Biology, Ecology and Diversity

Bionomy of two flies of sanitary and forensic importance: *Peckia* (*Sarcodexia*) *lambens* (Wiedemann) and *Oxysarcodexia amorosa* (Schiner) (Diptera, Sarcophagidae)

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A B S T R A C T

This study aims to elucidate the bionomy of *Peckia* (*Sarcodexia*) *lambens* and *Oxysarcodexia amorosa* to provide data for medical, veterinary and forensic entomology analyses. We analyzed larval stage duration (L1–L3), weight of the mature larvae (L3), pupal stage duration, L1–adult duration, adult emergence and viability of larvae and adults of both species. Larval viability of *P.* (*S.*) *lambens* was 82% and the mean duration of the larval stage was 3.51 ± 0.99 days. The mature larvae had a mean weight of 33.67 ± 7.13 mg. The mean duration of the pupal stage was 8.26 ± 0.93 days and the mean duration of the L1–adult was 11.53 ± 1.22 days. Mean lifespan for females and males was 39.33 ± 1.52 and 57.33 ± 4.72 days, respectively. Larval viability of *O. amorosa* was 76% and mean duration of larval stage was 3.51 ± 0.64 days. Mature larvae had a mean weight of 28.28 ± 3.38 mg. Mean duration of the pupal stage was 10.14 ± 0.63 days and mean duration of the L1–adult was 13.60 ± 0.69 days. Mean lifespan for females and males was 83.66 ± 15.94 and 84.00 ± 19.97 days, respectively. *Oxysarcodexia amorosa* showed a L1–adult stage longer than *P.* (*S.*) *lambens*; however both species showed low viability. *O. amorosa* laid more larvae than *P.* (*S.*) *lambens*, this fact may occur because *O. amorosa* had longer life duration.

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Introduction

Insects present on carcasses accelerate the decomposition process and are responsible for degrading about 90% of the body weight, thus demonstrating an important ecological role (Jirón and Cartín, 1981). Dipterans of the Sarcophagidae family are present in all biogeographic regions, although most species are concentrated from tropical to temperate regions (Shewell, 1987; Pape and Dahlem, 2010). Several species of flies show high synanthropy and are present in living tissues, excrements, rotten organic matter, carcasses, corpses, domestic garbage and feces in different regions of the world. They are considered potential transmitters of pathogens such as viruses, fungi, bacteria, and parasites (Oliveira et al., 2002; Förster et al., 2007).

Peckia (*Sarcodexia*) *lambens* (Wiedemann, 1830) and *Oxysarcodexia amorosa* (Schiner, 1868) are found as larvae and adults on corpses, as well as carcasses of fishes, rats, pigs and rabbits (Lopes and Leite, 1989; Carvalho and Linhares, 2001; Oliveira-Costa et al., 2001; Leandro and d'Almeida, 2005; Barbosa et al., 2009). *P.* (*S.*) *lambens* is considerate an obligatory wound myiasis and infested 12.1% of 66 wound myiasis cases in Goiás, Brazil (Fernandes et al., 2009; Francesconi and Lupi, 2012). These flies are most commonly found in the Neotropical Region and have been reported as a predator of wounded insects, a producer of myiasis in birds and mammals, as well as a species that uses vertebrate and invertebrate carcasses to lay its larvae on (Guimarães et al., 1983; d'Almeida, 1988, 1989; Fessl et al., 2001; Mulieri et al., 2010).

Oxysarcodexia is one of the largest genera within the Sarcophagidae, with 81 known species, which are morphologically very similar to one another. The genus occurs main in the Neotropical Region, particularly in Brazil (Pape, 1996). Some species have the habit of laying their larvae on human feces or feces of other animals (Tibana and Mello, 1985). *Oxysarcodexia amorosa* is

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distributed throughout the Americas (from Mexico to Brazil) and it is one of the most frequently found species on carcasses of pigs in the city of Rio de Janeiro (Barbosa et al., 2009).

