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Synanthropy and Temporal Variability of Calliphoridae Living in Cosenza (Calabria, Southern Italy)

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ABSTRACT. The aim of this study was to investigate the synanthropy of Diptera: Calliphoridae, insects of forensic importance, in Calabria (southern Italy). The study lasted 2 years, from February 2010 to January 2012, and was carried out in three areas of Cosenza province representing “urban”, “rural”, and “wild” environments. Bottle traps baited with pork were used to catch Calliphoridae. Six species were identified, *Calliphora vicina* Robineau-Desvoidy 1830, *Calliphora vomitoria* (L.), *Chrysomya albiceps* (Wiedemann 1819), *Lucilia ampullacea* Villeneuve 1922, *Lucilia caesar* (L.), and *Lucilia sericata* (Meigen 1826). Data on phenologies in the study areas are reported for these species and the Synanthropy Index was calculated to evaluate their relationship with the human environment.

Key Words: Calliphoridae, synanthropy, habitat association, phenology, forensic entomology

Knowledge of the necrophagous species living in a particular geographical area is fundamental to forensic entomology. It is important to know the temporal distribution and habitat preferences of species active in the decomposition of human corpses (Smith 1986, Byrd and Castner 2010). Numerous studies have been carried out worldwide to identify the insect species involved in corpse decomposition and to record their ecology and behavior on the cadaver (Benecke 2001).

Diptera Calliphoridae are generally the most abundant insects in carion communities and they play an important role as Post Mortem Interval indicators in forensic entomology (Byrd and Castner 2010). Some blow fly species can breed on excrement or other types of organic matter and they can be vectors of animal and human diseases (Greenberg 1971, Mariluis et al. 1989, Fischer et al. 2001 in Centeno et al. 2004). Others can cause myiasis in animals and humans (Zumpt 1965, Hall and Wall 1995, Guimarães et al. 1983 in Centeno et al. 2004). Many insect species are associated with environmental conditions created by man (synanthropy) (Nuorteva 1963). As reported by Centeno et al. (2004), some species are more associated with human settlements (eusynanthropy), whereas others avoid them (asynanthropy) or live in ecotones or zones of transition (hemisynanthropy) (Nuorteva 1963, Linhares 1981, Schnack et al. 1995).

Habitat preferences of blow fly species and the structure of local communities may exhibit significant geographical variations (Nuorteva 1963, Mariluis et al. 2008, Hwang and Turner 2005). The species distribution is important because of human health influence and forensic importance (Centeno et al. 2004, Figueroa-Roa and Linhares 2004).

No information on Calliphoridae activity was available for Calabria, southern Italy, until the studies of Bonacci et al. (2010, 2011) with pig carcasses. Entomological evidences were reported for a human cadaver by Bonacci et al. (2009) in an urban habitat of Cosenza.

The aim of the present study was to investigate the synanthropy of Calliphoridae species living in Cosenza province and to acquire knowledge of their phenology in three different areas surrounding the city of Cosenza.

Materials and Methods

Study Areas. Sampling was carried out simultaneously in three areas with different ecological characteristics, a wild area, a rural area, and an

urban area, all located in Cosenza province. In total, 24 traps were used for the three sites.

The wild area is situated near San Fili village at an altitude of ~985 m asl. The geographical coordinates are 39° 19'12.37" N and 16° 6'45.86" E. The area is a woodland of *Fagus* spp. with dense cover in which there are no human settlements.

The rural area is represented by the Botanical Garden of the University of Cosenza situated at 216 m asl with geographical coordinates 39° 21'25" N and 16° 13'42" E. It is characterized by variable vegetation, mainly many fruit trees (*Olea europaea* and *Pyrus* spp.) and individuals of *Quercus virgiliana*, and little human interference.

The urban area extends between Rende and Cosenza, near the city center of Cosenza, situated at 181 m asl and with geographical coordinates 39° 20'42" N and 16° 14'33" E. It contains dense housing, many commercial activities and heavy traffic.

Sampling Method. A modified bottle trap (Hwang and Turner 2005) was used for fly trapping. The trap contained two small containers, one with 200 g of pork and the other with saline solution plus 200 g of meat in order to avoid rapid dehydration of the bait. Eight traps were used for each study area. The sampling started in February 2010 and ended in January 2012. Trap replacement occurred simultaneously every month at the three locations. The trends of mean temperature and rainfall during the study period were obtained from the ARPACAL meteorology site (<http://www.cfd.calabria.it/>).

