



Entomological data from the first year of the Forensic Entomology Division formalization at Santa Catarina Scientific Police

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ABSTRACT

Forensic entomology has been developing in Brazil in recent years. In cases where traditional forensic methods cannot accurately determine the postmortem interval (PMI), entomological evidence can be crucial. In this novel study, we present the first results of the Forensic Entomology Division at Santa Catarina Scientific Police, southern Brazil, formally established in January 2022. From Jan 2022 to July 2023, minimum PMI was calculated based on entomological evidence in 34 cases. A total of 21 species of insects (16 species of Diptera belonging to 6 families and 5 species of Coleoptera belonging to 4 families) were collected from human bodies at different decomposition stages and in different types of environments. The most abundant and relevant species to estimate PMI were: *Chrysomya albiceps* (in 38% of the cases), followed by *Hermetia illucens* (18%), *Oxelytrum discicollae* (14%), *Chrysomya megacephala* (12%) and *Peckia (Pantonella) intermutans* (12%). Some species were reported for the first time colonizing human corpses in Santa Catarina and used for the first time to estimate minimum PMI in Brazil. Understanding the entomofauna present on a human corpse becomes an important tool in death investigations and is essential for forensic entomology applications. Our findings provide better understanding of entomological evidence from Santa Catarina State and have important implications for the advancement of forensic entomology in Brazil.

Introduction

Brazil has high rates of homicide and violent crime. During 2017, Brazil witnessed a record-breaking of 65,602 homicides - the highest number in its recorded history (Aransiola et al., 2021; Cerqueira et al., 2023). However, there has been a decline in the homicide rate since then, and around 47,000 homicides were recorded in 2021 (Cerqueira et al., 2023). Despite this positive development, Brazil still has one of the world's highest homicide rates, with 4 cities listed among the 20 most violent in the world (Statista, 2024). It is also concerning that only 4 out of 10 homicides are solved, which is far below the resolution rates of developed countries (Instituto Sou da Paz, 2022). One way to decrease criminal rates of violent crimes is to invest in forensic institutes, which are responsible for producing material evidence to support the criminal prosecution process.

Forensic entomology is a scientific field that study insects to answer questions related to criminal investigations (Smith, 1986). It has been particularly useful in cases of violent deaths, such as homicides and suicides (Introna Junior et al., 1998; Pujol-Luz et al., 2008a; Vasconcelos et al., 2019) as well as incidents of abuse and illicit drug production (Benecke and Lessig, 2001; Macedo et al., 2013). The primary

application of forensic entomology is to estimate the postmortem interval (PMI), which is the time between death and body's discovery (Catts and Goff, 1992). In cases involving human corpses at advanced decomposition stages, forensic entomology may be a precious method to estimate minimum PMI (Hu et al., 2023).

This field has been studied in Brazil since 1908 and has been developing in recent years (Pujol-Luz et al., 2008b). However, despite being around for over a century, the use of entomological evidence in criminal investigations in Brazil is still scarce and rarely used in Brazilian forensic institutes (Oliveira-Costa, 2013). Its use has been limited by several factors, including the vast size of the country with a great diversity of necrophagous species, lack of specialized professionals (such as taxonomists), insufficient investments in research, unequal resource distribution and absence of entomological databases for applications. A recent survey conducted among Brazilian forensic police experts revealed other important factors, such as restraints imposed by the new chain of custody legislation (Brasil, 2019) and, most importantly, the intrinsic limitations of forensic entomology (Guimarães et al., 2022). Regarding the chain of custody, standardization of procedures for collection, preservation and identification of all kind of evidences, including insect specimens, became a new concern for Brazilian forensic institutes demands (Guimarães et al., 2022).

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Despite all challenges and difficulties, collaboration between entomologists and crime scene investigators of forensic institutes has made it possible to catalog the cadaverous entomofauna, promoting studies, applications and development of forensic entomology in Brazil (e.g. Carvalho et al., 2000; Oliveira and Vasconcelos, 2010; Kosmann et al., 2011; Thyssen et al., 2018; Corrêa et al., 2019; Vasconcelos et al., 2019; Meira et al., 2020). According to Guimarães et al. (2022), recently a growing interest in forensic entomology can be detected among forensic experts and innovative research on this field has been also evidenced in Brazil (Lei et al., 2019).

