ELSEVIER

Forensic Science International 126 (2002) 63–70

Forensic Science International

www.elsevier.com/locate/forsciint

Seasonal patterns of arthropods occurring on sheltered and unsheltered pig carcasses in Buenos Aires Province (Argentina)

N. Centeno[a,*], M. Maldonado[a], A. Oliva[b]

[a]*Centro de Estudios e Investigaciones–Programa de Investigaciones en Interacciones Biologicas (CEI–PIIB), Universidad Nacional de Quilmes, Roque Sáenz Peña 180, Bernal, B1876BXD Buenos Aires, Argentina*

[b]*Consejo Nacional de Investigaciones Cientificas y Tecnologicas (Conicet)—Chief of the Laboratorio de Entomologia forense, Museo argentino de Ciencias naturales, Av. A. Gallardo 470, C1405DJR Buenos Aires, Argentina*

Received 8 February 2001; received in revised form 7 February 2002; accepted 8 February 2002

Abstract

Differences in the succession of insects and other Arthropoda (invertebrate animals with jointed legs), on domestic pig carcasses placed under a roof and under the open sky have been studied in Buenos Aires Province, Argentina (latitude 34°45′S) in all the seasons of the year. Faunal associations proved different for each treatment in winter: the common bluebottle *Calliphora vicina* was found in both, but on the sheltered carcass *Cochliomyia macellaria* and the rare *Phaenicia cluvia* were found as well. In the fall, the difference between sheltered and unsheltered carcasses was small (six species on the former and five species on the latter); in spring and summer, the difference was negligible.

Keywords: Cadaveric succession; Sheltered corpses; Calliphoridae; Neotropical fauna; Forensic entomology

1. Introduction

Decay of a dead body is greatly influenced by organisms which feed upon the body in the different stages of decomposition. The knowledge of this succession is an important tool in forensic studies to estimate the interval since death from the species of organisms found on the body. The most frequent and numerous living beings to be found on a dead body are the joint-legged invertebrates comprised in the phylum Arthropoda, and among these, the class Insecta. Among the many large groups (orders) of insects, the flies (Diptera) and the beetles (Coleoptera) have been given the greatest attention as being instrumental in recycling animal remains [1]. Our survey is based mainly on insects.

Forensic entomology is based on the knowledge of association of certain species with a given stage of decay, and of the life-cycles of these species. Insects appear on corpses at different stages of their development, and in species of the greatest importance for forensics, such as blowflies, the different life stages may have quite different anatomical structures. An adult fly lays eggs; from these a worm-like larva (maggot) will hatch; the larva feeds voraciously, increasing its size at a remarkable rate; when feeding is completed, the larva becomes sluggish while its gut contents turn into reserve fat [2]; then the larva will bury itself in the soil or otherwise seek to hide (a few species may remain on the feeding substrate at this point of development) and turn into an immobile pupa, inside a case (puparium); the pupa turns into a fly that must emerge from the puparium, and often from the soil, before spreading its wings [3].

Insects have outer skeletons made up of plates secreted by their dermis (cuticle). As cuticle stretches only to a moderate degree, a growing larva has to discard it, a process called moult. Breathing is performed through a pair of spiracles in the rear end of the body and a pair of anterior spiracles that appears after the first moult. Spiracles are useful to determine the larval instar, of which there are three: ''larva I'' between hatching and the first moult, ''larva II'' between larval moults, ''larva III'' between the last larval moult and pupation. The puparium is derived from the cuticle of the

* Corresponding author. Tel.: +54-11-4365-7100x225; fax: +54-11-4365-7182.
E-mail address: ncenteno@unq.edu.ar (N. Centeno).

0379-0738/02/$ – see front matter
PII: S0379-0738(02)00037-3

larva III, which hardens into a barrel-shaped brown colored case.

Insects and other arthropods colonize the body from the first stages of decay, in successive waves; each wave modifies its own substratum, which has the effect of making it attractive to the next one [4].

Payne [1] studied communities of arthropods associated with stages of decomposition on the domestic pig *Sus scrofa* L.; he exposed carcasses to arthropod activity and studied decay stages and faunal colonization patterns with the passing of time. Studies of arthropod succession were performed in several parts of the world [5–10]. There is a precedent in [4] for experiment with a roof covering the corpse to keep off the rain, but the results were not contrasted with those from an unsheltered one. Also, the animal model used in [4] was guinea pig, much smaller in size than any human corpse. In forensic experiments, pig carcass is widely used because the animal model must closely approximate the pattern of human decomposition [11]. Pigs are easy to obtain, their digestive tract resembles the human one (both species being omnivorous), and the fact that it is often used as a model makes easier and more accurate any comparing of results. More about experimental research on forensic entomology in [11]; the history of forensic entomology is reviewed in [12].

