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Ecology

Diversity of Calliphoridae and Sarcophagidae (Diptera: Oestroidea) in a forested area in the municipality of Macaé, RJ, Brazil

Anna Beatriz Costa dos Santos, **Márcia Souto Couri** & **Cátia Antunes Mello-Patiu†**

Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil. †In memoriam.

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Abstract. Sarcophagidae and Calliphoridae are Diptera families comprising approximately 3,100 and 1,500 species worldwide, respectively, with notable medical and veterinary importance as vectors of pathogens. Despite their significance, Diptera fauna in many Brazilian ecosystems, including certain Atlantic Forest phytophysiognomies, remains poorly studied. In the present study, two expeditions were carried out, one in the rainy season and the other in the dry season, using four traps baited with fish and exposed for 48 h in the field in the Parque Natural Municipal Atalaia in the municipality of Macaé. Collected specimens were curated at Instituto de Biodiversidade e Sustentabilidade - NUPEM/UFRJ and identified at Laboratório de Biodiversidade e Sistemática de Diptera - Museu Nacional, UFRJ (MNRJ). A total of 712 specimens of Calliphoridae and 27 of Sarcophagidae were collected. The sampling effort for Sarcophagidae collection was average, since the species accumulation curve continues to rise, unlike the Calliphoridae curve, which began to approach an asymptote. The study included species considered asynanthropic, as *Hemilucilia semidiaphana* (Rondani, 1850) (Calliphoridae), but also invasive species, like those of the genus *Chrysomya* Robineau-Desvoidy, 1830 (Calliphoridae). Therefore, the present study contributed to expand knowledge about both families in the Atlantic Forest, in Rio de Janeiro, and emphasized the importance of continuing studies in the region, as many species are asynanthropic, while others are invasive, which can impact native populations.

Keywords: Atlantic forest; biodiversity; blow-flies; flesh-flies; inventory.

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Corresponding author:
Anna Beatriz Costa dos Santos
annabeatriz.cds@gmail.com

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Sarcophagidae includes flies known as "flesh flies", whose appearance is characterized by a grayish color, with the presence of three longitudinal black stripes on the mesonotum and abdomen with a checkered pattern. The family consists of about 3,100 species described worldwide and is divided into three subfamilies: Miltogramminae, Paramacronychiinae and Sarcophaginae (Mello-Patiu *et al.* 2009; Pape *et al.* 2011).

Calliphoridae is a family whose individuals are known as "blowflies" and are characterized by having a metallic luster over the entire body or part of it, coloration varying from green to blue, setae in the pleural sclerites and by the conspicuous angulation at the distal part of the vein M in the wing (Carvalho & Mello-Patiu 2008). The group is represented by approximately 1,500 species worldwide and is divided into four subfamilies: Calliphorinae, Chrysomyinae, Luciliinae, Mesembrinellinae and Toxotarsinae (Nasser *et al*. 2021; Marinho & Madeira-Ott 2024).

Both families hold significant forensic importance as the initial decomposers that colonize carcasses, serving as indicators of the decomposition timeline of human bodies (Baz *et al*. 2007; Vairo *et al*. 2011). Additionally, they have sanitary relevance because they transmit pathogenic microorganisms, including viruses, bacteria, protozoa, and helminths, due to their egg-laying habits on carcasses, urban waste, and feces (Vianna *et al*. 2004). Furthermore, they can cause myiasis in both animals and humans (Mariluis *et al*. 2008).

Although there are extensive studies on these groups in the literature for southeastern Brazil, many ecosystems remain poorly studied, including various phytophysiognomies of the Atlantic Forest. This ecosystem, located in coastal areas, is heavily impacted by real estate development and a high demographic index, particularly in the state of Rio de Janeiro, which has one of the highest population densities (Santos *et al*. 2020; Grelle *et al*. 2021). There are no records of these families in the northern region of Rio de Janeiro (Mello-Patiu *et al*. 2009), highlighting the need for studies on the diversity of fauna in these areas.

