

# Dynamics of *Ctenocephalides felis felis* (Siphonaptera: Pulicidae) Infestations on Urban Dogs in Southeastern Brazil

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**ABSTRACT** The cat flea, *Ctenocephalides felis felis* (Bouché, 1835), is an important ectoparasite of dogs and cats throughout the world, causing annoyance to the animals and acting as a vector of infections and a cause of allergic dermatitis in dogs and cats. Although climatic variability and seasonality are known to influence the diversity and abundance of fleas, few investigations of seasonal prevalence of cat flea infestation have involved the same group of dogs being examined regularly over an extended period. The aim of this study was to determine the effects of temperature, rainfall, and relative humidity on the infestation by *C. felis felis* on 88 outdoor dogs in southeastern Brazil. The dogs, which were of mixed breed, sex, and age, were examined for ectoparasites every month during the period August 2011 to July 2012, and samples of fleas were randomly collected and identified. Meteorological data, comprising mean temperature, total rainfall, and mean relative humidity, were recorded for the calendar month prior to that in which the examinations were performed. Dogs were found to be infested only with *C. felis felis*, with a higher prevalence in the months with lowest rainfall (July, August, and September). The data obtained in this investigation can be used in control programs in order to establish an efficient strategy for environmental management and the application of insecticides, particularly during the driest months of the year based on the seasonal pattern of infestation of dogs by *C. felis felis*.

**KEY WORDS** *Ctenocephalides felis felis*, infestation, seasonality, dog

The cat flea, *Ctenocephalides felis felis* (Bouché 1835), is the main flea species to infest dogs, causing annoyance to the animals and acting as a vector of infections and a cause of allergic dermatitis in dogs and cats (Rust and Dryden 1997, Blagburn and Dryden 2009). Furthermore, *C. felis felis* can act as a reservoir and potential vector for a variety of pathogens including species of *Bartonella* and *Rickettsia*, the causative agents of bartonellosis and rickettsiosis in both man and animals (Bitam et al. 2010, McElroy et al. 2010). Of particular concern is the recent suggestion that the ectoparasite may be a mechanical vector of *Leishmania* spp., potentially presenting an alternative route for the transmission of the protozoa between dogs (Paz et al. 2010, 2013).

Infestation rates of dogs and cats by *C. felis felis* appear to vary widely. In Brazil, for example, epidemiological surveys carried out in different regions of the

country established prevalence rates ranging from 3.7 to 100% (Linardi and Guimarães 2000, Linardi and Santos 2012). However, only a few studies have focused on the factors that influence the seasonal occurrence of *C. felis felis* in Brazil (Oliveira and Ribeiro 1982/1983, Costa-Junior et al. 2012).

In order to optimize the temporal patterns of control of *C. felis felis* in domestic animals, a better understanding of the factors that influence the levels of infestation of the parasite is required. The aim of the study was to determine the climatic influences, in terms of temperature, relative humidity, and rainfall, on the population of cat fleas collected from a single group of dogs during different seasons. It was anticipated that the data relating to the seasonal pattern of infestation obtained in this study could be employed in establishing a more efficient strategy for the application of insecticide.

## Materials and Methods

The study was submitted to and approved by the Ethics Committee for Research with Animals of the Oswaldo Cruz Foundation (CEUA/Fiocruz) under protocol number LW-76/12. All procedures involving experimental animals were conducted according to the guidelines of the Brazilian College for Experiments with Animals (Colégio Brasileiro de Experimentação Animal/COBEA).

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The study area was in the district of Belo Horizonte, Minas Gerais, Brazil (latitude: 19° 55'15" S; longitude: 43° 56'16" W). This area was selected on the basis of environmental and socio-economical characteristics (Buss and Pelegrini 2007), and comprised a relatively flat, densely populated urban district containing predominantly one- or two-story buildings with woody vegetation between the plots (Fig. 1).

The canine study group consisted of 88 domestic dogs as determined by the canine census (according to the local health department). The animals were distributed within 68 households, 52 of which had only one dog, 12 had two dogs, and four had three dogs. Dog owners were interviewed using a questionnaire with questions covering sex, age, breed, if their dogs live outdoors or indoors, and the use of any type of flea control product.