In Southern America, research is being done in Brazil; results from rat carcasses [13] and from pig carcasses [8–10] are available. In Argentina, some descriptive reports on cadaveric insects has been published [8], but up to now, no attempt was made to determine faunal associations related to stages of decomposition. Understanding of these associations is useful, as they contribute to estimation of postmortem interval and other cases, like children neglected by their parents, corpse movement after death, etc. [14,15].

The following paper compares decay stages and cadaveric fauna on sheltered and unsheltered pig carcasses, for each season of the year. Domestic pig *S. scrofa* was selected as an animal model [11].

The area where the experiment was performed has a warm-temperate, humid climate. Usually, summer (December–March) is warm, winter (June–September) mildly cold with occasional frosts, fall is subject to strong southeastern winds with cold and drizzle, which may last for several days; falls of rain are frequent in spring.

2. Material and methods

The experiments were performed on a field (property of the Universidad Nacional de La Plata), about 30 ha in surface, located at Santa Catalina (34°45′S, 58°25′W), some 20 km SE from the city of Buenos Aires, Argentina. The field was sown with maize; alongside there is a wood of elmtrees and tala trees (a local species of *Celtis*). The area of work was 500 m long × 20 m wide, set between the field and the wood; it had a low vegetation of thistles, nettles and a few shrubs. Logs, fallen branches, leaf mould and small amounts of inorganic garbage were found in the area.

The climate in this part of the country is humid warm-temperate. Summers are usually warm, varying from dry sunny days when the maximum temperatures approach 40 °C, to sudden showers of rain which may lower temperatures to some 18 °C. Sultry weather may prevail for several days running. Minimum temperatures keep high even at night, rarely descending below 18 °C except after a fall of rain. High minimum temperatures make for an extremely small diel variance, sometimes hardly more than 1 °C. Winters are mildly cold, with frosty spells which are usually short and interspersed with thaws in which maximum temperature may attain 17 and 18 °C. Southeastern winds, sustained for several days, causing rain and drizzle, occur at any time of the year, but with greatest frequency in the fall. Spring and fall very unstable; both frosts and spells of sultry warmth may occur, interspersed with cool to mildly warm weather. Annual rainfall for this part of the province is estimated around 900–950 mm.

For each experiment two wooden cages, 120 cm × 80 cm × 60 cm, were used, one with a wooden roof and the other one roofless. The cages had a wire mesh 2.5 cm wide. Inside each cage the body of a domestic pig weighing 15–17 kg, was placed. The pigs were killed by a stab in the heart (the usual procedure of commercial butchers) 1 h before exposure, and kept in a plastic bag to avoid insect infestation before the setting of the experiment. Around each cage and at a distance of 40 cm were placed six pitfall traps, two along each of the longer sides, one on each of the shorter ones. Pitfall traps consist of a small pit dug in the soil, containing a vial without a bait. For control, six further pitfall traps were placed at a distance of some 4 m, following the same spatial pattern. The cages were separated by a distance of approximately 4 m.

The stages of decay were defined as in [1], with slight modification, as follows:

1. *Fresh stage*: no decomposition odor or swelling.
2. *Bloated stage*: abdomen bloated; bubbles of blood at the nose and anus; in later part of this stage odor becomes noticeable and fluids seep out. It clearly ends when the corpse deflates.
3. *Active decay stage*: odor strong; liquefaction and disintegration noticeable; usually skin pierced by feeding insects; flesh may have been removed from the first points of attack, such as mouth and eyes, in extreme cases from most of the head.
4. *Advanced decay stage*: odor begins to fade; most of the flesh has disappeared, some soft tissue still found in the abdomen.
5. *Remains stage*: odorous disappear; only bones, hair and remnants of dried skin remain.

The carcasses were visited daily at the beginning of the experiment (fresh stage), and afterwards at varying intervals, from 3–4 days, according to season (Figs. 1–4).

