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Adult Fanniidae associated to pig carcasses during the winter season in a semiarid environment: Initial examination of their potential as complementary PMI indicators

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ABSTRACT

Besides the dominant necrophagous dipteran of the families Sarcophagidae and Calliphoridae usually used for post mortem interval (PMI) estimations, species of other families such as Fanniidae have frequently been reported in forensic studies. Though less abundant, these species are prevalent in decomposing carcasses with most reports being anecdotal. In this study we identified adults of the fly family Fanniidae associated to pig carcasses located under different local environmental conditions (sun and shade) in a semiarid area at Mendoza, Argentina during the winter season. We examined the potential of species of this family as indicators of PMI by measuring abundance, time of occurrence and residency time at the carcasses. We identified six species of Fanniidae: *Euryomma peregrinum* Meigen, *Fannia albitarsis* Stein, *Fannia femoralis* Stein, *Fannia fusconotata* Rondani, *Fannia heydenii* Wiedemann and *Fannia sanihue* Domínguez and Aballay. Overall, fly abundance was higher at the sunlit than at the shaded carcass. The most abundant species at the sun was *F. fusconotata* while at the shaded carcass *F. femoralis* was the most abundant species. Based on their residency time, however, species with higher potential as PMI indicators seem to be *F. heydenii* and *F. sanihue* as their residency time at the carcass was restricted to a short period of the decomposition process. Other species were present throughout most of the decomposition process or in such a low abundance (*E. peregrinum*) that they were not useful as indicators. These preliminary results indicate that adults of some species of Fanniidae could act as a good complementary indicator species during the winter season. In particular, *F. heydenii* and *F. sanihue* should be the focus of further studies which should also expand to other seasons.

The relevance of accompanying fauna in estimates of post-mortem interval (PMI) is high when estimating PMI during the late post-mortem period. While PMI estimations at the early period after death are based on a direct age assessment of immature stages of the dominant necrophagous insects of Diptera (Calliphoridae, Muscidae, and Sarcophagidae) and Coleoptera (Dermestidae) [1–4], PMI estimation during the late post-mortem period is based on the composition of the arthropod community as it relates to expected successional patterns [5]. It is in this period when insects belonging to other less dominant families constitute an important complement for the estimation of PMI. Although less abundant than the dominant families mentioned above, Diptera such as Fanniidae are prevalent in decomposing carcasses (Table 1), but only a few studies [25,27] have examined their usefulness in forensic research.

In forensic investigations, it is the immature stages of insects which are generally used for PMI estimations. The adults of certain necrophagous insects, however, may provide useful complementary information. Some studies have shown that adult necrophagous species occur at a carcass at a predictable moment of colonisation [25,28]. In addition, using adults of species known to breed on carcasses has the additional advantage of avoiding the noise caused by larval predation which occurs among some necrophagous taxa [29–31].

Matuszewski et al. [25] found that those predictable species that constitute good PMI indicators have a short residence period at a carcass usually related to their specialised feeding habits and, in the case of adults, have an intermittent presence at the carcass while larvae have a permanent residency period. Intermittent presence may signal changes in weather conditions affecting adult presence as well as changes in carcass conditions that affect its attraction to specialised carrion-dependent species.

In this study, we examine the potential of adults of Fanniidae as indicators of PMI during the decomposition process at carcasses placed under different environmental conditions (sun and shade)

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Table 1
Studies in which species of Fanniidae have been reported.

