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Risk factors associated with malaria infection in an urban setting

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Abstract

Incidence of malaria in urban settings is a growing concern in many regions of the world and individual risk factors need to be identified to appropriately adjust control strategies. We carried out a cross-sectional study in 1993/94 in an urban area of the largest port of the Pacific Coast of Colombia, where transmission has had an upward trend over the past 5 years. Prevalence of malaria infection was estimated in areas of the city with the highest incidence of disease, and the association between some characteristics of the population and the risk of malaria infection was assessed. Prevalence of malaria infection was 4·4% among the 1380 studied people and we found that it decreased with older age, and with knowledge of disease and preventive measures directed to elimination of breeding sites. In addition, the infection was positively associated with exposure to the forest ($P < 0·05$), although most of the cases (57/61, 93%) were likely to have been acquired in the urban area. We also found that individuals receiving antimalarial treatment in the previous month had around twice the risk of being infected as compared with those without treatment. In addition, our results suggest that use of bednets could not be a very effective protective measure in settings such as that of our study, and that environmental interventions may be needed to decrease the risk of infection.

Keywords: malaria, *Plasmodium vivax*, *Plasmodium falciparum*, urban risk factors, control, antimalarials

Introduction

Although transmission of malaria is predominantly rural, there is a growing concern about the urbanization of malaria. Unplanned growth of the cities at poor urban and peri-urban areas, without public services and with favourable conditions for *Anopheles* breeding sites, could create appropriate environments for disease transmission (TRAPE & ZOULANI, 1987).

Risk factors associated with transmission of urban malaria may be different than those identified in rural areas. However, most studies have been carried out in rural areas and little is known about individual characteristics that make a person living in a city more likely to acquire the infection. It is thus important to characterize risk factors associated with malaria infection in the urban settings so that adjustments of control strategies can be rationally implemented.

In South America, excluding Brazil, Colombia is the country with the largest number of malaria cases per year, with about 180 000 cases in 1998. The disease in Colombia is clustered in 5 high-risk areas: Bajo Cauca (central), Orinoquia and Amazonia (east), Uraba (northwest Atlantic coast), and Pacifico (west coast) (WHO, 1997).

Malaria is the most common vector-borne disease in the Pacific coast of Colombia. This region, with less than 3% of the Colombian population, accounts for about 13% of cases registered in the country. Buenaventura, the largest Colombian port on the Pacific coast, had in 1991 a large malaria outbreak with more than 8000 cases. During that year, the urban area presented a 5-fold increase in the annual endemic levels and contributed 40% of the total number of cases in the municipality, compared with an average of 20% of the total number of cases in the preceding years (MENDEZ & CARRASQUILLA, 1995).

In this paper, we report a cross-sectional study designed to identify demographic and social risk factors associated with malaria in urban communities of Buenaventura. We measured the prevalence of malaria infection in areas of the city with the highest incidence of disease, and assessed the association between some characteristics of the population and the risk of malaria infection. Specifically, the evaluated risk factors for malaria infection included: demographic characteristics, use of health services, malaria antecedents, symptoms and medication, knowledge of the disease, and knowledge and use of preventive measures.

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Materials and Methods

Study area

The port of Buenaventura is in a very humid tropical forest zone in the Pacific Coast of Colombia. Mean temperature is around 28°C and annual rainfall ranges from 6000 to 9000 mm. The municipality has almost 300 000 inhabitants, 85% of them living in the urban area that is composed of 12 boroughs (*comunas*).

Malaria incidence has a long-term periodicity with peaks occurring every 4 years. The average annual parasite index (API) is about 60–100/1000 in the rural area and 1–3/1000 in the urban area. Cases of malaria occur during the whole year, with 2 seasonal increases usually registered between April and May and between September and October (MENDEZ & CARRASQUILLA, 1995).

In the port of Buenaventura, malaria is clustered at the peri-urban zone which accounts for almost 70% of urban cases and where all positive breeding sites for *Anopheles* spp., primarily *An. albimanus*, are located (OLANO *et al.*, 1997). In a previous report, we found that between 1987 and 1995 the most peri-urban borough of the city (*comuna* 12) had an incidence 5–6 times greater than more urbanized boroughs of the city (MENDEZ & CARRASQUILLA, 1995).

