# Fecundity, body size and population dynamics of *Chrysomya albiceps* (Wiedemann, 1819) (Diptera: Calliphoridae)

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(With 6 figures)

## Abstract

In this study, the seasonal variation of fecundity, wing and tibia length were investigated in natural populations of *Chrysomya albiceps* (Wiedemann, 1819) in an attempt to determine the changes in life history of the species as a function of seasonality. A relative constant temporal trajectory was found for fecundity, wing and tibia length over twenty-four months. Positive correlations between fecundity and wing size, fecundity and tibia size and wing and tibia sizes were observed. The implications of these results for population dynamics of *C. albiceps* are discussed.

*Keywords:* Calliphoridae, fecundity, population dynamics, *Chrysomya albiceps.*

## Fecundidade, tamanho corpóreo e dinâmica populacional de *Chrysomya albiceps* (Wiedemann) (Diptera: Calliphoridae)

## Resumo

Neste estudo, a variação sazonal da fecundidade, comprimentos de asa e tíbia foram investigadas em populações naturais de *Chrysomya albiceps* (Wiedemann, 1819) como uma forma de determinar as variações bionômicas da espécie em função da sazonalidade. Uma trajetória temporal constante foi encontrada para fecundidade, comprimentos de asa e tíbia durante vinte e quatro meses. Correlações positivas entre fecundidade e comprimento de asa, fecundidade e comprimento de tíbia e comprimentos de asa e tíbia foram observadas. As implicações destes resultados para a dinâmica populacional de *C. albiceps* foram discutidas.

*Palavras-chave:* Calliphoridae, fecundidade, dinâmica de populações, *Chrysomya albiceps.*

## 1. Introduction

*Chrysomya albiceps* (Wiedemann, 1819) is a blowfly originary from the Southern Palaeartic Region, North Africa Eastwards to Northwest India, throughout Africa, including Afrotropical Islands of Aldabra, Cape Verde, Madagascar, Mauritius, Réunion, Rodriguez, St. Helena, Seychelles and Socotra (Zumpt, 1965; Baumgartner and Grennberg, 1984; Smith, 1986). This species was found in South America around 1975, together with two other species, *C. putoria* (Wiedemann, 1830) and *C. megacephala* (Fabricius, 1794). These species rapidly dispersed throughout the continent, with *C. megacephala* reaching the United States (Greenberg, 1988; Wells, 1991).

The *Chrysomya* invasion has apparently caused the displacement of *Cochliomyia macellaria* (Fabricius, 1775), a species native to the Americas (Guimarães et al., 1979; Prado and Guimarães, 1982; Greenberg and Szyska, 1984). *Chrysomya albiceps* is a facultative predator during larval stage, and some investigations have suggested that it has a stronger impact than other blowfly species , attacking third instar larvae of *Cochliomyia macellaria* (Faria et al., 1999; Faria and Godoy, 2001). Besides being a predator, *C. albiceps* also acts as a cannibal through the larval stage (Ullyett, 1950; Faria et al., 2004a).

Exotic species introduction, such as the one which occurred with *C. albiceps*, frequently produce complex interactions at the ecological and genetic levels (Pimentel, 1993; Brown, 1993). Among the main biological factors, dynamic behaviour is an important component for the assessment of relevant demographic aspects concerning biological invasions (Hengeveld, 1989). However, dynamic behavior usually depends on factors associated to demography, such as growth rate and carrying capacity (Hengeveld, 1989; Lande, 1993; Uchmanski, 1999). The values of demographic parameters associated with population growth may exhibit high variation among different species and populations (Gotelli, 1995). The causes of variation are usually diverse and depend on the environment and/or biological attributes of each organism (Brewer, 1994).