This study aims to elucidate the bionomy of *P. (S.) lambens* and *O. amorosa* in order to provide data for medical, veterinary and forensic entomology analyses. Knowledge of the development of these larvae deposited on carcasses, such as the time of development from the first larval stage (L1) to the adult, can be used to obtain an estimate of the post mortem interval (PMI). PMI can be used as a tool to help criminal investigators (Liu and Greenberg, 1989), and can help to identify cases of mistreatment and neglect of children, elderly and powerless peoples (Benecke et al., 2004).

Material and methods

The experiment was performed in a climatic chamber at $27 \pm 1\,°C$, $50 \pm 10\%$ RH with 12 h of photophase. Colonies were established from adult flies captured on the campus of Instituto Oswaldo Cruz (IOC, FIOCRUZ) (22°51′06″S 43°14′27″W), in the metropolitan area of Rio de Janeiro, Brazil, during August and September 2011. The adult flies were captured with a Shannon-type trap containing carcasses of albino mice (*Mus musculus* L.). Specimens of both species were identified by us using an identification key (de Carvalho and Mello-Patiu, 2008), transferred and kept in wooden cages (30 cm³) covered with a nylon mesh. Meat for larviposition was placed in the cages. New adults, during the first 3 days after emergence, received only water and sugar for their diet. On the fourth day was provided a diet of putrefied ground beef, which served as a food source and stimulus for larviposition.

After stabilization of the colony, 200 larvae of each species were removed from the meat and transferred using a fine brush (number zero) to four plastic containers (50 larvae in each) containing 100 g of ground beef at the initial stage of putrefaction. These containers were placed in bigger containers containing vermiculite on the bottom to maximize the process of pupation after the mature larvae (L3) abandoned the diet.

The weight of mature larvae (L3), the duration of the larval (L1–L3) and pupal stages, the duration of the L1 to adult stage and the adult emergence were recorded for the bionomics data. In addition, the viability of the larvae and adults throughout the experiment was observed. Immediately after the adult emergence, three wooden cages containing 15 couples from the four containers were observed for their biotic potential and lifespan, and the number of larvae deposited on ground beef at an initial stage of putrefaction was recorded daily.

The survival curves for males and females were represented by the Weibull distribution model. This model shows if arthropods reared in laboratory are comparable to the wild ones. The main advantage of using Weibull distribution for survival analysis is that, by estimating only two parameters, information on both lifespan and type of survival curve is obtained (Sgrillo, 1982). Chi-square test was carried out to analyze the survival distribution of the insects in order to confirm if they followed the Weibull distribution model.

Results

The values of chi-square show a good concordance between observed values and expected values; therefore, the survival distribution followed the Weibull model. For *P. (S.) lambens*, the chi-square value for males was 0.1217 (not significant) and the chi-square value for females was 0.4642 (not significant). For *O. amorosa*, the chi-square value for males was 0.6641 (not significant) and for females was 1.6049 (not significant).

Table 1

Duration and viability of the immature stages of *Peckia* (*Sarcodexia*) *lambens* kept under laboratory conditions ($27 \pm 1\,°C$, $60 \pm 10\%$ RH with 12 h of photophase).

Biological features	Duration (days)		Viability (%)
	Mean ± SD	Range	
Larval stage	3.51 ± 0.99	2–7	82.00
Pupal stage	8.26 ± 0.93	6–12	65.24
L1 to adult	11.53 ± 1.22	9–15	54.50

SD, standard deviation.

Table 2

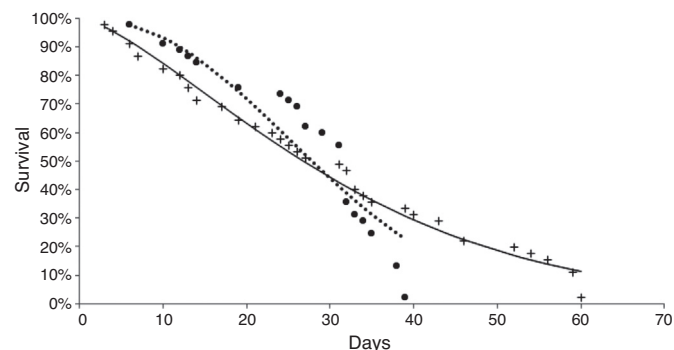Weight (mg) of L3 larvae of *Peckia* (*Sarcodexia*) *lambens* kept under laboratory conditions ($27 \pm 1\,°C$, $60 \pm 10\%$ RH with 12 h of photophase).

| Mature larva (L3)	Weight (mg)	
	Mean ± SD	Range
Females	34.36 ± 7.62	24–51
Males	35.18 ± 6.22	22–48
Females and males	33.67 ± 7.13	16–51

SD, standard deviation.