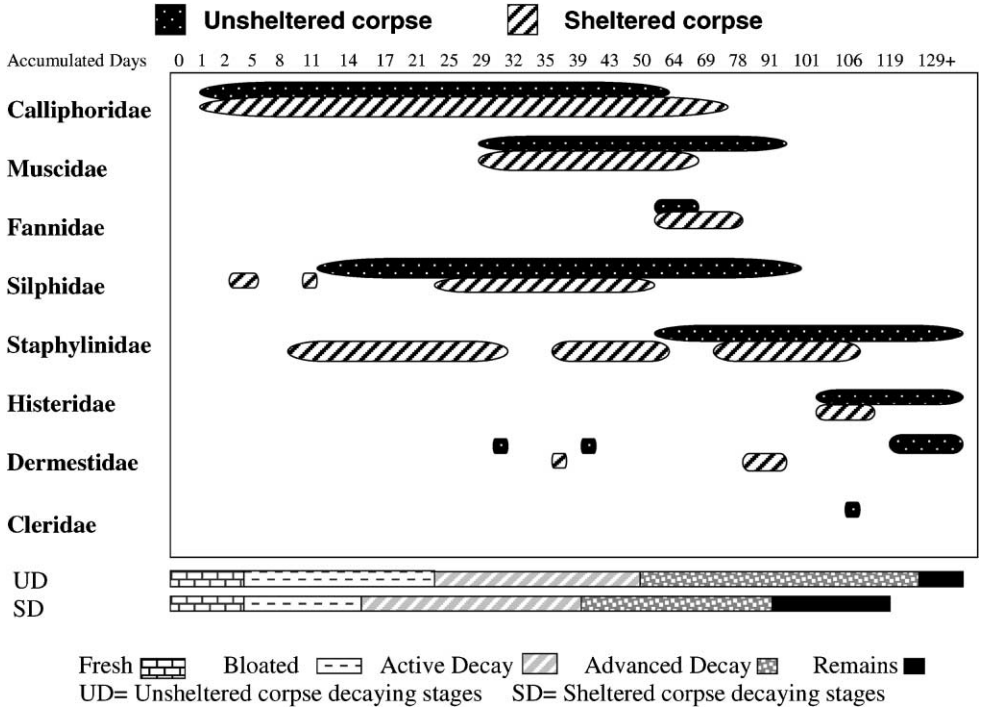

Fig. 1. Successional pattern in fall, for forensically important insects; Calliphoridae (blowflies), Muscidae (housefly and relatives), Fannidae (latrine flies), Silphidae (carrion beetles), Staphylinidae (rove beetles), Histeridae (hister beetles), Dermestidae (skin beetles) and Cleridae (ham beetles).

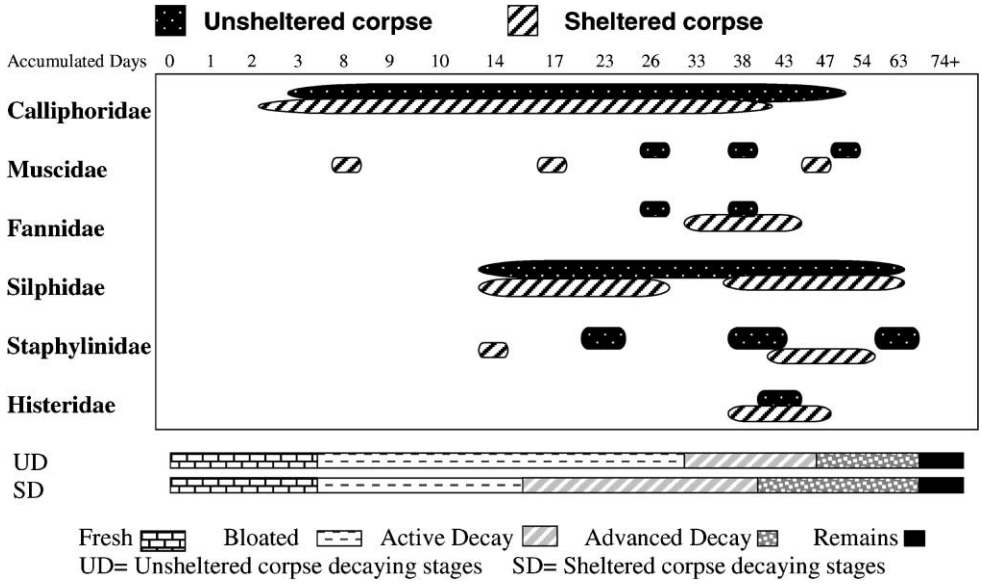

Fig. 2. Successional pattern in winter, for forensically important insects; Calliphoridae (blowflies), Muscidae (housefly and relatives), Fannidae (latrine flies), Silphidae (carrion beetles), Staphylinidae (rove beetles), Histeridae (hister beetles), Dermestidae (skin beetles) and Cleridae (ham beetles).

