



Systematics, Morphology and Biogeography

Comparative morphology and identification key for females of nine Sarcophagidae species (Diptera) with forensic importance in Southern Brazil



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ABSTRACT

The identification of female flesh flies was always considered a difficult task since morphological descriptions and keys for females are rare. Even in a forensic entomology framework, where females play a major role, female flesh flies are usually not identified. In order to fill this gap in Southern Brazil fauna we provide detailed descriptions and key for the female of nine species included in four genera: *Microcerella halli* (Engel), *Oxysarcodexia paulistanensis* (Mattos), *Oxysarcodexia riograndensis* (Lopes), *Peckia (Euboettcheria) australis* (Townsend), *Peckia (Euboettcheria) florencioi* (Prado and Fonseca), *Peckia (Pattonella) intermutans* (Walker), *Peckia (Pattonella) resona* (Lopes), *Peckia (Sarcodexia) lambens* (Wiedemann), and *Sarcophaga (Bercaea) africa* (Wiedemann). These species are distinguished mainly by genital characters as tergite 6 divided or undivided, presence of tergite 8, spermatheca morphology and vaginal plate shape.

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Introduction

Sarcophagidae Hagen, 1881 is widely distributed with about 3100 described species in 400 genera. Although it has worldwide geographic distribution, Sarcophagidae richness is remarkably concentrated in regions of tropical and warm temperate climate (Shewell, 1987; Pape, 1996) and in Neotropical region more than 800 species are found. There are three subfamilies, Miltoigramminae, Paramacronychiinae and Sarcophaginae, but only Sarcophaginae has species of forensic and medical importance in the Neotropics (Pape, 1996).

The external morphology of most Sarcophaginae adults is extremely similar. The species share three black stripes pattern in the mesonotum, meron with bristles, undeveloped subscutellum, and abdomen checkered or spotted and medium to large size, ranging from 8 to 14 mm (de Carvalho and Mello-Patiu, 2008). Probably because of this morphological similarity and the lack of keys, this group is considered to be difficult for identification (Barros et al., 2008; Mulieri et al., 2010; Vairo et al., 2011).

Female flesh flies are much more abundant than males on carcasses. They use the corpse not only as source of food and mating site but also as larviposition site. In forensic entomology, the species that rear on corpses are considered the most important data source. The biological data from these species are essential to estimate the minimum post mortem interval (PMI), which corresponds to the period of insect activity on corpse (Tomberlin et al., 2011). In addition to their use in applied sciences, such as forensic entomology, females have their own place in Sarcophagidae systematics and can provide important characters for mapping the group evolution (Lopes, 1941, 1958; Tibana and de Mello-Patiu, 1985; de Mello-Patiu and Santos, 2001) although females are still unknown in many species. However, despite their importance, Sarcophagidae females are usually neglected in taxonomic and applied research.

In southern Brazil, forensic entomology is well disseminated (Vairo et al., 2015; Corrêa et al., 2014) but there are no available keys for all necrophagous female flesh flies, making this group under utilized in forensic cases. Mulieri et al. (2010) provided a key to male and female adults of Sarcophaginae from Buenos Aires Province, including 39 species, that can be used partially to identify fauna from southern Brazil, but only four species herein analyzed were included among them. Nevertheless, a more detailed comparison of females of most species of forensic importance is essential to provide a greater number of characters and minimize the difficulties

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in the problematic task of female identification, especially by non-taxonomists, in medical, veterinary and forensic applications (de Carvalho and Mello-Patiu, 2008; Mulieri et al., 2010). Therefore, as a first step to fill this gap, we present a pictorial key for females of nine necrophagous species of Sarcophaginae from southern Brazil.

Material and methods

All species chosen met two criteria: can be reared in organic matter, thus being necrophagous, and have their geographic range reaching Southern Brazil. Those species are: *Oxysarcodexia paulistanensis* (Mattos, 1919), *Microcerella halli* (Engel, 1931), *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830), *Peckia* (*Pattonella*) *resona* (Lopes, 1935), *Peckia* (*Pattonella*) *intermutans* (Walker, 1861), *Oxysarcodexia riograndensis* (Lopes, 1946), *Peckia* (*Euboettcheria*) *australis* (Townsend, 1927), *Peckia* (*Euboettcheria*) *florencioi* (Prado and Fonseca, 1932) and *Sarcophaga* (*Bercaea*) *africa* (Wiedemann, 1824). The first five species have larvae already sampled on carcasses and/or human corpses (Salviano, 1996; Moura et al., 1997, 1998, 2005; Carvalho and Linhares, 2001; Oliveira and Vasconcelos, 2010; Vairo et al., 2011) and the last four have adults sampled in Paraná, Santa Catarina and Rio Grande do Sul and reared in laboratory with putrefied bovine meat.

Although 22 species of fleshflies with potential forensic importance were already registered in Southern Brazil (Vairo et al., 2011), in this present contribution we were interested in species that could be used to estimate the minimum post mortem interval, i.e., not only species attracted by carrion, but those species in which the larvae are reared on carcasses or corpses.