Study population and methods

We carried out the study between November 1993 and January 1994 in *comuna* 12. The questionnaire was designed according to the results of a previous focus-group study in the area (NIETO *et al.*, 1999). Questions were selected to obtain demographic and medical information, including diagnosed episodes of malaria, antimalaria treatments by prescription or self-administration, knowledge about malaria and its prevention, and use of personal protective measures. The questionnaire was administered by a team composed of a general-medicine practitioner and 2 nurses who were trained by the epidemiologist prior to conducting the interviews. Field supervision and co-ordination was carried out by the primary epidemiologist of the research team (F.M.).

The *comuna* had about 30 000 inhabitants, and the sampling frame was based on water-supply records and maps covering 95% of the total population. For the other 5%, houses were identified in the field and included in the sampling frame using the most recent 1:1000-scale map of the *comuna*. We based our sample-size estimation on data of previous studies done in the region which showed that the prevalence of disease for our study was expected to be between 5 and 7% (ROJAS *et al.*, 1992; SEVILLA-CASAS, 1993). Using this preliminary information and assuming an odds ratio for protective factors around 0·5 (i.e., for risk factors around 2·0) and a range of frequencies of exposure in controls between 20 and 60%, we used methods for comparison of proportions of samples of unequal size (FLEISS, 1981) resulting in required sample sizes between 1200 and 2000 individuals ($\alpha = 0{\cdot}05$ and $1-\beta = 0{\cdot}8$).

Sampling was accomplished in 2 stages. In the first stage, households were randomly selected from the sampling frame. During the second stage, the interviewer made a list of individuals living in each household and selected 1 of them using a list of random numbers. If the person selected was not at home during the first visit, 2 additional attempts were made to contact him or her. For individuals aged <10 years, the questionnaire was answered by his/her mother or close relative. Informed consent was obtained and signed by the interviewee or his/her relative. A thick smear was taken and read by an experienced laboratory technician, who diagnosed a sample as negative after reading 200 Giemsa-stained fields. Individuals with positive thick smears received treatment according to standard medical practice.

Statistical analysis

At the first stage of analysis, univariate associations were assessed using 95% confidence intervals (CI) to evaluate differences in distribution of cases of infection and all non-cases according to each of the putative risk factors for malaria infection.

For the second stage of the analysis, we divided the putative risk factors into 4 categories, namely: demographics (gender, age, race, years in the neighbourhood, education and occupation); malaria antecedents and medication (diagnosis and number of episodes of malaria during the previous year, chloroquine intake during the previous month); knowledge of disease and preventive measures (knowledge of symptoms, aetiology and preventive measures); and use of personal preventive measures (bednets, repellents and insecticides). Selection of variables within each category above was carried out using a step-wise procedure. Variables significant at $P<0{\cdot}15$ were selected for the next stage of variable selection. Finally, a logistic regression model was fitted including the variables that were significant from each of the 4 groups. Evaluation of interaction between the risk factors and assessment of the goodness of fit of the final model was done by χ^2 test and by checking the distribution of Pearson residuals (HOSMER & LEMESHOW, 1989).

Results

The sample for the study consisted of 1380 individuals, 53·9% of whom were female, and whose ages ranged from 0 to 85 years. These gender and age distributions were consonant with the census data of Buenaventura.

Malaria infection prevalence was 4·4% (61/1380), with *Plasmodium vivax* accounting for most of the cases (43/61, 70·5%) and the remainder being infected with *P. falciparum*. Almost 70% of the individuals with infection (42/61) reported ≥1 symptom related to malaria during the preceding month: fever, chills and/or headache; but at the moment of the interview, <10% of them (6/61) were acutely sick.

Univariate analysis

The univariate analysis is summarized in Table 1. We present here the results of the 4 categories of variables described in the Methods section.

Demographic variables. Older individuals showed lower risk of malaria infection. Specifically, malaria prevalence decreased from 6·5% (21/324) in children aged 0–9 years to 4·3% (15/348), 4·1% (18/441) and 2·6% (7/267) in individuals aged 10–19, 20–39 and ≥40 years, respectively. Nevertheless, a significant difference was found only between the first (0–9 years) and last (≥40 years) categories.