Peckia (Sarcodexia) lambens (Wiedemann, 1830)

The larval viability of *P. (S.) lambens* was 82% (Table 1). The mean duration of the larval stage was 3.51 ± 0.99 days, with a minimum of 2 and a maximum of 7 days (Table 1). Mature larvae (L3) of *P. (S.) lambens* started pupation with a mean weight of 33.67 ± 7.13 mg, with a minimum of 16 mg and a maximum of 51 mg. The mean weight of L3 that originated adult males was 35.18 ± 6.22 mg, ranging from 22 to 48 mg, and the mean weight of L3 that originated adult females was 34.36 ± 7.62 mg, ranging from 24 to 51 mg (Table 2). The pupal viability was 65.24% (Table 1). The average duration of the pupal stage was 8.26 ± 0.93 days, ranging from 6 to 12 days (Table 1). The percentage of males and females was, respectively, 51.4% and 48.6% and the sex ratio was 0.48. The duration of the L1 to adult ranged from 9 to 15 days, showing a mean duration of 11.53 ± 1.22 days and a viability of 54.5% (Table 1). The mean lifespan for females and males was 39.33 ± 1.52 and 57.33 ± 4.72 days, respectively. The female flies showed a more pronounced mortality peak starting from Day 30 (Fig. 1). The male flies had a more homogeneous decline throughout the days, and did not show any mortality peak (Fig. 1). The number of larvae deposited per female ranged from 0.38 to 10.17 (Fig. 2). At the end of the experiment 1433 larvae had been deposited on the putrefied ground beef, between Days 7 and 38.

Fig. 1. Survival curve following the Weibull distribution model. Male [observed (crosses); expected (solid line)] and female [observed (large dots); expected (dotted line)] of *Peckia* (*Sarcodexia*) *lambens* kept under laboratory conditions ($27 \pm 1\,°C$, $60 \pm 10\%$ RH with 12 h of photophase).
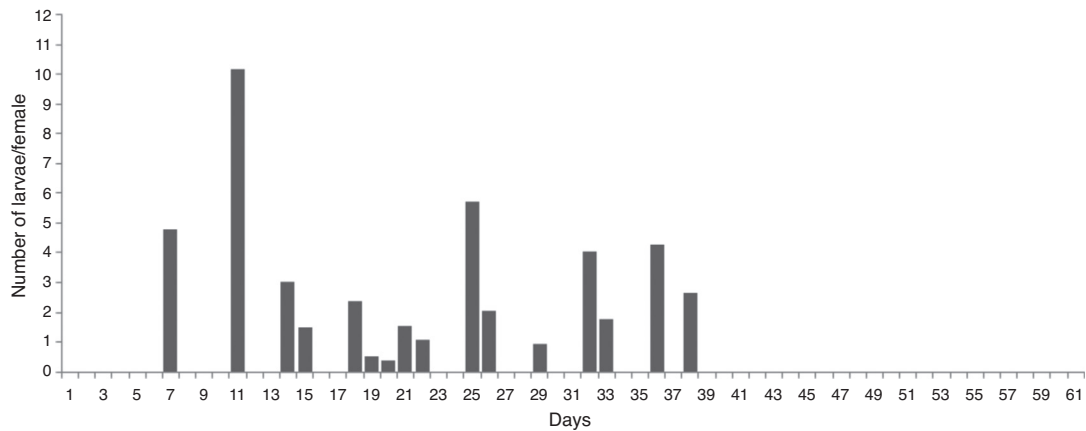
Fig. 2. Number of larvae deposited on putrefied ground beef throughout the experiment per female of *Peckia* (*Sarcodexia*) *lambens* kept under laboratory conditions (27 ± 1 °C, 60 ± 10% RH with 12 h of photophase).