Among the biological parameters directly associated to growth rate in blowflies, fecundity plays an important role in population persistence since it determines the population growth potential (Von Zuben et al., 1993; Reis et al., 1996; Godoy et al., 1996). Studies focusing on dynamic behavior of blowflies analysed by mathematical models have revealed that the stability of population equilibrium depends essentially on survival and fecundity (Godoy et al., 1996; Reis et al., 1996; Teixeira et al., 1998). Using bifurcation theory to perform a parametric sensitivity analysis, Godoy et al. (1996) observed that the variation of fecundity and survival produces qualitative changes in the population dynamics of *C. macellaria*, *C. megacephala* and *C. putoria*. The three species exhibited changes from stable equilibrium to a two-point limit cycle (Godoy et al., 1996). However, the increase of fecundity values in *C. megacephala* promoted successive changes in dynamics behavior, starting with two-point limit cycle, going through four-point limit cycle and then reaching chaos (Godoy et al., 1996). The values used in these simulations are apparently real in natural populations (Ullyett, 1950); nevertheless, nothing is known about the seasonal variations in fecundity and other biological characteristics such as the body size of *C. albiceps* natural populations.

Fecundity, survival, developmental rate, weight and body size are generally density-dependent characters influenced by environmental factors in insect populations (Bryant, 1977; Reis et al., 1994; Ribeiro et al., 1995; James and Partridge, 1998; Rosa et al., 2004). Thus, it is important to design studies focusing on the association between bionomics and seasonality, since competitive ability has been considered different among species and populations (Ribeiro et al., 1995; Partridge et al., 1994; James and Partrigde, 1998; Reis et al., 1999).

In the present study we analyzed the seasonal variation of fecundity, wing and tibia length in natural populations of *C. albiceps*. The seasonal influence of life history parameters has been frequently studied in insects, showing a strong association between environmental variables and their effects on demography and body size in several taxonomic groups (Reigada and Godoy, 2005). *Chrysomya albiceps* is a species which has different characteristics if compared to other blowfly species, principally in terms of larval behavior. In blowflies, the larval stage is the most important life phase because its performance in nutritional terms can be reflected in adulthood since the interactive processes that occurred during the immature stage may be determined by exploitative larval competition (Rosa et al., 2004). The result of this can significantly influence the magnitude of parameter values, with consequences for population dynamics of the species, especially if facultative predation by an intraguild predator is taken into account, as happens with *C. albiceps.* Thus, the examination of the seasonal effects on its fecundity as well as body size can bring important informations about its dynamics, permitting comparisons with recent results of investigations of this nature focused on non predator species, such as the recent study carried out by Reigada and Godoy (2005) in *C. megacephala*.

The objective of this study then was to investigate the seasonality of fecundity and body size expressed by the wing and tibia length during two years, as an attempt to understand the population dynamic of *C. albiceps.*

## 2. Material and Methods

Specimens of *C. albiceps* were collected monthly from April (2002) to March (2004) in the vicinities of the campus of São Paulo State University in Botucatu, São Paulo, Brazil. A total of 300 blowfly females were collected over the investigated period. Adult flies were maintained under laboratory conditions in cages (30 cm x 30 cm x 30 cm) at 25 ± 1 °C and fed water and sugar ad libitum. Adult females were fed fresh liver to permit complete development of the gonotrophic cycle (Linhares, 1988). Females were dissected and the number of eggs was recorded. Body size was estimated by measuring right wing and tibia length of the flies. Seasonal fecundity and wing and tibia length were compared by one-way ANOVA. Pearson's coefficient was used to analyse the correlation between life-history parameters. Mean monthly temperatures for Botucatu area were obtained from Meteorological Station of São Paulo State University in Botucatu, São Paulo, Brazil.