At each trap replacement, the entomological material was sorted in the Laboratory of General and Forensic Entomology, University of Calabria. Adults were separated from larvae and stored according to the guidelines of Amendt et al. (2007). Adults were sorted by family and the Calliphoridae species were identified with the help of international identification keys (Rognes 1980, 1991, Wallman 2001, Whitworth 2006, Marshall et al. 2011).

The specimens were deposited in the Entomological Collection of the Department of Biology, Ecology and Earth Science, University of Calabria.

Data Analysis. The abundances of the sampled Calliphoridae were subjected to Pearson's Chi-square and the species distribution among the study areas was evaluated by a correspondence analysis (CA) performed with MVSP 3.1 Software (Kovach 1998). The

Synanthropy Index (SI) proposed by Nuorteva (1963) was calculated using the formula:

$$SI = \frac{(2a + b - 2c)}{2}$$

where: a is the percentage of individuals for a given species collected in the urban area; b is the percentage of individuals for a given species collected in the rural area; and c is the percentage of individuals for a given species collected in the wild area.

The SI ranges from +100 (species totally synanthropic) to -100 (species totally wild).

The phenology for each species in each area was evaluated in order to observe the differences among the species.

Results

Six Calliphoridae species were identified: *Calliphora vicina* Robineau-Desvoidy 1830; *Calliphora vomitoria* (L.); *Chrysomya albiceps* (Wiedemann 1819); *Lucilia ampullacea* Villeneuve, 1922; *Lucilia caesar* (L.); and *Lucilia sericata* (Meigen 1826). Table 1 shows the list of Calliphoridae captured and the percentages of adult abundances. The most representative species were: wild area, *C. vomitoria* 49.75%, *L. caesar* 28.31%, and *C. vicina* 21.69%; rural area, *L. caesar* 63.89% and *C. vicina* 17.36%; urban area, *C. vicina* 69.23%, *L. sericata* 14.10%, and *L. caesar* 13.37%. *Ch. albiceps* 1.79% and *L. ampullacea* 0.99% were collected in smaller numbers in the rural area.

Pearson's Chi-square revealed significant differences in abundance values (χ^2 -square = 7499.355; df = 10; $P < 0.0001$). The species with wide distribution were *C. vicina* and *L. caesar*, sampled in all three areas, whereas *C. vomitoria* was related to the wooded environment and very rare in the urban area. *Ch. albiceps* and *L. ampullacea* were related to the rural area, with low activity in the other areas. Finally, *L. sericata* was strongly related to the urban area, being absent in the wild area.

The CA confirmed the habitat-species associations (Fig. 1). Axis 1 explained 65.96% of the total variation, whereas axis 2 explained 34.04%; hence, only two axes were sufficient to explain the data variation. From this graph and Table 1, it can be observed that *L. sericata* and *C. vicina* were related to the urban area, *C. vomitoria* to the wild area, and *L. caesar*, *L. ampullacea*, and *Ch. albiceps* to the rural area.

The relationship between species and habitat was completed by the SI (Table 2). The SI value of *L. sericata* (+66.33) indicates that it prefers human environments even though it was caught mainly in the rural area (Kruskal-Wallis = 20.473; df = 2; $P < 0.000$); *C. vomitoria* was the wildest species (-77.22) and was caught mainly in the wild area (Kruskal-Wallis = 19.079; df = 2; $P < 0.000$). Because the other species (*C. vicina*, *L. caesar*, *Ch. albiceps*, *L. ampullacea*) had positive but low SI values (Table 1), they can be defined as hemisynanthropic.