MATERIAL AND METHODS

The study was carried out in the Parque Natural Municipal Atalaia (PNMA) (Figure 1), located in the districts of Córrego do Ouro, 5th District of Macaé and Cachoeiras de Macaé in the Municipality of Macaé, state of Rio de Janeiro (-22.25000 to -22.33333; -42.96667 to -42.03333), in the north of Rio de Janeiro, covering an area of 11 km in perimeter. The PNMFA is part of the Atlantic Forest biome, with vegetation of the Seasonal Semideciduous Forest type (Werneck *et al.* 2011), characterized as dense forest with regeneration rates. The climate can be described as tropical, with droughts in winter, with an annual average temperature of 23.5 °C, with peaks of 26.9 °C in summer (January), and a minimum of 19 °C

in winter (July) and annual precipitation of 1,126 mm.

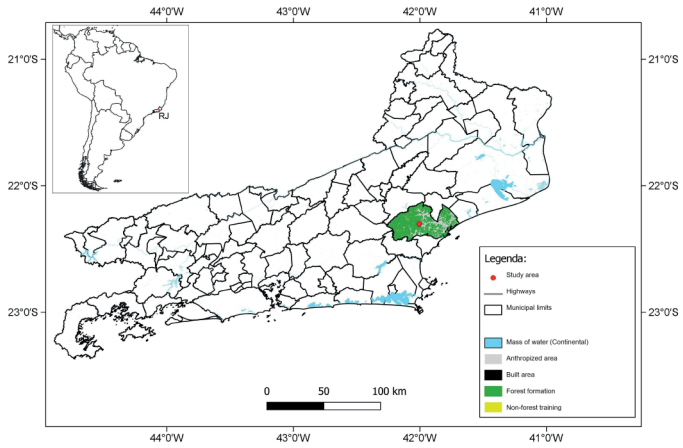

Figure 1. Study location map.

Inside the park, four traps (Figure 2) were baited with fish (Clupeidae) still with their viscera and previously left at room temperature for 48 h. The traps were tied to trees and arranged in a grid, 1.5 m from the ground and at a distance of 100 m from each other (Figure 3) and exposed for 48 h in the field. The first collection took place in the rainy season, in March 2019, while the second collection took place in the dry season, in August 2019.

Figure 2. Trap used in the study, fixed to a tree and baited with fish for collections conducted between March and August.

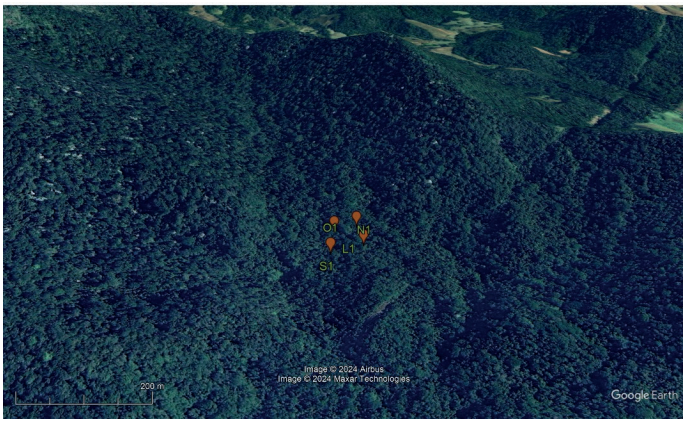

Figure 3. Location of the sampling points in Parque Natural Municipal Atalaia, Macaé, RJ.

The material was collected and taken to the laboratory for identification using identification keys (Carvalho & Mello-Patiu 2008; Kossman *et al*. 2013) and, following the classification adopted by these works, Mesembrinellinae was considered a subfamily of Calliphoridae. Subsequently, the individuals were compared with material from the Entomological Collection at the Museu Nacional/UFRJ (MNRJ). The identified specimens were registered and tabulated for further analysis. The identified specimens were incorporated into the same collection. A species accumulation curve was carried out using EstimateS (Cowell 2019) in order to verify the sampling effort of both families.