Author	Country/distribution	Species	Developmental stage	Season	Decomposition stage[a]
Payne [6]	South Carolina, USA	*Fannia* sp.	Larvae, adult	Spring, summer	AD
Smith [1]		*Fannia canicularis*, *F. manicata*, *F. scalaris*	Larvae, adult		
Goff et al. [7]	Hawaiian Islands	*Fannia pusio*			
Souza and Linhares [8]	Brazil	*Fannia* sp.	Adult	Spring	
Marchiori et al. [9]	Itumbiara, Brazil	*Fannia pusio*	Adult		
Carvalho et al. [10]	Brazil	*Fannia pusio*, *F. canicularis*	Adult		
Byrd and Castner [4]	Cosmopolitan	*Fannia scalaris*, *F. canicularis*			
Benecke and Lessig [11]	Germany	*Fannia canicularis*	Larvae, adult	Summer	D
Wolff et al. [12]	Medellin, Colombia	*Fannia* sp.	Adult	7 months	D, AD, Dry
Anderson [13]		*Fannia* sp.			
Centeno et al. [14]	Buenos Aires, Argentina	*Fannia fusconotata*	Adult	All year	D, AD, Dry
Iannacone [15]	Callao, Peru	*Fannia canicularis*	Adult, pupa	Fall, winter	D
Grassberger and Frank [16]	Viena, Austria	*Fannia canicularis*, *F. scalaris*, *F. manicata*	Eggs, larvae, adult, pupae	Spring, summer, fall	B, D, AD, Dry
Watson and Carlton [17]	LA, USA	*Fannia canicularis*, *F. scalaris*	Larvae, adult	Fall, winter	
Pérez et al. [18]	Medellin, Colombia	*Fannia canicularis*	Adult	Spring	B, D, AD, Dry
Domínguez and Aballay [19]	Mendoza, Argentina	*Fannia sanihue*	Adult	Winter	B, D, AD, Dry
Aballay et al. [20]	San Juan, Argentina	*Fannia femoralis*, *F. fusconotata*	Adult	All year	D, AD, Dry
Matuszewski et al. [21]	Western Poland	*Fannia* sp.	Larvae	Summer, fall	AD, Dry
Quiroga and Domínguez [22]	Jujuy, Argentina	*Fannia yunguensis*	Adult, larvae	Fall, winter, spring	
Segura et al. [23]	Bogotá, Colombia	*Fannia* sp.	Adult, larvae	Summer	B, D, AD, Dry
Byrd and Castner [24]		*Fannia canicularis*, *F. scalaris*	Adult, larvae	Summer	
Matuszewski et al. [25]	Poland, Central Europe	*Fannia canicularis*, *F. coracina*, *F. manicata*	Adult, larvae	Spring, summer, fall	AD, Dry
Battán Horenstein et al. [26]	Cordoba, Argentina	*Fannia femoralis*, *Fannia* sp.	Adult	All year	B, D, AD
Matuszewski et al. [27]	Poland, Central Europe	*Fannia canicularis*, *F. coracina*, *F. manicata*	Adult, larvae	Spring, summer, fall	B, D, AD, Dry

[a] B, bloated; D, active decay; AD, advanced decay; Dry, dry remains.

during the winter season in a semiarid environment. Specific goals of the study are: (1) identification of the species of Fanniidae that occur on pig carcases in the province of Mendoza during the winter season under different insolation conditions and (2) assessment of this fly family as PMI indicators studying the variation in abundance and time of residency at a carcass of the different species.

1. Materials and methods

The study was carried out at Instituto Argentino de Investigaciones de las Zonas Áridas, CCT-Mendoza, Argentina (32°53′53.39″S; 68°52′26.28″W) during the austral winter on 5 May 2007 until completion of the decomposition process 130 days later. The study area lies approximately 800 m above sea level, has an average annual temperature of 15.6 °C and has an annual rainfall of 200 mm. The site is located in the biogeographical province of the Monte, which is a warm shrub desert extending between the Puna and Patagonia to the east of the Andes mountain range [32]. The study area is covered with native vegetation of *Opuntia ficus-indica*, *Larrea divaricata*, *Prosopis chilensis*, *Prosopis flexuosa*, *Atriplex lampa*, among others. The winter is dry and cold, the average temperature from May to October is 9.8 °C (minimum and maximum average temperature for the same period were 4.96 °C and 24.58 °C) and has an average rainfall of 39 mm (Programa Regional de Meteorología, IANIGLA, CONICET).

Two pig carcasses, weighing 16 kg each, were set 300 m apart in the experimental field of the CCT-Mendoza under two local insolation conditions: sun and shade. Pigs were slaughtered following Centeno et al. [14]. They were washed with water to eliminate the fauna that could come from the breeding site (farm), placed in plastic bags and taken to the study area. The plastic bags were then removed and the pig carcasses were placed in separate wooden cages covered with chicken wire (1.20 m high × 1.20 m long × 1 m wide) to avoid vertebrate scavengers but allowing the entrance of the arthropod fauna. Within each cage, 5 cm of soil was set to ensure the same conditions of acidity (and other variables) under the pigs and in their surroundings. Modified Malaise traps were set in each cage and over the corpses. Each Malaise trap consisted of a cone-shaped structure (1.10 m × 0.90 m at its base). The vertex of the cone is connected to a rectangle (1.10 m × 90 m × 0.30 m) where the flies that abandoned the carcass were trapped. The trap was set at 10–15 cm above the ground to allow the entrance of flying arthropods. The samples were taken throughout the five stages of decomposition defined by Anderson and Vanlaerhoven [33]: fresh (F), bloated (B), active decay (D), advanced decay (AD), and dry remains (Dry). During the first 40 days, the traps were checked daily, then twice a week for 22 days and finally once a week until skeletisation.

