A Preliminary Analysis of Insects of Medico-legal Importance in Curitiba, State of Paraná

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*A survey of the carrion fauna was made at two sites in Curitiba, State of Paraná, with the objective of describing the insects associated with carrion and setting up a preliminary data-base for medico-legal purposes in south Brazil. Vertebrate exclusion experiments were carried out in each season between 1994 and 1995 with a 250 g laboratory-bred rat (*Rattus norvegicus*). Five stages of decomposition were identified: fresh, bloated, decaying, dry and adipocere-like. Some species showed seasonal and site preference and so could be used to identify the probable place and season where death took place.* Sarconesia chlorogaster *(Diptera, Calliphoridae) was restricted to an open field site and to cooler months.* Hemilucilia semidiaphana *(Diptera, Calliphoridae) and* Pattonella resona *(Diptera, Sarcophagidae) were restricted to the forest site and warmer months.* Phaenicia eximia *(Diptera, Calliphoridae) and* Oxyletrum discicolle *(Coleoptera, Silphidae) were present at both sites throughout the year and could be useful for population level analysis.* Dissochaetus murray *(Coleoptera, Cholevidae) was present throughout the year at the forest site and was associated with the adipocere-like stage. Ants played an important role producing post-mortem injuries to the carcasses. Insects of 32 species are reported as being useful in community level approaches.*

Key words: carrion fauna - Coleoptera - Diptera - Formicidae - medico-legal entomology

Medico-legal entomology has received little attention in Brazil despite the considerable value of this procedure that has been demonstrated in several countries (Greenberg 1985, Smith 1986, Goff & Flynn 1991).

A few papers were published between 1908 and 1940 in Brazil (see Pessoa & Lane 1941, Carrera 1991), mostly directly influenced by the pioneer work of Mégnin (*cf.* Carrera 1991). Between 1940 and 1991 not a single paper on this subject was published in Brazil, but since then research groups have appeared (Salviano et al. 1994, Souza 1994, Von Zuben et al. 1996) which have dealt with some of the related topics.

As a contribution to filling this gap in our knowledge, this paper describes the insects associated with carrion at two sites, as a preliminary step towards setting up a data-base for medico-legal purposes in south Brazil.

Contribution no. 940 from the Department of Zoology - UFPR.
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Received 6 May 1996
Accepted 25 November 1996

MATERIALS AND METHODS

During 1994 and 1995 a survey was made of the carrion fauna at two sites located in the city of Curitiba (25º25'S, 49º25'W), State of Paraná using vertebrate exclusion cages with mesh of 1 inch (*cf.* Monteiro-Filho & Penereiro 1987).

The two sites were located in an urban environment (site A) and in a forest (site B). Site A was an open field unshaded during the day and site B was a heavily shaded forest.

During this period and during each season a laboratory-bred rat carcass (*Rattus norvegicus*), weight 250 ± 10 g and killed by cervical dislocation, was exposed at each of the two sites. Daily observations were made at both sites simultaneously for periods of at least 120 min each. In the course of these observations larvae and adult insects on the carcass were collected, and information was gathered on the rate of decomposition. All adult insects were collected using a modified entomological net (Monteiro-Filho & Penereiro 1987) killed and then pinned to identification. Whenever an oviposition or larviposition was recorded at least 10 larvae per day were collected with a small tweezer and killed in near-boiling water and then transferred into 70% alcohol. A third part of each sample that contained third instar larvae was kept alive for rearing in plastic jars with gauze tops maintained at field conditions. An at-

tempt was made to minimize disturbances to the decaying process and to the community structure whilst the samples were taken.

The temperatures and humidity at site A were obtained at a meteorological station located just 500 m away and the temperatures and humidity of site B were obtained by a standard field weather station.

To classify the stages of decomposition we followed Reed (1958) and Rodriguez and Bass (1983) who give a full description of these stages.

RESULTS

During this study five stages of decomposition were identified: fresh, bloated, decaying, dry and adipocere-like. The time taken for each stage during each season at the two sites is shown in Table I.

During the fresh stage, small injuries caused by some ants were evident on the lips, ears, tongue and scrotum, and after some hours oviposition by blow flies was seen to have taken place in the mouth, anus, eyes and inside the ears.