RESULTS

In the rainy season, 267 specimens of Calliphoridae belonging to six genera and eight species were collected (Table 1). Of the obtained genera, *Chrysomya* Robineau-Desvoidy, 1830 was the most abundant with 168 specimens (62.92%) represented by three species: *Chrysomya putoria* (Wiedemann, 1830), with 102 specimens, *Chrysomya albiceps* (Wiedemann, 1819) with 37 specimens and *Chrysomya megacephala* (Fabricius, 1754) with 29 specimens. The second most abundant genus was *Hemilucilia* Brauer, 1895 comprising 53 individuals of a single species, *Hemilucilia semidiaphana* (Rondani, 1850) (19.85%). *Hemilucilia* was followed by *Mesembrinella* Giglio-Tos, 1893, represented by 21 individuals of a single species, *Mesembrinella bellardiana* Aldrich, 1922 (7.86 %). The remaining genera: *Lucilia* Robineau-Desvoidy, 1830, *Laneella* Mello, 1967 and *Cochliomyia* Townsend, 1915 were also represented by a single species: *Lucilia eximia* (Wiedemann, 1819), represented by five individuals, *Laneella* nigripes Guimarães, 1977, represented by 19 specimens and *Cochliomyia hominivorax* (Coquerel, 1858), represented by a single specimen respectively, and constituted less than 10% of the total abundance of the collected blow flies.

Likewise, the family Sarcophagidae was represented by 13 specimens belonging to four genera, three subgenera and seven species (Table 1). Of the collected genera, *Peckia* Robineau-Desvoidy, 1830 was the most abundant (61,53%), consisting of 8 specimens distributed in 3 subgenera: *Peckia* Robineau-Desvoidy, 1830, represented by a single species, *Peckia* (*Peckia*) *pexata* (Wulp, 1895) with one specimen; *Euboettcheria* Townsend, 1927, represented by *Peckia* (*Euboettcheria*) *collusor* (Curran & Walley, 1934) with five specimens and *Peckia* (*Euboettcheria*) *anguilla* (Curran & Walley, 1934) with one specimen; and *Sarcodexia* Townsend, 1892, represented by a single species, *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830). The remaining genera, *Oxysarcodexia* Townsend, 1917 and *Engelimiya* Lopes, 1975 were equally represented, each comprising two individuals of a single species (15.38%): *Oxysarcodexia thornax* (Walker, 1849) and *Engelimyia inops* (Walker, 1949), while the genus *Ravinia* Robineau-Desvoidy, 1863 was represented by a single species, *Ravinia belforti* (Prado & Fonseca, 1932), with a single individual, constituting 7.69% of the total abundance.

Conversely, in the dry season, 445 specimens of Calliphoridae were collected, belonging to five genera and nine species were collected (Table 1). Of the obtained genera, *Hemilucilia* was the most abundant with 303 specimens (68.08%) represented by two species, *He. semidiaphana*, with 296 individuals, and *Hemilucilia segmentaria* (Fabricius, 1805) with seven individuals. *Chrysomya* was the second most abundant genus, covering 65 individuals distributed in three species (14.58%): *Ch. albiceps*, represented by 36 individuals, *Ch. megacephala*, with 27 specimens and *Ch. putoria*, with two individuals. *Mesembrinella* was represented by 47 individuals distributed in two species (10.55%), *Me. bellardiana* with 43 specimens, and *Mesembrinella semihyalina* Mello, 1967, with four specimens. The other taxa *Lucilia* and *Lanella* were represented by a single species: *Lu. eximia*, with 14 specimens, and *La. nigripes*, covering 16 individuals, constituting 3,14% and 3,59% of the total abundance, respectively.

Similarly, a total of 14 specimens of Sarcophagidae were collected in the dry season (Table 1), belonging to two genera, three subgenera and four species of the obtained genera, *Peckia* was the most representative, consisting of 13 specimens (92.85%) distributed in three subgenera: *Peckia*, represented by *Peckia* (*Peckia*) *chrysostoma* (Wiedemann,

Table 1. Species collected of Calliphoridae and Sarcophagidae from the Parque Natural Municipal Atalaia, municipality of Macaé, state of Rio de Janeiro, Brazil, in March (Rainy) and August (Dry) in 2019.

