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HOST AVAILABILITY LIMITS POPULATION DENSITY OF *PANSTRONGYLUS MEGISTUS**

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Abstract. In order to determine whether host availability limits triatomine population growth, 5th-stage *Panstrongylus megistus* were maintained in feeding chambers containing 0, 1, 2, or 3 mice. During the 5-day feeding period, triatomines exposed to two or three mice gained significantly more weight than did bugs exposed to one mouse. In addition, half of the bugs exposed to two or three mice molted, as compared to one-fifth of the *P. megistus* exposed to one mouse. Thus, weight gain and molting were related to host density. In contrast, bug mortality was related to the triatomine-mouse ratio, being greatest among bugs exposed to one mouse. Twenty-nine nonplastered mud-stick houses in a Chagas' disease endemic area were censused and examined for triatomines. About 70% of houses with ≥4 persons contained dense bug populations, while only 20% of houses with 1–3 persons were densely infested. Moreover, blood-meal identifications demonstrated that two-thirds of the *P. megistus* collected from these houses fed on man. The density of triatomines present in infested houses is related to the number of persons available as hosts.

Various factors influence the density of domestic triatomine populations. House construction directly affects triatomine household infestation; *Panstrongylus megistus* frequently infests nonplastered mud-stick houses while plastered mud-stick houses are rarely infested.[1] The presence of predators and parasites, principally the parasitic wasp, *Telenomus fariai,* reportedly influences bug densities.[2–4] In addition, host availability may play a crucial role in determining domestic triatomine densities. On the basis of life-table data, Schofield hypothesized that nutritional status regulated *Triatoma infestans* population growth.[5] Moreover, *T. infestans* nutritional status in three infested houses was related to the continued presence of hosts.[6] Although Schofield suggested that host biomass limits the size of bug populations,[6] we lack direct observations confirming this relationship.

Laboratory studies have demonstrated a relationship between host availability and the growth of triatomine populations. These studies either varied the interval between host access,[7] or the density of bugs contained within a feeding chamber.[8,9] However, such experiments restricted bug feeding to specific intervals; extended access to hosts, as occurs in infested houses, was not permitted. Accordingly, we allowed triatomines to feed ad lib on 0, 1, 2, or 3 mice during a 5-day period. Weight gain, mortality, and subsequent molting of these bugs were measured. Moreover, 63 houses in a *P. megistus*-endemic area were censused and examined for bugs, in order to determine whether the number of residents limits the density of domestic triatomine infestations. Blood-meal identifications were performed to establish the importance of humans as hosts for domestic *P. megistus*.

MATERIAL AND METHODS

Triatomine colonies

Panstrongylus megistus colonies, originating from the states of Bahia and Sao Paulo, Brazil,

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had been maintained for up to 10 years at the *Centro de Pesquisas Goncalo Muniz* (Salvador, Bahia) as previously described.[9,10] Routinely, bugs were fed on chickens at weekly intervals. However, fifth-stage *P. megistus* were starved for 10–30 days post-molting before exposure to hosts. Each experimental group of 12 5th-stage nymphs consisted of six males and six females. We used the method described by Szumlewicz and Cruz[11] to separate male and female nymphs. Triatomines were constantly maintained at room temperature (25–30°C; 70–90% RH).

Hosts

Male and female laboratory mice, weighing 15–20 g, were used as hosts for *P. megistus*. Potatoes and standard mouse ration were provided ad lib during the course of the experiment.

Feeding chamber

Plastic cylinders (19.5 cm diameter, 18 cm height) were converted into feeding chambers. A wooden platform of the same diameter as the plastic cylinder was fitted into each chamber. The platform rested on legs 7 cm high. Each platform contained 11 holes, 1.2 cm in diameter. Thus, mice were confined to the top of the platform and triatomines were able to pass freely through the holes. Bugs generally rested on the underside of the platform or on the legs, passing through the holes only to feed. Triatomines were removed from the chamber during 30 min daily and weighed, during 5 consecutive days, on a Mettler H80 balance accurate to 0.1 mg.

Study area

The study area consisted of three "fazendas" in the "municipio" of Castro Alves, Bahia, Brazil. These three fazendas (Engenho Novo, Esconso, and Lagoa) adjoin the 10-fazenda study area previously described.[12] *Panstrongylus megistus* is the only triatomine known to infest houses in the study area.[1,13] The number of persons living in each house and the type of house construction were determined as previously described.[1,12] We censused houses and inspected for triatomines during May 1982. Insecticide had not been applied to houses in these three fazendas since SUCAM (*Superintendencia de Campanhas de Saude Publica*) applied BHC in 1975–76. SUCAM began to spray all houses with BHC in the municipio of Castro Alves soon after this study was completed.

Triatomine collection

Panstrongylus megistus were collected by manual inspection with the aid of a flashlight and forceps. Each house was searched for triatomines by two individuals for a total of 30 min (= 1 man-hour). The same two individuals inspected all 63 houses.