## 3. Results and Discussion

*Chrysomya albiceps* exhibited a relatively stable temporal trajectory for fecundity, wing and tibia length during twenty four months (Figures 1-3). Correlations between fecundity and temperature, wing length and temperature, and tibia length and temperature were non-significant. A moderate positive correlation between wing length and fecundity ($r = 0.56$, $p < 0.05$), and tibia length and fecundity ($r = 0.55$, $p < 0.05$) was also detected (Figures 4, 5). The analysis of correlation between wing and tibia lengths (Figures 6) showed a strong positive correlation between the two variables ($r = 0.67$, $p < 0.05$). These two variables are generally well correlated in flies (Reigada and Godoy, 2005). However, in certain taxonomic groups the wing size investment can be higher in response to flight requirement or sexual selection (Reis et al., 1994; Hasson and Rossler, 2002).

The weak oscillations found for fecundity, wing and tibia length indicate that the three characteristics were maintained relatively constant over the two years, suggesting practically no impact of the seasonality on these variables. Considering the usual strong correlation between body size and fecundity found in most Diptera (So and Dudgeon, 1989a,b; Armbruster and Hutchinson, 2002; Bochdanovits and De Jong, 2003), the results obtained in this study are surprising, since the correlations were moderate, but perhaps stem from rather restricted variation in body size in this tropical location.

