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INFLUENCE OF CLIMATIC FACTORS ON THE POPULATION DYNAMICS OF *HAEMAGOGUS JANTHINOMYS* (DIPTERA: CULICIDAE), A VECTOR OF SYLVATIC YELLOW FEVER¹

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ABSTRACT: The influence of three climatic variables (temperature, air humidity and rainfall) on the incidence of populations of *Hg. janthinomys* in two geographical regions of Brazil, in the states of Goiás and Tocantins, was studied from February 1996 to December 1997. Rainfall significantly influenced the incidence of the populations of *Hg. janthinomys* between the months studied ($p > 0.01$). Rainfall was the positive factor determining the biological cycle of the species.

KEY WORDS: *Haemagogus*, yellow fever vectors, ecological and climatic factors

Yellow fever virus is usually maintained in Brazil between monkeys and certain mosquitoes in the genera *Haemagogus* and *Sabethes*. Transmission is associated with the beginning of the rainy season, when vector densities are higher (Degallier et al., 2006). Because of the high mortality among humans (5-10%) caused by sylvatic yellow fever (SYF), this disease is considered very important (Taylor 1951).

Hg. janthinomys is probably the most important vector of SYF in Brazil, due to its high susceptibility to experimental infection, association with primates, transovarial transmission and diurnal biting habits. The distribution of this species coincides with most endemic areas of SYF (Vasconcelos, 2003). In fact, it has been found from northern Argentina/southern Brazil to Honduras and Nicaragua; in Brazil, it has been reported in all states from Paraná northwards (Arnell, 1973).

Although mosquitoes of this species have been reported as preferring to fly and bite at the level of the forest canopy, where the virus circulation is more frequent (Komp 1952; Trapido and Galindo, 1957), they have been observed biting people in houses near forests and at roadsides in Ilhéus (State of Bahia) and in the Amazon region, respectively by teams from the Diptera Laboratory of the Oswaldo Cruz Foundation and the Evandro Chagas Institute (unpublished data).

Knowledge of medical ecology and geography is essential for understanding the underlying modes of action of these mosquitoes in relation to infections and parasitic diseases and for their control (Ávila-Pires, 1989). Since the biology of the vectors of sylvatic yellow fever is poorly known, this disease can only be

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prevented by vaccinating the population. Understanding the ecology of potential mosquito vectors is becoming increasingly important.

In the present study, the influence of climatic factors (temperature, relative humidity and rainfall) on the population dynamics of *Hg. janthinomys* was studied in two regions in Brazil.

METHODS

Mosquitoes studied

Specimens were collected in secondary forest during three two-hour periods of the day: morning (9-11 a.m.), afternoon (2-4 p.m.) and night (around sunset: 5:30-7:30 p.m.) in Peixe (State of Tocantins; 12°01'30"S 48°32'21"W; 24m above sea level) and Minaçu (State of Goiás; 13°31'59"S 48°13'12"W; 351m above sea level), respectively in the northern and central-western regions of Brazil. The collections took place from February 2004 to April 2006 at Peixe and from February 1996 to December 1997 at Minaçu.

Members of the team from the Diptera Laboratory (IOC/FIOCRUZ) caught mosquitoes resting on vegetation and possibly attracted by humans, utilizing oral suction tubes (Marcondes et al., 2007). The measurements of mean humidity, maximum, minimum and compensated mean temperature and mean rainfall were obtained from the National Meteorological Institute (*Instituto Nacional de Meteorologia*, INMET).

The mosquitoes collected were taken to the Diptera Laboratory (IOC/FIOCRUZ) and then were mounted on entomological pins, labeled and incorporated into the Entomological Collection of the Oswaldo Cruz Institute, under the title "Peixe and Minaçu collection" (*Coleção de Peixe e Minaçu*).

The specimens were identified by means of observing morphological characteristics, using the dichotomous keys proposed by Arnell (1973) and Forattini (2002). *Haemagogus* was abbreviated in accordance with Reinert (1975).

Description of the study areas

The study areas have typical savanna ("cerrado") vegetation. In broad terms, according to Eiten (1972), the vegetation characteristics of the Brazilian savanna have a very diversified appearance, going from very open landscapes like savanna grasslands (*campos limpos*) to relatively densely vegetated forms such as riverbank forests and dry forest (*cerradão*). The predominant weather in the region is of rainy tropical type, with a dry season (zoned as Aw in Köppen system).

