

Beetles (Insecta, Coleoptera) associated with pig carcasses exposed in a Caatinga area, Northeastern Brazil

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Abstract

The species richness, abundance and seasonality of Coleoptera fauna associated with pig carcasses exposed in a Caatinga area were examined. Tray, pitfall and modified Shannon traps were settled together to collect these insects during two seasons (dry and rainy). 4,851 beetles were collected, belonging to 19 families and 88 species. Staphylinidae (2,184) and Histeridae (1,264) were the most abundant families and accounted for 71.1% of the specimens collected. Scarabaeidae (15) showed the highest species richness. The most abundant species were *Atheta iheringi* Bernhauer, 1908 (Staphylinidae) (1,685), *Euspilotus* sp. (Histeridae) (461), *Stelidota geminata* (Say, 1825) (Nitidulidae) (394), *Xerosaprinus diptychus* (Marseul, 1855) (Histeridae) (331) and *Dermestes maculatus* De Geer, 1774 (Dermestidae). Amongst these species, *X. diptychus* showed to be strongly influenced by seasonality, since 96.1% of the specimens were collected during the dry season.

Keywords: animal decomposition, biodiversity, forensic entomology, necrophagous insects, seasonality.

Coleópteros (Insecta, Coleoptera) associados a carcaças de suínos em Caatinga, Nordeste do Brasil

Resumo

A riqueza, abundância e sazonalidade da coleopterofauna associada a carcaças de suínos expostas em uma área de Caatinga foram examinadas. Para captura desses insetos foram utilizadas armadilhas do tipo bandeja, *pitfall* e *Shannon* modificada, durante duas estações (seca e chuvosa). 4.851 coleópteros foram coletados, pertencentes a 19 famílias e 88 espécies. Staphylinidae (2.184) e Histeridae (1.264) foram as famílias mais abundantes e somaram 71,1% dos espécimes coletados. Scarabaeidae (15) apresentou a maior riqueza. As espécies mais abundantes foram *Atheta iheringi* Bernhauer, 1908 (Staphylinidae) (1,685), *Euspilotus* sp. (Histeridae) (461), *Stelidota geminata* (Say, 1825) (Nitidulidae) (394), *Xerosaprinus diptychus* (Marseul, 1855) (Histeridae) (331) e *Dermestes maculatus* De Geer, 1774 (Dermestidae). Entre essas espécies, *X. diptychus* mostrou-se fortemente influenciada pela sazonalidade, uma vez que 96,1% dos espécimes foram coletados durante a estação seca.

Palavras-chave: decomposição animal, biodiversidade, entomologia forense, insetos necrófagos, sazonalidade.

1. Introduction

Insects are usually the first animals to locate a cadaver, attracted by the odours and gases released by it, and then start to use it as a resource for feeding, reproduction and larval development (Cornaby, 1974). This entomofauna attracts also another kind of fauna, consisting of predatory insects (Smith, 1986). The beetles belong to both ecological categories. Few species are effectively necrophagous, while most of them are predatory, but both categories can provide useful information from the forensic point of view, especially concerning to the estimation of the postmortem interval (PMI) (Catts and Goff, 1992; Santos et al. 2013).

In Brazil, important contributions to diversity, ecology and taxonomy of the fauna associated with carcasses have

been made in the last two decades, but the majority of the studies have focussed on Diptera and are concentrated in the Southeast and South regions (Pujol-Luz et al., 2008). However, due to their succession pattern, Coleoptera are the most useful insects for the estimation of PMI when skeletonised corpses are found (Kulshrestha and Satpathy, 2001). In some cases, it is possible to estimate the PMI based on rates of development of some species (Arnaldos et al., 2004). Coleoptera can also be used to support the PMI estimate from Diptera data (Goff and Flynn, 1991).