Family	Species	Rainy	Dry
Calliphoridae	*Chrysomya albiceps* (Wiedemann, 1819)	37	36
Calliphoridae	*Chrysomya megacephala* (Fabricius, 1754)	29	27
Calliphoridae	*Chrysomya putoria* (Wiedemann, 1830)	102	2
Calliphoridae	*Cochliomya hominivorax* (Coquerel, 1858)	1	0
Calliphoridae	*Hemilucilia segmentaria* (Fabricius, 1805)	0	7
Calliphoridae	*Hemilucilia semidiaphana* (Rondani, 1850)	53	296
Calliphoridae	*Laneella nigripes* Guimarães, 1977	19	16
Calliphoridae	*Lucilia eximia* (Wiedemann, 1819)	5	14
Calliphoridae	*Mesembrinella bellardiana* Aldrich, 1922	21	43
Calliphoridae	*Mesembrinella semihyalina* Mello, 1967	0	4
Sarcophagidae	*Engelimyia inops* (Walker, 1849)	2	1
Sarcophagidae	*Oxysarcodexia thornax* (Walker, 1849)	2	0
Sarcophagidae	*Peckia* (*Euboettcheria*) *anguilla* (Curran & Walley, 1934)	1	0
Sarcophagidae	*Peckia* (*Euboettcheria*) *collusor* (Curran & Walley, 1934)	5	0
Sarcophagidae	*Peckia* (*Euboettcheria*) *subducta* (Lopes, 1935)	0	4
Sarcophagidae	*Peckia* (*Pattonella*) *intermutans* (*Walker, 1861*)	0	1
Sarcophagidae	*Peckia* (*Peckia*) *chrysostoma* (Wiedemann, 1830)	0	8
Sarcophagidae	*Peckia* (*Peckia*) *pexata* (Wulp, 1895)	1	0
Sarcophagidae	*Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830)	1	0
Sarcophagidae	*Ravinia belforti* (Prado & Fonseca, 1932)	1	0

1830) with eight specimens; *Pattonella* Enderlein, 1928 with one individual; and *Euboettcheria*, represented by *Peckia* (*Euboettcheria*) *subducta* (Lopes, 1935) with four specimens. The genera *Engelimiya*, was represented by a single specimen, *En. inops*, constituting 7.69% of the total abundance.

All of the collected Calliphoridae and Sarcophagidae species already had records for the state of Rio de Janeiro (Mello-Patiu *et al.* 2009; Oliveira-Costa *et al.* 2013). However, all species are considered as new records for the municipality of Macaé, since there are no studies about the diversity of both groups for the region.

DISCUSSION

Within Calliphoridae, the species in the genus *Chrysomya* were introduced to the American continent around 1970 and quickly dispersed (Guimarães *et al.* 1978; Baumgartner & Greenberg 1984), causing a decline in native populations, as in the case of *Cochliomyia macellaria* (Fabricius, 1775), which ceased to be abundant and diverse in numerous regions after the introduction of this genus (Wells & Sperling 1999; Gomes *et al*. 2000; Gonçalves *et al*. 2011). The species of *Chrysomya* were more abundant during the rainy season, which aligns with the results obtained by Vianna *et al*. (2004).

Three species of the subfamily Mesembrinellinae were collected, which is an exclusively neotropical group (Bonatto & Marinoni 2005) and considered a bioindicator of preserved forest environments because they are abundant and diverse in these locations, such as primary humid forests, exhibiting a rapid population response in these areas. In secondary forests and human-altered environments, they are absent (Gadelha *et al*. 2009; Figueiredo *et al*. 2018; Marinho *et al*. 2016), which characterizes them as asynanthropic, defined by Polvony (1971) as organisms that do not have the capacity to tolerate anthropogenic modifications in the environment.

Another genus identified was *Hemilucilia*, characterized as predominantly neotropical (Furusawa & Cassino 2006). Similar to Mesembrinellinae, *Hemilucilia* is an asynanthropic group found in forested environments, which aligns with findings by Furusawa & Cassino (2006) and Sousa *et al*. (2010). Its prevalence was higher during the dry season, consistent with observations by Mello *et al*. (2007).

Among the collected Sarcophagidae, the genus *Peckia* is one of the most representative of the Neotropical region and has forensic importance, since they are one of the main groups of decomposer organisms (Ramos *et al*. 2018). Among its species collected in the present study, *Peckia* (*Peckia*) *chrysostoma* (Wiedemann, 1830), *Peckia* (*Sarcodexia*) *lambens* (Wiedemann, 1830) and *Peckia* (*Patonella*) *intermutans* (Walker, 1861) have already been identified as important from a forensic point of view, the former also causing myiasis in other animals (Gomes & Mello-Patiu 2021; Madeira-Ott *et al*. 2022; Silva *et al*. 2023). Other sarcophagids collected in the present study, which are also considered as forensic indicators, are *Ox. thornax* and *Ra. belforti* (Barros *et al*. 2008; Alves *et al*. 2014).