Table 3
Duration and viability of the immature stages of *Oxysarcodexia amorosa* kept under laboratory conditions (27 ± 1 °C, 60 ± 10% RH with 12 h of photophase).

Biological features	Duration (days)		Viability (%)
	Mean ± SD	Range	
Larval stage	3.51 ± 0.64	3–6	76.00
Pupal stage	10.14 ± 0.63	9–11	88.15
L1 to adult	13.60 ± 0.69	12–16	67.00

SD, standard deviation.

Oxysarcodexia amorosa (Schiner, 1868)

The larval viability of *O. amorosa* was 76% (Table 3). The larval stage had a mean duration of 3.51 ± 0.64 days, with a minimum of 3 and a maximum of 6 days (Table 3). L3 abandoned the diet and started pupation with a mean weight of 28.28 ± 3.38 mg, with a minimum of 14 mg and a maximum of 39 mg. The mean weight of L3 that originated adult males was 28.83 ± 2.53 mg, ranging from 22 to 37 mg, and the mean weight of L3 that originated adult females was 28.28 ± 3.33 mg, ranging from 14 to 33 mg (Table 4). No significant differences between the larval weight of *O. amorosa* males and females were observed (Table 4). The pupal viability was 88.15% (Table 3). The mean duration of the pupal stage was 10.14 ± 0.63 days, ranging from 9 to 11 days (Table 3). The percentage of males and females was, respectively, 53% and 47% and the sex ratio was 0.47. The duration of the L1 to adult ranged from 12 to 16 days, showing a mean duration of 13.60 ± 0.69 days and a viability of 67% (Table 3). The mean lifespan of *O. amorosa* was 83.66 ± 15.94 days for females and 84.00 ± 19.97 days for males (Fig. 3). The number of larvae deposited per female of *O. amorosa* ranged from 0.33 to 12.07 (on Day 29) (Fig. 4). At the end of the experiment 4781 larvae had been deposited on the putrefied ground beef, between the 12th and 85th day of the experiment.

Table 4
Weight (mg) of L3 larvae of *Oxysarcodexia amorosa* kept under laboratory conditions (27 ± 1 °C, 60 ± 10% RH with 12 h of photophase).

| Mature larva (L3)	Weight (mg)	
	Mean ± SD	Range
Females	28.28 ± 3.33	14–33
Males	28.83 ± 2.53	22–37
Females and males	28.28 ± 3.38	14–39

SD, standard deviation.

Discussion

Salviano et al. (1996) obtained a value of larval viability of 89.82% at 27 °C, for *P.* (*S.*) *trivittata* (Curran, 1927) (as *Squamatoides trivittatus*) and Madubunyl (1986) obtained a value of larval viability of 80.69% at 23–28 °C for *Sarcophaga* (*Bercaea*) *africa* (Wiedemann, 1824) (as *Sarcophaga haemorrhoidalis*). These results were similar to *P.* (*S.*) *lambens*. However, *O. amorosa* showed a low viability at 27 °C, compared to these species.

The results of the larval stage duration for *P.* (*S.*) *lambens* and *O. amorosa* were similar those by Ferraz (1995) with *Peckia* (*Peckia*) *chrysostoma* (Wiedemann, 1830), where the duration of the larval stage was 3.91 ± 0.08 days at 25.9 °C. However, the results were unlike those obtained by Salviano et al. (1996) for *P.* (*S.*) *trivittata*, where the mean duration was 4.2 days at 27 °C.

Nassu et al. (2014) studied the developmental rate of two immature flesh flies, and obtained 4.6 days for the mean duration of the larval stage of *Sarcophaga* (*Liopygia*) *ruficornis* (Fabricius, 1794) at 25 °C and 6.5 days for *Microcerella halli* (Engel, 1931) at 25 °C. At 30 °C, the mean duration of the larval stage of these species was very similar to what was observed at 25 °C (4.5 and 6 days, respectively). Therefore, *S.* (*L.*) *ruficornis* and *M. halli* show duration of larval stage different from *O. amorosa* and *P.* (*S.*) *lambens*, regardless of the temperature is lower or higher.