Considering the State of Santa Catarina, southern Brazil, forensic entomology studies are relatively recent (Gaedke and Mougá, 2017; Bonfanti et al., 2018a, 2018b). In recent years, the State government provided significant funding for public security investment's and Santa Catarina Scientific Police has invested in human resources and development of several forensic science areas, making Santa Catarina one of the safest States and with the best homicide resolution rates in the country (Instituto Sou da Paz, 2022; SESP, 2023). In 2021, 712 homicides were registered, reflecting a rate of 9.7 homicides per 100,000 inhabitants, the lowest rate in southern Brazil and less than half of the national rate (Cerqueira et al., 2023).

In this context, forensic entomology was one of the forensic science fields financed in Santa Catarina State and Forensic Entomology Division (FED) of Scientific Police was formally established in January 2022, initially performing exams to estimate minimum PMI. After formalization, FED developed internal procedures for collection, preservation and identification of insect specimens. These procedures are guided by the chain of custody legislation (Brasil, 2019) and based on standardization studies (Amendt et al., 2007, 2015; Oliveira-Costa et al., 2021).

Aiming to explore the necrophagous entomofauna of southern Brazil, in this novel study we share entomological data of the first death investigations cases analyzed at FED of Santa Catarina Scientific Police, listing the species of insects collected from human corpses at different decomposition stages and in different types of environments.

Material and methods

Locality

Santa Catarina is a Brazilian State located in southern region of the country, with an area of 95.730,690 km² and estimated population of 7.610.361 in 2022 (IBGE, 2024). The FED's laboratory is located at Joinville city, northern region of the State.

Data collection

Entomological evidence from 34 death investigations were collected by forensic experts (crime scene investigators and coroners) from Santa Catarina Scientific Police, between January 2022 to July 2023, following internal standardization methods. This study was approved by Santa Catarina Scientific Police ethical committee.

Each reported case presented only one human cadaver and these cases did not necessarily involved violent deaths (homicide, suicide and accidental death). All human corpses were analyzed at the crime scene and during the exam performed at the Legal Medicine Sectors, as part of a death investigation routine.

Along with entomological data, we also gathered information on State's region, environment type and decomposition stage for each case reported. The decomposition stages categorization followed França (2017). Environmental data (mean daily temperature values) were obtained by consulting the meteorological stations closest to

the areas of interest. Based on the information obtained, minimum PMI was estimated using the accumulated degree-day (ADD) method (Oliveira-Costa, 2011).

Entomological sampling, preservation and identification procedures

Immature specimens such as larvae and pupae were collected using sterilized tweezers and/or brushes before washing the corpses. These entomological samples were fixed and preserved in 70% liquid ethanol. If logistically possible, some of the remaining specimens were collected and kept alive to be sent to FED for rearing until emergence. Live specimens were preserved in plastic containers with lids that had ventilation holes and food substrate (raw ground beef). The temperature data was recorded until the specimens arrived at the laboratory, which should be within 24 hours.

Arriving at FED, larval samples were reared in plastic recipients containing raw ground beef at laboratory conditions (25 °C ± 1°C, 70 ± 10% RH and 12h of photofase). Pre-pupae and pupae samples were transferred to containers containing vermiculite and kept in a dark environment. Insects' specimens were monitored every 12 hours until they reached adulthood. After emergence, adult specimens collected were pinned and identified using the available literature (Carvalho and Ribeiro, 2000; Carvalho et al., 2002; Carvalho and Mello-Patiu, 2008; Almeida and Mise, 2009; Vairo et al., 2011; Celli et al., 2015; Rochefort et al., 2015) and consulting dipteran taxonomists (specialists on Fanniidae, Muscidae and Sarcophagidae families).

