ACTA
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The influence of climatic parameters in the haematophagic daily activity of *Cerqueirellum argentiscutum* (Shelley & Luna Dias) (Diptera: Simuliidae) in Amazonas, Brazil

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ABSTRACT

We studied the influence of climatic parameters in the daily haematophagic activity of *Cerqueirellum argentiscutum* from September/ 1999 to August/2000. The bite activity observed was different according to the annual rain precipitation (dry and rainy seasons). Humidity and temperature were the factors that most influenced it in both periods. During the dry season, it was greater in the beginning of the morning, showing a positive association with the humidity. However, during the rainy season, it was negatively related to that same factor. When wind speed was higher than 10 $Km.h^{-1}$, it was reduced abruptly. Light intensity, atmospheric pressure and cloudiness seemed to act as secondary factors in the daily abundance of *C. argentiscutum*.

KEY WORDS

Simuliidae, *Cerqueirellum argentiscutum*, climatic parameters, Amazonas, Brazil.

Influência de parâmetros climáticos na atividade hematofágica diária de Cerqueirellum argentiscutum *(Shelley & Luna Dias) (Diptera: Simuliidae) no Amazonas, Brasil*

RESUMO

Foi estudada a influência dos parâmetros climáticos na atividade hematofágica diária de *Cerqueirellum argentiscutum* durante setembro/ 1999 a agosto/2000. Foi observado que a atividade foi diferente conforme as estações (seca e chuvosa). A umidade e a temperatura foram os fatores que mais influenciaram na atividade em ambas as estações. Na estação seca foi maior no início da manhã apresentando uma associação positiva com a umidade. Porém na estação chuvosa se mostrou negativamente relacionada com este mesmo fator. Quando a velocidade do vento foi superior a 10 $Km.h^{-1}$ diminuiu bruscamente. A luminosidade, pressão atmosférica e nebulosidade parecem atuar como fatores secundários na abundância diária de *C. argentiscutum*.

PALAVRAS-CHAVE

Simuliidae, *Cerqueirellum argentiscutum*, parâmetros meteorológicos, Amazonas, Brasil.

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INTRODUCTION

Cerqueirellum argentiscutum (Shelley & Luna Dias) is one of the species involved in the transmission of *Mansonella ozzardi* (Manson) in Brazil (Shelley *et al*., 1980; Medeiros & Py-Daniel, 2004). This species is essentially associated with the big rivers in the Amazon basin, commonly found in the states of Amazonas, Acre and Rondônia; and also in the neighboring countries: Colombia, Bolivia and Peru. The only occurrence in Brazil outside the Amazon region is in the state of Bahia (Shelley & Luna Dias, 1980; Py-Daniel, 1983).

Few studies have been undertaken with *C. argentiscutum* in Brazil, and the only long duration studies are those of Medeiros & Py-Daniel (2002; 2003; 2004), which observed aspects of the daily haematophagic activity, seasonality, and transmission levels of *M. ozzardi* for a period of a year. However there is little important information about this vector's biological aspects. An understanding of the factors that limit this vector's activity could generate useful information for controlling its populations.

Haematophagic activity of simuliids, or biting activity (or simply activity), seems to be influenced by local climatic factors. According to Lacey & Charlwood (1980), some factors act as a block, creating favorable terms for the bite stimulus in the morning or evening period. Simuliids initiate their activity in the first hours of the morning, stimulated by luminosity (Peterson & Wolfe, 1956).

The object of this study is to verify the influence of some climatic parameters in the haematophagic daily activity of *C. argentiscutum* in the dry and rainy periods.

MATERIAL AND METHODS

STUDY AREA

This study was conducted from September 1999 to August 2000, in the community of Porto do Japão (3º34'S/61º09'W), located on the left margin of the lower Solimões River, in the State of Amazonas, Brazil.

THE PROCEDURE TO CAPTURE THE SIMULIIDS

Collections were made during four consecutive days of each month, beginning at 6:00am until 06:15pm, with 25 daily collecting periods (12 in the morning and 13 in the evening). The collecting period lasted 15 minutes with a 15 minute interval between collections. Simuliids were captured using manual suction collectors according to the methodology described in Medeiros & Py-Daniel (2003).

CLIMATIC PARAMETERS

These were measured every 15 minutes at the site where the collecting of simuliids were made. Temperature data, relative humidity of the air and atmospheric pressure were obtained using a conjugated digital device (Automatic Weather Forecasting – Oregon Scientific BA-888). Luminosity was registered with a digital lux meter (ICEL LD-500) and the wind velocity in a digital anemometer (ICELAND300). Cloudiness was estimated through visual observation, and classified as clean weather (clouds absence or presence of some few and sparse), clouded (sky totally covered by clouds) and rainy (independent of intensity).