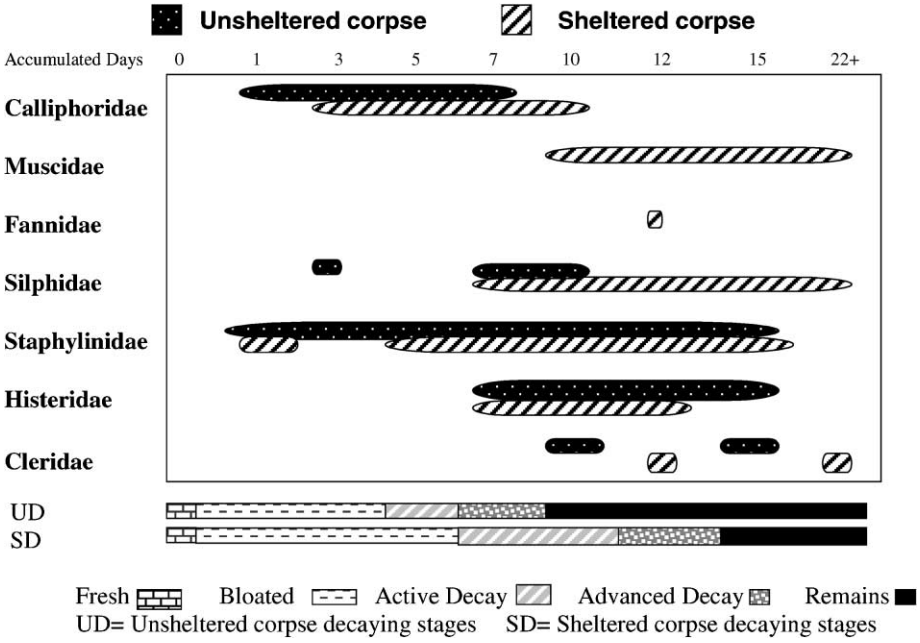

Fig. 3. Successional pattern in spring, for forensically important insects; Calliphoridae (blowflies), Muscidae (housefly and relatives), Fannidae (latrine flies), Silphidae (carrion beetles), Staphylinidae (rove beetles), Histeridae (hister beetles), Dermestidae (skin beetles) and Cleridae (ham beetles).

On each visit, samples of arthropods on the body, under it, in flight and in the pitfalls were taken. Catching devices included forceps, spoons, entomological nets, aspirators and other implements. In advanced stages of decomposition, samples of soil were taken, both from under the body and around it.

Ambient and carcass temperatures were measured, the latter by means of a 15 cm probe thermometer fully inserted in the anus. A *t*-test [16] was performed comparing both sheltered and unsheltered mean body temperatures, from the bloated to the beginning of advanced decay stages (which were the maximum maggot activity periods) for each season.

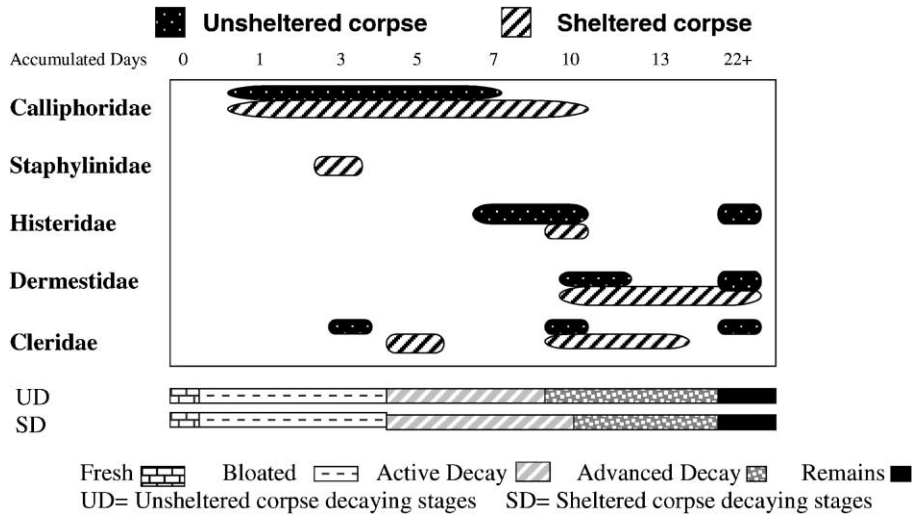

Fig. 4. Successional pattern in summer, for most forensically important insects; Calliphoridae (blowflies), Muscidae (housefly and relatives), Fannidae (latrine flies), Silphidae (carrion beetles), Staphylinidae (rove beetles), Histeridae (hister beetles), Dermestidae (skin beetles) and Cleridae (ham beetles).

Fresh and remains stages were not considered for analysis because carcass temperature did not rise above air temperature, as observed in [1].

