CHAPTER 12

FEEDING PATTERNS OF *HAEMAGOGUS CAPRICORNII* AND *HAEMAGOGUS LEUCOCELAENUS* (DIPTERA: CULICIDAE) IN TWO BRAZILIAN STATES (RIO DE JANEIRO AND GOIÁS)

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Jeronimo Alencar
Laboratório de Diptera, Instituto Oswaldo Cruz-FIOCRUZ, Rio de Janeiro, Brazil

Carlos Brisola Marcondes
Departamento de Microbiologia e Parasitologia, Universidade Federal de Santa Catarina, Florianópolis, Brazil

Nicolau Maués Serra-Freire
Laboratório de Diptera, Instituto Oswaldo Cruz-FIOCRUZ, Rio de Janeiro, Brazil

Elias Seixas Lorosa
Laboratório de Diptera, Instituto Oswaldo Cruz-FIOCRUZ, Rio de Janeiro, Brazil

Juliana Barreto Pacheco
Laboratório de Diptera, Instituto Oswaldo Cruz-FIOCRUZ, Rio de Janeiro, Brazil

Anthony Érico Guimarães
Laboratório de Diptera, Instituto Oswaldo Cruz-FIOCRUZ, Rio de Janeiro, Brazil

ABSTRACT: We present the identification of bloodfeeding sources of *Haemagogus* (*Haemagogus*) *capricornii* Lutz and *Haemagogus* (*Conopostegus*) *leucocelaenus* (Dyar & Shannon) (Diptera: Culicidae) from different regions of Brazil, as analyzed by precipitin tests. Anti-sera for bird, bovine, equine, human, opossum, and rodent were used. Two hundred one mosquitoes were examined (147 *Hg. leucocelaenus* and 54 *Hg. capricornii*), of which 177 reacted for some anti-serum. For *Hg. leucocelaenus*, 86 (68.3%) reacted to one blood source, 38 (30.2%) to two sources, and two (1.6%) to three sources; the combinations of bird + human (18.4%), bird + rodent (15.8%), and bird + marsupial (15.8%) were the most frequent. For *Hg. capricornii*, 34 (66.7%) reacted to one blood source; combinations bird + rodent (37.5%) and bird + marsupial (25%) were the most frequent combinations. Mosquito preference for bloodfeeding sources was different in these areas, possibly because of the availability of sources. This diversity of sources can have important epidemiological implications.

KEYWORDS: blood feeding source, *Haemagogus*, regional variation, Culicidae

Knowledge of the bloodfeeding sources of mosquitoes is important for understanding their biology and for planning their control. This knowledge also can be used for planning their rearing in insectaries, which can in turn produce useful information on their biology.

Haemagogus leucocelaenus (Dyar & Shannon) is the most common species of the genus in Brazil and has been incriminated as a vector of the virus of sylvatic yellow fever in southeastern and southern Brazil (Vasconcelos et al. 2003). This mosquito, previously included in the *Aedes* (*Finlaya*) genus, occurs from Trinidad to southern Brazil and Argentina (Misiones and Tucumán) (Zavortink 1972). This mosquito and several others of this genus and of the genus *Sabethes* can have a long life and go through several gonotrophic cycles (Dégallier et al. 1998). *Hg. leucocelaenus* has been found naturally infected by yellow fever (YF) virus and is a more eficient experimental vector than *Aedes aegypti* (L.) (Waddell 1949).

Haemagogus capricornii Lutz is widely distributed in Brazil, from Bahia to Rio Grande do Sul, and also in Misiones, Argentina (Forattini 2002). Because its dis- tinction from *Hg. spegazzinii* Brethes has been dificult, its distribution and role as a vector of YF virus are badly defined. It (or both) seems to be a good experimental vector (Waddell 1949). *Hg. capricornii* usually feeds in the forest canopy, but can also feed at ground level (Neves and Silva 1973, Forattini et al. 1978).

The eradication of sylvatic yellow fever is impossible owing to its cycle among wild monkeys and possibly marsupials (Vasconcelos et al. 2003). Because vertical transmission occurs in some *Haemagogus* mosquitoes (Vasconcelos et al. 2003), the determination of bloodfeeding sources of the mosquitoes involved would be important to understanding the cycle of the virus and to n evaluating the roles of the species. The blood feeding sources of *Hg. leucocelaenus* and *Hg. capricornii* from two Brazilian states were studied by the precipitin technique.