Data analysis

The data were analyzed to investigate the ecological relationship between populations of *Hg. janthinomys* and temperature, rainfall and relative humidity. The mean results were shown as Williams means (X_w) (Williams 1937). The Kruskal-Wallis (H) test, based on analysis of variance for classifying small samples, was used to evaluate whether "K" independent samples came from different populations, taking critical significance to be a P level of 5% ($P > 0.05$). This test analyzes H_0 (null hypothesis), which supposes that the "K" samples are

undistinguishable from the central trend measurement (Serra-Freire, 2002). The data were analyzed using the “t” test to investigate the ecological relationship between Goiás and Tocantins, with regard to temperature, rainfall and relative humidity.

The following formula was used:

$$H = \{12 \div [n \cdot (n + 1)] \cdot [\sum_{j=1}^n (R_j)^2 \div n_j] - 3(n + 1)\}$$

Where:

H = index for the hypothesis

n = total number of observations

$\sum R_j$ = sum of classification values

n_j = number of observations on each sample

RESULTS AND DISCUSSION

One thousand, two hundred and ninety-seven adult specimens of *Hg. janthinomys* were collected. The monthly fluctuation in specimen numbers indicated that there was a direct association between the numbers found in each month and some aspects of the regional climate (Table 1 and Figs. 2A, B and C).

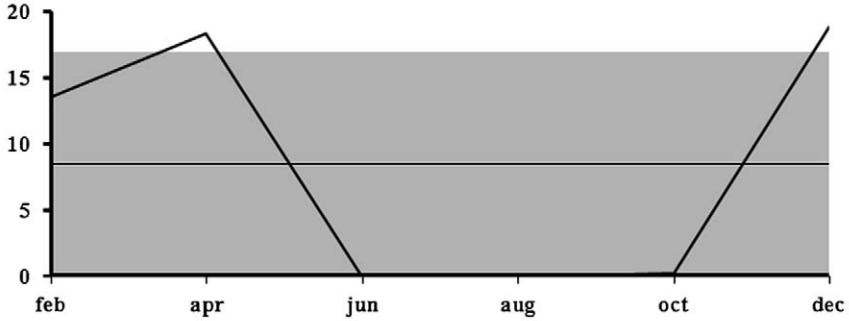
Table 1: Monthly average frequency of the populations of *Haemagogus janthinomys*, taking into consideration the sum of the occurrences from the two areas of capture. Values obtained by the Williams’ media calculation among the absolute values of each month in the two areas between February 2004 and April 2006.

Media frequency	Peixe – TO			Minaçu – GO		
	n	%	X_w	n	%	X_w
February	371	39.3%	13.53	72	20.4%	5.63
April	440	46.6%	18.30	48	13.6%	2.74
June	0	0	0.00	0	0	0.00
August	0	0	0.00	1	0	0.41
October	5	.5%	0.35	60	17.0%	4.20
December	128	13.6%	18.84	172	48.7%	16.32
Total	944	100%	14.88	353	100%	5.77

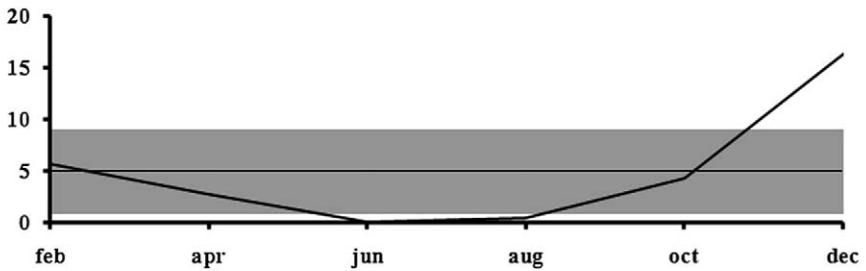
Fewer samples of *Hg. janthinomys* were found in Peixe in July, August and October, during the driest period of the year, with low accumulated rain and low relative humidity (Table 1 and Figs. 2A and 1C). The highest mean numbers of mosquitoes collected (X_w) occurred in February, April and December (respectively 13.53, 18.30 and 18.84), which are the months with the highest accumulated rain and relative humidity. The mosquito population showed two peaks, in April and December, which were much higher than what was defined by the tolerance interval (Table 1 and Fig. 1A).

Hg.janthinomyis (TO)

Xw



Xw

Hg.janthinomyis (GO)

■ Tolerance interval expected

— Distribution medium value

— Population curve

Figs. 1A & 1B. Monthly frequency chart for the populations of *Haemagogus janthinomyis*, considering the sum of the occurrences at Peixe (Tocantins) and Minaçu (Goiás), with the respective tolerance intervals. Values for each month in Peixe, between February 2004 and April 2006, and Minaçu, between February 1996 and December 1997.