Blowfly eggs and half of collected maggots were reserved for lab rearing; the remaining larvae were killed in hot water at 80 °C and preserved in ethanol 70%. Adult flies were killed with ethyl acetate vapor and placed in paper envelopes; the remaining arthropods were kept in 70% ethanol. Cultures were kept in plastic jars 7 cm in diameter; beef was used as food, placed on pieces of aluminium foil, on a base of perlite as suggested in [17]. The cultures were placed in a hothouse at 24 °C until completion of development, to confirm determination through the adults. Determinations were based on [18–20].

This experiment was repeated in the four seasons of the year beginning in the winter (June–September) of 1998 and ending in the summer (December–March) of 2000.

Since there was a single set of data for each combination of variables, no statistical analysis of the results concerning insect sampling was feasible. The results of analysis of internal temperature measurements and their correlation with external conditions are shown in Table 3.

3. Results

The first blowflies eggs were always found during the fresh stage for both treatments: after the first day in the fall, after the second day in winter, within the first day in spring and summer. In later stages, fresh egg-laying by blowflies occurred (recolonization): in fall, this was observed until day 41 on the sheltered and day 48 on the unsheltered carcass; in winter, until day 15 on the sheltered and day 45 on the unsheltered carcass; in spring and summer, there was recolonization until day 5 for both treatments.

The first records of larvae III were made on the third day after the carcass was exposed, for both treatments, in spring and in summer. In fall, the first record was made on the eighth day, for both treatments. Only in winter a difference between treatments showed itself; the first record of larvae III on the sheltered carcass was in the eighth day, on the unsheltered carcass, on the day 14.

Figs. 1–4 show the faunal associations, how each relates to decomposition stages and to day accumulation from the day of exposition onwards, for each season and for each treatment. The largest segment of the association was made

Table 1
Insects of forensic importance collected on corpses

Diptera (true flies)	Calliphoridae (blowflies)	*C. vicina* Robineau-Desvoidy
		C. nigribasis Macquart
		P. sericata (Meigen)
		P. cluvia (Walker)
		Paralucilia pseudolyrcea (Mello)
		Chrysomya albiceps (Wiedemann)
		C. chloropyga (Wiedemann)
		C. megacephala F.
		C. macellaria F.
		Sarconesia chlorogaster (Wiedemann)
	Muscidae (housefly and its relatives)	*Ophyra argentina* Bigot
		Morellia spp.
		Muscina stabulans(Fallen)
		M. asimilis Fallen
		Musca domestica L.
	Fannidae (latrine flies)	*Fannia fusconotata* (Rondani)
	Phoridae (scuttle flies)	*Megaselia scalaris* (Loew)
		Spiniphora bergenstammi (Mik)
		Puliciphora rufipes Silva Figueroa
Coleoptera (beetles)	Silphidae (carrion beetles)	*Hyponecrodes* sp.
	Cleridae (ham beetles)	*Necrobia ruficollis* F.
		N. rufipes De Geer
	Histeridae (hister beetles)	*Saprinus patagonicus* (Blanchard)
		Hister sp.
	Staphylinidae (rove beetles)	*Creophilus maxillosus* L.
		Paederus sp.
	Dermestidae (skin beetles)	*Dermestes ater* De Geer
		D. maculatus De Geer
Hymenoptera	Formicidae (fire ants)	*Solenopsis* sp.

up of blowflies (Calliphoridae), although flies of the housefly family (Muscidae) and latrine flies or lesser houseflies (Fanniidae) also occurred.

The fresh stage was characterized by blowflies eggs and larvae I; the blowflies larvae II and III was the main components in the bloated stage together with carrion beetles (Silphidae) adults; active decay stage showed mostly larvae III of blowflies and the coexistence of carrion beetle larvae and adults; advanced decay stage showed a majority of blowfly postfeeding larvae leaving the body and carrion beetle larvae (no adults); in the remain stage, beetles were the most abundant group, although no family appeared to be especially associated to this stage.

The families of Diptera and Coleoptera that were collected on the carcasses are shown in Table 1. Taxa, that were present in the control traps but not in the carcass are listed in Table 2. For the analysis of the Dipteran faunal associations, larvae alone were considered. Adults flying nearby were not taken into account. Insects trapped in control traps were not taken into account, save for rove and carrion beetles which have been recorded as associated with corpses [1,4].

In the fall, slight differences were observed between sheltered and unsheltered carcasses. On the later, *Calliphora vicina*, *C. nigribasis*, *Phaenicia sericata*, *P. cluvia* and *Cochliomyia macellaria* occurred; on sheltered carcass, the same precedent five species occurred, and *C. albiceps* which is usually associated with warm weather was found as well. In winter, the difference was more marked; on the unsheltered carcass only *C. vicina* (the most common species at this time of the year) occurred, while on the sheltered carcass *C. vicina*, *P. cluvia* and *C. macellaria* were found.