In the bloated stage, some parts of the body became discoloured and some, such as the scrotum in site A samples, had part of the skin eaten by ants.

During the decaying stage remarkable changes took place in the shape of the body, with the skin splitting in several areas. At site A it was possible to observe some exposed bones in the head, clavicles, ribs and scrotal area. The skin that was in contact with the soil had been almost removed and part of the exposed side was drying out. At site B the head and anal area were half buried, probably by ants.

At both sites the abdomen showed greater feeding activity by the maggots, but some muscular tissue and cartilage remained. It has proved very difficult to define the transition from this stage to the next.

The adipocere-like stage took place in all seasons at site B but only in winter at site A. In the course of this some subcutaneous adipose tissue began to decompose slowly, producing a viscous putrefying material in the abdominal region. The end of this stage was arbitrarily defined as the day with lowest activity by the species present.

The dry stage occurred at site A when the skin dried completely, and several bones were exposed and became disarticulated at this time. The skin became tanned and formed a shelter for some opportunistic species and some maggots. There was a similar problem defining the end of this stage as there was with the adipocere-like stage.

Decomposition rates varied greatly between the two sites with the rate of site A being almost always faster than at site B (Table I). The only exception was in the summer, when there was a prolonged dry stage at site A.

Temperature (maximum and minimum) and humidity data are shown in Fig. The maximum temperature at site A was on average 3.8°C higher than at site B, but the minimum temperature (excluding winter) did not follow this trend with the difference being on average below 1°C. The average humidity for site A was 85% and for site B 90%. Differences between humidity averages for the two sites occurred in spring and summer, with values of 13%.

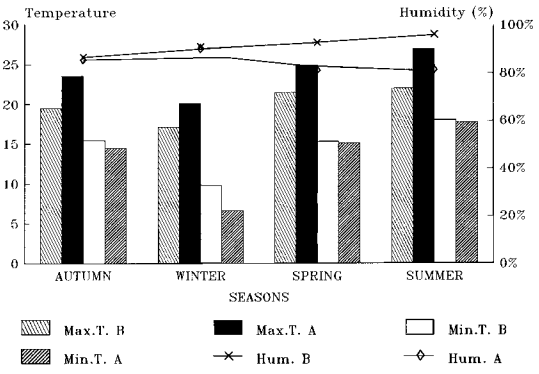
The correlation between meteorological variables and decomposition rates is straightforward for the fresh stage. In warmer seasons (spring and summer) this stage lasted less than 24 hr. The bloated stage at site B showed the same pattern but at site A the trend was for a uniform time throughout the year. The other decomposition stages showed no patterns.

TABLE I

Seasonal and site differences (in days) for decompositon stages of laboratory-bred rat carcasses at Curitiba, State of Paraná

Season	Site	Decomposition stages				
		Fresh	Bloated	Decaying	Dry	Adipocere-like
Autumn	A	1	2	5	2	-
	B	2	2	4	-	8
Winter	A	1	5	9	5	5
	B	3	7	20	-	11
Spring	A	1	2	5	9	-
	B	1	3	6	-	9
Summer	A	1	2	5	18	-
	B	1	1	5	-	10

A: openground; B: woodland



Meteorological variables (average values) during the study. Max. T. A (maximum temperature at site A), Max. T. B (maximum temperature at site B), Min. T. A (minimum temperature at site A), Min. T. B (minimum temperature at site B), Hum. A (relative humidity at site A) and Hum. B (relative humidity at site B).

The necrophagous species guild (species that play a significant role in the decomposition process) consisted of 17 species (Table II). Of these, 8 species were collected from site B, 5 from site A and 4 were encountered at both sites.

The blow flies *Phaenicia eximia*, *Sarconesia chlorogaster*, *Hemilucilia semidiaphana*, the flesh fly *Pattonella resona* and the carrion beetle *Oxyletrum discicolle* were the only species reared from carcasses and could be useful in population level analysis. *P. eximia* was reared in all seasons at both sites, *S. chlorogaster* was reared only at site A in winter, *H. semidiapha* and *P. resona* were reared from carcasses from site B in spring and summer, and *O. discicolle* was reared from carcasses at both sites in autumn and at site B in winter and spring.