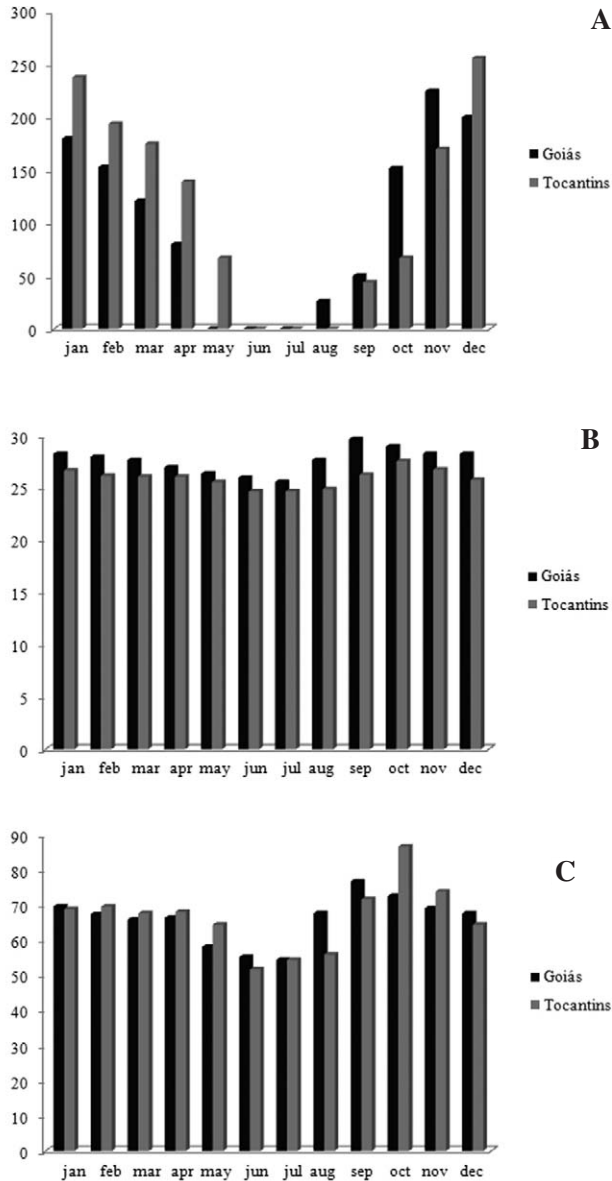


Fig. 2. A. Comparison between the mean rainfall recorded in Goiás, in 1997, 1998 and 1999, and Tocantins, in 2004, 2005 and 2006, for the *Haemagogus* collection points. No significant differences between the rainfall of localities was observed ($p > 0.01$). B. Comparison between the mean temperatures recorded in Goiás, in 1997, 1998 and 1999, and Tocantins, in 2004, 2005 and 2006, for the *Haemagogus* collection points. No significant differences between the months of the years ($p > 0.01$). C. Comparison between the relative air humidities recorded in Goiás, in 1997, 1998 and 1999, and Tocantins, in 2004, 2005 and 2006. No significant differences between the months of the years ($p > 0.01$).

Table 2. Mean temperature, relative humidity and precipitation in Peixe (Tocantins), between February 2004 and April 2006, and Minaçu (Goiás), between February 1996 and December 1997.

Months	State of Goiás											
	1 9 9 7			1 9 9 8			1 9 9 9			Mean		
	Rain	Temp	humi	Rain	Temp	humi	Rain	Temp	humi	med	med	med
Jan	343	30	78.5	230	28	65	180	27	65.5	251	28.3	69.7
Feb	390	29	72	174	28	65	153	27	65.5	239	28	67.5
Mar	440	28	67,5	110	28	65	121	27	65.5	224	27.7	66
Apr	239	27	62.5	40	27.6	68.5	80	26.4	68.5	120	27	66.5
May	38	26.1	56.5	0	27	62	0	26	56	13	26.4	58.2
Jun	12	25.5	52.5	0	26.4	57.5	0	26	56	4	26	55.3
Jul	0	25	51	0	25.8	56	0	26	56.5	0	25.6	54.5
Aug	26	28	69.5	0	27.5	64	26	27.5	70	17	27.7	67.8
Sep	48	31	84	0	29	73	50	29	73.5	33	29.7	76.8
Oct	225	31	84.5	181	28.6	69.5	152	27.5	64	186	29	72.7
Nov	198	31	84.5	238	28	67.5	225	26	55.5	220	28.3	69.2
Dec	206	29.2	75.5	192	27.5	60	200	28.1	67.5	199	28.3	67.7