MATERIALS AND METHODS

Mosquitoes were collected from four different localities in Brazil: state of Rio de Janeiro: 1-Municipality of Duque de Caxias (22º 47' S, 43º 18' W, altitude 19 m); 2-Tinguá Biological Reserve (22º 45' 33" S, 43º 13'12" W, 700 m); 3-Itatiaia National Park (22º 16' S, 44º 34' W, altitude 800 m). State of Goiás: 4-Munic- ipality of Niquelândia (14º 28'26" S, 48º27'35" W, 583 m altitude) (Fig. 1).

All the areas were preserved. The first three were constituted by Atlantic primary forest, and the other three by gallery forest and savanna ("cerrado").

The mosquitoes were caught using an entomological net with a 30-cm-diameter opening, 60 cm length of, and a short handle. The specimens were packed in polyethylene cages, labeled according to locality, and stored in cool isothermic boxes for live transportation to the laboratory. Subsequently, the mosquitoes were anesthetized by exposure to chloroform vapor and kept in a freezer at -4ºC, to interrupt the digestive process.

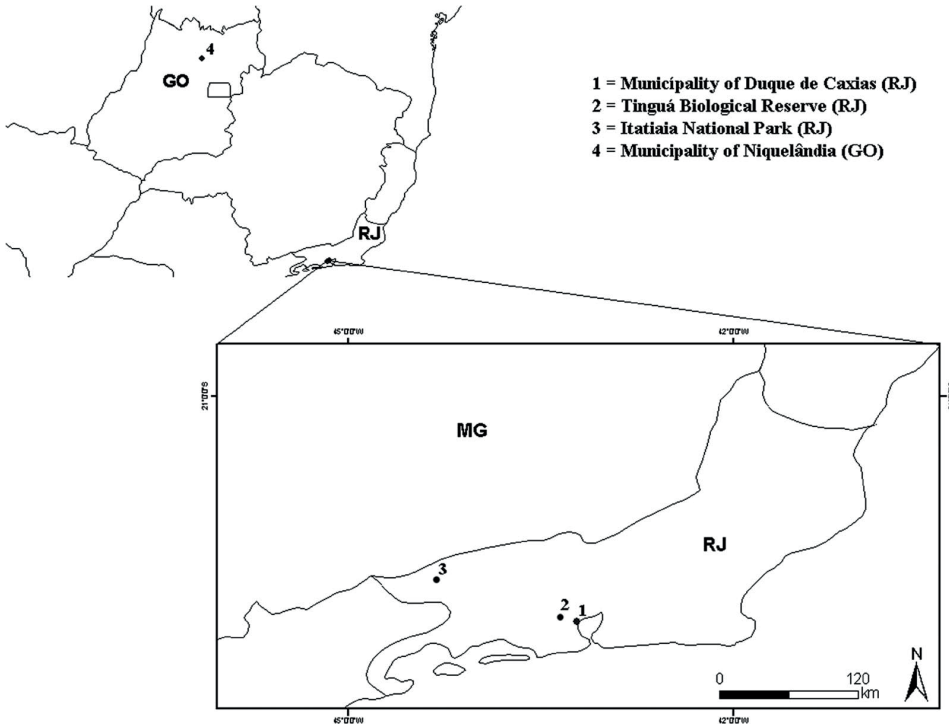

Fig. 1. Location of the collection sites in Brazil.

The insects were identified and then triturated with 0.85% solution of NaCl, applying the precipitin technique (Siqueira 1960 modified by Lorosa et al. 1998). Preparation of antisera and the evaluation of reactivity and specificity also were developed according to Siqueira (1960). The following antisera (with dilutions and species between brackets) were used: bird (1: 10,000, *Gallus*), human (1:10,000, *Homo*), rodent (1: 15,000, *Rattus*), bovine (1:15,000, *Bos*), equine (1:15,000, *Equus*), and marsupial (1:15,000, *Didelphis*).

The blood feeding behavior was preliminarily analyzed by chi-square test, and by coeficient of similarity and significance tests. The following factors were considered for the analysis: types of hosts, and regions and localities sampled.

The coeficient of similarity was calculated by $CS_S = (2C)/(n_1 + n_2)$, where CS_S is coeficient of similarity, C is number of species common to both localities, n_1 is number of species in one community, and n_2 is number of species in the other community (Serra-Freire 2002).