Regional and seasonal studies are essential to identify specific cadaveric fauna, since each biome and season has its specific fauna because of particular environmental

conditions (Mise et al., 2010; Rosa et al., 2011). The main objective was to analyse the diversity of the Coleoptera fauna associated with pig (*Sus scrofa* Linnaeus, 1758) carcasses, during the dry and wet seasons in Caatinga, a dry forest endemic to Brazil, whose insect fauna is poorly known (Vasconcellos et al., 2010; Creão-Duarte et al. 2013; Alves et al., 2014). Brief comments on the main families of forensic importance are also included, highlighting the richness, abundance, behaviour and ecological aspects of some species.

2. Material and Methods

The study was carried out during October 2010 (dry season) and February 2011 (rainy season) at the Private Reserve for the Environmental Inheritance Fazenda Almas (RPPN Fazenda Almas), in São José dos Codeiros, state of Paraíba, Brazil (7° 28' 19" S, 36° 53' 40" W). The study area is located at an altitude of 650 m a.s.l. and 300 km away from the coast. The vegetation varies from open to dense arboreal Caatinga, with a strong deciduous characteristic during the dry season. The soil is sandy and arid and the topography is irregular, with inselbergs and rocky outcrops (Vasconcellos et al., 2010).

Two male pig carcasses, weighing around 15 kg each, were used in both seasons. The animals were killed with a single gunshot to the head. Each carcass was exposed in an iron cage to prevent interference of vertebrate scavengers. Underneath the cage there was a trap tray buried at ground level containing sawdust in order to collect actively the Coleoptera that take shelter under the carcasses. Four

pitfall traps were settled around the cage, 1 m away from it, to passive capture. Each cage was also covered by a modified Shannon trap with a collector tube containing 70% alcohol at the apex (Alves et al., 2014). Coleoptera were collected daily in and from the traps.

The identification of the Coleoptera was done by experts and specific literature (Mazur, 2001; Navarrete-Heredia et al., 2002; Almeida and Mise, 2009; Vaz-de-Mello et al., 2011; Aballay et al., 2013). All material used was incorporated into the Coleção Entomológica do Departamento de Sistemática e Ecologia at Universidade Federal da Paraíba (DSEC/UFPB).

3. Results and Discussion

A total of 4,851 adults belonging to 19 families and 88 species was collected (Table 1). Staphylinidae was the most abundant family with 2,184 individuals, followed by Histeridae (1,264), Nitidulidae (395), Dermestidae (333), Scarabaeidae (300), Cleridae (120), Carabidae (75) and Trogidae (75), amounting to 97.8% of the specimens.

Under similar conditions different results were obtained by Carvalho et al. (2000), in Campinas, state of São Paulo, whose decreasing order of abundance was Scarabaeidae, Histeridae, Silphidae and Staphylinidae. Mise et al. (2007), in Curitiba, State of Paraná, found Staphylinidae as the most abundant family, as in the present study, followed by Silphidae, Histeridae and Cleridae. Rosa et al. (2011), in areas of Cerrado, in Uberlândia, State of Minas Gerais, collected mainly Dermestidae, Histeridae, Cleridae and

Table 1. Absolute (n) and relative (%) abundance, and species richness (S) of Coleoptera families associated to pig carcasses during dry and rainy seasons in a Caatinga area, state of Paraíba, Brazil.

Family	Dry season			Rainy season			Total		
	n	%	S	n	%	S	n	%	S
Staphylinidae	292	13.4	6	1,892	86.6	13	2,184	45.02	13
Histeridae	433	34.3	4	831	65.7	13	1,264	26.06	13
Nitidulidae	312	79.0	1	83	21.0	2	395	8.14	2
Dermestidae	229	68.8	1	104	31.2	2	333	6.86	2
Scarabaeidae	9	3	4	291	97	14	300	6.18	15
Cleridae	74	61.7	1	46	38.3	1	120	2.47	1
Carabidae	2	2.7	2	73	97.3	6	75	1.55	7
Trogidae	13	17.3	1	62	82.7	1	75	1.55	1
Tenebrionidae	35	94.6	6	2	5.4	1	37	0.76	7
Curculionidae	5	23.8	3	16	76.2	7	21	0.43	10
Chrysomelidae	3	16.7	2	15	83.3	6	18	0.37	8
Elateridae	8	100	2	-	-	-	8	0.16	2
Anobiidae	-	-	-	7	100	1	7	0.14	1
Erotylidae	3	75	1	1	25	1	4	0.08	1
Hydrophilidae	3	100	1	-	-	-	3	0.06	1
Bostrichidae	-	-	-	3	100	1	3	0.06	1
Mordellidae	-	-	-	2	100	1	2	0.04	1
Melyridae	-	-	-	1	100	1	1	0.02	1
Ptiliidae	-	-	-	1	100	1	1	0.02	1
Total	1,421	29.3	35	3,430	70.7	72	4,851	100	88