Months	State of Tocantins											
	2 0 0 4			2 0 0 5			2 0 0 6			Mean		
	Rain	Temp	humi	Rain	Temp	humi	Rain	Temp	humi	med	med	med
Jan	294	28	70,5	211	26.2	71,5	209	25.8	65	238	26.7	69
Feb	296	26	67.5	140	26.5	73	147	26.2	68.5	194	26.2	69.7
Mar	223	26.2	68	127	26.4	72	176	25.7	63.5	175	26.1	67.8
Apr	131	26.6	73.5	94	26.3	71	192	25.5	60	139	26.1	68.2
May	75	25.7	64	58	25.5	65				67	25.6	64.5
Jun	0	24.8	55.5	0	24.5	48				0	24.7	51.8
Jul	0	24.6	53	0	24.7	56				0	24.7	54.5
Aug	0	24.5	52	0	25.3	60				0	24.9	56
Sep	62	26.2	68.5	25	26.4	75				44	26.3	71.8
Oct	95	27.6	87	39	27.6	86,5				67	27.6	86.8
Nov	187	27	76	153	26.5	72				170	26.8	74
Dec	268	26.1	68	244	25.4	61				256	25.8	64.5

Rain: Rainfall; Temp: Temperature; humi: Relative humidity

The greatest incidence occurred during the periods with the highest precipitation, with marked decline in the drier months with sparse rainfall.

In Minaçu, *Hg. janthinomys* mean populations (X_w) were greater in February, October and December (respectively 5.63, 4.20 and 16.32), while the lower one occurred in August (0.41). The December peak was higher than the tolerance level (Fig. 1B).

The difference in frequencies of specimens between the localities was significant, according to the Kruskal-Wallis test ($p > 0.01$), with $H = 1,897.5$. The differences in mean occurrences of specimens in each month (1997, 1998 and 1999 in Minaçu vs. 2004, 2005 and 2005 in Peixe) in relation to mean rainfall in the localities were significant ($p > 0.01$) (Fig. 1A).

Table 2 shows the temperatures and relative humidity for both localities. In Tocantins, temperatures oscillated around 25.9°C and humidity around 71.4% and the total annual rainfall was around 1350 mm. In Goiás, these figures were respectively 27.7°C, 68.5% and 1506 mm (Table 2).

Comparison between mean temperatures at the collection points in Goiás, for the years 1997, 1998 and 1999, and Tocantins, for the years 2004, 2005 and 2006, indicated that there were no significant differences between the months ($p > 0.01$) (Fig. 1B), thus enabling comparisons between localities and periods.

Comparison of means and indices at the collection points for Goiás, between the years 1997, 1998 and 1999, and Tocantins, between the years 2004, 2005 and 2006, also indicated that there were no significant differences between the months ($p > 0.01$) (Fig. 2A, 2B and 2C).

In general, both populations of *Hg. janthinomys* analyzed in this study were significantly influenced by climatic factors. These factors changed the pace of the species' activities, with higher populations in the rainy periods.

The immature stages of this species develop in tree holes in the forest canopy. Eggs hatch when immersed in water, and sometimes only after several immersions (Alencar et al., 2008), thereby inducing a complex relationship between rainfall and population density. An intense period of dryness occurs during the months of June, July and August in both areas, and this was apparently a significant factor in reducing the populations, such that adult mosquitoes almost completely disappeared during these periods. In forests, the population density of this mosquito is more than six times greater in the rainy season than in the dry season (Forattini, 2002). Chadee et al. (1992) also reported higher densities of *Hg. janthinomys* in the rainy season. The present results corroborate this tendency. The fluctuation of the rainfall in the study areas seemed to influence the *Hg. janthinomys* populations.

Tropical climates alternate with temperate ones in some regions of Brazil (Nimer 1979). However, in the regions of the present study, tropical climate can be considered predominant.

Some observations from Costa Rica have shown that *Hg. janthinomys* (as *Haemagogus spegazzinii falco*) occurs more frequently in isolated sunny places and on bright days, and that after dry periods, it becomes more abundant on bright days that come after dry days. This may indicate that this species tends to come from areas in which the humidity is greater than 85% (Galindo and Trapido, 1955).

Bates and Roca-Garcia (1945) noticed that in tropical climates, the incidence of mosquitoes is controlled mainly by precipitation due to the small seasonal fluctuations in temperature. The results from the present study show that the population dynamics of *Hg. janthinomys* in the two different geographic regions are influenced by rainfall and humidity. In the same way as observed in Costa Rica by Galindo and Trapido (1955), the different temperatures during the specimen collection periods did not have any influence on the incidence of the two study populations of *Hg. janthinomys*.

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