Notes on Phenology. The phenology of the species differed among the three study areas (Fig. 2). The trends of mean temperature and rainfall during the study period were plotted for all three study areas (Fig. 3). The Calliphoridae species showed different abundances in the sampling months according to their phenology. The abundance values relative to the sampling date for each area had statistical significance (wild area, Pearson's $\chi^2 = 875.939$; df = 60; $P < 0.0001$; rural area, Pearson's $\chi^2 = 6959.667$; df = 100; $P < 0.0001$; urban area, Pearson's $\chi^2 = 937.976$; df = 100; $P < 0.0001$). *C. vicina* was active for almost the entire sampling period, except for the warmer months (from June to September) in the rural and urban areas and the cooler months in the wild area (from November to January). *C. vomitoria* was active in the wild area during spring and autumn and absent during the cold winter months. This species was almost absent in the urban and rural areas, but was captured during the cold months. *Ch. albiceps* was rare in the wild and urban areas, so its phenology was related to the rural environment where it was active in summer and autumn. The activity of *Lucilia* species was related to the warmer months. In fact, *L. ampullacea* was most active in the rural area from spring to autumn. The abundance of *L. caesar* peaked in the rural area from spring to autumn, while in the

Table 1. Relative abundance (%) of Calliphoridae species sampled in the three study areas in 2 years of sampling

Species	% Abundance		
	Urban area	Rural area	Wild area
<i>C. vicina</i>	69.23	17.36	21.69
<i>C. vomitoria</i>	0.53	2.39	49.75
<i>Ch. albiceps</i>	1.79	5.24	0.07
<i>L. ampullacea</i>	0.99	6.64	0.18
<i>L. caesar</i>	13.37	63.89	28.31
<i>L. sericata</i>	14.1	4.49	0

Table 2. Synanthropy Index calculated for each Calliphoridae species sampled in 2 years

Species	SI
<i>L. sericata</i>	+66.33
<i>Ch. albiceps</i>	+51.94
<i>L. ampullacea</i>	+50.00
<i>C. vicina</i>	+38.85
<i>L. caesar</i>	+35.23
<i>C. vomitoria</i>	-77.22

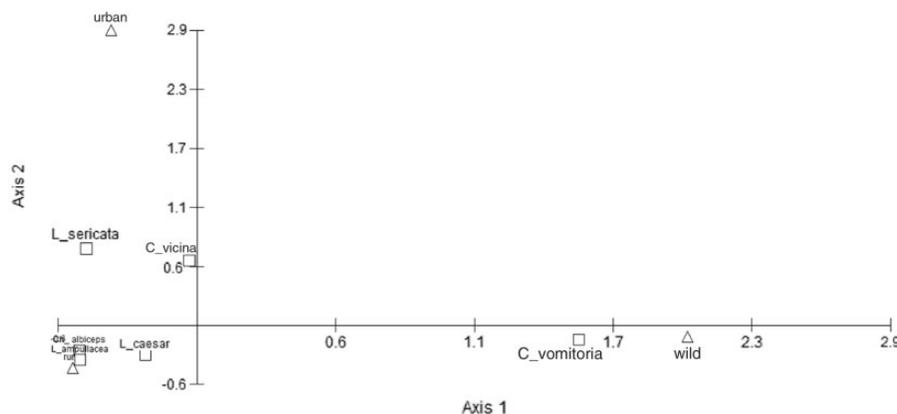


Fig. 1. The ordination diagram of CA of Calliphoridae species distribution along the three study areas.