The larval analysis of these species reveals that third instar larvae of calliphorids could be found between 3 to 4 days after death which was in average the first day of decaying. Third instar larvae of *P. resona* were found 5 days after death in spring and between 3 to 4 days in summer. Prepupae of *P. eximia* was also observed leaving the carcass about 4 to 5 days after death in spring and summer and 10 to 12 days after death in autumn and winter. *O. discicolle* larvae were never found before 5 days after death in autumn and spring or 30 days in winter.

The seasonal variation in adult occurrence divides the necrophagous guild into three major groups : I - species that are common throughout the year, II - species that occurred in specific seasons, and III - species that occurred only in one season (Table IV).

Successional patterns of the species reveal the following: *P. eximia* and *S. chlorogaster* arrived at the carcass in the fresh stage, and *H. semidiaphana*, *P. resona*, *O. discicolle* and *Pinotus* sp. at the end of the bloated stage and beginning of decay. All the remaining Coleoptera occurred at the decaying stage, and the adipocere-like stage was characterized by the presence of *Dissochaetus murray*.

TABLE II

Necrophagous insects collected on laboratory-bred rat carcasses at Curitiba, State of Paraná between autumn 1994 and spring 1995 at an urban site (A) and a forest site (B)

Order	Family	Specie	Site
DIPTERA	Calliphoridae	*Phaenicia eximia* (Wied.)	Both
		Sarconesia chlorogaster (Wied.)	A
		Hemilucilia semidiaphana (Rond.)	B
	Sarcophagidae	*Pattonella resona* (Lopes)	B
COLEOPTERA	Silphidae	*Oxyletrum discicolle* (Brullé)	Both
	Cholevidae	*Dissochaetus murray* Reitter	B
	Scarabaeidae	*Phaenaeus saphirinus* Sturm	B
		Megathopa sp.	B
		Eurysthernus sp.	B
		Pinotus sp.	B
		Canthidium sp.	A
	Trogidae	unidentified species	A
HYMENOPTERA	Formicidae	*Solenopsis* sp.	Both
		Acromyrmex sp.	Both
		Camponotus rufipes F.	A
		Camponotus sp.	A
		Ectatoma sp.	B

TABLE III

Distribution of third instar larvae of insects in laboratory-bred rat carcasses at an urban site (A) and a forest site (B) at Curitiba, State of Paraná between 1994-1995

Species	Site	Stages of decomposition					N
		F	B	D	Ad	Dr	
Phaenicia eximia	A	-	-	AU,WI,SP, SM	-	AU,WI,SM,SM	134
Sarconesia chlorogaster	A	-	-	AU,WI,SP, SM	-	-	7
Phaenicia eximia	B	-	-	WI, SP, SM	AU, SP	-	138
Hemilucilia semidiaphana	B	-	-	SP, SM	SP, SM	-	29
Pattonella resona	B	-	-	SP, SM	SP, SM	-	17
Oxyletrum discicolle	Both	-	-	AU,WI,SP, SM	AU,WI,SP,SM	-	50

F: fresh; B: bloat; D: decaying; Ad: adipocere-like; Dr: dry; N: number of larvae analyzed; AU: autumn; WI: winter; SP: spring; SM: summer

TABLE IV

Seasonal variation of necrophagous species atracted to laboratory-bred rat carcasses between 1994 and 1995 at an urban site (A) and a forested site (B) at Curitiba, State of Paraná

Species	Site A				Site B				Group
	AU	WI	SP	SU	AU	WI	SP	SU	
Phaenicia eximia	+	+	+	+	+	+	+	+	I
Solenopsis sp.	+	+	+	+	+	+	+	+	I
Oxyletrum discicolle	+	-	-	-	+	+	+	+	I
Hemilucilia semidiaphana	-	-	-	-	+	+	+	+	I
Pattonella resona	-	-	-	-	+	+	+	+	I
Dissochaetus murray	-	-	-	-	+	+	+	+	I
Camponotus sp.	+	-	+	+	-	-	-	-	II
Sarconesia chlorogaster	+	+	-	-	-	-	-	-	II
Acromyrmex sp.	-	-	-	+	-	+	+	-	II
Phaenaeus saphirinus	-	-	-	-	-	-	+	+	II
Camponotus rufipes	+	-	-	-	-	-	-	-	III
Trogidae gen. sp. indet.	+	-	-	-	-	-	-	-	III
Canthidium sp.	-	-	+	-	-	-	-	-	III
Pinotus sp.	-	-	-	-	+	-	-	-	III
Eurysthernus sp.	-	-	-	-	-	+	-	-	III
Ectatoma sp.	-	-	-	-	-	-	+	-	III
Megathopa sp.	-	-	-	-	-	-	-	+	III

AU: autumn; WI: winter; SP: spring; SM: summer; (+): presence; (-) absence

The ants, except *Solenopsis* sp. and *Camponotus* sp., were associated with the decaying and dry stages.