Table 2
Groups present only in control traps without forensic importance

Coleoptera (beetles)	Carabidae, Scarabaeidae, Coprinae, Lampyridae, Tenebrionidae
Heteroptera (true bugs)	Reduviidae, Nabiidae, Pyrrhocoridae
Homoptera (leaf hoppers)	Fulgoroidea, Cicadelidae, Aphidoidea
Hymenoptera (ants and bees)	Attinae (leaf-cutting ants), Apidae (bees)
Dictyoptera (cockroaches)	Blattodea (cockroaches)
Lepidoptera (butterflies)	Larvae (caterpillar)
Collembolla (springtails)	Isotomidae, Onychiuridae, Poduridae
Chilopoda	Centipedes
Diplopoda	Millipedes
Opiliones (harvestmen)	Pallpatores and Laniatores
Araneae (spiders)	Lycosidae (wolf spider)
Crustacea	Isopoda (pill bugs)
Mollusca	Gasteropoda (snails)

In the spring, no difference between sheltered and unsheltered carcasses was observed. In both cases, *C. macellaria*, *C. albiceps*, *P. sericata*, *P. pseudolyrcea* and *C. chloropyga* were found. In the summer, there was a small number of species, without significant differences between sheltered and unsheltered carcasses; decomposition took a short space of time (22 days), *C. albiceps* and *C. macellaria* occurred, and in smaller numbers *C. megacephala*. From the first day,

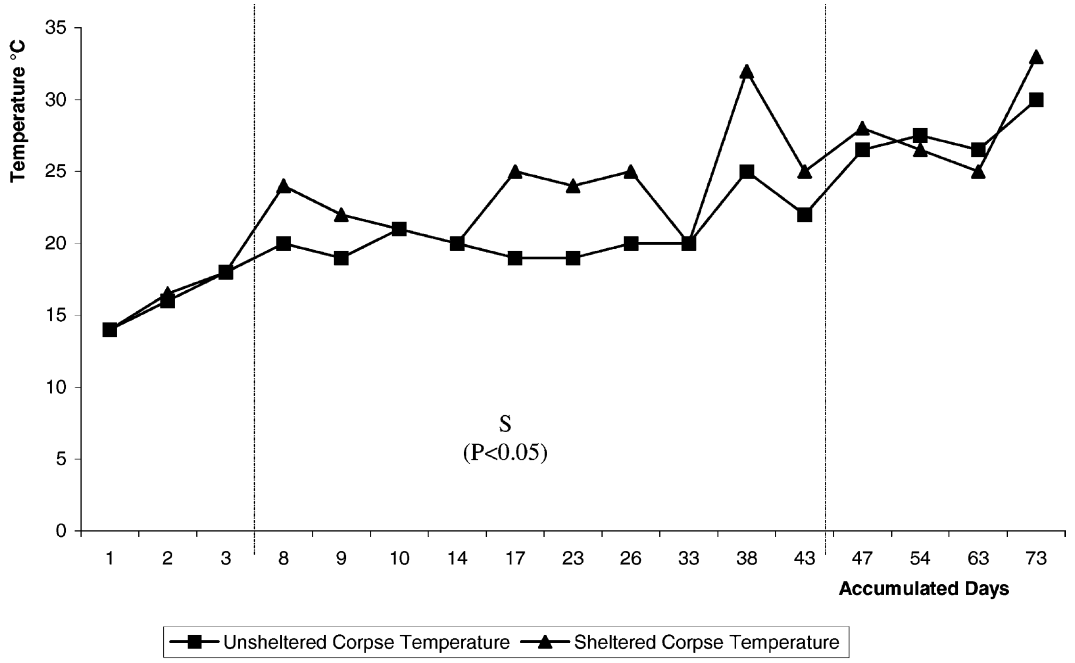

Fig. 5. Winter temperatures. Comparison of sheltered and unsheltered corpse temperatures. Interval between broken lines showing interval of days analyzed with *t*-test of difference between both mean temperatures. Significance level, $\alpha = 0.05$; S: significant at the 0.05 level.