Salviano et al. (1996) suggested discriminate male and female by L3 larvae weight. The mean weight of *P.* (*S.*) *trivittata* was 257 ± 33 mg for L3 males and 238 ± 34 mg for L3 females. However, for the L3 weight of *P.* (*S.*) *lambens* and *O. amorosa*, no significant
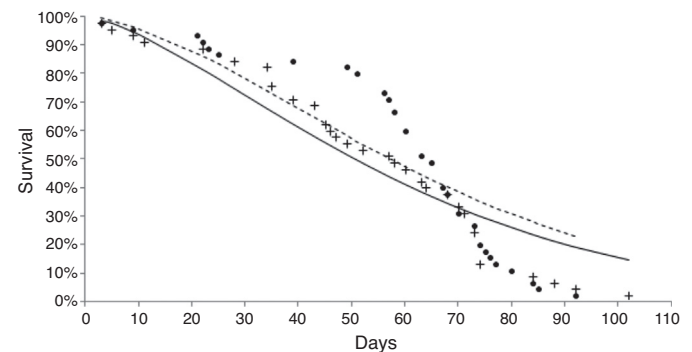
Fig. 3. Survival curve following the Weibull distribution model. Male [observed (crosses); expected (solid line)] and female [observed (large dots); expected (dotted line)] of *Oxysarcodexia amorosa* kept under laboratory conditions (27 ± 1 °C, 60 ± 10% RH with 12 h of photophase).
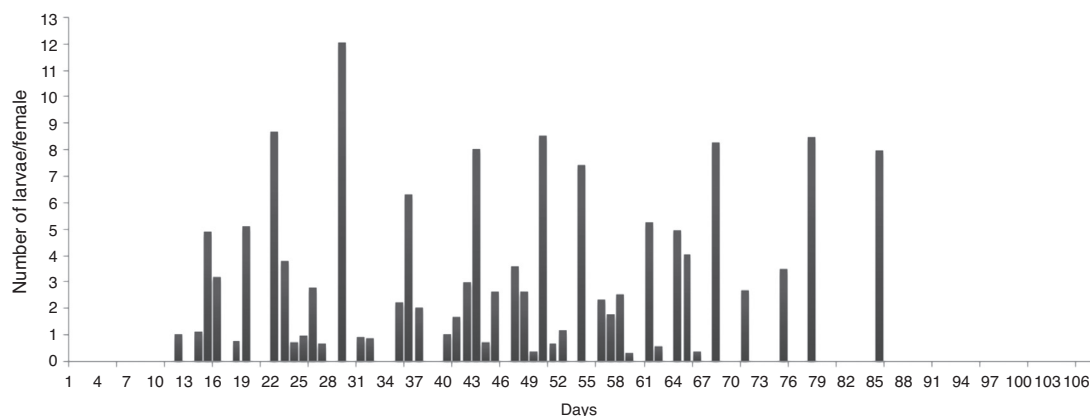
Fig. 4. Number of larvae deposited on putrefied ground beef throughout the experiment per female of *Oxysarcodexia amorosa* kept under laboratory conditions (27 ± 1 °C, 60 ± 10% RH with 12 h of photophase).

value was observed to discriminate the males from the females. Larvae of *P.* (*S.*) *lambens* that weighed less than 22 mg reached the pupal stage, but they did not emerge as adults; this may be considered a threshold weight for adult development (Table 2). No threshold weight was observed to *O. amorosa*.

Ferraz (1995) obtained a pupal viability of 96.9 ± 2.5% for *P.* (*P.*) *chrysostoma* at 25.9 °C, while Salviano et al. (1996) obtained a pupal survival of 92.75% for *P.* (*S.*) *trivittata* at 27 °C. Madubunyl (1986) working with *S.* (*B.*) *africa*, reported a pupal viability of 89.83% at 23–28 °C, similar to the results obtained here for *O. amorosa*. Ferraz (1995) obtained a pupal viability for *P.* (*P.*) *chrysostoma* of 69.9% at 25.9 °C, similar to the results obtained for *P.* (*S.*) *lambens*.