Considering immature samples preserved in alcohol, larvae samples were dissected and prepared on slides following Caneparo et al. (2021), in order to identify the species and the respective larval phase, using stereoscopic or optical microscopes (Oliveira-Costa, 2013; Prado et al., 2022). After all procedures, the specimens analyzed were preserved in 70% ethanol at FED's custody center.

Data analysis

Relative frequency or proportion (P) was calculated dividing the number of observations (NO) for a particular category (such as species or family) by the total number of observations (TO), then multiplying this value by 100 to obtain the proportion: $P = (NO/TO) * 100$ (Corrêa et al., 2019).

Results

During the first year (January 2022 to July 2023) of FED's establishment at Santa Catarina Scientific Police, 34 cases were analyzed to estimate minimum postmortem interval (minPMI).

Case data was collected from 13 Santa Catarina locations: Araquari (~ 9% of case reports), Campo Alegre (~ 9%), Chapecó (~ 3%), Garuva (~ 3%), Iomerê (~ 3%), Itajaí (~ 3%), Itapoá (~ 9%), Joinville (~ 36%), Mafra (~ 3%), Papanduva (~ 3%), São Francisco do Sul (~ 6%), São Bento do Sul (~ 9%) and Urupema (~ 3%) (Fig. 1).

Considering the study period, a total of 21 species of insects was reported. From this total, 16 species of flies (76%) belonging to 6 families were collected in this period: *Chrysomya albiceps* (Wiedemann, 1819), *Chrysomya megacephala* (Fabricius, 1794), *Hemilucilia segmentaria* (Fabricius, 1805), *Cochliomyia macellaria* (Fabricius, 1775), *Sarconesia chlorogaster* (Wiedemann, 1830) (Calliphoridae); *Fannia canicularis* (Linnaeus, 1761) (Fanniidae); *Muscina stabulans* (Fallén, 1817), *Hydrotaea (Ophyra) aenescens* (Wiedemann, 1830), *Synthesiomyia nudiseta* (Wulp, 1883) (Muscidae); *Microcerella halli* (Engel, 1931), *Peckia (Pantonella) intermutans* (Walker, 1861), *Sarcophaga ruficornis* (Fabricius, 1794),