Table 3
Results of the *t*-test to compare mean corpse temperatures between both sheltered and unsheltered pig carcass

Season	Day interval	U mean (°C)	S mean (°C)	d.f.	Significance
Fall	5–43	18.73	18.79	22	NS
Winter	8–43	20.50	23.80	18	S
Spring	1–10	31.87	29.50	7	NS
Summer	1–7	41.75	40.75	6	NS

U mean: mean corpse temperature (°C) for unsheltered pig carcass; S mean: mean corpse temperature (°C) for sheltered pig carcass; d.f.: degree of freedom of the test; significance level, $\alpha = 0.05$, S: significant at the 0.05 level ($P < 0.05$) and NS: not significant at the 0.05 level ($P > 0.05$).

C. albiceps was the most numerous, although the finding of a single larva I of *C. macellaria* on the day after exposition suggests that this species may be the first to colonize the carcass.

Comparison between sheltered and unsheltered mean carrion temperatures, on bloated and active decay stages, showed significant differences only in winter ($P < 0.05$; 18 d.f.; see Fig. 5). In contrast, results of the test (Table 3) showed no significant differences for the fall, spring or summer.

4. Discussion

Stages of decomposition: Differences between sheltered and unsheltered carcasses were clear-cut. This might be attributed to the effect of the roof. The trend in fall and in winter is towards a shorter bloated stage in sheltered carcasses. Both active decay and advanced decay were shorter for unsheltered carcasses in winter, but this might be due to an overlap of the beginning of active decay with the end of the bloated stage; in the unsheltered experiment, the bloated stage remained well-defined until the first postfeeding larvae appeared (postfeeding larvae usually appear from the advanced decay stage on). These differences may be explained by the fact that the roof protects the carcass from rain and frost. This idea is also supported by the higher temperatures recorded for the sheltered corpse (Fig. 5); this may possibly accelerate decomposition.

In spring, on the other hand, active decay and advanced decay were shorter in the unsheltered carcass than in the sheltered one. This may be due to the reduction in the insolation caused by the roof, making for a longer decay period, although records of temperatures do not show lower values (see Table 3).

At a lower latitude, as in Brazil [13], the stages of decomposition were longer in winter than in any other season. In Buenos Aires Province, however, the difference was more clear-cut, e.g. the active decay stage lasted 3 days in summer and 19 days in the fall. Similar differences may be remarked for the other stages (Figs. 1–4).

The first stages showed important differences both for each season and between treatments. In the fall, the fresh stage was shorter than in winter, but comparable for both carcasses, and distinctly longer than in spring or summer. The period between the bloated stage and the end of active decay stage, both in the fall and in winter, was comparable but not equal for both treatments, being shorter for the sheltered carcass. In the fall, the advanced decay stage was distinctly longer for the unsheltered carcass, while in winter values were similar for both treatments.

In spring, succession was very quick, in 22 days the carcasses had arrived at the remains stage [1]. This might be an effect of insolation which increases temperature. A fact which supports this supposition is that the higher temperature values were recorded for the unsheltered carcass; on the following day after beginning the experiment, there was a temperature difference of 6 °C between the two treatments. This acceleration in the successional rate affected all the stages, the unsheltered carcass arrived at the remains stage 5 days before the sheltered one. In summer, no significant differences were recorded between the two treatments; as in spring, the remains stage was attained in 22 days.

The differences found in the assemblage of Calliphoridae in the cold months (April–August), have been considered as the effect of the roof on the process of decomposition. On the sheltered corpses, the presence of summer blowflies species [21] such as *C. albiceps*, *P. cluvia* and *C. macellaria*, as well as the fast development of the larvae III (in comparison with other treatment), could be due to the protection of the roof. On the other hand, in the unsheltered carcass slow decomposition allowed recolonization by blowflies until a later date than on the sheltered one.

The families of Coleoptera (beetles) showed different seasonal patterns. Skin beetles (Dermestidae) were found from summer to the beginning of the fall. Carrion beetles (Silphidae) occur along the whole year, except in summer. Rove beetles (Staphylinidae) showed no seasonal differences. However, in the fall they appeared earlier on the sheltered carcass; this fact may be due to a microclimate generated by the roof.

In conclusion, differences between sheltered and unsheltered carcasses were found to be significant for the succession of necrophagous insects. A shelter or cover affects the decomposition process, making it shortest in cold seasons (fall/winter) and longest in warm seasons (spring/summer), as compared with an exposed condition of a corpse. The successional pattern and the species recorded, show differ-

ences due to sheltering during cold seasons. This is of interest, because in criminal cases there may be attempts to conceal the body with branches or some other covering.

Acknowledgements

The authors would like to thank to Dr. Carlos Naranjo, Director of the Instituto Fitotecnico de Santa Catalina, and Enrique Michel, foreman of the same Institute; Dr. Arturo Roig, from the Museo Argentino de Ciencias Naturales, for determination of Hymenoptera, and Bruno Frasanito, from the Universidad Nacional de Quilmes, for their help in the field studies. This work was made with the financial support from the Universidad Nacional de Quilmes.