Nassu et al. (2014) obtained a mean duration of the pupal stage of *S.* (*L.*) *ruficornis* and *M. halli* of 12 days and 14 days at 25 °C, respectively. Some authors claim that the duration of the pupal stage of flesh flies, at a temperature of around 27 °C, ranges from 10 to 20 days (Nishida, 1984; Jirón and Bolaños, 1986). This duration is considerably greater than that of the pupal stage of *P.* (*S.*) *lambens* (6–12 days), which shows that some species of Sarcophagidae may have a more rapid adult emergence.

The percentage of males and females obtained by Salviano et al. (1996) for *P.* (*S.*) *trivittata* was 54.36% for male and 45.64% for female. This result is very similar to the sex ratio for *P.* (*S.*) *lambens* and *O. amorosa*.

Loureiro et al. (2005) observed that the duration from neolarvae to adult stage for *Peckia* (*Pattonella*) *intermutans* (Walker, 1861) ranged from 17 to 20 days, under the same conditions of temperature and humidity as in the present work. Gomes et al. (2003) reported an average duration of the neolarvae to imago stage of 19.33 ± 1.59 days for *P.* (*P.*) *chrysostoma*, also under the same conditions of temperature and humidity.

Salviano et al. (1996) obtained a mean lifespan for *P.* (*S.*) *trivittata* of 11.9 ± 1.1 days for females and 14.7 ± 1.3 days for males. These values suggest that, at 27 °C, both *P.* (*S.*) *lambens* and *O. amorosa* have longer lifespans than *P.* (*S.*) *trivittata*. Salviano et al. (1996) reported an increased lifespan in females of *P.* (*S.*) *trivittata* under temperatures of 16 °C, whereas at 27 °C the same species showed a longer lifespan of male flies, similar to the present study. Salviano et al. (1996) also highlighted that a shorter female lifespan might be due to the energy spent on ovarian development.

The number of larvae laid by *O. amorosa* was more than three times greater than the number of larvae laid by *P.* (*S.*) *lambens*. This high fertility may be related to the fact that *O. amorosa* presented a greater lifespan of the females, showing a biotic potential greater than *P.* (*S.*) *lambens*. Interestingly, despite having a higher biotic potential, *O. amorosa* took almost double the time to perform the

first larviposition compared to *P.* (*S.*) *lambens*, which may suggest that *P.* (*S.*) *lambens* has a short larviposition duration. Furthermore, the process of ovarian maturation and of the first copulations occur much sooner for this species when compared to *O. amorosa*.

These results can be important to assist medico-legal investigations and causes of mistreatment. Flesh flies such as *O. amorosa* and *P.* (*S.*) *lambens* have a high synanthropy (Dias et al., 1984; Leandro and d'Almeida, 2005; Yepes-Gaurisas et al., 2013) and are vectors of several pathogens, e.g. viruses, fungi, bacteria, helminthes eggs and larvae (Greenberg, 1973; Sukontason et al., 2006). It is important to know the information about the life cycles of these species, which can be used in control techniques, to improve public health. Moreover, as there was no record of the bionomy of these two species in the scientific literature, these results add knowledge to what is already known about them. These preliminary results are not yet sufficient for an accurate estimate of the PMI, because the development of these flies need to be analyzed at different temperatures. Also, it must be stated that flesh flies show a different behavior *in natura*, where they are exposed to several abiotic factors that can influence its development.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

References

Barbosa, R.R., Mello-Patiu, C.A., Mello, R.P., Queiroz, M.M.C., 2009. New records of calyptrate dipterans (Fanniidae, Muscidae and Sarcophagidae) associated with the decomposition of domestic pigs in Brazil. Mem. Inst. Oswaldo Cruz 6, 923–926.

Benecke, M., Josephi, E., Zweihoff, R., 2004. Neglect of elderly: forensic entomology cases and considerations. Forensic Sci. Int. 165, S195–S199.