The t of the significance test was calculated by $t = (x - M) \div EPa$, where t is calculated index of significance, x is mean of the sample, M is mean of the population, and EPa is standard deviation of mean. So, EPa was calculated by $EPa = S \div \sqrt{n}$, where S is standard deviation of population and n is number of observation of mean (Serra-Freire 2002).

RESULTS

Material from 201 adult females (*Hg. leucocelaenus* and 54 *Hg. capricornii*) was examined, 147. Of this number, only 177 (88.1%) reacted to some antiserum, and 24 (11.9%) did not react. The results for the antisera are in Table 1.

From reactive specimens of *Hg. leucocelaenus,* 86 (68.3%) reacted to only one source. In Niquelândia, there was no reaction to bird and bovine sera, whereas in Tinguá the only sera to which there was no reaction was that of bovine. In Itatiaia, there were reactions to all sources (Table 1). From the three localities where specimens of *Hg. leucocelaenus* were studied, those from Niquelândia were different, because the reactivity to anti-rodent was predominant (Table 1). From those mosquitoes reacting to more than one source, 38 (95%) were positive for two sources, and two (5%) to three sources (Table 2).

Among the reactive specimens of *Hg. capricornii,* 34 (66.7%) reacted to only one source. In Tinguá, no reaction to bovine and equine was observed, whereas in Caxias there were specimens reacting to all sources (Table 1).

Table 1. Results of precipitin tests of *Hg. capricornii* and *Hg. leucocelaenus* females, from different regions of Brazil

Reaction	Caxias-RJ			Tinguá-RJ						Itatiaia-RJ			Niquelandia-GO		
	Hg. capricornii			*Hg. capricornii*			*Hg. leucocelaenus*			*Hg. leucocelaenus*			*Hg. leucocelaenus*		
	n	% total	% react.[a]	*n*	% total	% react.	*n*	% total	% react.	*n*	% total	% react.	*n*	% total	% react.
Bird	9	52.9	52.9	8	40.0	47.1	2	22.2	25.0	25	28.7	35.7	0	0.0	0.0
Bovine	1	5.9	5.9	0	0.0	0.0	0	0.0	0.0	9	10.3	12.9	0	0.0	0.0
Equine	2	11.8	11.8	0	0.0	0.0	1	11.1	12.5	5	5.7	7.1	1	9.1	12.5
Marsupial	1	5.9	5.9	3	15.0	17.6	2	22.2	25.0	4	4.6	5.7	2	18.2	25.0
Human	2	11.8	11.8	2	10.0	11.8	2	22.2	25.0	14	16.1	20.0	2	18.2	25.0
Rodent	2	11.8	11.8	4	20.0	23.5	1	11.1	12.5	13	14.9	18.6	3	27.3	37.5
Non-reactive	0	0.0		3	15.0		1	11.1		17	17.5		3	27.3	
Total	17	100.0	100.0	20	100.0	100.0	9	100.0	100.0	87	100.0	100.0	11	100.0	100.0

[a] For all groups: $x^2 = 14.26$, $x^2_{\text{tab 20 df, 5\%}} = 31.4$; for *Hg. capricornii:* $x^2 = 4.73$, $x^2_{\text{tab 5 df, 5\%}} = 11.7$; for *Hg. leucocelaenus:* $x^2 = 14.07$, x^2 df, 5% = 18.31.

Among insects reacting to two sources, the combi- nation bird + rodent combination was the more usual (37.5%), followed by bird + marsupial (25%). Only one *Hg. capricornii* from Tinguá presented triple reaction (bird + marsupial + human). Any of the mixing samples of both species reacted to antiserum equine + marsupial and marsupial + rodent (Table 2).

Blood feeding preferences of all samples and between samples of each species were not significantly different by chi-square (Table 1). *Hg. capricornii* from Tinguá and Caxias presented low similarity between the ranges of hosts (CS_S = 63.15%). *Hg. leucocelaenus* from Tinguá and Itatiaia also presented low similarity between host ranges (CS_S = 62.50%), and the similarity between states of Rio de Janeiro and Goiás (CS_S = 57.14%) and between Itatiaia and Niquelândia (CS_S = 44.44%) was even lower.

The difference for *Hg. leucocelaenus* was not significant in both states; the species preferred bird, followed by human and rodent. The significance of the difference was 10% only in Tinguá, and 5% in all others.