Staphylinidae. These divergent results highlight the importance of local studies for forensic practice in Brazil.

High species richness of beetles associated to carcasses has been registered in the Neotropical region: 62 and 113 species were mentioned respectively by Luederwaldt (1911) and Pessôa and Lane (1941) in São Paulo and neighbourhood; 112 species were collected by Mise et al. (2007) in Curitiba, state of Paraná; and 41 species were found by Mise et al. (2010) in Manaus, State of Amazonas. These data demonstrate the importance of Coleoptera when sampling strategies do not neglect this taxonomic group.

Smith (1986) considered as Coleoptera families with forensic importance: Carabidae, Hydrophilidae, Silphidae, Leiodidae, Staphylinidae, Histeridae, Cleridae, Anthicidae, Dermestidae, Nitidulidae, Rhizophagidae, Ptinidae, Tenebrionidae, Scarabaeidae, Geotrupidae and Trogidae. Ten of these families were found in the present study and represented 98.7% of the specimens collected (Table 2).

Amongst the collected species, *Pterostichus* sp., *Eremosaprinus* sp., *Ateuchus carbonarius* (Harold, 1868), *Canthidium manni* Arrow, 1913, *Coprophanaeus pertyi* (Olsoufieff, 1924), *Deltochilum verruciferum* Felsche, 1911, *Dichotomius geminatus* (Arrow, 1913), *Acylophorus* sp., *Philonthus figulus* Erichson, 1840 and *Tribolium* sp. are reported for the first time associated to carcasses in the Neotropical region.

The most abundant beetles collected, with number of individuals greater than 1% of the total, were represented by 17 species: *Atheta iheringi* Bernhauer, 1908 (1,685), *Euspilotus* sp. (461), *S. geminata* (394), *Xerosaprinus diptychus* (Marseul, 1855) (331), *Dermestes maculatus* De Geer, 1774 (330), *Philonthus* sp. 2 (294), *Euspilotus azureus* (Sahlberg, 1823) (188), *A. carbonarius* (129), *Necrobia rufipes* (De Geer, 1775) (120), *Phelister* sp. (114), *Aleochara bonariensis* Lynch, 1884 (102), *Hister punctifer* Paykull, 1811 (82), *Omorgus suberosus* Fabricius, 1775 (75), *Omalodes foveola* Erichson, 1834 (67), *Loxandrus* sp. (65), *Belonuchus* sp. 2 (48) and *C. manni* (47) (Table 2). These species totaled together 93.1% of all beetles collected. Future specific studies, mainly about succession pattern, life cycle and diet, are required for a better understanding of the relationship of these species with carcasses and thus establish its forensic importance.

Rove beetles (Staphylinidae) are common on carcasses because they are predators of larvae of other insects, with a preference for fly larvae (Navarrete-Heredia et al., 2002; Byrd and Castner, 2010). In addition, larvae of some species of *Aleochara* are ectoparasites of fly pupae (Smith 1986). Staphylinidae was the most abundant family in the study, with 2,184 specimens, mainly represented by *A. iheringi* (1,685) and species of *Philonthus* (326). Most of the Staphylinidae were collected in the rainy season (86.6%), which also showed higher species richness (13) (Table 2).