The positive association with education in individuals aged >19 years was not significant and could be partially explained by age being a confounding factor. Specifically, people aged >40 years have a lower level of education (0 years of education: 84/267, 31·5%) than those aged 20–39 years (0 years of education: 43/441, 9·8%). Therefore, individuals with higher levels of education had a higher risk of being infected, at least in part, because they were younger.

In addition, rural occupation was found to be strongly associated with infection for those individuals aged >19 years. However, in this age-group, individuals with rural occupation accounted for only 16% (4/25) of the malaria cases.

Antimalarial medication. To determine the effect of medication in the previous month, we first divided the study population in 3 groups: individuals without antimalarials intake, individuals who used prescribed treatment after microscopy diagnosis, and individuals in which medication was self-administered. Individuals without medication in the previous month appeared to have a lower prevalence of malaria infection at the survey. The prevalence of malaria infection in individuals who received a prescribed treatment (chloroquine and/or pyrimethamine–sulfadoxine) was higher (odds ratio [OR] 1·83) although not significantly different (95% CI 0·70–4·77) from those without medication. In contrast, a significant association (OR 2·11; 95% CI 1·09–4·09) was seen when comparing individuals without antimalarial intake with those receiving self-treatment (usually chloroquine at subtherapeutic doses).

Knowledge of disease and preventive measures. Most of the population knew the aetiology of disease (1174/1380, 85·1%), and a protective effect was statistically important ($P = 0{\cdot}072$) to include this variable in the final multivariate analysis. In addition, a significant association ($P = 0{\cdot}021$) was detected with knowledge about elimination of breeding sites as an effective measure to prevent the disease, but a non-significant ($P = 0{\cdot}442$) association was found with knowledge about use of bednets.

Use of personal protective measures. Although use of bednets, repellents or insecticides appeared protective for malaria infection, none of them showed significant associations. No correlation was found between age and use of personal protective measures that could partially explain the lack of protective effect.

Age and rural occupation. Table 2 shows the results from the analysis of age and rural occupation as risk factors for malaria. In order to evaluate the effect of rural occupation on the association of age with malaria infection, we stratified individuals aged >19 years according to occupation. Occupational strata for individuals aged ≥40 years were collapsed because those with rural occupation were all negative (Table 2).

It can be seen that the protective effect of increasing age for malaria infection is reversed at age 20–39 years if individuals get exposed to rural environments ($P = 0{\cdot}015$).

Multivariate analysis

The final multiple regression model was obtained in 2 stages. First, we developed a step-wise selection of variables within the 4 categories of putative risk factors. We looked carefully for evidence of collinearity between some variables within categories. In particular, we decided to redefine variables in the 'knowledge' category. We combined knowledge of symptoms, knowledge of aetiology of malaria *and* knowledge of elimination of

Table 1. Univariate analysis of risk factors for malaria infection, Buenaventura, Colombia, 1994

	n	Proportion positive (%)	OR (95% CI)
I. Demographic			
Age in years			
0–9	324	6·5	1
10–19	348	4·3	0·65 (0·33–1·28)
20–39	441	4·1	0·61 (0·32–1·17)
≥40	267	2·6	0·39 (0·16–0·93)
Gender			
Female	745	4·0	1
Male	635	4·9	1·22 (0·74–2·03)
Race			
Non-black	502	5·0	1
Black	878	4·1	0·82 (0·49–1·37)
Years of residence			
>1 year	1027	4·1	1
≤1 year	353	5·4	1·33 (0·77–2·31)
Years of education[a]			
No (0)	127	1·6	1
Elementary (1–5)	370	4·3	2·82 (0·64–12·45)
More than elementary (>5)	211	3·3	2·14 (0·44–10·49)
Occupation[a]			
Non-rural	667	3·2	1
Rural	41	9·8	3·32 (1·14–9·77)
II. Antimalarial treatment in the previous month[b]			
No treatment	1146	3·8	1
Prescribed treatment	75	6·7	1·83 (0·70–4·77)
Self-administered treatment	158	7·6	2·11 (1·09–4·09)
III. Knowledge			
Aetiology of disease			
No	206	6·8	1
Yes	1174	4·0	0·57 (0·31–1·05)
Bednets as prevention			
No	1028	4·7	1
Yes	352	3·7	0·78 (0·42–1·45)
Breeding sites elimination			
No	891	5·4	1
Yes	489	2·7	0·48 (0·26–0·89)
IV. Use of personal preventive measures			
Use of bednets			
No	536	5·0	1
Yes	844	4·0	0·79 (0·47–1·32)
Use of repellents			
No	1329	4·6	1
Yes	51	0·0	Undefined
Use of insecticides			
No	600	4·8	1
Yes	780	4·1	0·84 (0·51–1·40)