To start the colonies we collected specimens from Curitiba (Paraná), Campinas (São Paulo) and Bombas (Santa Catarina). Females were captured using a butterfly bait trap, which allows the researcher to choose flies in the field. All females were reared individually in small cages until larviposition, thus producing an isolate. The larvae were reared in putrefied bovine meat until the emergence of adults. After the emergence, males were identified based on Vairo et al. (2011), thus ensuring the correct identification of females. Colonies were established and maintained at the Universidade Federal do Paraná, Centro Politécnico, Curitiba, Paraná, Brazil, except the colony of *P. intermutans* established at the Universidade Estadual de Campinas, Campinas, São Paulo, Brazil. The females were mounted and the abdomens removed and cleared in 10% potassium hydroxide, washed a few times in distilled water and immersed in 10% acetic acid. Photographs were taken with a Leica DFC 500 digital camera and Auto-Montage Pro Digital Imaging System (Syncropy), using a Leica MZ16 stereomicroscope. The illustrations were produced using drawing tube and edited with GIMP 2.8. Fig. 1 presents a general sketch of the female terminalia showing the main structures used in species identification. We adopted the terminology of Shewell (1987) for general morphology and Lopes (1939) for “vaginal plate”. Synonymic information for each species is available in Pape (1996). Updated distribution data after Pape (1996) are also provided (Barros et al., 2008; Barbosa et al., 2009; Rosa et al., 2009; Souza et al., 2011; Vairo et al., 2011, 2014; Buenaventura and Pape, 2013). Vouchers are deposited in Coleção Entomológica Padre Jesus Santiago Moure, Universidade Federal do Paraná (DZUP) and Coleção Entomológica do Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ).

Results

The results are divided in an identification key that provides descriptions of each species with illustrations (Figs. 2–12).

Key to female flesh flies with forensic importance in Southern Brazil.

1. Tergite 6 undivided..... 2
- 1'. Tergite 6 divided into two plates..... 4
2. Mid tibia with long median anterior seta that extends beyond the apex of tibia; spermatheca rounded; epiproct present..... *P. (S.) lambens*
- 2'. Mid tibia without a long median anterior seta that extends beyond the apex of tibia; spermatheca not rounded, with a different shape as above; epiproct absent..... 3
3. Tergite 8 well sclerotized, vaginal plate conspicuous..... *O. riograndensis*
- 3'. Tergite 8 absent, vaginal plate absent or completely membranous..... *M. halli*
4. Tergite 6 as two separated plates dorsally folded..... *S. (B.) africa*
- 4'. Tergite 6 as two plates separated by a membrane or by a sclerotized area, not folded dorsally..... 5
5. Vaginal plate well sclerotized, almost the same size as hypoproct, rectangular, with concave posterior margin and central area with a depression; tergite 6 as two plates separated by a sclerotized area..... *O. paulistanensis*
- 5'. Vaginal plate absent or, if present, not as described above; tergite 6 as two plates separated by a membrane..... 6
6. Spermatheca spherical, without striations and segmental constrictions; tergite 8 absent..... 7
- 6'. Spermatheca with segmental constrictions, divided into proximal and distal part; tergite 8 present..... 8
7. Vaginal plate absent..... *Peckia (Euboettcheria) australis*
- 7'. Vaginal plate present, with a median finger-like projection..... *P. (E.) florencioi*
8. Tergite 8 wider than long; tergite 5 with two lateral golden spots..... *P. (P.) intermutans*
- 8'. Tergite 8 longer than wide; tergite 5 with no lateral golden spots..... *P. (P.) resona*

Oxysarcodexia paulistanensis (Mattos, 1919) (Figs. 2, 11A, and 12A)

Description – differs from male in the following: Two proclinate orbital setae, the superior one with half length of the inferior; inner vertical setae differentiated from postocellar setae. Tergite 5 with a dorsolateral light golden spot. Tergite 6 divided, the median region connecting the two plates are sclerotized; spiracle 6 in membrane and 7 within the sclerites. Six to eight strong marginal setae accompanied by thin setae. Tergite 7 absent. Tergite 8 as two lateral bare plates, relatively pigmented, centrally extended and tapered at the top and bottom, joined by a membrane. Epiproct absent. Sternites 2–6 rectangular with rounded corners with strong setae in the posterior margin and weak setae in the median part; sternite 6 shorter and wider on comparing to sternite 5; sternite 7 wider than 6 with 3 strong setae in each lateral and some setulae; sternites 6, 7 and 8 fused; sternite 8 broadly membranous with an small marginal sclerotized area with setulae. Vaginal plate present, well sclerotized, almost the same size as hypoproct, rectangular, with concave posterior margin and central area with a depression. Spermatheca elongated and slightly oval with transversal striations in all extension.

Distribution: Argentina (Buenos Aires, Córdoba, Entre Ríos), Brazil (Distrito Federal, Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, São Paulo), Chile (Santiago).

Material examined: eight females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, ii. 2011. K. Vairo col.

Oxysarcodexia riograndensis (Lopes, 1946) (Figs. 3, 11B, and 12B)

Description – differs from male in the following: Two proclinate orbital setae, the superior one with similar size as frontals and the inferior one two times the size as the superior; inner vertical setae differentiated from the postocellar setae. Tergite 5 with a dorsolateral golden light spot. Tergite 6 undivided; spiracle 6 in membrane and spiracle 7 within the sclerite, with 6–9 strong marginal setae. Tergite 7 absent. Tergite 8 as two lateral sclerotized bare plates, two times the cercus size. Epiproct absent. Sternites 1–5 dark-brown, darker compared to the others; sternites 2 and 5 with square shape, posterior corners rounded, strong setae in the posterior margin and

