Rica, Cuba, Mexico, Paraguay .... *Sarcophaga* (*Bercaea*) *africa* (Wiedemann)

17'. Phallus with juxta never distinctly separated from distiphallus, vesica variable, yellow microtomentose ... 18



Figs. 33–34. Terminalia of *Udamopyga percita* and *Boettcheria aurifera*, lateral view. Scale: 0.5 mm.

Figs. 35–38. 35–36, Terminalia of *Sarcophaga* (*Lipoptilocnema) lanei*, lateral view. 37–38, Terminalia and head of *Sarcophaga* (*Bercaea*) *africa*, lateral view. Scale: 0.5 mm.

18. Marginal scutellar setae three (including apical seta) (Fig. 39); pregonite enlarged (Fig. 41); distiphallus with apex distinctly enlarged 19

18'. Marginal scutellar setae four (including apical seta) (Fig. 40); pregonite slender (Fig. 42); distiphallus without distinctly enlarged apex 20

19. Surstylus slender; apex of cercus with anterior pointed projection; distiphallus anteriorly flattened and enlarged (Fig. 43). Neotropical – Argentina (Corrientes), Brazil (Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo) ..... *Peckia* (*Pattonella*) *resona* (Lopes)

19'. Surstylus round; apex of cercus with anterior round projection; distiphallus shaped as a cotyledon (Fig. 44). Neotropical – Brazil (Ceará, Goiás, Mato Grosso, Pará, Paraná, Rio de Janeiro, Santa Catarina, São Paulo), Costa Rica, Ecuador, Guatemala, Guyana, Honduras, Mexico (Jalisco), Panama, Paraguay, Peru, St. Lucia, Trinidad & Tobago (Tobago, Trinidad) .... *Peckia* (*Pattonella*) *intermutans* (Walker)

20. Cercus with a tuft of pre-apical setae, expanded dorsally and intensely microtomentose; phallus short (Fig. 45). Neotropical – Argentina, Bolivia, Brazil (Bahia, Ceará,

Figs. 39–42. 39–40, Scutellum of *Peckia* (*Pattonella*) *intermutans* and *Peckia* (*Euboettcheria*) *australis*, dorsal view. 41–42, Terminalia (pregonite) of *Peckia* (*Pattonella*) *resona* and *Peckia* (*Euboettcheria*) *florencioi,* lateral view. Scale: 0.5 mm.

Mato Grosso, Paraná, Rio de Janeiro, Santa Catarina), Costa Rica, Guyana, Panama, Trinidad & Tobago (Trinidad) .... *Peckia* (*Euboettcheria*) *collusor* (Curran & Walley)

20'. Cercus without a tuft of pre-apical setae, not intensely microtomentose; phallus short or long 21

21. Cercus with strong spines on the anterior apical half, with setae concentrated on the posterior portion, phallus short and slightly enlarged (Fig. 46). Neotropical – Argentina (Misiones, São Luis), Brazil (Mato Grosso, Paraná, Rio Grande do Sul, Santa Catarina, São Paulo) .... *Peckia* (*Euboettcheria*) *florencioi* (Mattos)

21'. Cercus without spines, with setae sparsely distributed along its axis, phallus slender and very long (Fig. 47). Neotropical – Argentina (Misiones), Brazil (Mato Grosso, Paraná, Rio Grande do Sul, Santa Catarina, São Paulo), Paraguay ..... *Peckia* (*Euboettcheria*) *australis* (Fabricius)

DISCUSSION

This contribution provides a quick and efficient tool to identify the species that visit pig carcasses in the region of Curitiba, Paraná. Given the species' distributions, our key

Figs. 43–47. 43–44, Terminalia of *Peckia* (*Pattonella*) *resona* and *Peckia* (*Pattonella*) *intermutans,* lateral view. 45–47, Terminalia of *Peckia* (*Euboettcheria*) *collusor, Peckia* (*Euboettcheria*) *florencioi* and *Peckia* (*Euboettcheria*) *australis,* lateral view. Scale: 0.5 mm.

may be extrapolated to other areas in the southern and southeastern Brazil.

Titanogrypa (*Sarconeiva*) *fimbriata* and *Udamopyga percita* are mollusk parasitoids (Lopes 1940) and their presence in our samples are most likely accidental, as each species was collected only once by us. However, they had not been previously recorded in the region. Even though taxonomical studies are important to the biological sciences in general, they are particularly relevant to forensics, because erroneous species identifications can mislead expert reports. For this reason, basic taxonomic research is essential to the progress of this science in the country.

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