[a]From a total of 25 positives and 683 negatives among those older than 19 years ($n = 708$).
[b]1 missing value.
OR (95% CI), odds ratio (95% confidence interval).

Table 2. Age and rural occupation as risk factors for malaria, Buenaventura, Colombia, 1994

Age-group/occupation	n	Proportion positive (%)	OR (95% CI)
0–9 years	324	6·5	1
10–19 years	348	4·3	0·65 (0·33–1·28)
20–39 years/urban	424	3·3	0·49 (0·25–0·98)
20–39 years/rural	17	23·5	4·44 (1·33–14·81)
≥40 years	267	2·6	0·39 (0·16–0·93)

OR (95% CI), odds ratio (95% confidence interval).

breeding sites as a preventive measure in a single variable that we called 'knowledge of disease and prevention'.

In the second stage, variables previously selected in each of the 4 categories were included in a logistic regression model. The variables remaining associated with malaria infection are shown in Table 3 and were: age, rural occupation, self-medication of malaria treatment, and knowledge of disease and prevention by breeding-site elimination. These variables did not show significant statistical interaction.

Table 3. Results of multiple logistic regression analysis of risk factors for malaria infection, Buenaventura, Colombia, 1994

Variable	OR (95%CI)	*P* value
Age-group/occupation		
0–9 years	1	
10–19 years	0·61 (0·30–1·22)	0·161
20–39 years/urban	0·44 (0·22–0·90)	0·026
20–39 years/rural	2·95 (0·81–10·81)	0·102
≥40 years	0·34 (0·14–0·84)	0·019
Malaria treatment in previous month		
No treatment	1	
Treatment prescribed	1·77 (0·66–4·76)	0·256
Self-medication	2·02 (0·98–4·15)	0·057
Knowledge of disease and prevention by breeding sites elimination		
No	1	
Yes	0·49 (0·26–0·95)	0·033

OR (95% CI), odds ratio (95% confidence interval).

Diagnostic checks showed an acceptable goodness of fit of the final model (Pearson χ^2, 22 d.f., 14·7; $P = 0·87$) and an adequate distribution of the Pearson residuals.

Discussion

In this study, conducted in a periurban area of a major port on the Pacific coast of Colombia, we found that prevalence of malaria infection decreased with older age and with knowledge of disease and preventive measures directed to elimination of breeding sites. In addition, the disease was positively associated with exposure to the forest and self-medication with antimalarials in the previous month.

Changes in risk of malaria with age are conventionally explained by the development of antimalarial immunity as individuals accumulate infection experiences with the antigenic repertoire of wild parasites (BAIRD, 1995). The prevalence of malaria in moderate and low endemic areas, such as urban Buenaventura, has been classically described as one increasing with age from younger ages in children to finally stabilizing in adults (ARON, 1988). This pattern has been associated with behavioural factors, and mobility to the forest has been identified as a main determinant of risk. In these situations, it is expected that children and older individuals are less exposed and, subsequently, the incidence of disease is higher in adults aged 20–39 years (ARANHA *et al.*, 1996).