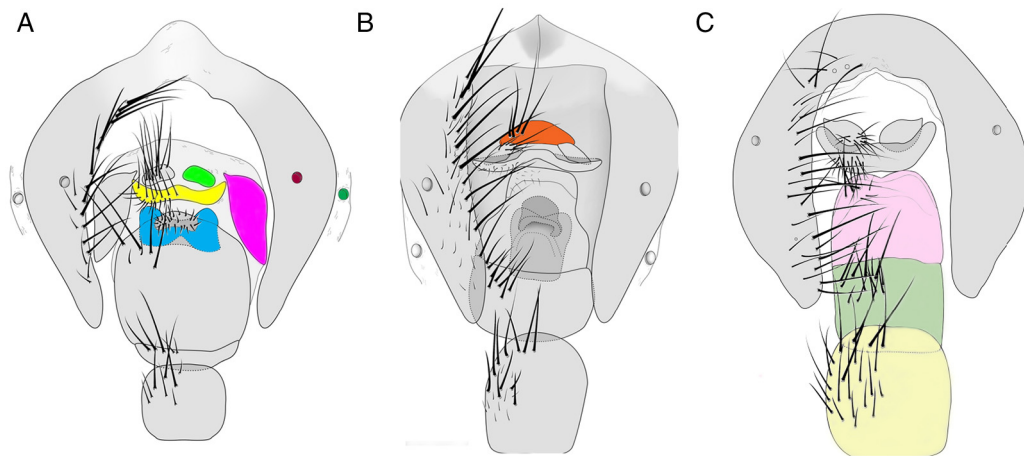


Fig. 1. General morphology of female terminalia. (A) *Oxysarcodexia paulistanensis* (pink = tergite 8; green = cercus; yellow = hypoproct; blue = vaginal plate; dark red = spiracle 6; dark green = spiracle 7. (B) *Peckia (Euboettcheria) florencioi* (orange = epiproct). (C) *Microcerella halli* (light yellow = sternite 5; light green = sternite 6; light pink = sternites 7 + 8).

some setulae in the median part; sternite 5 shorter than 6; sternites 6, 7 and 8 fused; sternite 6 wider than 5 with one row of setae, 3 strong setae on each side and with many setulae in central part; sternite 7 almost 1.5 times the size of sternite 5, posterior margin concave, marginal setae being three strong lateral ones and other small weak setae; sternite 8 membranous with median area rounded and pigmented, margin with some setulae. Vaginal plate sub-rectangular, posterior margin slightly concave. Spermathecae slightly elongated with transversal striations in all extension.

Distribution: Argentina (Jujuy), Brazil (Paraná, Rio de Janeiro, Rio Grande do Sul).

Material examined: six females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, ii. 2011. K. Vairo col.

Peckia (Pattonella) intermutans (Walker, 1861)
(Figs. 4, 11C, and 12C)

Description – differs from male in the following: two well-developed proclinate orbital setae; inner vertical setae differentiated from postocellar setae. Tergite 5 with one lateral golden spot and a light golden coloration at posterior margin in dorsal view. Tergite 6 divided into two big plates separated by a narrow membrane; spiracles 6 and 7 within the sclerite; 10–12 strong setae on posterior margin. Tergite 7 absent. Tergite 8 as two small bare plates, slightly larger than cercus. Epiproct absent. Sternites 2–5 square shaped with strong setae on posterior margin; sternites 6, 7 and 8 separated; sternite 6 square shaped, a bit smaller

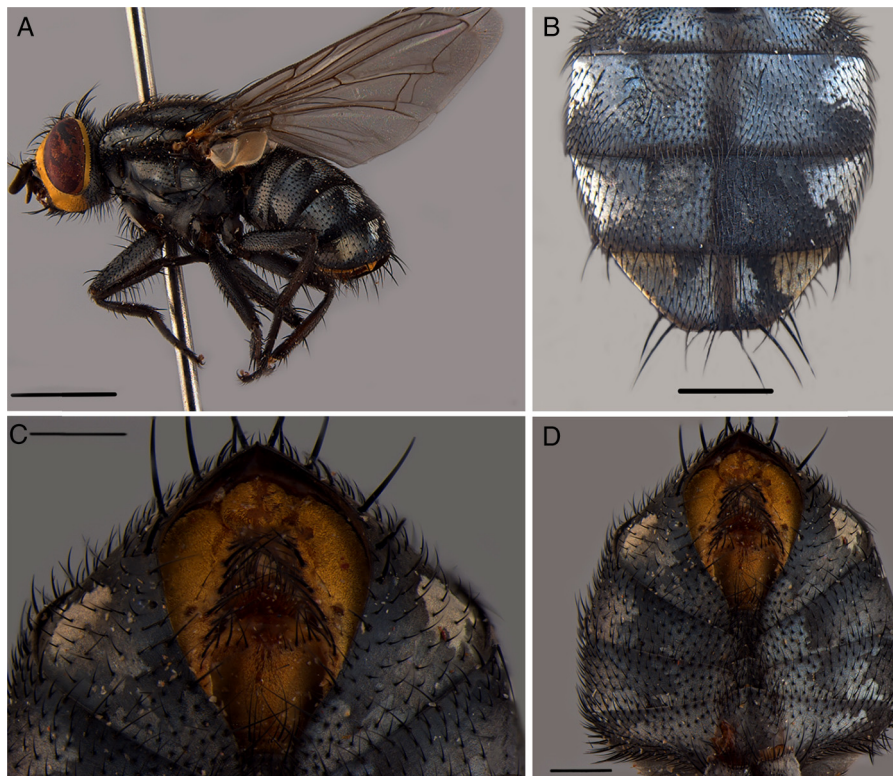


Fig. 2. External female morphology of *Oxysarcodexia paulistanensis*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 1 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view; scale: 1 mm.