The dry and rainy seasons were considered according to Ribeiro & Adis (1984), which indicated two seasons for the Central Amazon: the dry season (between June and November) and the rainy (from December to May).

ANALYSIS OF DATA

A strong negative correlation between the temperature and the relative humidity of the air (r= - 0.954) was observed. These two factors also were strongly correlated with the luminosity factor (r= 0.502 and – 0.482, respectively). The use effect of correlated factors as independent variables in the same linear model denominated multicollinearity can generate spurious results or mask effects of the other variables (Zar, 1996). Because of this, the luminosity and the temperature were removed from the model, and only the relative air humidity (RH) was utilized. That variable, for practical ends, synonymizes the effect of the others that were removed from the test, and could be interpreted jointly with the relative air humidity. A multiple linear general model (LGM) was generated to find out the effect of the selected variables about C. *argentiscutum* hourly abundance. Due to 25 collections made during the course of a day, a model in block was used for each day to avoid the effect of multiple observations on the same day (temporal pseudoreplica), as well as removing the noise of the variation between collecting days, the relation between factor and the dependent variable, keeping only the general tendency. The block factor, therefore, is not interpretable for this work's end.

RESULTS

C. argentiscutum abundance showed strong variation according to the season. The abundance average in the dry season was about 4.72 (± 7.83) individuals per sampling / hour, while in the rainy season it was about five times greater (22.48 ± 20.94). Due to this difference in magnitude, the relation between the *C. argentiscutum* hourly abundance and the measured climatic factors were analyzed separately for each season. The significant relations among blocks (collection days) and the climatic parameters showed that the relation between the *C. argentiscutum* abundance and these parameters can have a daily intensity variation. However, leaving aside the effect of that difference, we noted that different parameters can influence the haematophagic activity among the periods of the day when compared to the results of the two seasons.

We observed that the biting activity was different according to the period of the year: in the dry season, the highest peaks of activity occurred early in the morning (6:00 – 7:30 am) and the lowest occurred at the end of the morning (11:00 – 11:30 am) and at the end of the afternoon (06:00 pm); in the rainy season, the greatest activity occurred in the afternoon (01:30 – 04:00 pm), with the highest peaks at 01:30 and 04:00 pm (Figure 1).

EFFECTS OF THE METEOROLOGICAL PARAMETERS IN *C. argentiscutum* DAILY ACTIVITY

Atmospheric pressure does not mean to explain the daily activity during the dry season (Table 1), however the largest number of simuliids was collected early in the morning when the atmospheric pressure was low (between 30.09 and 30.33 in Hg). During the rainy season a significant relation was observed (Table 2), where the activity and the atmospheric pressure occurred inversely (Figure 2A), mainly in the afternoon. The relation in this case seems to follow a non-linear model (bimodal), because the periods of lower atmospheric pressure (beginning in the morning – 30.21 and at the end of afternoon 30.12 in Hg) coincided with the minor activity. However, during the morning, the activity increases strongly with a small increase in atmospheric pressure, after which it shows the negative pattern. In afternoon, the highest activity peaks occurred as the atmospheric pressure decreased, until 04:00pm. The highest measured pressure was 30.36 and the lowest 30.00 in Hg.

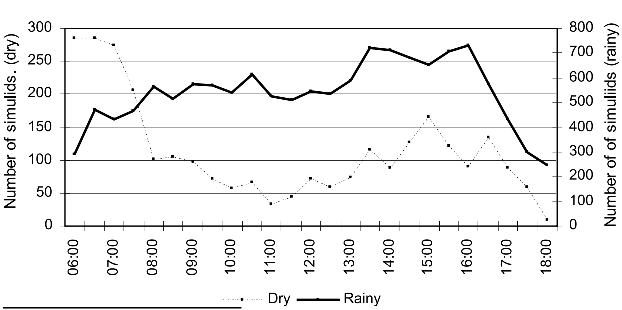

Figure 1 - Hourly abundance of *Cerqueirellum argentiscutum* during the dry and rainy periods in Porto do Japão, Amazonas, Brazil.

Table 1 - Linear model for hourly abundance of *Cerqueirellum argentiscutum* in relation to the climatic parameters in the dry period, in the Porto do Japão community, Amazonas, Brazil.