References

[1] J.A. Payne, A summer study of the baby pig *Sus scrofa* Linnaeus, Ecology 46 (5) (1965) 592–602.
[2] B. Greenberg, Forensic entomology: case studies, Bull. Entomol. Soc., Am. 31 (4) (1985) 25–28.
[3] M.L. Goff, E P. Catts, Arthropod basics stucture and biology, in: N.H. Haskell, E.P. Catts (Eds.), Entomology and Death: A Procedure Guide (1997, 2nd Edition), Joyce's Print Shop Inc., Clemson, SC, USA, 1990, Chapter 3, pp. 1–183, ISBN: 0-9628696-0-0.
[4] G.F. Bornemisza, An analysis of arthropod succession in carrion and the effect of its decomposition on the soil fauna, Aust. J. Zool. 5 (1957) 1–12.
[5] E.N. Richards, M.L. Goff, Arthropod succession on exposed carrion in three contrasting tropical habitats on Hawaii Island, Hawaii, J. Med. Entomol. 34 (3) (1997) 328–339.
[6] J.B. Davis, M.L. Goff, Decomposition patterns in terrestrial and intertidal habitats on Oahu Island and Coconut Island, Hawaii, J. Foren. Sci. 45 (4) (2000) 836–842.
[7] F.W. Avila, M.L. Goff, Arthropod succession patterns onto burnt carrion in two contrasting habitats in the Hawaiian Islands, J. Foren. Sci. 43 (3) (1998) 581–586.
[8] A.M. de Souza, A.X. Linhares, Diptera and Coleoptera of potential forensic importance in southeastern Brazil: relative abundance and seasonality, Med. Vet. Entomol. 11 (1997) 8–12.
[9] L.M.L. Carvalho, P.J. Thyssen, A.X. Linhares, F.A.B. Palhares, A checklist of arthropods associated with pig carrion and human corpses in southeastern Brazil, Mem. Inst. Oswaldo Cruz (Rio de Janeiro) 95 (1) (2000) 135–138.
[10] L.M.L. Carvalho, A.X. Linhares, Seasonality of insect succession and pig carcass decomposition in a natural forest area in southeastern Brazil, J. Foren. Sci. 46 (3) (2001) 604–608.
[11] M.L. Goff, Estimation of postmortem interval using arthropod development and successional patterns, Foren. Sci. Rev. 5 (1993) 81–94.
[12] M. Benecke, A brief history of forensic entomology, Foren. Sci. Int. 120 (2001) 2–14.
[13] M.O.C. Moura, J.B. de Carvalho, E.L.A. Monteiro-Filho, A preliminary analysis of insects of medico-legal importance in Curitiba, State of Parana, Mem. Inst. Oswaldo Cruz (Rio de Janeiro) 92 (2) (1997) 269–274.
[14] M. Benecke, Six forensic entomology cases: description and commentary, J. Foren. Sci. 43 (797–805) (1998) 1303.
[15] M. Benecke, R. Lessig, Child neglect and forensic entomology, Foren. Sci. Int. 120 (2001) 155–159.
[16] F.E. Croxton, Elementary Statistics with Applications in Medicine and the Biological Sciences, Dover Publications Inc., New York, 1959, 376 pp.
[17] N. H. Haskell, Procedures in the entomology laboratory, in: N.H. Haskell, E.P. Catts (Eds.), Entomology and Death: A Procedure Guide (1997, 2nd Edition). Joyce's Print Shop Inc., Clemson, SC, USA, 1990, Chapter 7, 1990, pp. 1–183, ISBN: 0-9628696-0-0.
[18] A. Oliva, Insectos de interes forense de Buenos Aires (Argentina). Primera lista ilustrada y datos bionómicos. Revista del Museo argentino de Ciencias naturales ''Bernardino Rivadavia'', Entomologia 7 (2) (1997) 13–59.
[19] D. Liu, B. Greenberg, Immature stages of some flies of forensic importance, Ann. Entomol. Soc., Am. 82 (1) (1989) 80–83.
[20] J.C. Mariluis, Clave para la identificación de los Calliphoridae de la República Argentina, Revta Soc., Ent. Arg. 40 (1–4) (1981) 27–30.
[21] J.A. Schnack, J.C. Mariluis, N.D. Centeno, J. Muzon, Composición específica, ecología y sinantropía de Calliphoridae (Insecta: Diptera) en el Gran Buenos Aires, Revta Soc., Ent. Arg. 54 (1-4) (1995) 161–171.