In our study, individual exposure to the forest, measured by rural occupation, was associated with a higher risk of malaria. However, in the final multiple regression model, this association was not statistically significant ($P = 0·102$) and only a small proportion of the total number of cases occurred in individuals with exposure to the forest (4/61, 7%). Therefore, although activities in the forest are risk factors for malaria and individuals infected there could represent reservoirs for parasites to keep transmission in the city, the observed infections in children require transmission in the urban area to explain most of the cases. A similar pattern of transmission was reported in a hypoendemic region in the Philippines where malaria prevalence decreased from 11% in individuals aged 11–19 years to 4·7% and 1·3% in those aged 20–39 and ≥40 years, respectively (BELIZARIO *et al.*, 1997). Also, a study developed in a rural community in the Pacific Coast of Colombia showed a decrease in prevalence of infection from 10·4% in those aged 0–9 years to 5·2% in individuals aged ≥44 years (GONZALEZ *et al.*, 1997). Although the relationship between age and prevalence may also depend on migration, our results were practically unchanged when adjusted by years of residence. In the setting of our study, the most likely scenario is that older individuals are at lower risk because of development of anti-disease immunity after many years of chronic exposure.

We also found that individuals receiving antimalarial treatment in the previous month had around twice the risk of being infected as compared with those without treatment, and this could be partially explained by re-infection in a highly susceptible or exposed group. Furthermore, individuals with a treatment based on thick smear diagnosis have a slightly lower (and non-significant) risk when compared to self-medicated individuals. Individuals with thick smear diagnosis typically have a higher compliance with treatment and, in the case of *P. vivax*, they also received anti-tissular drugs such as primaquine. It is likely that the increased risk observed in this group is due to chloroquine resistance of *P. falciparum*. Conversely, self-medicated individuals took subtherapeutic doses of chloroquine and anti-tissular drugs (i.e., primaquine) were absent in their treatment schemes. Therefore, treatment failures in *P. falciparum* infections and relapses in *P. vivax* infections are likely to occur in self-medicated individuals. In summary, this finding suggests that new infections and/or relapses are about twice as likely to occur in individuals who received antimalarial treatment, but also that a slightly better outcome could have been seen in individuals attending health services, having a proper diagnosis and receiving complete treatment, than in those buying the treatment over the counter without a microscopy diagnosis.

It has been stated that control strategies should consider treatment-seeking behaviours. The choice of treatment has been shown to be affected by a number of factors, including access, cost, attitudes toward providers and beliefs about disease (MCCOMBIE, 1996). We reported elsewhere that traditional remedies were not considered by the community as a first choice for malaria treatment, but that individuals believed modern medicines were the adequate option for treatment (NIETO *et al.*, 1999). However, about 70% (158/233) of individuals receiving antimalarial treatment in this study were self-medicated.

The self-medicated individuals can be a major source of drug pressure to increase drug resistance in an area. In Mali, a higher prevalence of resistant mutant parasites was found in urban communities, where drugs were available and their use was uncontrolled, as compared with those settings where antimalarials were not available in pharmacies or markets and where drugs were provided by a community-supported dispensary (PLOWE *et al.*, 1996).

In rural areas where health workers are frequently unavailable, training of the community for adequate use of antimalarial drugs has been considered important (KROEGER *et al.*, 1996). However, in urban areas where health posts and/or trained community health workers with microscopes can provide a 24-h health service, and even in rural areas if this can be achieved, a major effort should be made to increase access to microscope-based treatment.

Finally, we also found that knowledge of disease and knowledge of prevention by elimination of breeding sites had a protective effect for malaria. We carefully distinguished adequate knowledge of disease symptoms and aetiology and knowledge of appropriate breeding sites for *Anopheles* (e.g., clean water, bromeliads) as compared to breeding sites for other mosquitoes in the area (e.g., tyres, dirty water). Hence, the finding suggests that only individuals having a qualitatively better understanding of malaria were at lower risk.

A direct relationship between individual knowledge of environmental interventions and actually taking preventive measures was not addressed in this study; and confounding by socioeconomic status, housing conditions or other factors may explain part of this association. Nevertheless, other studies have shown that mothers' knowledge about malaria is associated with a lower risk of disease in children (KORAM *et al.*, 1995) and also that taking preventive measures is associated with knowledge of malaria (VUNDULE & MHARAKURWA, 1996).