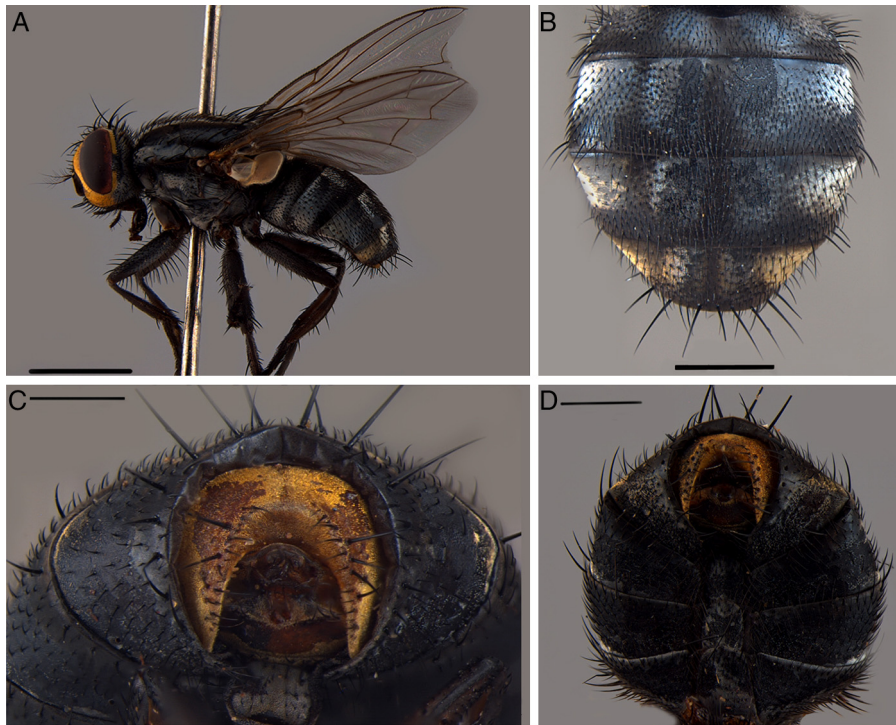


Fig. 3. External female morphology of *Oxysarcodexia riograndensis*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 1 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view; scale: 1 mm.

than sternite 5, with numerous strong marginal and premarginal setae; sternite 7 square with setae more concentrated on posterior margin, with a strong pair on each side; sternite 8 membranous, not well pigmented, about half of length of sternite 7, with 5 long setae. Vaginal plate membranous, slightly pigmented; anterior

margin rounded and posterior margin with a median depression. Spermatheca elongated with a segmental constriction separating a narrower proximal part and a not striated distal part.

Distribution: Brazil (Amazonas, Ceará, Distrito Federal, Goiás, Mato Grosso, Minas Gerais, Pará, Rio de Janeiro, Paraná, Santa



Fig. 4. External female morphology of *Peckia (Pattonella) intermutans*. (A) Habitus, lateral view; scale: 1 mm; (B) abdomen, dorsal view; scale: 2 mm; (C) abdominal terminal segments, ventral view; scale: 1 mm; (D) abdomen, ventral view; scale: 2 mm.



Fig. 5. External female morphology of *Peckia (Pattonella) resona*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 2 mm; (C) abdominal terminal segments, ventral view; scale: 1 mm; (D) abdomen, ventral view; scale: 2 mm.



Fig. 6. External female morphology of *Peckia (Euboettcheria) australis*. (A) Habitus, lateral view; scales: 2 mm; (B) abdomen, dorsal view; scale: 2 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view; scale: 1 mm.



Fig. 7. External female morphology of *Peckia (Euboettcheria) florencioi*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 1 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view, scale: 1 mm.



Fig. 8. External female morphology of *Peckia (Sarcodexia) lambens*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 1 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view; scale: 1 mm.

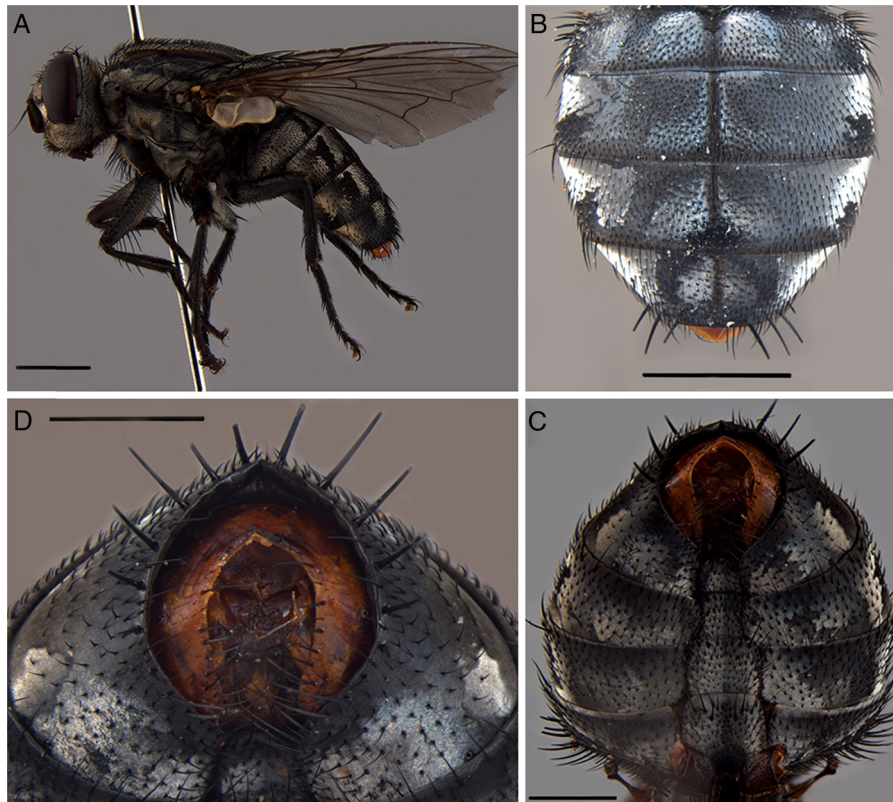


Fig. 9. External female morphology of *Microcerella halli*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 2 mm; (C) abdominal terminal segments, ventral view; scale: 1 mm; (D) abdomen, ventral view; scale: 1 mm.