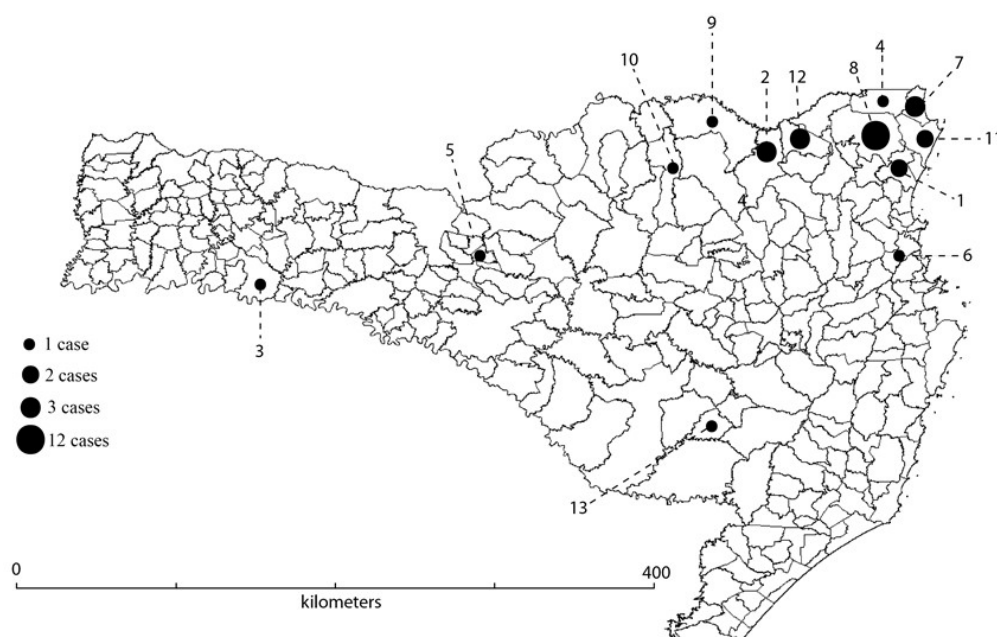


Figure 1 Santa Catarina State (southern Brazil) and locations where entomological evidence were collected: Araquari (1), Campo Alegre (2), Chapecó (3), Garuva (4), Iomerê (5), Itajaí (6), Itapoá (7), Joinville (8), Mafra (9), Papanduva (10), São Francisco do Sul (11), São Bento do Sul (12) and Urupema (13).

Sarcophagidae sp. 1, Sarcophagidae sp. 2 (Sarcophagidae); *Piophilidae casei* (Linnaeus, 1758) (Piophilidae); and *Hermetia illucens* (Linnaeus, 1758) (Stratiomyidae) (Table 1). Regarding coleopterans diversity, 5 species (24%) belonging to 4 families were collected: *Dermestes maculatus* (De Geer, 1774) (Dermestidae); *Euspilotus azureus* (Sahlberg, 1823) (Histeridae); *Necrobia rufipes* (DeGeer, 1775) (Cleridae); *Oxelytrum discicollae* (Brullé, 1840) and Staphylinidae sp. 1 (Staphylinidae) (Table 2).

Calliphorids and sarcophagids showed greater species richness among Diptera, with 5 species recorded for each family, followed by Muscidae (3 species), Fanniidae (1), Piophilidae (1) and Stratiomyidae (1). Among necrophagous beetles, each family collected (Cleridae, Dermestidae, Histeridae) had only one species, excepting Staphylinidae, highlighting the most abundant species *O. discicollae* with greater relevance to estimate minPMI. The most frequently species recorded was *C. albiceps* (38% of the cases), followed by *H. illucens* (18%), *O. discicollae* (14%), *C. megacephala* (12%) and *P. intermutans* (12%).

Minimum PMI estimate ranged from 2 (*C. albiceps*) to 65 days (*H. illucens*). The human corpses were found in different types of environments, including rural and urban, and indoor and outdoor locations. Most of these cases (61%) involved corpses found in rural environments (outdoors), and 44% were human bodies in the gaseous phase of putrefaction.

Discussion

Entomological data can be crucial to determine minPMI in criminal investigations, helping the police to demonstrate several circumstances relating to the death (Byrd and Sutton, 2020; Hu et al., 2023). Forensic entomology laboratories are not common in Brazil, with only four official departments associated with Scientific Polices (Bahia, Paraíba, Rio de Janeiro and Santa Catarina) performing specific applications in the field (personal data). Currently, entomological evidence is increasingly being used to estimate PMI through successful partnerships between entomologists and forensic experts in some Brazilian States, such as Paraná (Corrêa et al., 2019), Rio Grande do Norte (Meira et al., 2020) and São Paulo State (Thyssen et al., 2018). However, despite these

advances, entomological data is still overlooked in practice by many forensic experts and coroners nationwide (Guimarães et al., 2022), including those from Santa Catarina Scientific Police.

Although internal standardization methods have been developed, the collection of entomological evidence in forensic investigations still largely relies on the expertise and autonomy of the forensic experts. According to Guimarães et al. (2022), most survey respondents argued that most homicide victims are found within 48h, which validates traditional methods for PMI estimation. They also raised a series of challenges for forensic entomology applications and chain of custody procedures, and stated no procedures related to collecting, handling and/or identifying necrophagous insects in their routine. In other words, forensic entomology requires specialized knowledge to be part of daily practices. Besides all these difficulties, we also report logistic issues to transfer samples of insects to the laboratory, especially live specimens.