Mise et al. (2007) highlighted Staphylinidae as the most abundant family, as in this study, with 29 species and 2,450 individuals captured. In many studies conducted in the Neotropical region, due to lack of specialists, the identification of these beetles is done only until genus.

However, there seems to be a similarity of the composition of the Staphylinidae fauna among different regions in Brazil, mainly represented by *Aleochara* and *Philonthus* (Souza and Linhares, 1997; Mise et al., 2007; Mise et al., 2010; Rosa et al., 2011; Silva and Santos, 2012). In other countries, several different genera were recorded occurring on carcasses (Wolff et al., 2001; Battán Horenstein and Linhares, 2011; Aballay et al., 2012).

The great abundance of the family Histeridae is mainly due to the fact that their species are predators of larvae of flies, food resource widely available on carcasses (Smith, 1986; Byrd and Castner, 2010). Histeridae was the second most abundant family in this study, represented mainly by species of *Euspilotus* (649), collected mostly during the rainy season (92.4%), and *X. diptychus* (331), in the dry season (96.1%) (Table 2).

Aballay et al. (2012) found *X. diptychus* and five species of *Euspilotus* on pig carcasses in a different kind of arid environment, in San Juan, Argentina. The other genera and species of Histeridae collected are commonly found on carcasses throughout the Neotropical region (Souza and Linhares, 1997; Carvalho et al., 2000; Wolff et al., 2001; Mise et al., 2007, 2010; Battán Horenstein and Linhares, 2011; Silva and Santos, 2012; Aballay et al., 2013).

Larvae and adults of Nitidulidae are generally saprophagous or xylophagous, feeding on decaying or dead wood. However, some species are exclusively phytophagous or mycophagous and others occur on carcasses or are predators (Smith, 1986; Marinoni et al., 2001). Nitidulidae was the third family in order of abundance and was almost totally represented by *S. geminata* with 394 individuals collected, mostly during the dry season (79.2%) (Table 2).

According to Ewing and Cline (2005), *S. geminata* is commonly found in leaf litter and in decaying fruits and wood. The species probably plays a facultative necrophagous role in the carcasses, although it has not been observed feeding directly from it. Future studies about the biology of the species need to be done to elucidate this issue. Payne and King (1970), in South Carolina, USA, found nine species of Nitidulidae during advanced stages of decomposition of pigs together with Dermestidae. However, records of the family on carcasses are rare in the Neotropical region (Wolff et al., 2001; Mise et al., 2007; Battán Horenstein and Linhares, 2011; Silva and Santos, 2012).

Many larger beetles (Dermestidae) species, especially those of the genus *Dermestes*, are of considerable forensic importance. In cases in which the mummification of the body takes place, even indoors, these beetles can accelerate the skeletonisation process (Voigt, 1965; Schroeder et al., 2002) and, even so, adults and larvae can be found associated with the remains years after death (Byrd and Castner, 2010). In the present study, three individuals of *Dermestes haemorrhoidalis* Küster, 1852 and 330 individuals of *D. maculatus* were collected. The last one is the most forensically important Coleoptera species in the Neotropical region and was more abundant in the dry season (69.4%) (Table 2).

Table 2. Absolute (n) and relative (%) abundance of Coleoptera species of forensic importance associated to pig carcasses during dry and rainy seasons in a Caatinga area, State of Paraíba, Brazil.