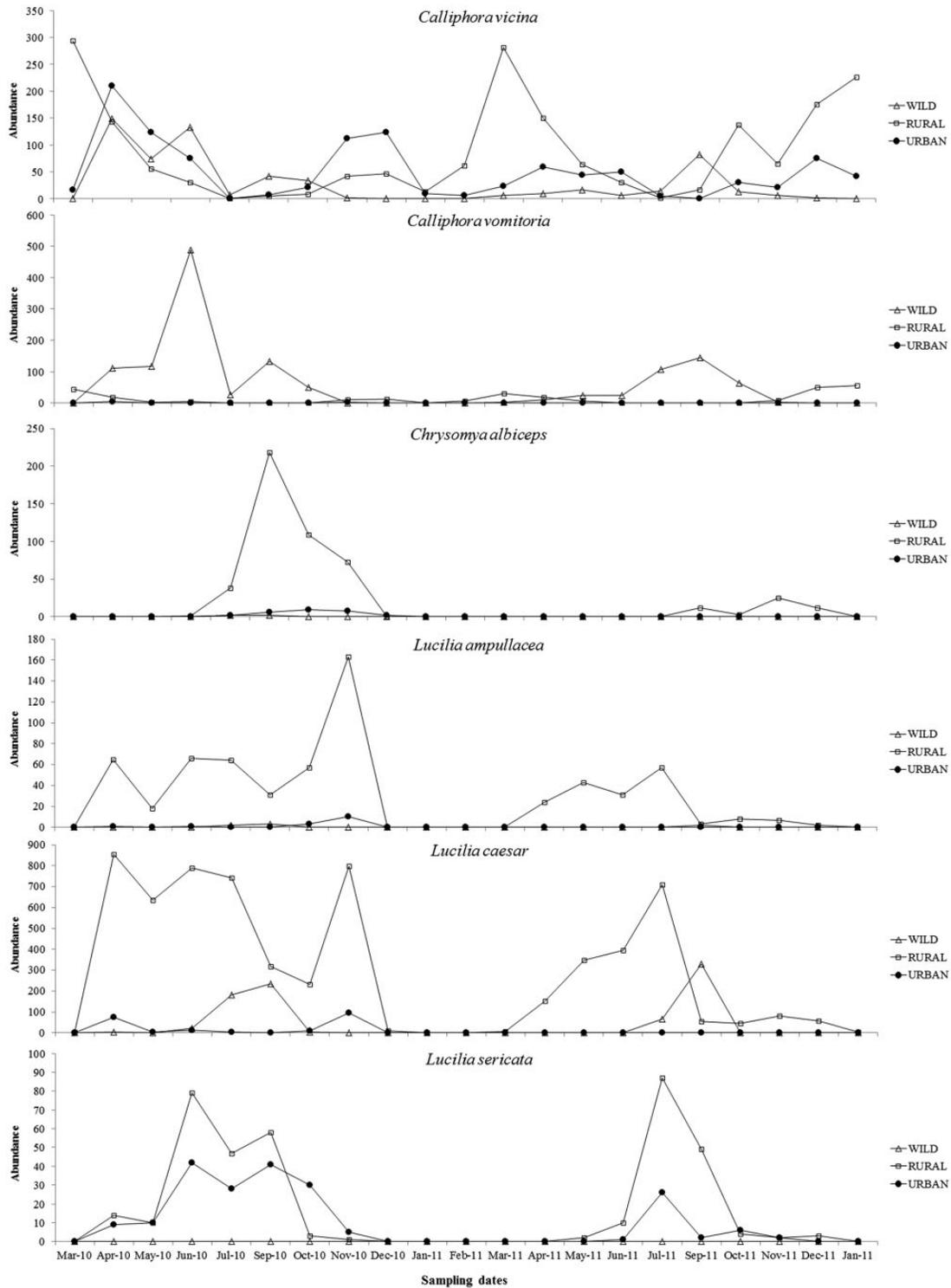


Fig. 2. Phenology of Calliphoridae species from February 2010 to January 2012. Vertical axis shows the number of individuals sampled each month.

wild area it was active only during summer and in the urban area its abundance was lowest during summer. *L. sericata* was totally absent in the wild area but showed the same phenology in the other two areas, being more active during summer.

Discussion

This article presents the first data on the distribution, synanthropy, and phenology of Calliphoridae species living in southern Italy. The

spatial distribution calculated with the CA showed the habitat preferences of the species, which were confirmed by the SI. According to the SI results, *L. sericata* is the most synanthropic species in Cosenza province, with a value of +66.33. This is in agreement with the results of other authors (Hwang and Turner 2005).

For most authors, *C. vicina* is defined as a eusynanthropic species because it is strongly related to human settlements. For example, a SI value of +55.2 was reported by Figueroa-Roa and Linhares (2002),