Fig. 10. External female morphology of *Sarcophaga (Bercaea) africa*. (A) Habitus, lateral view; scale: 2 mm; (B) abdomen, dorsal view; scale: 2 mm; (C) abdominal terminal segments, ventral view; scale: 0.5 mm; (D) abdomen, ventral view; scale: 1 mm.

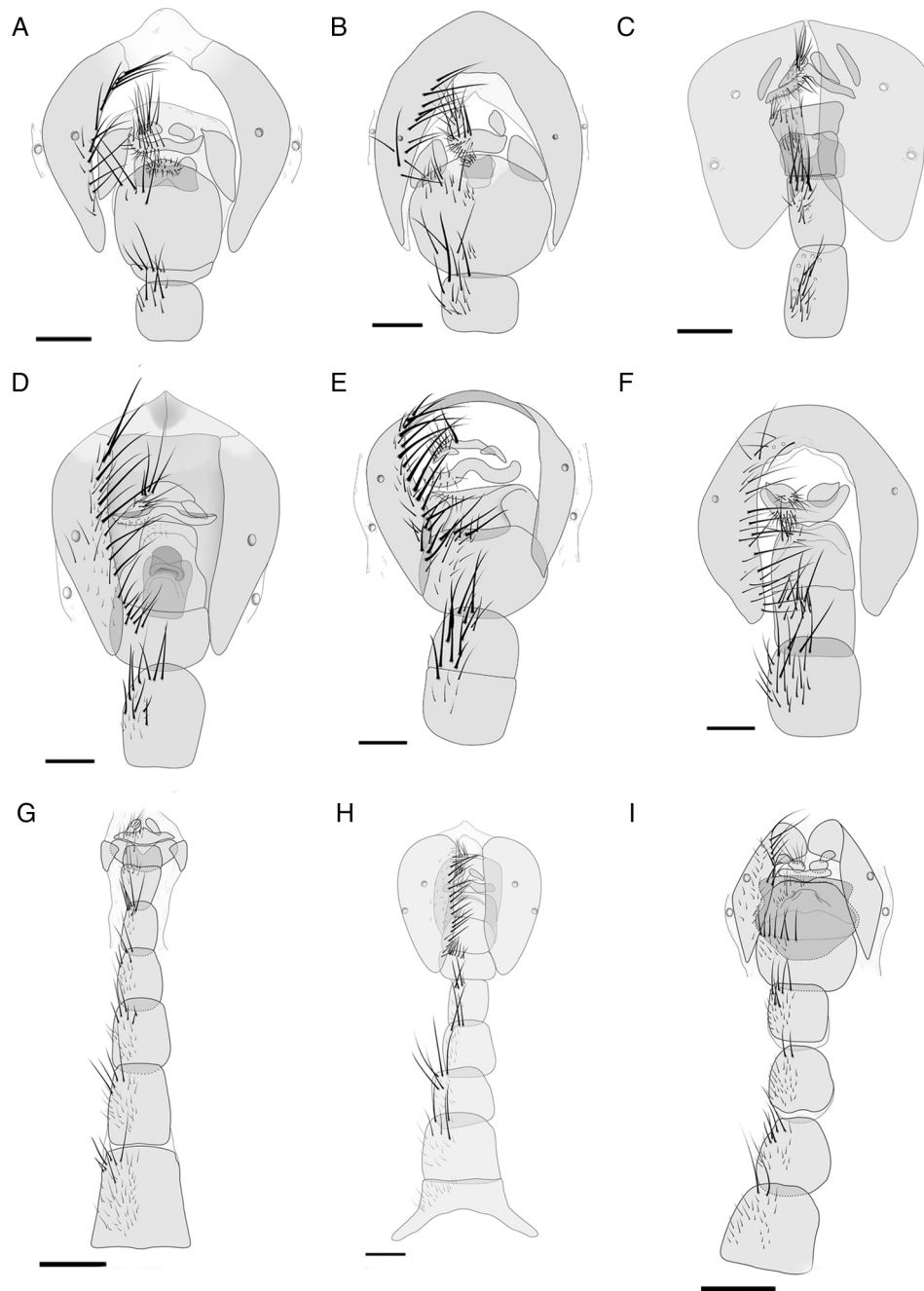


Fig. 11. Female terminalia. (A) *Oxysarcodexia paulistanensis* (sternites 1–4 omitted); (B) *Oxysarcodexia riograndensis* (sternites 1–4 omitted); (C) *Peckia (Pattonella) resona* (sternites 1–4 omitted); (D) *Peckia (Euboettcheria) florencioi* (sternites 1–4 omitted); (E) *Peckia (Sarcodexia) lambens* (sternites 1–4 omitted); (F) *Microcerella halli* (sternites 1–4 omitted); (G) *Peckia (Pattonella) intermutans* (tergite 6 and sternite 1 omitted); (H) *Peckia (Euboettcheria) australis*; (I) *Sarcophaga (Bercaea) africa* (sternite 1 omitted). Scales: 1 mm.

Catarina, São Paulo), Costa Rica, Ecuador, Guatemala, Guiana, Honduras, Mexico (Jalisco), Panama, Paraguay, Peru, St. Lúcia, Trinidad and Tobago (Tobago, Trinidad).

Material examined: nine females from colonies initiated by specimens collected in Brazil, São Paulo, Mogi Guaçu, iv. 2011. M. Grella col.