The preference of *Hg. capricornii* for blood sources is quite similar; bird is preferred, followed by human and rodent. The preference for blood sources is not significantly different in Tinguá and Duque de Caxias.

Table 2. Double and triple reactions to food sources of *Hg. capricornii* and *Hg. leucocelaenus* females from different regions of Brazil

Blood feeding sources	*Hg. capricornii*		*Hg. leucocelaenus*	
	n	%	*n*	%
Bird + bovine	0	0.0	3	7.5
Bird + equine	1	5.9	4	10.0
Bird + marsupial	4	23.5	6	15.0
Bird + rodent	2	11.8	7	17.5
Bovine + equine	6	35.3	6	15.0
Bovine + marsupial	1	5.9	1	2.5
Bovine + human	0	0.0	1	2.5
Bovine + rodent	0	0.0	1	2.5
Equine + human	0	0.0	1	2.5
Equine + rodent	1	5.9	2	5.0
MArsupial + rodent	0	0.0	2	5.0
Marsupial + human	0	0.0	3	7.5
Human + rodent	1	5.9	1	2.5
Bird + marsupial + human	1	5.9	0	0.0
Bird + marsupial + rodent	0	0.0	1	2.5
Bird + human + rodent	0	0.0	1	2.5
Total	17	100.0	40	100.0

DISCUSSION

The studied mosquitoes had a wide range of hosts in all the localities, and almost one third of them tended to bite more than one source. These mosquitoes are usually attracted to humans (Forattini 1965), but Komp (1936) observed humans were not very attractive for them. The used anti-sera probably did not differentiate bloodmeals on human and monkeys, and additional studies, more specific for the blood source, should be developed on this mosquito.

Alencar et al. (2005) considered *Hg. janthinomys* Dyar an opportunistic and eclectic species; *Hg. capricornii,* as observed here, also feeds on several animals. Bird was the most frequent source for *Hg. capricornii* and *Hg. leucocelaenus* in Caxias, Itatiaia, and Tinguá, whereas rodent was the most frequent in Niquelândia. This preference for birds was also observed in Parque Nacional da Serra dos Órgãos, a high-altitude area in state of Rio de Janeiro (Davis 1945), but Guimarães et al. (1987) referred to *Hg. capricornii* as highly anthropophilic in the above-mentioned area.

In the studied places, municipal district of Caxias and RBT, there was no difference between blood feeding sources of *Hg. capricornii,* which presented a difference only in relation to a preference for blood feeding sources, with bird characterized as a primary host. Our data corroborate previous studies (Davis 1945, Guimarães et al. 1987), both on eclectic feeding habits and on the preference for birds. Reactivity for anti-bird serum was 52.94% in Caxias and 40% in Tinguá (Table 1). The variation between preferences in Niquelândia and the localities in Rio de Janeiro can be a result of biological characteristics and/or to the availability of blood sources.

The preference of *Hg. capricornii* for human blood could indicate a potential role as a vector of yellow fever virus. The occurrence of reaction to marsupial anti-serum can reinforce this role, because marsupials and edentates have also been suspected as reservoirs (Vasconcelos et al. 2003).

The high incidence of reaction for bird can indicate a potential role for transmission of other arboviruses, of which these animals are reservoirs (Forattini 2002). The frequency of the combinations bird + other animals, including horses (Table 2) could reinforce this potential role.

Hg. janthinomys, Hg. albomaculatus Theobald, *Hg. leucocelaenus,* and *Sabethes chloropterus* (von Hum- boldt) are usually found in the tree canopy (Forattini 1965). However, contrasting to the observed attraction for primates in *Hg. capricornii* and *Hg. leucocelaenus* (Davis 1945), the present observations indicate a tendency to feed on birds, similar to observations on *Hg. janthinomys* (Alencar et al. 2005). The availability of humans/monkeys for these mosquitoes in the areas should be an important factor.

Hg. leucocelaenus is predominantly acrodendrophilous (Galindo et al. 1955). The rarity of reactions to human (or primate) anti-serum can be influenced by the availability of these blood sources, to be analyzed in the studied regions.

The preferences of both species vary in the studied regions, indicating they are highly eclectic for the blood source. The potential of the species as vectors of arboviruses in the regions may be different, accord- ing to their preferences.

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