Family	Species	Dry season		Rainy season		Total	
		n	%	n	%	n	%
Carabidae	<i>Loxandrus</i> sp.	1	1.5	64	98.5	65	1.36
	<i>Pterostichus</i> sp.	-	-	4	100	4	0.08
	Carabidae spp. (5)	1	16.7	5	83.3	6	0.13
Cleridae	<i>Necrobia rufipes</i> (De Geer, 1775)	74	61.7	46	38.3	120	2.51
Dermestidae	<i>Dermestes maculatus</i> De Geer, 1774	229	69.4	101	30.6	330	6.90
	<i>Dermestes haemorrhoidalis</i> Küster, 1852	-	-	3	100	3	0.06
Histeridae	<i>Eremosaprinus</i> sp.	2	50	2	50	4	0.08
	<i>Euspilotus azureus</i> (Sahlberg, 1823)	-	-	188	100	188	3.93
	<i>Euspilotus</i> sp.	49	10.6	412	89.4	461	9.63
	<i>Hister punctifer</i> Paykull, 1811	-	-	82	100	82	1.71
	<i>Hololepta reichii</i> Marseul, 1853	-	-	6	100	6	0.13
	<i>Omalodes foveola</i> Erichson, 1834	-	-	67	100	67	1.40
	<i>Phelister</i> sp.	64	56.1	50	43.9	114	2.38
	<i>Xerosaprinus diptychus</i> (Marseul, 1855)	318	96.1	13	3.9	331	6.92
	Histeridae spp. (5)	-	-	11	100	11	0.23
	Hydrophilidae	Hydrophilidae sp.	3	100	-	-	3
Nitidulidae	<i>Stelidota geminata</i> (Say, 1825)	312	79.2	82	20.8	394	8.23
	Nitidulidae sp.	-	-	1	100	1	0.02
Scarabaeidae	<i>Ataenius</i> sp.	2	50	2	50	4	0.08
	<i>Ateuchus carbonarius</i> (Harold, 1868)	2	1.6	127	98.4	129	2.70
	<i>Canthidium manni</i> Arrow, 1913	-	-	47	100	47	0.98
	<i>Canthon</i> sp.	-	-	1	100	1	0.02
	<i>Coprophanæus pertyi</i> (Olsoufieff, 1924)	-	-	2	100	2	0.04
	<i>Deltochillum verruciferum</i> Felsche, 1911	-	-	13	100	13	0.27
	<i>Dichotomius geminatus</i> (Arrow, 1913)	-	-	25	100	25	0.52
	<i>Dichotomius nissus</i> (Olivier, 1789)	-	-	9	100	9	0.19
	<i>Ontherus digitatus</i> Harold, 1868	1	100	-	-	1	0.02
	<i>Onthophagus hirculus</i> Mannerheim, 1829	-	-	22	100	22	0.46
	<i>Trichillum</i> sp.	-	-	27	100	27	0.56
	<i>Uroxys</i> sp.	4	36.4	7	63.6	11	0.23
	Aphodiinae sp. 1	-	-	3	100	3	0.06
	Aphodiinae sp. 2	-	-	5	100	5	0.10
	Melolonthinae sp.	-	-	1	100	1	0.02
	Staphylinidae	<i>Acylophorus</i> sp.	-	-	1	100	1
<i>Aleochara bonariensis</i> Lynch, 1884		8	7.8	94	92.2	102	2.13
<i>Atheta iheringi</i> Bernhauer, 1908		177	10.5	1,508	89.5	1,685	35.21
<i>Belonuchus</i> sp. 1		-	-	2	100	2	0.04
<i>Belonuchus</i> sp. 2		23	47.9	25	52.1	48	1.00
<i>Heterothops</i> sp. 1		1	9.1	10	90.9	11	0.23
<i>Heterothops</i> sp. 2		-	-	4	100	4	0.08
<i>Philonthus figulus</i> Erichson, 1840		3	13.6	19	86.4	22	0.46
<i>Philonthus</i> sp. 1		-	-	10	100	10	0.21
<i>Philonthus</i> sp. 2		80	27.2	214	72.8	294	6.14
<i>Xenopygus analis</i> (Erichson, 1840)		-	-	2	100	2	0.04
Staphylinidae spp. (2)		-	-	3	100	3	0.06
Tenebrionidae	<i>Tribolium</i> sp. 1	13	100	-	-	13	0.27
	<i>Tribolium</i> sp. 2	8	100	-	-	8	0.17
	Bolitophagini sp.	11	100	-	-	11	0.23
	Tenebrionidae spp. (4)	3	60	2	40	5	0.10
Trogidae	<i>Omorgus suberosus</i> Fabricius, 1775	13	17.3	62	82.7	75	1.57
Total		1,402	29.3	3,384	70.7	4,786	100