Peckia (Pattonella) resona (Lopes, 1935) (Figs. 5, 11C, and 12D)

Description – differs from male in the following: two proclinate well-developed orbital setae, both twice the size of frontal setae; inner vertical setae distinguish from the postocellar setae. Tergite 5 with an anterior silver spot in dorsal view. Tergite 6 divided into

two big plates separated by a narrow membrane; spiracles 6 and 7 within the sclerite; 12 strong marginal setae concentrated in the median region. Tergite 7 absent. Tergite 8 as two small and narrow bare plates, a bit bigger than cercus. Epiproct absent. Sternites 2–6 squared shaped with strong and long setae on the posterior margin; sternites 6, 7 and 8 individualized; sternite 6 square, a bit smaller than sternite 5, with strong and long setae concentrated on the posterior third; sternite 7 with the half length of sternite 6, with long setae on the posterior half and strong posterior margined setae; sternite 8 membranous; sparsely pigmented, with a similar length of sternite 7, with long and thin setae on posterior margin. Vaginal plate absent or probably completely membranous and not apparent. Spermatheca elongated with a segmental constriction

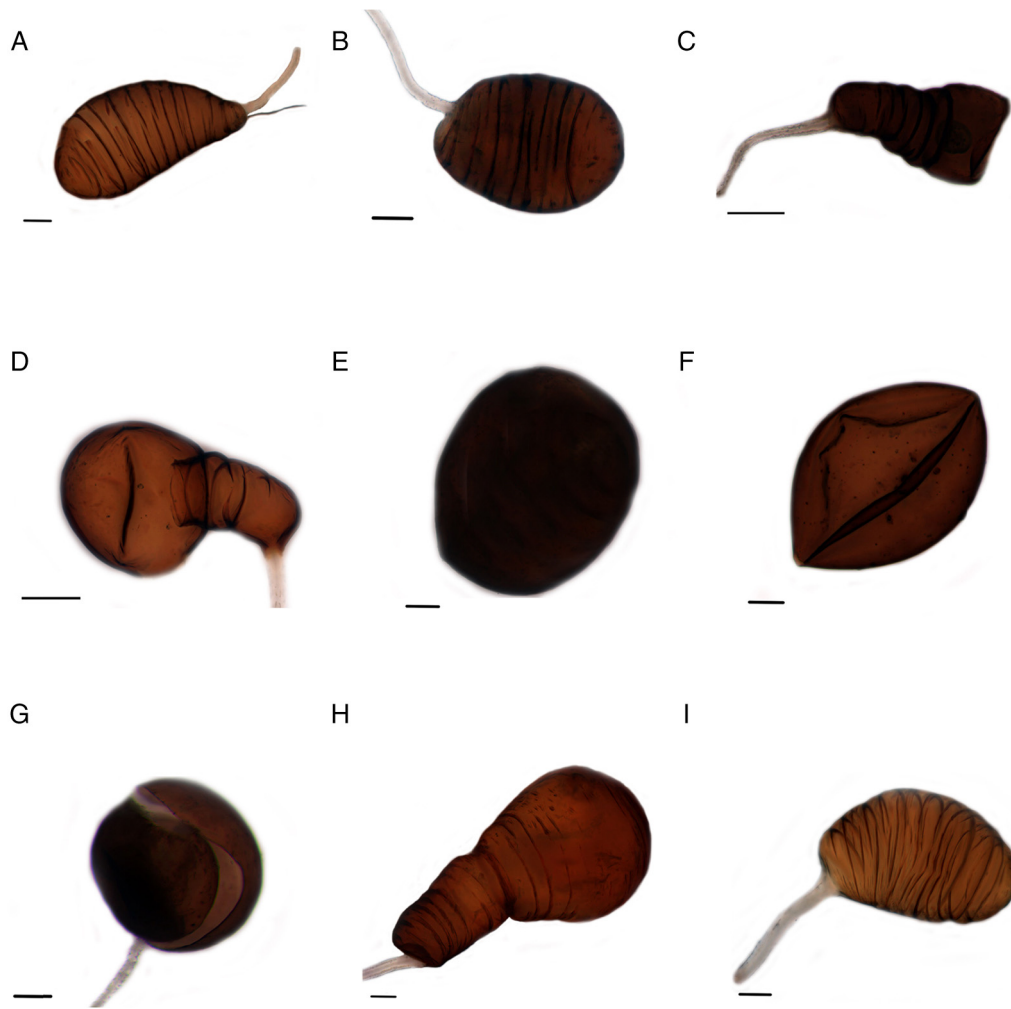


Fig. 12. Spermathecae. (A) *Oxysarcodexia paulistanensis*, lateral view; scale: 0.05 mm; (B) *Oxysarcodexia riograndensis*, lateral view; scale: 0.05 mm; (C) *Peckia* (*Pattonella*) *intermutans*, lateral view; scale: 0.05 mm; (D) *Peckia* (*Pattonella*) *resona*, lateral view; scale: 0.05 mm; (E) *Peckia* (*Euboettcheria*) *australis*, lateral view; scale: 0.05 mm; (F) *Peckia* (*Euboettcheria*) *florencioi*, ventral view; scale: 0.05 mm; (G) *Peckia* (*Sarcodexia*) *lambens*, ventral view; scale: 0.05 mm; (H) *Microcerella halli*, lateral view; scale: 0.1 mm; (I) *Sarcophaga* (*Bercaea*) *africa*, lateral view; scale: 0.05 mm.

separating a narrower proximal part, and a rounded not striated distal part.

Distribution: Argentina (Corrientes), Brazil (Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Paraná, Minas Gerais, São Paulo).

Material examined: two females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, v. 2012. K. Vairo col.