Blood-meal identification

Digestive tracts of individual *P. megistus* collected in Castro Alves were removed and macerated in 150 μl PBS. The homogenate was then expressed onto Whatman 3M filter papers and dried at room temperature. Subsequently, filter papers were sealed in plastic bags and shipped to the Gorgas Memorial Laboratory (Panama). Host blood-meal identification by the microcapillary precipitin test was performed as previously described.[14]

RESULTS

In order to determine whether triatomine weight gain is related to host availability, we placed groups of 5th-stage *P. megistus* in feeding chambers containing designated numbers of mice. The weight of each triatomine was determined before feeding (day 0) and during 5 consecutive days of exposure to mice. Three trials consisting of groups of 12 triatomines exposed to 0, 1, 2, or 3 mice were performed. As expected, starved triatomines in control chambers (0 mice) lost 9% of their initial weight (Fig. 1). In contrast, *P. megistus* exposed to two or three mice gained significantly more weight than did bugs exposed to one mouse (Student's t-test: 2 vs. 1 mouse, $t_{63} = 3.1$, $P < 0.005$; 3 vs. 1 mouse, $t_{65} = 3.4$, $P < 0.05$, on day 3). Thus, host density was correlated positively with triatomine weight gain.

Triatomines were observed for 2 months following feeding to determine the proportion of bugs molting (Table 1). A greater proportion (½) of bugs exposed to two or three mice molted than did those exposed to one mouse ($^1/_5$). Molting, like weight gain, was proportional to host density.

The mortality of triatomines during the 5 days within feeding chambers was determined (Table 1). The principal cause of mortality was predation

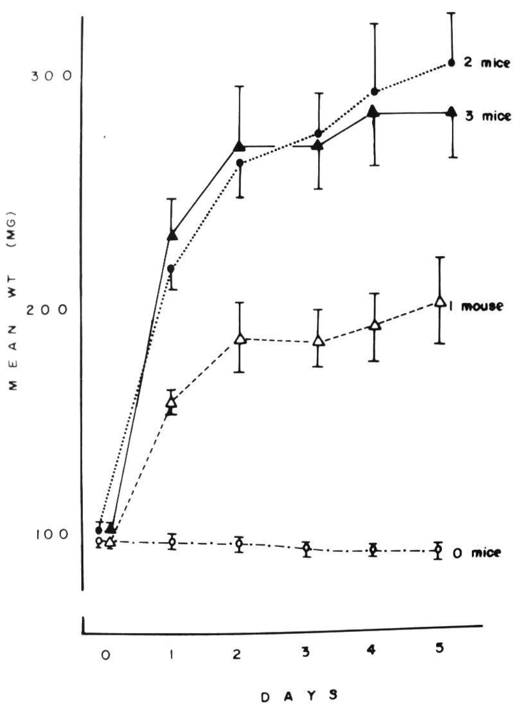

FIGURE 1. Weight gain of 5th-stage *P. megistus* allowed to feed ad lib on mice during 5 days. Means and standard deviations of combined values for three trials consisting of groups of 12 bugs per trial at each host density.

TABLE 1

Mortality and molting of 5th-stage P. megistus *fed on varying numbers of hosts*

No. of mice per chamber	Mortality* No. bugs	% mortality	Molting† No. bugs	% molting
0	36	2.8	23	0
1	36	33.3	16	18.8
2	36	16.7	20	50.0
3	36	2.8	23	48.0

* Mortality of bugs during 5 days of exposure to mice. Combined total of three trials involving 12 bugs in each group.
† Molting of bugs during 2 months post-exposure to mice. Combined total of bugs surviving 5-day exposure period in trials 2 and 3. Molting was not observed in trial 1.

by mice; while only one control triatomine died, bugs exposed to mice were frequently eaten. Significantly increased mortality (⅓) occurred among bugs exposed to one mouse (χ^2: 1 vs. 0 mice = 9.4, df = 1, $P < 0.01$). Lesser mortality was observed among bugs exposed to two ($^1/_6$) or three ($^1/_{36}$) mice. Thus, predation was related to the number of triatomines present per mouse.

In order to determine whether density of household triatomine infestation is related to the number of hosts available, we censused 63 houses in a Chagas' disease-endemic area and examined each house, during 1 man-hour, for bugs. Thirty-four of these houses were plastered, virtually eliminating the possibility of bug infestation regardless of the number of persons present. Only three of 34 plastered houses were infested. In contrast, 19 of 29 nonplastered mud-stick houses were infested. Among the 29 nonplastered houses, a clear relationship existed between the number of residents and the density of *P. megistus* infestation (Table 2). Ten of 14 houses (about 70%) with ≥4 persons contained dense (≥4 per man-hour) bug populations, while only 20% (3/15) of houses with 1–3 persons were densely infested (χ^2 = 8.23, df = 1, $P < 0.1$). Thus, the density of *P. megistus* was related to the number of persons available as hosts.