In addition of necrophagous species guild many others groups of arthropods were collected from the carcasses (Table V) which includes 18 families of Diptera, 9 of Coleoptera, 3 of Hymenoptera and at least 3 of Acarina. The successional patterns of these species could be very useful in community level approaches.

DISCUSSION

This study is a preliminary analysis of the carrion fauna, which is of value for medico-legal cases. The stages of decomposition that a human corpse undergoes are roughly the same as in a non-human, but caution in the use of timetables produced in non-human studies is necessary, even if a good model such as a pig is employed (Lane 1975, Catts & Goff 1992).

The general pattern of decomposition rates between sites and between seasons we found had been cited in previous papers that used human models (Rodriguez & Bass 1983, Galloway et al. 1989): corpses in cooler months maintain a fresh appearance for more time, in winter bloating and deflating is common, and corpses in forests have slower decomposition rates than corpses in urban environments.

Geographical variation in decomposition rates could be expected to be great, and this is confirmed when the present results are compared with other Brazilian studies (Freire 1914, Monteiro-Filho & Penereiro 1987, Souza 1994). Analysis of the meteorological data shows that maximum temperature is probably more important than minimum temperature in accounting for the variation in decomposition rates, which is in agreement with Shean et al. (1993). Humidity was also an important factor acting on decomposition rates and the presence of alternative states such as the adipocere-like stage (Galloway et al. 1989, Mann et al. 1990).

The fauna collected shows that certain species appear to be restricted to forest or open field situations, and so could indicate whether the remains were moved after death. Similarly, the seasonal variation shows some useful patterns too.

Sarconesia chlorogaster was found to be restricted to cooler months and to non forested habitats with a development time of 19,6 days at a temperature of 27ºC (Bonatto 1995). Other indicator species restricted to forest and warmer months are *H. semidiaphana* and *P. resona*. Species of the genus *Pattonella* have been reared from meat (Lopes 1973), pigs (Souza 1994) and human bodies (Jirón et al. 1983) with a development time of 23 days (Lopes 1973) and, species of the genus *Hemilucilia* have been reared from pig (Souza 1994) and human bodies (Freire 1914), with a developmental time between 13 and 20 days (Freire 1914).

Dissochaetus murray did not breed in carcasses but was present in the decaying and adipocere-like stages, which is in agreement with several earlier

TABLE V

Most commom arthropods associated with laboratory-bred rat carcasses between 1994 and 1995 at an urban site (A) and a forested site (B) at Curitiba, State of Paraná and the first day post mortem they were recorded as well as the corresponding stage of decomposition