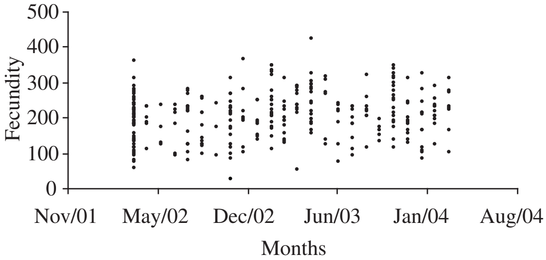


**Figure 1.** Seasonal variation of fecundity in *Chrysomya albiceps.*

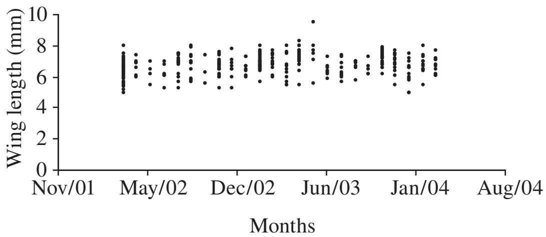


**Figure 2.** Seasonal variation of wing length in *Chrysomya albiceps.*

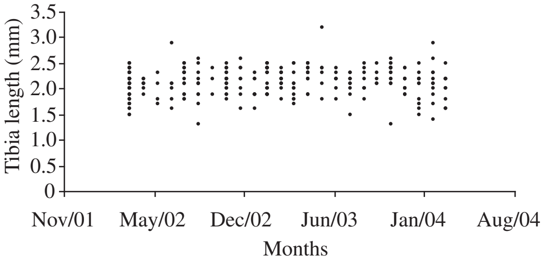


**Figure 3.** Seasonal variation of tibia length in *Chrysomya albiceps.*

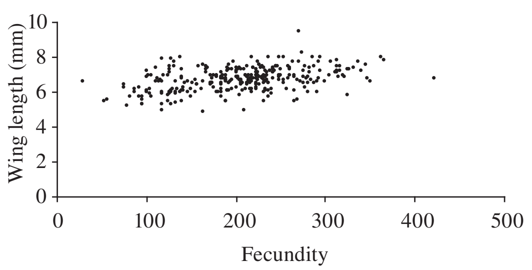


**Figure 4.** Correlation between wing length and fecundity.

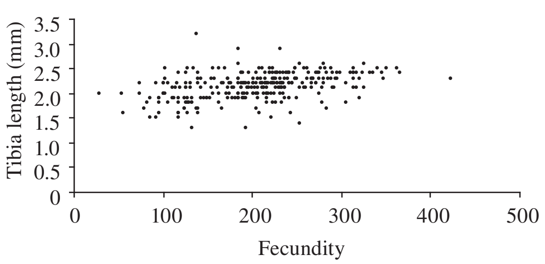


**Figure 5.** Correlation between tibia length and fecundity.

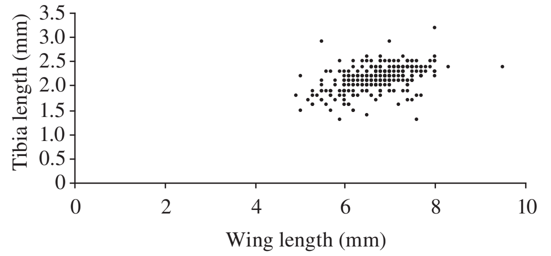


**Figure 6.** Correlation between wing and tibia length.

Seasonal fluctuations in the physical environment may affect the resource base, which the organisms use to feed from (Hannon and Ruth, 1997). The temporal oscillations in blowflies have been studied frequently to analyze the association between environmental seasonal factors and abundance of adults (Linhares, 1981; Mendes and Linhares, 1993; Schnack and Mariluis, 1995; Wall et al., 2001).

Among all environmental factors, temperature has been considered essential as it can directly influence the population dynamics of insects, such as the population growth of *M. domestica*, particularly in equatorial and tropical zones, where there are high densities of this species (Levine and Levine, 1991). The effects of temperature on the development and survival of insects have been extensively investigated (Roy et. al., 1991; Gilbert and Raworth, 2000; Bhattacharya and Banerjee, 2001; Nteletsana et al., 2001; Thind and Dunn, 2002). The rates of physiological processes are strongly influenced by body temperature (Hochachka and Somero, 1984; Prosser, 1986) as thermal sensitivity can profoundly affect the behaviour, ecology and evolution of ectotherms (Heinrich, 1981; Huey, 1982).

Although some studies have been designed to investigate population behavior in response to temperature, they have focused specifically on geographic variation, genetic divergence and natural selection, considering adult census (Anderson, 1972; Huey et al., 1991; Partridge et al., 1994; Santos et al., 1997), differently from the present investigation, which focused on the census of life-history characteristics. It is possible that in other blowfly species, the temperature affected much more the abundance of adult populations than was observed in this study. Even focusing on adults, significant differences have been found among the principal Calliphoridae species, for example, *Lucilia eximia* (Wiedemann, 1819) that apparently is able to maintain a more stable population size that other calliphorid species, when facing environmental disturbances (Linhares,1981; Moura et al., 1997).

Perhaps from the results found in this investigation two important questions could emerge. Do the Brazilian environmental conditions induce the life-history values to exhibit this result? What influences on life history would be expected in *C. albiceps* origin regions? The results observed in this study showed that the fecundity is maintained relatively constant during 24 months, in spite of its spectrum of variability. However, the number of eggs found over the period analyzed was slightly higher than *C. megacephala*, another species with fecundity recently censused (Reigada and Godoy, 2005). This result indicates quantitative differences in spite of the similar pattern population dynamics found for the two species. In addition, the comparison of the seasonal fecundity obtained in this investigation with the results observed by Reigada and Godoy (2005), indicates a difference in terms of variability of the fecundity between the two species. *Chrysomya albiceps* exhibited fecundity values that oscillated approximately between 30 and 400, against the values observed in *C. megacephala*, which oscillated between 130 to 270 (Reigada and Godoy, 2005).

We believe that the higher variability detected in *C. albiceps* could be attributed to the facultative larval predation, since the gain obtained consuming prey is occasional, leading the predator to eventually convert prey into offspring. It is possible that the apparent difference may be due to alternative food sources of *C. albiceps* as both intraguild predator and cannibal; behaviors, which seem important in terms of nutritional ecology and population dynamics (Polis et al., 1989; Faria et al., 1999, 2004b; Rosa et al., 2004).

In conclusion, in spite of the environmental condition producing some influence on the fecundity of *C. albiceps*, the interspecific interactions probably interfere more expressively on this demographic parameter. *Chrysomya albiceps* is currently one of the most abundant blowfly species in Brazil and we believe that the present results explain at least in part the success of the species following the occurrence of the biological invasion.

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