Peckia (*Euboettcheria*) *australis* (Townsend, 1927)
(Figs. 6, 11H, 12E)

Description – differs from male in the following: two proclinate orbital setae well developed, superior with half of the length of inferior; inner vertical setae differentiated of postocellar setae. Tergite 5 with a light golden microtomentum. Tergite 6 divided into two plates connected by a broad membrane; spiracle 6 in membrane and spiracle 7 within the sclerite, near the margin; 15–17 strong and long marginal setae. Tergites 7 and 8 not absent. Epiproct entire, narrow, with numerous setae on median region. Sternites 2–5 squared shaped with strong marginal setae; sternites 6 separated, 7 and 8 fused; sternite 6 larger than 5, but shorter in length, with strong marginal setae; sternite 7 with a depressed central area, sternite 8 represented by a narrow posterior membranous area with setulae, separated of the sternite 7 by a semicircular, swollen,

and setose area. Vaginal plate absent. Spermatheca spherical not striated.

Distribution: Argentina (Misiones), Brazil (Mato Grosso, Rio Grande do Sul, Santa Catarina, Paraná, São Paulo), Paraguay.

Material examined: eight females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, vii. 2011. K. Vairo col.

Peckia (*Euboettcheria*) *florencioi* (Prado and Fonseca, 1932)
(Figs. 7, 11D, and 12F)

Description – differs from male in the following: two proclinate orbital setae well developed; inner vertical setae differentiated of postocellar setae. Tergite 5 with light golden microtomentum in dorsal view. Tergite 6 divided into two plates with a broad connecting membrane; spiracle 6 in membrane and spiracle 7 within the sclerite near the margin; 12–15 strong and long marginal setae. Tergites 7 and 8 not absent. Epiproct entire, short, median region unpigmented, with strong and long setae. Sternites 6, 7 and 8 fused; sternite 7 with the same width as sternite 6, anteriorly rounded, without setae; sternite 8 narrower than sternite 7, posterior margin slightly swollen with sparse setulae. Vaginal plate present, well sclerotized, with a digitiform discal apophysis projecting inwards.

Spermatheca spherical not striated, with a postero-ventral unsclerotized area.

Distribution: Argentina (Misiones, San Luis), Brazil (Mato Grosso, Rio Grande do Sul, Santa Catarina, Paraná, São Paulo).

Material examined: eight females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, vi. 2012. K. Vairo col.

Peckia (*Sarcodexia*) *lambens* (Wiedemann, 1830)
(Figs. 8, 11E, and 12G)

Description – differs from male in the following: posterior femur without a patch of black short setae in the apical third of the anterior surface (male femoral organ). Tergite 5 with golden microtomentum in lateral and dorsal view. Tergite 6 undivided; spiracle 6 in membrane and 7 within the sclerite; 14–16 marginal strong setae accompanied by some setulae. Tergites 7 and 8 absent. Epiproct entire, with some fine setulae along the margin and one conspicuous strong setae on each side. Hypoproct broad with a conspicuous hollow at the medium part. Sternite 2 with 1.5 times the size of sternites 3 and 4; sternite 5 subrectangular with rounded corners and several developed setae; sternite 6 two times the sternite 5 width, with strong marginal setae and sparse discal setulae; sternites 7 and 8 narrower than sternite 6, both linked to the sternite 6 by a lateral conspicuous membranes; sternite 7 with no setae and sternite 8 broadly membranous, represented by a swollen and setulose marginal area. Vaginal plate absent. Spermatheca circular not striated with a posteroventral unsclerotized area.

Distribution: Argentina (Misiones, Tucumán), Bahamas (Grand Bahamas, New Providence), Bolivia, Brazil (Amazonas, Ceará, Mato Grosso, Rio de Janeiro, Santa Catarina, São Paulo, Paraná), Chile (Tarapacá), Colombia, Costa Rica, Cuba, El Salvador, Guyana, Haiti, Jamaica, Mexico (Jalisco, Nuevo Leon, Tamaulipas), Panamá, Paraguay, Peru, Puerto Rico, St. Vincent, Trinidad & Tobago (Tobago).

Material examined: seven females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, iv. 2011. K. Vairo col.

Microcerella halli (Engel, 1931) (Figs. 9, 11F, and 12H)

Description – differs from male in the following: two proclinate orbital setae well developed; no row of small and strong setae on anteroventral part of trochanter 3; tibia 2 with tree anterior setae and presence of a reddish sensorial area on posterior part of femur. Tergite 5 black with silver microtomentum. Tergite 6 undivided; reddish brown to orange, contrasting with the dark tergite 5; spiracle 6 in membrane and spiracle 7 within the sclerite; 20–24 strong marginal setae accompanied of small ones. Tergite 7, tergite 8 and epiproct absent. Sternites 1–5 reddish brown, darker than the others; sternites 2–6 squared shaped with a row of strong setae on posterior margin; sternites 6, 7 and 8 fused; sternite 6 wider and shorter than the sternite 5; sternite 7 quadrangular; central surface slightly depressed relative to the posterior margin, without setae; sternite 8 swollen, widely membranous except for the sclerotized posterior margin, posterior angles expanded with three apical setae each. Vaginal plate absent or probably completely membranous and not apparent. Spermatheca divided into two parts by a constriction, a narrow and cylindrical proximal part and a rounded distal one, less striated than the proximal and 2.0 times its width.

Distribution: Argentina (no further data), Bolivia, Brazil (Ceará, Minas Gerais, São Paulo, Paraná, Rio Grande do Sul).

Material examined: 10 females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, vi. 2011. K. Vairo col.