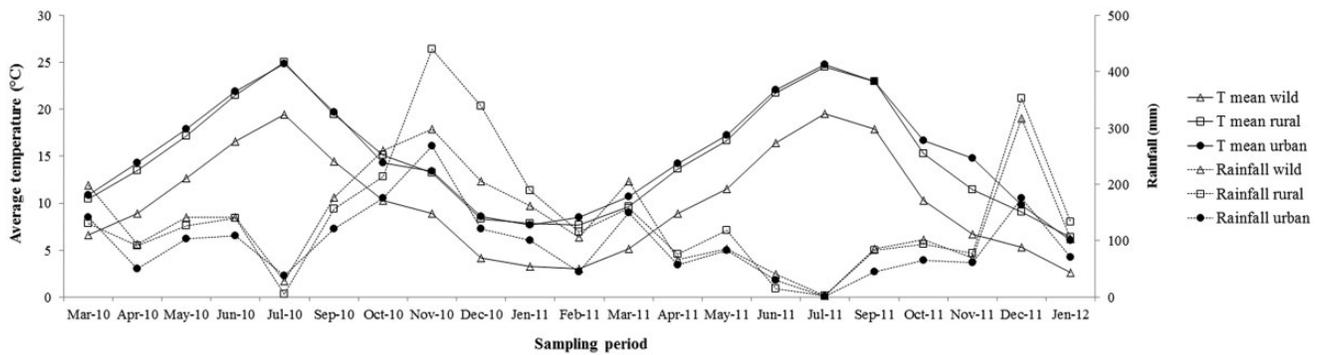


Fig. 3. Trend of average temperatures and rainfall in the three study areas during the sampling period.

+49.45 by Vianna et al. (1998), +72(± 25) by Patitucci et al. (2011), and +77.12 by Gabre and AbouZied (2003). The SI value of +38.85 found for *C. vicina* in our study suggests that it is not strongly influenced by human environments, in contrast to the reports by other authors. Most specimens were caught in the rural area (50.82%) rather than the urban one (31.31%). *L. caesar*, *Ch. albiceps*, and *L. ampullacea* showed medium SI values (+35.23, +51.94, +50.00, respectively) and according to Centeno et al. (2004) these species can be considered hemisynanthropic. Our values for these species are not very different from the results of other authors. However, *L. sericata* is often considered eusynanthropic, with several authors reporting high SI values such as +78.6 by Figueroa-Roa (2002), +49(± 37) by Patitucci et al. (2011), and +78.57 by Gabre and AbouZied (2003). Several authors also report that *L. sericata* is strongly related to human environments (Fischer 2000, Centeno et al. 2004, Schnack and Mariluis 2004, Hwang and Turner 2005).

L. caesar showed a preference for the wild and rural habitats, as confirmed by other authors (Hwang and Turner 2005, Baz et al. 2007). However, Fischer (2000) considered both *L. caesar* and *L. sericata* synanthropic, although *L. caesar* requires lower temperatures than *L. sericata*. *Ch. albiceps* and *L. ampullacea* were rare species during the sampling period, related mainly to the rural site. *C. vomitoria* represented the asynanthropic species with a value of -77.22 , as confirmed by the CA.

Our data on the phenology of the species show that *C. vicina* and *C. vomitoria* were caught more in the cooler months but their abundances were different according to their habitat preferences. As reported by Martinez-Sanchez et al. (2000), these species are considered thermophobic and adapted to relatively cold and wet habitats (Davies and Lawrence 1992 in Baz et al. 2007, Martin-Vega and Baz 2013). In our study, *C. vomitoria* was active for almost the entire sampling period in the wild area where the mean seasonal temperatures were lower than in the rural and urban areas. In a recent study, Martin-Vega and Baz (2013) reported that this species was not active during the cooler months and avoided habitats with high human activity.

Lucilia spp. and *Ch. albiceps* showed a thermophilic preference, in agreement with several authors (Hwang and Turner 2005, Baz et al. 2007, Martin-Vega and Baz 2013). The rarity of *Ch. albiceps* is interesting; usually, this species is more abundant during hot and dry seasons in other geographical areas (Martin-Vega and Baz 2013). Indeed this species was abundant during a summer study on a pig carcass carried out in the same rural area (Bonacci et al. 2010). In the present study, only a few individuals of *Ch. albiceps* were trapped during the sampling period.

A last consideration concerns the absence of *Lucilia illustris* (Meigen 1826), a species reported as a forensic indicator. This species is very abundant in the northern and southern Alps (Meoli et al. 2004) but was not found in our study, probably due to the species' climatic preferences. Calabria has a Mediterranean climate, whereas northern Italy has a temperate-continental climate. Thus these climatic differences could explain the present distribution of the species.

In conclusion, we obtained the first data on the ecology and synanthropy of Calliphoridae in Calabria. As reported by Greenberg (1973), synanthropic species are the most dangerous because they may contaminate fruit or other human food with the causative agents of many diseases. Moreover, they can cause myiasis and play the role of vectors for several parasites. Hence, these species are of great health importance and more attention should be paid to their control in human settlements.

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