Dogs were inspected monthly during the period August 2011 to July 2012 for the presence of fleas on the muzzle and cheek, ears, neck, back and flanks, belly, under the chest, and within the paws, especially in the spaces between the toes. Each dog was inspected for at least 5 min by one technician. During the inspection,

fleas were collected manually and transferred to tubes containing 70% ethanol for identification using appropriate taxonomic keys (Linardi and Guimarães 2000). The degree of infestation of each animal was scored as follows: 0, no infestation; 1, light/mild (1–3 fleas); 2, moderate (4–10 fleas); and 3, severe (>10 fleas; Costa-Junior et al. 2012). An index of infestation for each month was determined as the weighted mean of the infestation scores using the number of dogs in each infestation level as the weight.

The prevalence of infestation was assessed according to the season in which inspections were conducted, namely, winter (July, August, and September), spring (October, November, and December), summer (January, February, and March), and autumn (April, May, and June). Dogs were considered infested if adult fleas were detected during an examination. Prevalence values were compared using the McNemar  $\chi^2$  test for dependent samples in which the four seasons were taken in pairs (6 tests), coupled with the Bonferroni correction in which the significance level of each individual test was set at 0.008 (0.05 /6) to give an overall level of significance equivalent to 0.05.



**Fig. 1.** Picture of a typical domicile environment comprised a relatively flat, densely populated urban district containing predominantly one- or two-story buildings with woody vegetation between the plots.

Meteorological data comprised mean temperature (°C), total rainfall (mm), and mean relative humidity of the air (percentage) recorded for the calendar month prior to that in which the examinations were performed. Data were collected daily at the local meteorological station of the Instituto Nacional de Meteorología located 7 km from the study site. In order to evaluate potential relationships between the time series relating to infestation indices and meteorological data, cross correlation coefficients and 95% confidence intervals were estimated (Box and Jenkins 2008).

Results

Not all of the dogs could be assessed because either the owners refused to participate in the study or the residence was closed at the time of the study (Table 1).

Table 1. Prevalence of infestation of dogs by *C. felis felis* distributed according to season

| Season              | No. of dogs examined every month during the season | No. of dogs classified as infested | Prevalence of infestation (%) <sup>a</sup> |
|---------------------|----------------------------------------------------|------------------------------------|--------------------------------------------|
| Winter (July–Sept.) | 47                                                 | 26                                 | 55.31B                                     |
| Spring (Oct.–Dec.)  | 71                                                 | 38                                 | 53.52B                                     |
| Summer (Jan.–Mar.)  | 65                                                 | 18                                 | 27.69A                                     |
| Autumn (April–June) | 55                                                 | 20                                 | 36.36A,B                                   |

<sup>a</sup> Prevalence values bearing dissimilar upper case letters are significantly different ( $P < 0.005$ ) according to McNemar  $\chi^2$  test.

The studied dog population consisted of 38 (43.2%) males and 50 (56.8%) females, and the average age was  $5.8 \pm 1.1$  years (range 3 mo to 17 yr). The breeds included in the population were mongrels (53.1%), poodles (24.0%), pinschers (8.3%), Yorkshire terriers (3.1%), boxers, cocker spaniels, labradors and German sheppards (8.4%), and others (3.1%). All the dogs lived outdoors in a backyard, pen, on a balcony, loose or chained with collars (Fig. 2). None of the dogs were being treated with flea control products.

A total of 161 flea specimens were collected during the monthly examinations of the dogs. All specimens were identified as *C. felis felis* and the female-to-male ratio of the parasites was 1.73:1. The proportion of dogs presenting some degree of infestation with *C. felis felis* at monthly examination ranged between 13.1 and 43.7%, with the higher levels of infestation occurring during the winter months (July to September).

Figure 3 shows infestation indices from August 2011 to July 2012 plotted against monthly meteorological data (mean temperature, monthly rainfall, and mean relative humidity). Analysis of the cross correlation coefficients revealed a significant ( $P < 0.05$ ) negative correlation of  $-0.570$  between the infestation index and the rainfall time series and of  $-0.699$  between the infestation index and the relative humidity time series, with both when the series have a time lag of two months between them. Thus, when rainfall or relative humidity began to increase, the infestation index three



Fig. 2. Four dogs living outdoors in the study area.