Factor	Average of squares	DF	F	P
constant	6.223	1	0.175	0.676
Atmospheric Pressure	5.728	1	0.161	0.688
Cloudiness	139.632	2	3.933	0.020
Wind Speed	552.245	1	15.556	< 0.001
Relative Humidity	696.381	1	19.617	< 0.001
Block * Wind Speed	110.570	23	3.115	< 0.001
Block * Cloudiness	65.483	26	1.845	0.007
Block * Atmospheric Pressure	17.891	23	0.504	0.975
Block * Relative Humidity	123.663	23	3.484	< 0.001
general model	167.369	117	4.715	< 0.001
Error	35.500	482		

DF = Degrees of freedom

Cloudiness had a significant influence on the *C. argentiscutum* daily activity only during the dry season (Table 1), indicating that the greatest activity occurred in highly cloudy periods (Figure 2B). There was less activity in periods of intense sun (beginning of the afternoon), increasing in the periods classified as cloudy and rainy. In the rainy season the activity decreased greatly during the day at intervals when the weather conditions were cloudy and/or rainy (beginning in the morning). Few simuliids were collected in periods of torrential rain, thus increasing activity in periods of clear sky (in the afternoon).

Wind speed During the dry season the wind intensity and the hematophagic activity showed a significant relation (Table 1). An inverse relation between the wind velocity and *C.argentiscutum*'s activity was observed, where the biggest daily abundances occurred in periods when there was no apparent wind, or its intensity was very weak (1.63 ± 3.11 Km/h) (Figure 2C). The highest wind speeds (average) were registered at 01:00 pm (3.78 ± 6.24 km/h) and the lowest at 05:30 pm (0.47 ± 1.04 km/h). During rainy season the relation was also negative, but no significant relation was detected (Table 2). The highest average wind velocity also was registered at 01:00 pm (3.23 ± 3.42 km/h) and the slowest at 05:00 pm (0.35 ± 0.83 km/h). When the wind velocity was higher than 10.3 Km/h, a reduction in the abundance of the simuliids occurred, mostly in July, when wind velocities up to 22.4 Km/h were observed.

Relative humidity of the air, temperature and luminosity were the climatic parameters that mostly influenced the activity (Table 1 and 2). However the tendency was the opposite when comparing both periods. During the dry station, greater activity was observed early in the morning, in periods of high relative humidity (79.75 ± 3.30 %) (Figure 2D), and consequently, low temperature (< 24.6 ± 2.13 °C) and luminosity (< 1840.5 ± 1592.8 lux). The low humidity (average) was 61.70 ± 6.88

Table 2 - Linear model for hourly abundance of *Cerqueirellum argentiscutum* in relation to the climatic parameters in the rainy period, in the Porto do Japão community, Amazonas, Brazil.

Factor	Average of squares	DF	F	P
Constant	652.006	1	3.622	0.058
Atmospheric Pressure	839.505	1	4.663	0.031
Ccloudiness	10.364	2	0.058	0.810
Wind Speed	72.072	1	0.400	0.527
Relative Humidity	3051.277	1	16.949	< 0.001
Block * Wind Speed	340.615	21	1.892	0.010
Block * Cloudiness	314.199	31	1.745	0.009
Block * Atmospheric Pressure	325.711	21	1.809	0.016
Block* Relative Humidity	419.262	21	2.329	0.001
general model	1481.875	119	8.232	< 0.001
Error	180.022	480		