Carvalho, L.M.L., Linhares, A.X., 2001. Seasonality of insect successions and pig carcass decomposition on a natural forest area in Southeastern Brazil. J. Forensic Sci. 46, 604–608.

d'Almeida, J.M., 1988. Substratos utilizados para a criação de dípteros caliptrados em uma área urbana do Município do Rio de Janeiro. Mem. Inst. Oswaldo Cruz 83, 201–206.

d'Almeida, J.M., 1989. Substrato utilizados para a criação de dípteros caliptrados no Jardim Zoológico do Rio de Janeiro (RIO-ZOO). Mem. Inst. Oswaldo Cruz 84, 257–264.

de Carvalho, C.J.B., Mello-Patiu, C.A., 2008. Key to the adults of the most common forensic species of Diptera in South America. Rev. Bras. Entomol. 52, 390–406.

Dias, E.S., Neves, D.P., Lopes, H.S., 1984. Estudos sobre a fauna de Sarcophagidae (Diptera) de Belo Horizonte, Minas Gerais. III – Atratividade das iscas. Mem. Inst. Oswaldo Cruz 79, 413–417.

Fernandes, L.F., Pimenta, F.C., Fernandes, F.F., 2009. First report of human myiasis in Goiás state, Brazil: frequency of different types of myiasis, their various etiological agents, and associated factors. J. Parasitol. 95, 32–38.

Ferraz, M.V., 1995. Larval and pupal periods of *Peckia chrysostoma* and *Adiscochaeta ingens* (Diptera: Sarcophagidae) reared under laboratory conditions. Mem. Inst. Oswaldo Cruz 90, 611–614.

Fessl, B., Couri, M.S., Tebbich, S., 2001. *Philornis downsi* Dodge & Aitken, new to the Galapagos Islands (Diptera, Muscidae). Stud. Dipterol. 8, 317–322.

Förster, M., Klimpel, S., Mehlhorn, H., Sievert, K., Messler, S., Pfeffer, K., 2007. Pilot study on synanthropic flies (e.g. *Musca, Sarcophaga, Calliphora, Fannia, Lucilia, Stomoxys*) as vectors of pathogenic microorganisms. Parasitol. Res. 101, 243–246.

Francesconi, F., Lupi, O., 2012. Myiasis. Clin. Microbiol. Rev. 25, 79–105.

Gomes, C.M., d'Almeida, J.M., Santos, J.A.A., 2003. Avaliação do efeito do látex de *Euphorbia splendens* var. *hislopii* (Euphorbiacea), no desenvolvimento pós embrionário de *Peckia chrysostoma* (Wiedemann, 1830) (Diptera: Sarcophagidae), em condições de laboratório. Entomol. Vect. 10, 109–120.

Greenberg, B., 1973. Flies and Disease, Vol. II: Biology and Disease Transmission. Princeton University, Princeton.

Guimarães, J.H., Papavero, N., Prado, A.P., 1983. As miíases na região neotropical: identificação, biologia e bibliografia. Rev. Bras. Zool. 1, 239–416.

Jirón, L.F., Bolaños, R., 1986. Biology and larval morphology by scanning electron microscopy of *Panttonella intermutans* Walker (Diptera, Sarcophagidae). Rev. Bras. Ent. 30, 27–30.

Jirón, L.F., Cartín, V.M., 1981. Insect succession in the decomposition of a mammal in Costa Rica. J. N. Y. Entomol. Soc. 40, 245–250.

Leandro, M.J.F., d'Almeida, J.M., 2005. Levantamento de Calliphoridae, Fanniidae, Muscidae e Sarcophagidae em um fragmento de mata na Ilha do Governador, Rio de Janeiro, Brasil. Iheringia Sér. Zool. 95, 377–381.

Liu, D., Greenberg, B., 1989. Immature stages of some flies of forensic importance. Ann. Entomol. Soc. Am. 82, 80–93.