Considering logistic challenges, only forensic experts and coroners from northern region of Santa Catarina (Campo Alegre, Joinville, Mafra and São Bento do Sul) sent live specimens to FED's laboratory. These specimens were collected from death scenes and during autopsy procedures. Insect specimens from other state's region were collected only by coroners during autopsy and sent only preserved in 70% ethanol. Forensic experts and coroners from Joinville and São Bento do Sul have more knowledge in the field's procedures and adopted entomological evidence collection as part of death investigations routine, explaining most cases from these regions (Fig. 1).

Considering entomological data, the greater diversity of Calliphoridae and Sarcophagidae corroborates national literature data (e.g. Souza et al., 2008; Vasconcelos and Araújo, 2012; Corrêa et al., 2019). Blowflies are usually the first necrophagous insects to colonize corpses, due to their ability to detect organic compounds that are released during the decomposition process. However, local variables, such as finding the corpse in an indoor or outdoor environment, can interfere the colonizing process, bringing different patterns of entomological succession (e.g. Campobasso et al., 2001; Reibe and Madea, 2010; Vairo et al., 2017; Kruger and Correa, 2021). Furthermore, composition and fluctuation of

Table 1

Species of Diptera collected in human corpses from Jan 2022 to July 2023 in Santa Catarina State, southern Brazil.

Family	Species	Cadaveric phase	Environment	Location	Species proportion (%)
Calliphoridae	<i>Chrysomya albiceps</i>	Colliquative	Outdoor - rural	Araquari, Campo Alegre, Chapecó, Itapoá, Joinville, Papanduva, Urupema	38
		Gaseous	Indoor - urban		
		Remains			
	<i>Chrysomya megacephala</i>	Gaseous	Outdoor - rural	Joinville, Itapoá	12
		Remains			
	<i>Cochliomyia macellaria</i>	Gaseous	Indoor - urban	São Francisco do Sul	3
	<i>Hemilucilia segmentaria</i>	Gaseous	Outdoor - rural	Araquari, Joinville, Mafra	9
	<i>Sarconesia chlorogaster</i>	Preserved	Indoor - urban	Joinville, São Bento do Sul	9
		Gaseous			
		Colliquative			
Fanniidae	<i>Fannia canicularis</i>	Preserved	Indoor - urban	São Bento do Sul	3
Muscidae	<i>Muscina stabulans</i>	Preserved	Indoor - urban	São Bento do Sul	3
	<i>Hydrotaea (Ophyra) aenescens</i>	Colliquative		Araquari	3
	<i>Synthesiomyia nudiseta</i>	Gaseous	Indoor - urban	Joinville	3
Piophilidae	<i>Piophilidae casei</i>	Remains	Outdoor - rural	Joinville	3
Sarcophagidae	<i>Microcerella halli</i>	Preserved	Indoor - urban	São Bento do Sul	3
	Peckia (Pattonella) intermutans	Gaseous	Outdoor - rural	Araquari, Campo Alegre, Itapoá, Joinville	12
		Colliquative			
	<i>Sarcophaga ruficornis</i>	Gaseous	Indoor - urban	Campo Alegre	3
	Sarcophagidae sp. 1	Colliquative	Indoor - urban	Urupema	3
	Sarcophagidae sp. 2	Remains	Outdoor - rural	Papanduva	3
Stratiomyidae	<i>Hermetia illucens</i>	Saponification Colliquative, Remains	Outdoor - rural	Garuva, Itajaí, Joinville, São Bento do Sul, São Francisco do Sul	18

Table 2

Species of Coleoptera collected in human corpses from Jan 2022 to July 2023 in Santa Catarina State, southern Brazil.

Family	Species	Cadaveric phase	Environment	Location	Species proportion (%)
Cleridae	<i>Necrobia rufipes</i>	Mummified	Indoor - rural	Iomerê	3
Dermeestidae	<i>Dermestes maculatus</i>	Mummified	Indoor - rural	Iomerê	3
Histeridae	<i>Euspilotus azureus</i>	Colliquative	Outdoor - rural	Itajaí, Joinville	3
Staphylinidae	<i>Oxelytrum discicollae</i>	Colliquative, Remains Saponification	Outdoor - rural	Araquari, Joinville, São Bento do Sul, Urupema	14
	Staphylinidae sp. 1	Colliquative, Remains	Outdoor - rural	Joinville	3

dipteran communities are directly associated to several abiotic factors (Mello et al., 2007; Vasconcelos and Salgado, 2014).