DF = Degrees of freedom

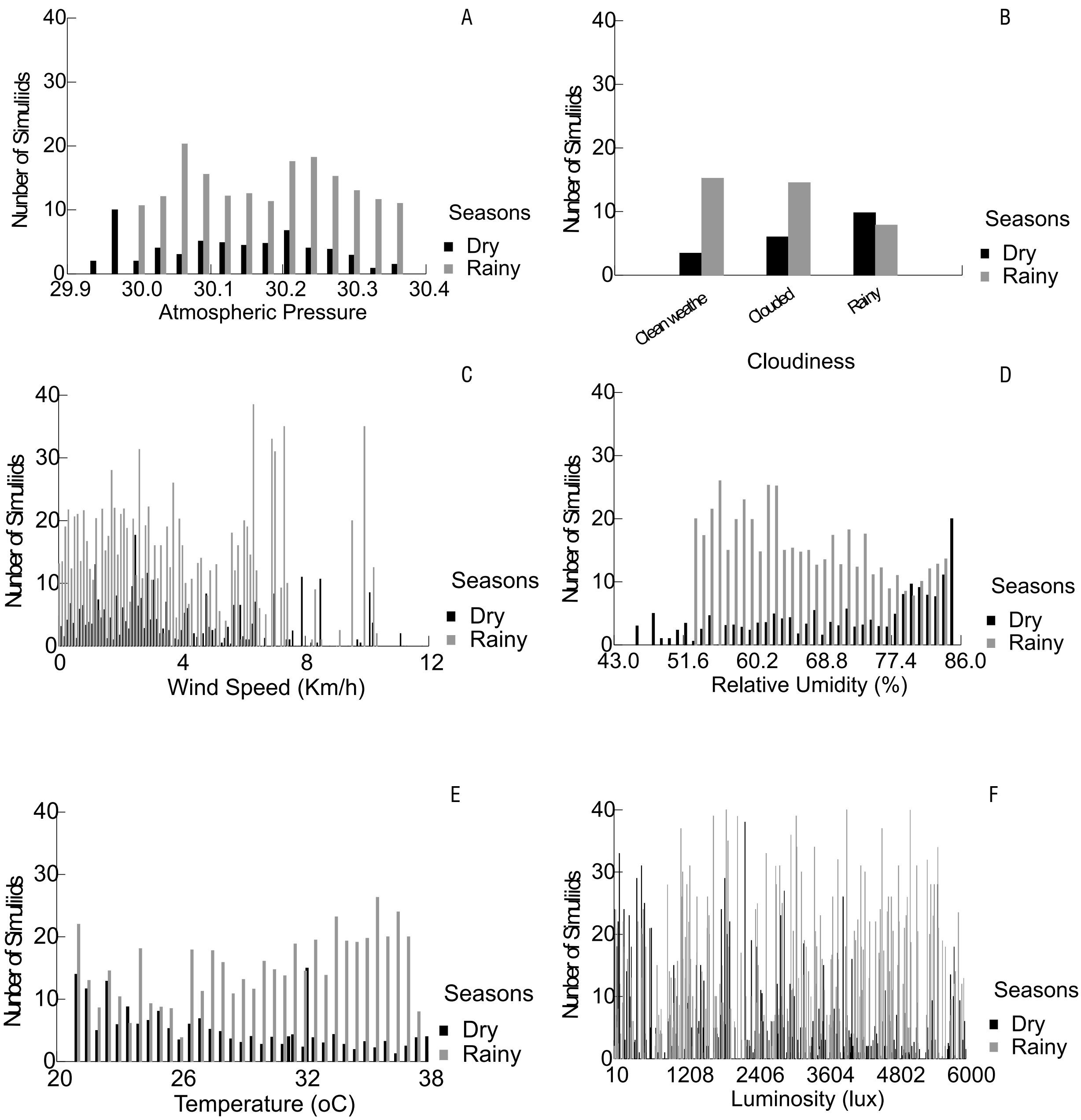

Figure 2 - Relationship among the climatic parameters (rainy and dry periods) and bite activity of *Cerqueirellum argentiscutum* in Porto Japão, Amazonas, Brazil.

% (at 01:30 pm) and the high was 81.29 ± 1.78 % (at 6:30 am). In the rainy season, the greatest activity was observed in the periods of the day where the relative humidity was lower (66.7 ± 5.46 %) and in temperature intervals higher than 30.0 °C (Figure 2E) and high luminosity (5994.3 ± 3492.5lux) (Figure 2F). The low relative humidity of the air (average) registered was 65.06 ± 4.72% (at 12:30 pm) and the high was 82.41 ± 1.24% (at 6:30 am).

DISCUSSION

In this study it was noted that the variation in the daily biting activity is directly related to climatic changes during the year. In both the dry and rainy seasons the relative humidity of the air and the temperature were the factors that indicated the biggest influence in the daily activity.

In the dry season, the greatest biting activity of the simuliids early in the morning presented a direct relation with the humidity and inverse with luminosity and temperature, or cloudiness, because in the highest activity periods, the weather was classified as cloudy or rainy. Most of the time, cloudy weather, involving other factors, is a presage of rain, which can cause a lack of food for the simuliids, increasing biting activity as a food storage strategy. Wind velocity showed a significant inverse relation, demonstrating that in some periods the activity was interrupted when wind velocity was higher than 10.3 $Km.h^{-1}$.

On the other hand, in the rainy season, activity was greater in the afternoon, possibly influenced by humidity, temperature and secondarily, by luminosity and atmospheric pressure, which caused retardation in the activity. In this season, the elevation of some factors, like temperature and luminosity, increases *C. argentiscutum* activity. The presence of rain at dawn caused an interruption in the activity.