To evaluate the importance of humans as a blood-meal source for domestic *P. megistus*, the host blood-meals of 496 *P. megistus* collected from houses in Castro Alves were determined. Of these, 385 (78%) contained sufficient blood for host identification to the family level (Table 3). Single host feedings were detected in 370 bugs and two-host feedings in 15. About two-thirds of *P. megistus* fed on man; chickens, dogs, and cats served as important secondary hosts. Overall, man was the principal source of blood for *P. megistus* in the domestic environment.

DISCUSSION

The number of triatomine bites a person receives per night may be quite high in bug-infested houses in endemic areas.[15–17] Despite the large

TABLE 2

Relationship between number of residents and density of P. megistus *in nonplastered houses in Castro Alves, Bahia, Brazil*

No. of persons per household	No. bugs collected per man-hour 0–3	≥4	Total
1–3	12	3	15
≥4	4	10	14
Total	16	13	29

TABLE 3

Hosts of Panstrongylus megistus, *collected from domestic habitat of Castro Alves, Bahia, Brazil, as identified by microcapillary precipitin tests*

Hosts	Number	Percentage
IDENTIFIED TO FAMILY		
Single feedings		
Hominidae (man)	261	70.5
Phasianidae (chickens)	86	23.2
Canidae (dogs)	16	4.3
Felidae (cats)	5	1.4
Bovidae (cows)	1	0.3
Acciptridae (hawks)	1	0.3
	370	
Double feedings		
Hominidae + Phasianidae	3	
Hominidae + Felidae	3	
Hominidae + Avian	1	
Phasianidae + Canidae	4	
Phasianidae + Carnivore	1	
Phasianidae + Acciptridae	1	
Phasianidae + Bovidae	1	
Phasianidae + Felidae	1	
	15	
NOT IDENTIFIED TO FAMILY		
Primate	30	
Mammal	17	
Carnivore	2	
Avian	4	
Insufficient	58	
	111	
Total	496	

blood reserve available from a single individual, bugs in houses with few residents may not be able to obtain sufficient nutrition due to host irritation.[5] In our experiments, bugs exposed to one mouse experienced difficulty in obtaining enough blood to molt, while bugs exposed to two or three mice engorged freely. Thus, host tolerance to bug bites may be an important factor controlling triatomine feeding. Whether host irritation and subsequent interference with triatomine feeding is the result of allergic reactions to bug bites[18, 19] has not been determined.

Our blood-meal identifications confirm previous reports that man is the principal host for domestic *P. megistus* in Bahia, Brazil, and chickens play a secondary role.[20, 21] Although Minter found that few *P. megistus* fed on dogs and cats,[20, 22] Mott et al.[23] suggested that the presence of infected dogs and cats was associated with greatly increased risk of transmission of *T. cruzi* to household residents. The prevalence of feedings on dogs (4.3%) and cats (1.4%) observed in our study suggests that these domestic animals play a limited role in the domestic *T. cruzi*-*P. megistus*-man cycle in Castro Alves. In addition, the absence of blood-meals from rodents and marsupials confirms the conclusion based on isoenzyme patterns that the sylvatic and domestic cycles of *T. cruzi* in Castro Alves remain separate.[24] The rare findings which indicate feedings from cows and hawks may have been due to cross reactions. However, hawks are very prevalent in the study area. Local residents often observe them resting on or near houses, reportedly preying on young chickens. In addition, cows are often in or around the domestic environment. Thus, infrequent contact with hawks and cows is possible.

We attempted to estimate the number of domestic animals available as blood-meal sources for triatomines in the endemic area. However, the number of domestic animals, especially chickens and turkeys, varied widely from week to week. At least one 67-year-old women who lived alone kept a large number of domestic animals in her home; the density of triatomines in her house was quite high (25 per man-hour). Despite this notable exception, the significant correlation between the number of human residents per household and density of *P. megistus* observed during our study ($r = 0.45$, df $= 29$, $P < 0.02$) emphasizes the importance of man as host for domestic *P. megistus* in Bahia.

Factors regulating the density of domestic triatomine populations are varied and complex. In a recent study in Mambai, Goias, Brazil, Marsden et al.[25] found that house construction, level of hygiene, age of house, family size, and number of visitors were all significantly related to *T. infestans* density. It seems clear that old, unplastered, mud-stick houses kept in a poor state of hygiene and containing large families with frequent visitors are the most likely to be densely infested by triatomines. However, field workers are often impressed by the fact that some houses in highly endemic regions which fit this description are devoid of triatomines.

Control programs designed to lower triatomine densities to a point where *Trypanosoma cruzi* transmission is interrupted must take the many factors which regulate triatomine density and distribution into account when forming control strategies. Since houses containing large families are often densely infested by triatomines, these houses should receive special attention when available vector control resources are limited.

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