The Diptera captured in each sample were killed using acetone, and the Fanniidae were separated and identified using the keys of Domínguez [34], Domínguez and Aballay [19] and Quiroga and Domínguez [22]. Relative humidity, temperature and atmospheric pressure were recorded daily using a thermo-hygrometer (Eurotime), and internal and external temperature of the carcass were recorded using puncture thermometry. Maximum, minimum and average daily temperatures were obtained from the meteorological station at the experimental field, located at 100 and 200 m from the sun and shade carcasses, respectively.

To evaluate differences in the duration (days) of the decomposition process under different insolation conditions (sun/shade), we used an X^2 analysis, using a contingency table.

2. Results and discussion

When comparing the duration of the decomposition process, we found that it lasted half the time in the sun than in the shade ($X^2 = 19.69$, $P > 0.05$, sun: 64 days; shade: 125 days). Except for the fresh(F) stage, all the stages were longer in the carcass placed in the shade (Fig. 1). Other studies carried out during the winter in other regions of Argentina, however, obtained different results. In an experiment that took place in the province of Córdoba, Battán Horestein [26] found that in the sunlit carcass the F and D stages were longer, and that the B and AD were shorter than in the shaded carcass, but both carcasses arrived to the remaining stage at the same time. In another study in Buenos Aires, Centeno et al. [14] found that the B stage was shorter in the carcass placed in a shelter but D and AD stages were longer. According to Anderson [35], insect colonisation of carrion depends on many factors, but one of the most important is the geographical region and biogeoclimatic zone in which the remains are found. The differences among localities in the duration of each stage, and between the two treatments (sun or shade) could then be explained by differences in environmental conditions of each locality where the experiments were done. The climate in Mendoza is much dryer than that in Córdoba and Buenos Aires.