Therefore, in this study, it was observed that the performance of a set of factors daily changes the *C.argentiscutum*'s activity according to the season. In the dry season, it is related to the humidity, temperature, luminosity, cloudiness and velocity of the wind, while in the rainy, it was related to the three first factors, plus to the atmospheric pressure, which acts as secondary factor. Other articles also mentioned that the daily activity is influenced by a series of factors acting jointly. Peterson & Wolfe (1956) attributed the changes in the activity of the simuliids to four variables: relative humidity of the air, temperature, velocity of the wind and light intensity. Fredeen & Mason (1991) noted that *Simulium luggeri* activity was changed by the wind velocity, illumination, saturation deficit, atmospheric pressure and cloud coverage. According to the same authors, an increase of the illumination and temperature favored a greater *S. luggeri* activity. Davis *et al.* (1994) noted that during the rainy season *S. yahense (=Edwardsellum yahanse)* was influenced by the temperature and humidity at dawn and at dusk, and in the dry season, only by the atmospheric pressure. According to Alverson & Noblet (1976) *S. slossonae*'s (= *Parabyssodon slossonae)* activity was influenced by the temperature, luminosity, velocity and atmospheric pressure.

According Andreazze *et al.* (2002) some factors influenced, as a block, the *Psaroniocompsa incrustata* activity. They observed different activity standards due to the temperature, humidity, luminosity, cloudiness and atmospheric pressure in the morning periods, and velocity of the wind in the afternoon period.

The greatest *C. argentiscutum* activity peaks occurred in temperatures between 21 – 32.5°C (dry season) and 23 – 38°C (rainy season), and humidity between 68 – 85% (dry season) and between 53 – 81% (rainy season). Dalmat (1955) collected *S. ochraceum* (= *Ectemnaspis ochracea)* in abundance when the temperature was from 34 to 35°C. Abreu (1960) verified *S. damnosum* (= *E. damnosum)* greater activity in temperatures between 27 – 30°C, but not below 18°C or above 40°C. According to Fredeen & Mason (1991), the number of *S. luggeri* grew with an increase in temperature (between 8 and 29.4°C). To *Prosimulium mixtum* and *P. slossonae* 10 – 32°C (Alverson & Noblet, 1976). Andreazze *et al.* (2002) observed minor activity of *P. incrustata* in temperatures averaging lower than 20°C and greater between 23.24 and 26.53°C. Lacey & Charlwood (1980) verified that the *S. sanguineum* (= *Cerqueirellum sp.)* activity was limited in the beginning of the morning when the temperature was lower than 18°C. Wolfe & Peterson (1960) verified greater activity of *S. venustum* when the humidity was between 29 – 95% and Davies (1952) observed less when the humidity was below 40%.

The luminosity is related to the biting activity in both seasons, maybe with a higher performance in the beginning of the morning and at the end of the afternoon. However luminosity does not seem to be a limiting factor. In the dry season the greatest activity occurred in periods of lower luminosity (12 – 6850 lux); the opposite was observed at the rainy season (330 – 18370 lux). According to Peterson & Wolfe (1956) luminosity is the first factor as stimulus for the beginning of simuliid activity. McCreadie *et al.* (1986) verified a greater effect of the luminosity at the daily activity in the end of afternoon, when other factors, like temperature, atmospheric pressure and velocity of the wind, showed small variations. Alverson & Noblet (1976) collected more simuliids in light intensity between 100 – 12000 lux.

The atmospheric pressure possibly acted as a secondary factor, and not a limiting factor for daily activity. A significant relation was only observed in the rainy season, when the greatest activity in the afternoon occurred when the pressure varied between 30.03 – 30.30 in Hg. The contrary effect of the atmospheric pressure in the morning and afternoon reinforces the idea that this factor acts secondarily in the daily activity, and this standard suggests the effect of a stronger variable, probably the temperature and relative humidity, regulating the activity, regardless of atmospheric pressure. For Andreazze *et al.* (2002) the atmospheric pressure was the parameter which most influenced the *P. incrustata* daily activity.

When wind velocity was superior to 10.3 $km.h^{-1}$, *C. argentiscutum* activity decreased, especially in the dry season. Posteriorly, an increase occurred, principally when the wind came from the west side of the Porto Japão. McCreadie *et al.* (1986) observed greater *P. mixtum a*ctivity when the wind velocity did not exceed 9.5 Km/h. For Fredeen & Mason (1991) wind velocity above 15 $km.h^{-1}$ was the most important variable followed by temperatures superior to 20°C that influenced *S. luggeri*. According to the same authors, saturation, cloud coverage, atmospheric pressure and luminosity become important when the wind velocity and the temperature were not limiting. The *P. slossonae* activity was less when the wind velocity was 16.8 km/h (Alverson & Noblet, 1976). Andreazze *et al.* (2002) observed greater influence of the wind velocity on *P. incrustata* activity at the beginning of the afternoon.

The knowledge of the climatic parameter's influence on the daily activity / season, along with an enlightened population, will be useful as preventive steps against exposure to the vector.

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