Both *Chrysomya* species are invaders of a wide ecological niche in South America, and patterns of population increase at the expense of decreasing populations of native species (*Cochliomyia macellaria*, for example) have already been described (Baumgartner and Greenberg, 1984). Therefore, *C. albiceps* higher frequency in the death cases may be associated with its high degree of competitiveness against native species (Faria et al., 1999; Reigada and Godoy, 2005; Rosa et al., 2006). Similar data were observed by Corrêa et al. (2019) in forensic studies in Paraná State, with *C. albiceps* presenting a frequency of 40% in analyzed cases. All calliphorid species reported in this study (*C. albiceps*, *C. megacephala*, *Co. macellaria*, *H. segmentaria* e *S. chlorogaster*) have already been described in human cadavers in different regions of Brazil

(Oliveira-Costa and Mello-Patiu, 2004; Kosmann et al., 2011; Vairo et al., 2015, 2017; Ramos-Pastrana and Wolff, 2017). In Santa Catarina, Gaedke and Mouga (2017) observed seven calliphorid species in 10 human corpses from April 2014 to March 2016, collecting *Calliphora loyesi* (Mello, 1962), *Hemilucilia semidiaphana* (Rondani, 1850), *Lucilia cuprina* (Wiedemann, 1830) and *L. eximia* (Wiedemann, 1830), species not found in our cases. In a case report occurred in Paraná State, southern Brazil, Vairo et al. (2015) mentioned the first record of *S. chlorogaster* to estimate minPMI in a human cadaver located indoors.

Sarcophagids can compete in diversity and abundance with calliphorids (Souza and Linhares, 1997), however, they have a very uniform external morphology, which makes their identification difficult and often only the male's genitalia can be used (Carvalho and Mello-Patiu, 2008; Vairo et al., 2011). The flesh fly *M. halli* has already been

described in a case report occurred in southern Brazil, providing the first record of this species on a human cadaver located indoors in Paraná State (Vairo et al., 2017). Although *P. intermutans* and *S. ruficornis* have already been collected in several survey studies of non-human carcass and classified as species of forensic interest (Vairo et al., 2011; Barbosa et al., 2019), the results of our work may be the first records of encounters in human corpses in the world.

Muscidae species collected in our study are also described as common forensic indicators and were collected in previous studies (Soligo and Panigalli, 2013). The species *H. aenescens* and *S. nudiseta* have already been recorded in cadavers in Argentina and the Iberian Peninsula (Mariani et al., 2014; Lo Pinto et al., 2017). The species *M. stabulans* has already been described in human corpses in Germany (Benecke et al., 2004).

Considering Stratiomyidae, the species *H. illucens*, known as black soldier fly, was used for the first time in Brazil to estimate PMI in a homicide case occurred in Amapá State, northern region of the country (Pujol-Luz et al., 2008a). It has already been registered in human bodies in Spain and Italy (Martínez-Sánchez et al., 2011; Vanin et al., 2011). The black soldier fly is an abundant species being collected in human corpses in Santa Catarina State, also collected by Gaedke and Mouga (2017). Differently from the most common flies of forensic relevance, the black soldier fly has 6 instars of larval development, with a longer biological cycle, making it highly relevant to estimate PMI in cases involving human remains and corpses in advanced stages of decomposition.

Piophilidae casei has not been reported in human cadaver in Santa Catarina studies. This species was described colonizing human corpse by Corrêa et al. (2019) and was the only Piophilidae recorded in this study. Larval samples were collected on human remains in a rural location, being usually associated with advanced stages of decomposition (Byrd and Castner, 2010). Our record is also the first description of *Fannia canicularis* occurrence on human cadavers in southern Brazil, described in a case report by Botteon et al. (2024). This species is attractive for both urine and feces, so it is common to be associated with occurrences involving death and abuses (Benecke and Lessig, 2001; Bonacci et al., 2017). *Fannia* species have been increasingly collected in Brazil (Vasconcelos et al., 2013). In a case report occurred in northeast Brazil, Vasconcelos et al. (2019) reported a death investigation involving an adult male corpse found in incomplete suspension, determining the minPMI from specimens of *F. pusio* (Wiedemann, 1803) associated with the body.