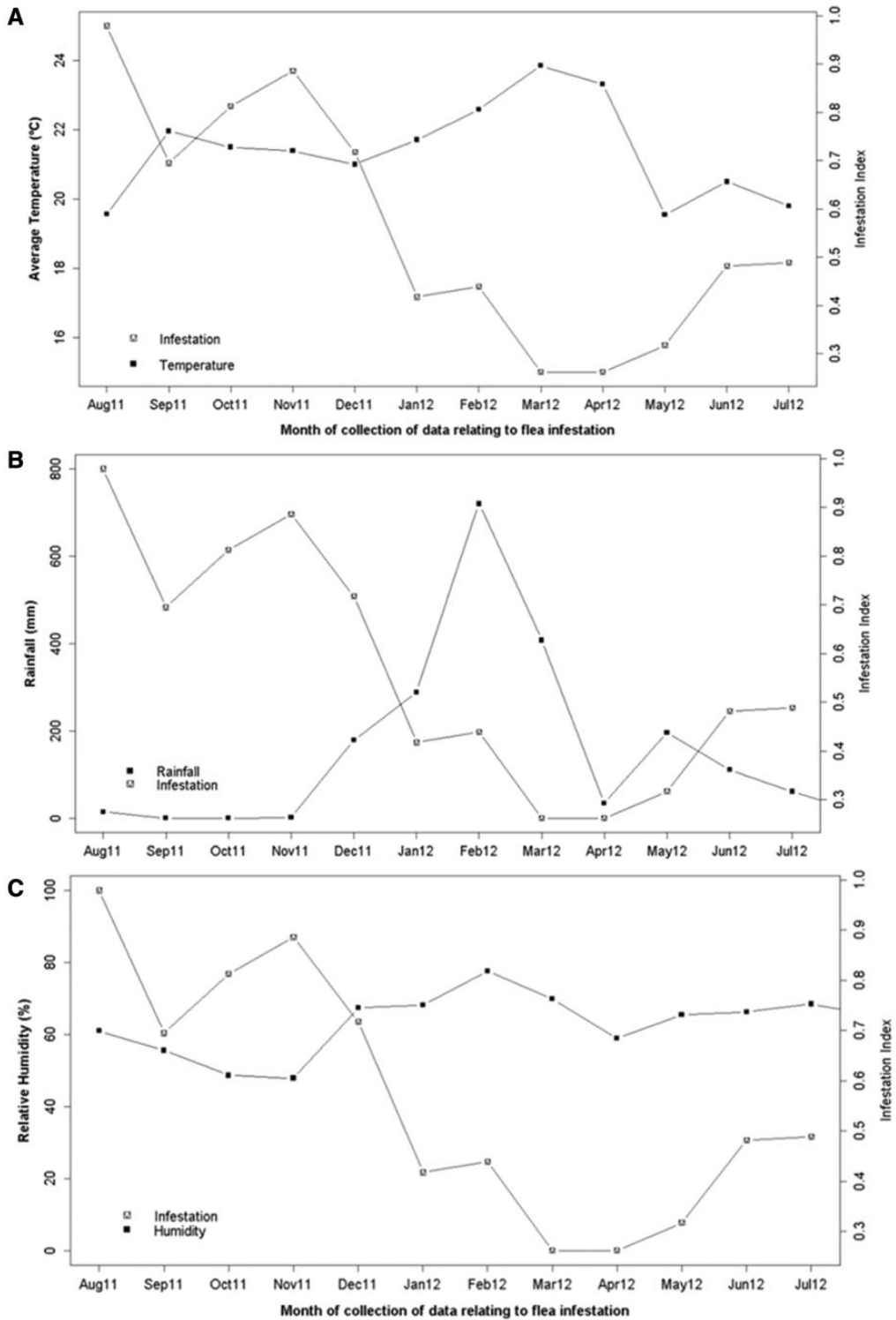


**Fig. 3.** Time series of index of infestation of dogs by *C. felis felis* together with (A) mean temperature (°C), (B) total rainfall (mm), and (C) mean relative humidity of the air (%) recorded monthly in Belo Horizonte, Minas Gerais, Brazil. In all cases, meteorological data were collected 1 mo prior to the corresponding collection of infestation data.

months ahead tended to decrease. In contrast, no statistically significant relationship could be established between the infestation index and the temperature time series.

The prevalence of infestation as a function of season was determined from data collected from all dogs that had been examined every month during the study period, and the results are presented in Table 1. Significant differences were observed between prevalences during winter and summer months ( $P = 0.003283$ ) and between spring and summer months ( $P = 0.00225$ ).