Several authors have reported the presence of adults and larvae of *D. maculatus* on carcasses and corpses in Brazil (Souza and Linhares, 1997; Carvalho et al., 2000; Carvalho et al., 2004; Mise et al., 2007; Rosa et al., 2011) and the rest of the Neotropical region (Iannacone, 2003; Velásquez, 2008; Valdes-Perezgasga et al., 2010; Battán Horenstein and Linhares, 2011; Aballay et al., 2012). Mise et al. (2007), in an Araucaria forest fragment, found only 22 specimens of *D. maculatus*, while Rosa et al. (2011), in an area of Cerrado, collected 4,874 individuals, the majority in the dry season (94.6%), the same as in the present study. Despite differences between sampling methods, it seems to be clear the divergence in the abundance status of *D. maculatus* among different habitats, with a preference for drier regions.

With over 19,000 species described, Scarabaeidae vary greatly in biology, ecology and behaviour (Byrd and Castner, 2010). The members of this family are mainly detritivorous, with larvae feeding on dung or pieces of decomposing carcasses (Smith, 1986; Marinoni et al., 2001). Many species dig oviposition chambers and tunnels under or near the carcasses, where pieces of the carcass are deposited to feed the larvae, which can cause postmortem movement of the bodies (Ururahy-Rodrigues et al., 2008). In the present study, this family was the fifth most abundant, with 300 individuals, mostly present in the rainy season (97%). Fifteen species were collected, especially of the subfamily Scarabaeinae, mainly represented by *A. carbonarius* (43.0%) and *C. manni* (15.7%) (Table 2), which were very abundant in a study carried out by Hernández (2007) in the same study area.

In Brazil, the studies by Luederwaldt (1911) and Pessôa and Lane (1941) about Scarabaeidae associated with carcasses of several animals in São Paulo and surrounding cities are historical references. Together, these authors recorded 124 species, most of them belonging to the genera *Canthidium*, *Canthon*, *Coprophanaeus*, *Deltochilum* and *Phanaeus*.

Most of Cleridae are predators of larvae of flies and other beetles, but the genus *Necrobia* has necrophagous habit, with a preference for carcasses and corpses in dry stages of decomposition (Payne and King, 1970; Arnaldos et al., 2004). This family was the sixth in order of abundance and represented only by *N. rufipes*, with 120 specimens collected and showing preference for the dry season (61.7%) (Table 2).

Rosa et al. (2011) collected that species in great abundance (2,321) in an area of Cerrado, most of them in the dry season as well (94.1%). Adults and larvae of *N. rufipes* are widely found on carcasses and corpses in Brazil (Luederwaldt, 1911; Souza and Linhares, 1997; Carvalho et al., 2000, 2004; Mise et al., 2007; Silva and Santos, 2012) and elsewhere in the Neotropical region (Wolff et al., 2001; Iannacone, 2003; Valdes-Perezgasga et al., 2010; Battán Horenstein and Linhares, 2011; Aballay et al., 2012).

The diversity of Coleoptera fauna was different from other studies carried out in the Neotropical region, which

may be a result not only from different environments, but also the capture method adopted. Ten species were recorded for the first time associated with carcasses in the Neotropical region. Populations of Staphylinidae and Histeridae, the most abundant families, can be considered as affected by seasonality, with only 13.4% and 34.2% of the specimens collected, respectively, in the dry season. Amongst the most collected species, *X. diptychus* showed to be strongly influenced by the dry season, since 96.1% of the specimens were collected during that period. *A. iheringi*, representing 34.7% of the total, was the most abundant species. Future studies are required to confirm the role of these beetles on carcasses and its possible forensic potential to Caatinga. In addition, the exceptional Coleoptera fauna found reinforces the need of regional studies about the composition of insects associated with carcasses throughout Neotropical region.

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