Now considering coleopteran species, Soligo and Panigalli (2013) collected 3,226 insect specimens in the western region of Santa Catarina State, including the abundant *Oxyletrum discicollae*. In a singular study occurred in the northeast of the Santa Catarina State, 257 coleopteran specimens were collected in human corpses from September 2016 to April 2017: Silphinae (210); Staphylinidae (22); Histeridae (7); Hydrophilidae (5); Scarabaeidae (5); Carabidae (4); Cleridae (4) (Bonfanti et al., 2018a). These authors also found the species *Euspilotus azureus*, *Necrobia rufipes* and *O. discicollae*, besides another species of beetles not found in our present survey. In Paraná State, Corrêa et al. (2019) also collected specimens of *Dermestes maculatus*, *E. azureus* and *O. discicollae* in human bodies.

The species *N. rufipes* was reported only in one case involving a mummified corpse found indoors. Only adult specimens were recovered in this particular case and *N. rufipes* specimens were not found in human corpses by Corrêa et al. (2019). This species is considered of forensic interest in different countries, such as Argentina and Mexico (Oliva, 2001; Valdes-Perezgasga et al., 2010), and has already been described in human cadavers in Italy (Vanin et al., 2011).

The carrion beetle *O. discicollae* was classified as an indicator of forensic value by Gaedke and Mouga (2017), being extremely common in southern Brazil and already found in human corpses (Corrêa et al., 2019). This beetle was the species most used to estimate minPMI in

our cases in Santa Catarina. Due to its abundance and importance in the State, Bonfanti et al. (2018b) studied the biology and development of this species, allowing a more accurate minPMI estimation in death investigations (Kotzsko et al., 2015; Lira et al., 2020).

Finally, *D. maculatus* is a cosmopolitan beetle with preference by skeletonized and mummified remains and has already been described in human cadavers in Brazil and other countries (Schroeder et al., 2002; Corrêa et al., 2019; Ciarleglio et al., 2020). Along with *N. rufipes*, this beetle has already been associated with mummified bodies (Ivorra et al., 2023) and was used for PMI estimation in several countries, such as China (Wang et al., 2019), France (Charabidze et al., 2014) and Saudi Arabia (Al-Qahtni et al., 2020). Our case is the first report of *D. maculatus* larvae being used in Brazil to estimate the minPMI of a mummified human body, which will be explored in other paper.

Concluding remarks

Forensic entomology is still incipient in southern Brazil. Thanks to significant investments in public security and several forensic science areas, the Forensic Entomology Division (FED) was officially established at Santa Catarina Scientific Police. The FED supports death investigations to estimate minimum PMI and is open to receive samples of necrophagous insects from all over the State. However, entomological evidence is primarily collected in the northern region of the State, where the laboratory and specialized human resources are located. The procedures and applications of forensic entomology must be disseminated to the other regions. One possible solution is to decentralize the FED into several laboratories spread across the State. However, this would require more highly specialized human resources in forensic entomology, making it difficult to implement. Currently, it is essential to address logistic challenges and raise awareness among forensic experts and coroners about the importance of entomological evidence.

This study will help to strengthen the application of forensic entomology in Brazil. Some species were found colonizing human corpses for the first time in Santa Catarina and used to estimate minPMI for the first time in Brazil. Additionally, we aim to conduct further studies to develop the use of entomotoxicology and entomogenetics at Santa Catarina Scientific Police.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

AG identified the species. AG, VMA and VWB analyzed and interpreted the entomological data. All authors write the manuscript, read and approved the final version. VWB coordinated the study.

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