Regarding the degree of synanthropy, the species *Pe.* (*Pa.*) *intermutans* and *Pe.* (*Eu.*) *collusor* are considered as synanthropic, since they cannot establish well in environments altered by man (Gomes & Mello-Patiu 2021). On the other hand, *Pe. chrysostoma* is considered synanthropic, that is, it can adapt to conditions created by man, having been reported in other studies in urban areas and with low presence in forest areas (Yepes-Gaurisas 2013).

The accumulation curve of Calliphoridae (Figure 4) showed a steep initial rise, indicating high species richness with increased sampling effort. The curve began to approach an asymptote, suggesting that most species in the area had been sampled. This indicates that the current sampling effort was sufficient to capture the majority of the species present, with observed richness closely aligning with estimated richness, thereby confirming the adequacy of the sampling effort. The curve of Sarcophagidae (Figure 5), however, showed an upward trend, indicate a low sampling effort. For a more robust sampling in future studies, more traps can be added to cover a larger area of the park in different months and years, to obtain a more complete picture of the local diversity.

Based on the results obtained, it can be inferred that the Atalaia Municipal Natural Park, despite being in the highly devastated northern region of Rio de Janeiro, has an abundant presence of species considered asynanthropic. This indicates that the park is minimally impacted, as many species found within it are exclusive to preserved areas. However, the forest already has the presence of invasive species, such as those of the genus *Chrysomya*, which can result in the inhibition of native species, as already observed by Leandro & D'Almeida (2005) and Baumgartner & Greenberg (1984). Therefore, it is important that there is continuity in the study of dipterans inside the park, since these, due to their rapid reproductive cycle, are able to respond more quickly to changes in the environment, thus signaling possible impacts on the conservation of this area.

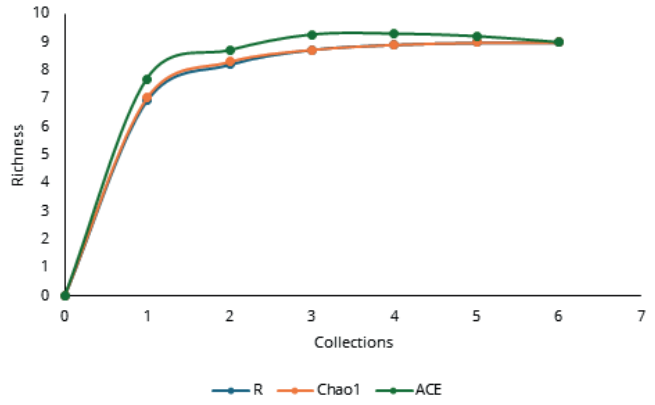

Figure 4. Species accumulation curve for the collected Calliphoridae from the Parque Natural Municipal Atalaia. Subtitle: R: Observed richness; Chao1: Chao1 richness estimator; ACE: ACE richness estimator.

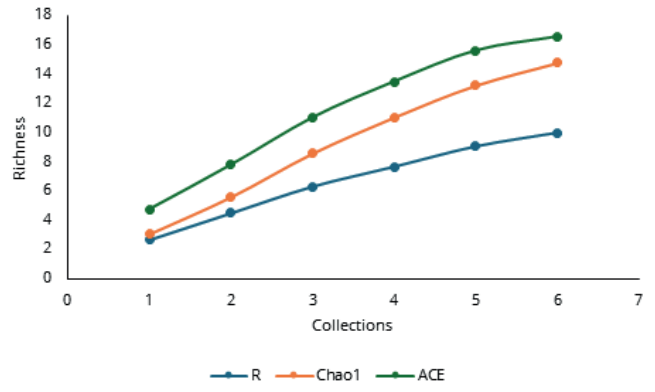

Figure 5. Species accumulation curve for the collected Sarcophagidae from the Parque Natural Municipal Atalaia. R: Observed richness; Chao1: Chao1 richness estimator; ACE: ACE richness estimator.

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AUTHORS CONTRIBUTION

ABCS: Sampling, species identification, statistical analyzes and writing of the article, CAM-P: Species identification and revision (*in memoriam*), MSC: Revision.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to disclose.

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