Sarcophaga (*Bercaea*) *africa* (Wiedemann, 1824)
(Figs. 10, 11I, and 12I)

Description – differs from male in the following: two proclinate orbital setae well developed; inner vertical setae differentiated of postocellar setae. Tergite 5 with golden microtomentum more conspicuous in lateral view. Tergite 6 divided into two plates well separated and dorsally folded; spiracle 6 in membrane and spiracle 7 within the sclerite; 15–16 strong and long marginal setae. Tergites 7 and 8 absent. Epiproct represented by two small dorsal plates without setae. Sternites 2–4 squared shaped with posterior margin rounded; two strong setae in each angle of posterior margin; sternite 5 quadrangular with strong marginal angular setae. Sternites 6, 7 and 8 fused; Sternite 6 almost two times wider than sternite 5, with a medially interrupted row of setae on posterior margin; sternite 7 with a noticeably elevated central area; sternite 8 like a narrow and swollen range fused with the posterior margin of sternite 7, with two lateral groups of setae, two strongest setae and many setulae. Vaginal plate well sclerotized, darker than the sternites, and very long, from the hypoproct to the middle of sternite 6 with a median suture. Spermatheca oval and slightly elongated with transversal striations in all surfaces.

Distribution: Argentina (Buenos Aires), Brazil (Rio de Janeiro, Paraná, Rio Grande do Sul), Costa Rica, Cuba, Mexico, Paraguay.

Material examined: 10 females from colonies initiated by specimens collected in Brazil, Paraná, Curitiba, viii. 2012. K. Vairo col.

Discussion

Undoubtedly the main female diagnostic characters are in terminalia. However, in a forensic context, where, in most of the cases, fresh material is collected at the death scene, the external color could help to identify some species. Color of the gena, postgena, and of the spots in tergites and sternites, for instance, can be very effective in identifying some species, like *S. (B.) africa* and *M. halli*.

On the other hand, other external characters may also be useful, like the presence of long setae in tibia and the size of orbital and postocellar setae. In some cases, these external characters are the main differences between males and females of some species, requiring attention in the identification because of this dimorphism.

The characters from the terminalia, such as the microtomentum of tergite 5, can distinguish species even in the same subgenera, as showed in *Pattonella*. The tergite 6 could be divided or undivided. We considered as divided tergite 6 when it has even a narrow or large, pigmented or not, membrane connecting the two plates, as occurs in *O. paulistanensis*. *Oxysarcodexia* has the three already described states of tergite 6, entire, divided and membranous (Tibana and de Mello-Patiu, 1985). An undivided tergite 6, but with different degrees of reduction, also occurs in *Nephochaetopteryx* (de Mello-Patiu and Santos, 2001). In this work, species with tergite 6 undivided were *O. riograndensis*, *P. (S.) lambens*, and *M. halli*.

Concerning the spiracles 6 and 7, all studied species, except those of *Peckia* subgenus *Pattonella*, have the spiracle 6 inside the membrane and the spiracle 7 within the sclerite (tergite 6). Shewell (1987) considered that the tergite 7 in *Sarcophagidae* is frequently absent and the tergite 8 is nearly always present, but usually reduced to bare lateral plates. In this work, we used the same interpretation and named as tergite 8 the bare plates in lateral position to the sternites 7 and 8. This sclerite was visible only in *Oxysarcodexia* and in *Peckia* (*Pattonella*) and its presence and shape showed to be an important character to discriminate some females of forensic species in Southern Brazil.

The epiproct, if present, can appear divided and undivided (Camargo, 2014). In this work only *P. (S.) lambens*, *P. (E.) australis*, *P. (E.) florencioi*, and *S. (B.) africa* have epiproct, entire in the first three

species and divided in the last one. The undivided epiproct seems to be the most common state of this character in *Peckia*, but this condition differs in some species of the same genera or subgenera such as *P. (E.) collusor* and *P. (E.) epimelia* (Camargo, 2014).

Although the shape of sternites can be a useful character in a general context, important information to distinguish sarcophagid females comes from the presence (or absence) of fusion of the sternites 6, 7 and 8. These sternites may be considered fused when the posterior margin of preceding sternite is contiguous, main laterally, with the anterior margin of the subsequent one, without a well-marked suture. In *O. paulistanensis*, *O. riograndensis*, and *S. (B.) africa* these sternites are fused; in *P. (E.) australis*, *P. (E.) florencioi* and *M. halli* only sternites 7 and 8 are fused; and in *P. (P.) resona*, *P. (P.) intermutans* and *P. (S.) lambens* all sternites are individualized.

Another key character to identify females of these flesh fly species is the presence and shape of vaginal plate. For some genera like *Oxysarcodexia* and *Nephochaetopteryx* the vaginal plate is one of the most important characters to segregate species because it has conspicuous interspecific differences (Tibana and Mello, 1983; de Mello-Patiu and Santos, 2001). As previously stated, we found that the shape of vaginal plate is a major character to properly identify *O. paulistanensis*, *O. riograndensis*, *P. (E.) florencioi*, *P. (P.) resona* and *S. (B.) africa*.

The morphology of the spermathecae also can help the differentiation of genera and subgenera. In *Oxysarcodexia* the shape is more elongate (pyriform) and the striations are conspicuous, similar as in *Sarcophaga*. In *P. (S.) lambens* and *P. (E.) florencioi* while also rounded it has an opening in ventral view, a characteristic that we are describing for the first time. In *Peckia* (*Pattonella*) and *Microcerella*, the spermathecae are quite different, as it is divided into well-defined distal and proximal portions, possessing some constrictions along.

Although Sarcophagidae, in general, and its females, in particular, are considered hard to identify, the key and the descriptions provided makes this task possible to both, taxonomists and non-taxonomists. So, we expect that forensic entomologists can identify the necrophagous female flesh flies in Southern Brazil in a short time and with low cost, broadening the number of species that can be used in crime scene investigations.

Conflicts of interest

The authors declare no conflicts of interest.

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