## Discussion

The total predominance of *C. felis felis* on dogs examined in the present study was expected since this species is the most prevalent in domestic dogs in Brazil (Costa et al. 1990, Rodrigues et al. 2001, Castro and Rafael 2006, Dantas-Torres et al. 2009, Costa-Junior et al. 2012, Linardi and Santos 2012), and is the only species to have been identified in previous surveys of fleas on dogs in Belo Horizonte (Costa et al. 1962, Linardi and Nagem 1973).

Among the specimens of *C. felis felis* collected in the present study, females outnumbered males by 1.73 to 1. This finding is consistent in general terms with the data presented by other authors, although the ratio established here differs somewhat from those of 3.73:1 (Rodrigues et al. 2001), 3:1 (Linardi and Nagem 1973), and 2.6:1 (Costa-Junior et al. 2012).

In the present study, all the dogs lived outdoors. According to Beugnet et al. (2004), the environmental conditions in yards and dwellings are important to the development of *C. felis felis*. Possibly because of the inability of the immature stages, particularly the larvae, to withstand extreme changes in temperature and humidity or from a failure of eggs to be deposited in favorable microhabitats, *C. felis* has adapted by having a large reproductive capacity. If host grooming activity is restricted, females are capable of producing 40–50 eggs per day during peak egg production, averaging 27 eggs per day through 50 d, and can continue to produce eggs for over 100 d (Dryden et al. 1989). The majority of eggs are laid during the last 8 h of scotophase (Rust, 1992). In the outdoor environment, most larval activity is likely restricted to the upper few millimeters of soil. Kern (1991) reported that in one experimental system, larvae burrowed an average of 2.36 mm into sand and reached a maximum depth of 7.5 mm. Excessive moisture at 95% and 100% RH promoted mold growth and totally inhibited larval development (Dryden and Rust 1994). It is likely that the mechanical action of rain is responsible for the elimination of free-living stages of *C. felis felis*, thereby reducing the number of eggs and larvae, and favoring higher rates of infestation in dry periods (Linardi and Guimarães 2000).

Few investigations of the seasonal prevalence of cat flea infestation have been conducted in which the same dogs were examined over yearly periods (Costa-Junior et al. 2012). In the present study, infestation by *C. felis felis* on the same population of dogs was assessed

throughout an entire year, and the highest indices of infestation were observed in the dry season.

The absence of a significant correlation between infestation index and temperature may reflect the small variation (range 19 and 24°C) in monthly mean temperatures during the dry and rainy seasons in Belo Horizonte through the period of study.

In temperate regions of the northern hemisphere, outdoor weather conditions favor the development of flea populations more in summer and autumn than in the cooler seasons of winter and spring (Rust and Dryden 1997). In Brazil, the seasonal profiles of infestation by *C. felis felis* show differences related to the climatic characteristics of the regions analyzed. Thus, in the city of Porto Alegre, Rio Grande do Sul, higher rates of infestation were observed in the summer months of December and January (Oliveira and Ribeiro 1982/1983). Considering that the climate of this region is of the humid temperate type with a rainy winter, the infestation levels correlate negatively with rainfall, as in the present study. Similarly, Costa-Junior et al. (2012) reported that dogs in the city of Nanuque, Minas Gerais, presented higher infestation indices in the dry season, while those in Lavras, a city in the same state, showed higher levels during the rainy season. The discrepancy between the two cities reported by Costa-Junior et al. (2012) may be explained by the differential environmental factors, mainly the microclimate of the study sites. Evaluation of infestation was carried out in animals living in two different rural areas without assessing the specific correlation between climatic factors and infestation in such study areas. In contrast, the present study evaluated not only the presence of infestation in dogs living in a defined homogenous urban area, but also assessed the correlation between the climatic data collected daily by a station close to the study site with the monthly infestation data.

*C. felis felis* is an important ectoparasite of dogs and cats producing direct harm to the animals such as itching and scratching, scabs, hair loss, allergic reactions, and secondary infections by pathogenic fungi and bacteria. Furthermore, this parasite has been considered a mechanical vector of *Leishmania* spp. and implicated in the transmission of leishmaniasis among urban dogs (Paz et al. 2010, 2013), which is largely favored in the driest months of the year when the natural vector (phlebotomine sandfly) diminishes in density or disappears.

The data obtained in this investigation can be used in control programs in order to establish an efficient strategy for environmental management and the application of insecticides, particularly during the driest months of year, based on the seasonal pattern of infestation of dogs by *C. felis felis*.

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