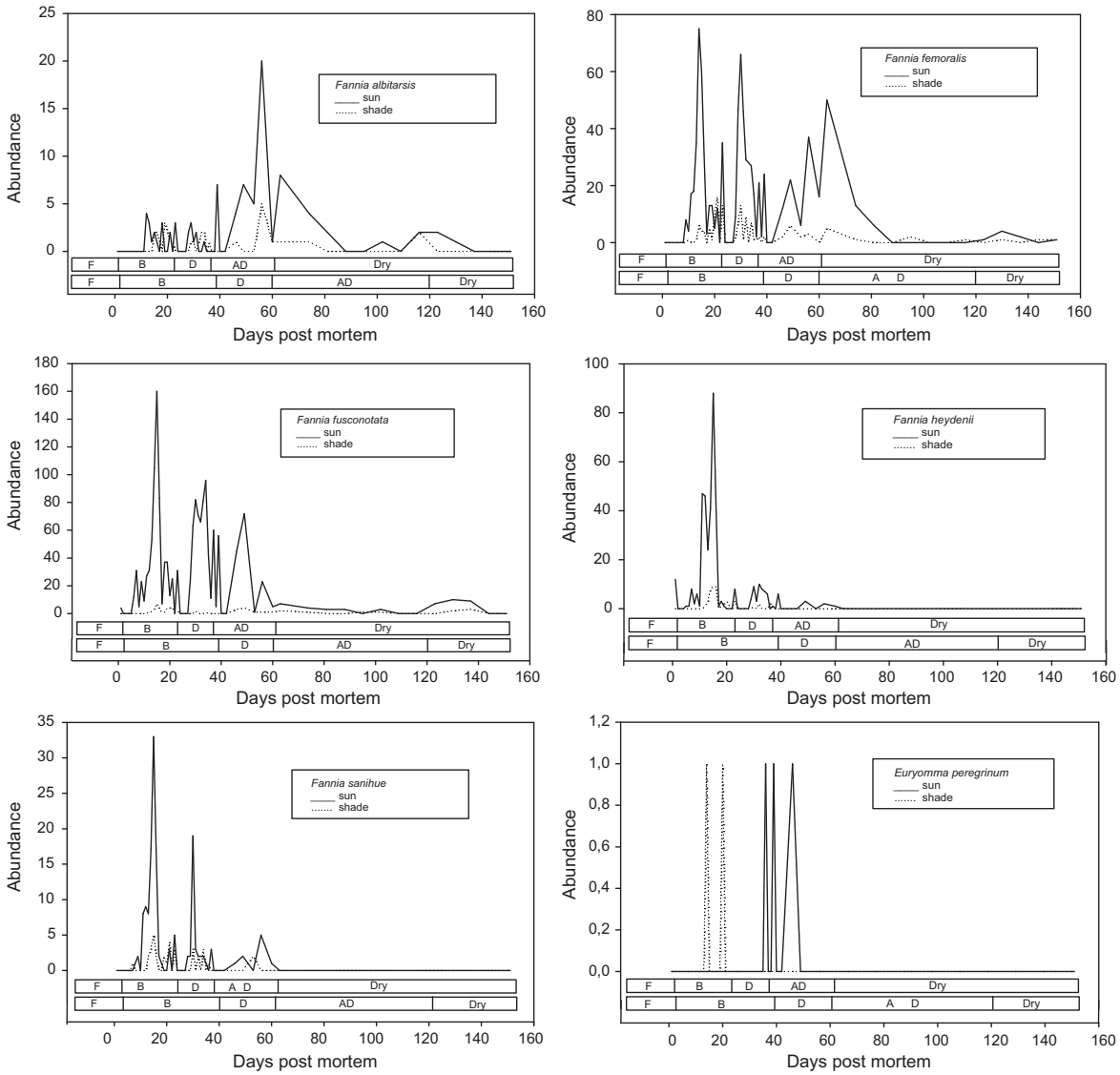

Fig. 1. Absolute abundance of all species of Fanniidae as a function of days post mortem and decomposition stages. (See Table 1 for decomposition stages abbreviations.)

When sampling Fanniids associated to carcasses, we collected a total of 3300 individuals. They were identified as belonging to six species: *Euryomma peregrinum* Meigen, *Fannia albitarsis* Stein, *Fannia femoralis* Stein, *Fannia fusconotata* Rondani, *Fannia heydenii* Wiedemann and *Fannia sanihue* Domínguez and Aballay. We collected females of all six species but males collected belonged to only three species: *F. sanihue*, *F. heydenii* and *F. femoralis*.

Fig. 1 shows the absolute abundances of the six species of fanniids found as a function of decomposition stage and insolation conditions. Total abundances throughout the decomposition process were higher in the carcass placed in the sun than that placed in the shade (Fig. 1). Overall, *F. fusconotata* was the most abundant species ($n = 1599$), accounting for almost 50% of total abundance at both carcasses, followed by *F. femoralis* ($n = 949$) and *F. heydenii* ($n = 439$).

While some of the species were present during most of the decomposition process, some others seemed to be associated to certain decomposition stages as judged by their abundance by decomposition stage and residency time (at a short period during the decomposition process). When comparing peak abundances, most species (*F. femoralis*, *F. fusconotata*, *F. heydenii* and *F. sanihue*) showed their higher abundance at the same stage under both insolation conditions suggesting an association with certain decomposition stages and only *F. albitarsis* and *E. peregrinum* peaked in abundance at different stages. In terms of residency time, with the exception of *F. heydenii*, *E. peregrinum* and, to a lesser degree, *F. sanihue*, the remaining species were abundant at the carcasses during most of the decomposition process (Fig. 1).

Other differences in species occurrence were found when comparing first colonisers at each carcass. At the sunlit carcass, species that appeared on day 1 were *F. fusconotata* and *F. heydenii* while at the shaded carcass the first coloniser was *F. sanihue* which first appeared on day 7 passed the onset of the B stage.

Based on the above results and despite overall differences in abundance between insolation conditions, *F. heydenii* showed a short residency time at the carcass coinciding with the stages with its maximum abundances: B and D stages. In addition, *F. sanihue* showed an association with certain stages although to a lesser degree than *F. heydenii*. This suggests that these two species may have preference for particular stages during decomposition what could make them good PMI indicators. Other abundant species such as *F. fusconotata* occurred throughout most of the decomposition process except for the F stage, indicating that it does not exhibit an association to any particular decomposition stage and may not constitute a potential PMI indicator. Thus, although these results constitute preliminary evidence, they suggest that

F. heydenii and *F. sanihue* could serve as a complementary PMI indicator and deserve further examination.

We have found Fanniidae larvae at the carcasses used in this study. However, due to cannibalisation by the Calliphorid *Chrysomya albiceps*, it was not possible to quantify them and breed them to adults (F.H. Aballay per. obs.). This is another reason why under circumstances such as this adults have the potential to be good PMI indicators, particularly when they provide information that complements data on other dominant fly species such as Sarcophagidae and Calliphoridae. In fact, Matuszewski et al. [25] consider the adults of *Fannia manicata*, a paleartic species, as of moderate usefulness as PMI estimator while their larvae are considered as of low usefulness, supporting the argument of the importance of adults as PMI indicators.

This is the first study to focus on Fanniidae as potential PMI indicators. Though preliminary, our results indicate that in this region the family Fanniidae could act as a good indicator of PMI in the winter season. In particular, this study highlights *F. heydenii* as focus species for further studies. Future studies should also include examination of carrion-related Fanniidae in the remaining seasons of the year. One of the attributes of this fly family, their comparatively small size, could allow them to penetrate spaces where the larger Calliphoridae and Sarcophagidae have limited access (Ref. [35], F.H. Aballay pers. obs.) and could be a good complement of data based on dominant fauna associated to carrion in semiarid regions, especially when corpses are found indoors.

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