Lopes, H.S., Leite, A.C.R., 1989. Morphology of the egg of *Sarcodexia lambens* (Diptera, Sarcophagidae). Mem. Inst. Oswaldo Cruz 84, 497–500.

Loureiro, M.S., Oliveira, V.C., d'Almeida, J.M., 2005. Desenvolvimento pós-embrionário de *Pattonella intermutans* (Thomson) (Diptera: Sarcophagidae) em diferentes dietas. Rev. Bras. Entomol. 49, 127–129.

Madubunyl, L.C., 1986. Laboratory life history parameters of the red-tailed fleshfly, *Sarcophaga haemorrhoidalis* (Fallen) (Diptera: Sarcophagidae). Int. J. Trop. Insect Sci. 7, 617–621.

Mulieri, P.R., Mariluis, J.C., Patitucci, L.D., 2010. Review of the Sarcophaginae (Diptera: Sarcophagidae) of Buenos Aires Province (Argentina), with a key and description of a new species. Zootaxa 2575, 1–37.

Nassu, M.P., Thyssen, P.J., Linhares, A.X., 2014. Developmental rate of immature of two fly species of forensic importance: *Sarcophaga* (*Liopygia*) *ruficornis* and *Microcerella halli* (Diptera, Sarcophagidae). Parasitol. Res. 113, 217–222.

Nishida, K., 1984. Experimental studies on estimation of postmortem interval by means of fly larvae infesting human cadavers. Nippon-Hoigaku-Zasshi 38, 24–41.

Oliveira, V.C., Mello, R.P., d'Almeida, J.M., 2002. Dípteros muscóides como vetores mecânicos de ovos de helmintos em jardim zoológico. Brasil. Rev. Saúde Pública 36, 614–620.

Oliveira-Costa, J., Mello-Patiu, C.A., Lopes, S.M., 2001. Dípteros muscóides associados com cadáveres humanos na cena da morte no estado do Rio de Janeiro, Brasil. Bol. Mus. Nac. Nova Sér. Zool. 464, 1–6.

Pape, T., 1996. Catalogue of the Sarcophagidae of the world (Insecta: Diptera). Mem. Entomol. Int. 8, 1–558.

Pape, T., Dahlem, G.A., 2010. Sarcophagidae. In: Brown, B.V., Borkent, A., Cumming, J.M., Wood, D.M., Woodley, N.E., Zumbado, M. (Eds.), A Manual of Central American Diptera, vol. 2. NRC Research Press, Ottawa, pp. 1313–1335.

Salviano, R.J.B., Mello, R.P., Beck, L.C.N.H., d'Almeida, J.M., 1996. Aspectos bionômicos de *Squamatoides trivittatus* (Diptera, Sarcophagidae) sob condições de laboratório. Mem. Inst. Oswaldo Cruz 91, 249–254.

Sgrillo, R.B., 1982. A distribuição de Weibull como modelo de sobrevivência de insetos. Ecossistema 7, 9–13.

Shewell, G.E., 1987. Sarcophagidae. In: McAlpine, J.F., Peterson, B.V., Shewell, G.E., Teskey, H.J., Vockeroth, J.R., Wood, D.M. (Eds.), Manual of Nearctic Diptera Research Branch, Agriculture Canada, Monograph 28, vol. 2, pp. 1159–1186.

Sukontason, K.L., Bunchu, N., Methanitikorn, R., Chaiwong, T., Kuntalue, B., Sukontason, K., 2006. Ultrastructure of adhesive device in fly in families Calliphoridae, Muscidae and Sarcophagidae, and their implication as mechanical carriers of pathogens. Parasitol. Res. 98, 477–481.

Tibana, R., Mello, C.A., 1985. O sintergito 6 + 7 das fêmeas de *Oxysarcodexia* Townsend, 1917 (Dipt. Sarcop.). Rev. Bras. Biol. 45, 439–445.

Yepes-Gaurisas, D., Sánchez-Rodriguez, J.D., Mello-Patiu, C.A., Wolff, M.E., 2013. Synanthropy of Sarcophagidae (Diptera) in La Pintada, Antioquia, Colombia. Rev. Biol. Trop. 61, 1275–1287.