Species	First day of occurrence/Stage of decomposition							
	Site A				Site B			
	AU	WI	SP	SU	AU	WI	SP	SU
DIPTERA								
Muscidae								
Hydrotaea nicholsoni (Curran)	-	-	-	-	-	27/D-Ad	-	-
Psilochaeta pampeana (S & D)	-	-	-	-	4/B-D	18/D-Ad	-	-
Ophyra albuquerquei Lopes	-	-	-	-	6/D-Ad	*	*	-
Bithoracochaeta atricornis (Mall.)	-	3/B-D	-	-	-	-	-	-
Cyrtoneurina maculipennis (Macq.)	-	D	-	-	-	-	-	
Cyrtoneurina sp.	-	-	-	-	1/F-D	10/B-Ad	-	-
Neomuscina sp.	-	-	-	-	-	19/D-Ad	-	-
Fanniidae								
Fannia punctipennis Albuquerque	2/B	-	2/B-D	-	-	-	-	-
Fannia obscurinervis Stein	-	-	-	-	5/D	1/F-Ad	-	-
Sarcophagidae								
Sarcophagula sp.	-	1/F-B	-	-	-	-	-	-
Oxysarcodexia paulistanensis (Mattos)	1/F-B	1/F-D	-	2/B-D	-	-	-	-
Drosophilidae								
Stegana sp.	-	-	-	-	-	27/D-Ad	-	-
Drosophila tripunctata group sp.	-	-	-	-	2/F-D	15/D-Ad	*	3/B-D
Drosophila canalinea group sp.	-	-	-	-	4/B-D	-	-	-
Sepsidae								
Palaeosepsis maculata (Duda)	-	-	-	-	-	31/Ad	-	
Archisepsis armata (Schiner)	-	-	-	-	4/B-D	-	-	-
Sphaeroceridae								
Poecilossomella sp.	-	-	-	-	-	-	-	1/B-D
Archiborborus sp.	-	-	-	-	-	34/Ad	*	-
Phoridae								
Megaselia sp.					-	1/F-Ad	1/B-D	2/B-D
Puliciphora sp.	-	-	-	-	-	1/F-Ad	4/B-D	-
Dolichopodidae								
Gen. sp. not ident.	-	-	-	-	-	-	1/B-D	1/B-D
COLEOPTERA								
Staphilinidae								
Gen. sp. not ident.	4/D-Dr	6/B-Dr	3/B-Dr	3/D	6/D-Ad	11/D-Ad	3/B-Ad	-
ACARINA								
Gen. sp. not ident	-	-	-	-	-	4/B-Ad	6/D	2/B-Ad

F: fresh; B: bloat; D: decaying; Ad: adipocere-like; Dr: dry; AU: autumn; WI: winter; SP: spring; SM: summer; (*) means a taxa had a single occurence in this season.

authors (Reed 1958, Cornaby 1974, Johnson 1975), and it could serve as an indicator species for these stages in addition to being restricted to forest habitats.

Phaenicia eximia could serve as a key species in estimating post mortem interval (PMI) under population levels because it showed neither seasonal nor habitat trends. *P. eximia* has been reared from a wide variety of corpses, including pig (Souza 1994) and human bodies (Freire 1914, Salviano et al. 1994), with a development time between 13 and 20 days (Freire 1914).

The first appearence of third-instar calliphorid larvae was consistent with laboratory data for *S. chlorogaster* but was in average one day later than indicated in life tables for *P. eximia* and *H. semidiaphana* (Greenberg & Szyska 1984, Bonatto 1995).

Another important species is *Oxyletrum discicolle*. *O. discicolle* is very common in carrion (Peck & Anderson 1985), and has a development time of 30 days (Costa et al. 1988). As adults and larvae showed a consistent pattern of arriving in carrion, they could be very useful in population

level as well as in community level approaches.

Information on the other Coleoptera species is very scarce (Pessôa & Lane 1941) but they could be used in a community level approach together with the remaining species collected because knowing the seasonal, site and stage occurence of several species serves as indication of the limits of PMI (Goff & Flynn 1991) and to determine if the body has been moved (Keh 1985).

The ants, especially *Solenopsis* sp., played an important role in producing some post-mortem injuries that could produce confusing variables for a forensic investigator (Freire 1914, Keh 1985).

In addition to the species discussed above, two further species could be very useful in medico-legal investigations: *Chrysomya putoria* (Wied.) and *Chrysomya albiceps* (Wied.) which probably breed in large carcasses and not in small or medium-sized carcasses (pers. obs., Salviano et al. 1994, Souza 1994).

The fauna collected in the course of this work did not differ from species collected from pig carrion (Souza 1994) or from human bodies (Salviano et al. 1994) but contained fewer species than were previously recorded as occurring in corpses by Freire (1914). This means that more effort needs to be devoted to achieving a good forensic entomology program, employing more models and biological studies of the species involved and cooperation between law enforcement agencies and researchers.

ACKNOWLEDGEMENTS

To Adrian Pont, Ronaldo Toma, Sérgio F dos Reis and one anonymous referee for critical reviews of the manuscript and Márcio R Pie (Formicidae), Pedro Gnaspini (Cholevidae), Rita Tibana (Sarcophagidae) and Carlos Vilela (Drosophilidae) for identifications.

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