Bednets were associated with a protective effect (4% prevalence among 844 bednets users vs 5% among 536 non-users); however, it was not shown to be statistically significant. Indeed, detection of significant difference between 4% and 5% would have required a sample size of 9110 users and 5694 non-users. Although our findings could be partially explained by lack of statistical power at this level of effect, we also believe that they could be due to the local conditions of transmission. Specifically, entomological studies done in the periurban area of Buenaventura had demonstrated that *An. albimanus*, the most important vector in the area, has a greater peridomiciliar activity with a peak biting-hour between 18:00 and 22:00 (OLANO *et al.*, 1997). This is also the time for social activities (children playing and adults meeting) outside the house in this community and the more likely time for acquiring malaria. Therefore, use of bednets during the night could not be a very effective protective measure and environmental interventions may be needed to decrease the risk of infection.

Urbanization of malaria mainly affects peripheral areas of the cities and it is a major concern in many regions of the world. In this study, we report indirect evidence of malaria transmission in the periurban area of Buenaventura, and entomological studies in the area demonstrated later direct evidence of transmission (OLANO *et al.*, 1997).

We attempted to characterize epidemiological factors related to malaria in this urban setting in order to help in the design of a control programme. The results of this study suggest that individual protective measures (e.g., bednets) would be probably less effective than community interventions directed to the environment. In addition, knowledge of preventive measures appeared less commonly in individuals with the infection, which suggests that an educational intervention should be implemented. Taking into account findings about a higher prevalence of infection in those medicated, we also considered factors related with treatment-seeking behaviour and determinants of access to health care in the design of the programme. As a result, an educational strategy was designed and implemented. The programme in this urban area focused on environmental measures directed to control of breeding sites with community participation, and training of leaders in the reading of thick smears at home for microscopy diagnosis of malaria.

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Short Report

High density of *Rhodnius prolixus* in a rural house in Colombia

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Rhodnius prolixus (Hemiptera, Reduviidae, Triatominae) is the primary vector of Chagas disease (American trypanosomiasis) in Colombia, Venezuela and parts of Central America. From available prevalence data (e.g., WHO, 1991; SCHOFIELD & DUJARDIN, 1997) we can estimate that *R. prolixus* may be responsible for well over 2 million cases of human infection with *Trypanosoma cruzi* (the causative agent of Chagas disease) throughout its current distribution. In Colombia, *R. prolixus* is mainly distributed along the central Magdalena valley and in some regions of the llanos bordering Venezuela. In these regions it appears to be entirely domestic, and may have been accidentally introduced from Venezuela by early European explorers (SCHOFIELD & DUJARDIN, 1999). As part of a series of studies of the ecology of *R. prolixus* and the epidemiology of Chagas disease in Colombia, we report here the results of study of a single rural house that revealed the highest level of infestation yet recorded.

The house was situated in a rural area of the municipality of San Joaquín, Department of Santander (6°26′N, 72°52′W) at an altitude of 1850 m above sea level. The region is mainly subAndean humid forest with a mean annual temperature of 18°C and mean annual rainfall of 1874 mm, and has been extensively exploited for the cultivation of sisal (*Agave americana*). Our studies during 1996 had indicated that 24·2% of houses in this region were infested with *R. prolixus*, which is one of the highest infestation rates of the Department. The house chosen for this study was known to be infested, and was scheduled to be replaced under the national rural housing programme 'Vivir Mejor'. It had a total floor area of 24 m^2, with floor and walls of beaten earth (*barro pisado*) and a tile roof, and had been constructed about 15 years ago. The family of 2 adults and 7 children claimed that they had never used insecticide against the bugs in their house, but frequently made small traps of twisted sisal fibres that they hung in the roof space; these served as artificial refuges for the bugs and were periodically collected and burned.

The house was first surrounded with a mesh curtain supported on poles placed 2 m from the walls and extending 2 m high. All domestic items were removed from the interior of the house (2 beds and numerous cardboard boxes of clothes and utensils). These were carefully examined for adults and nymphs of *R. prolixus*. Large numbers of bug eggs and exuviae were also seen but not collected. After examination, the domestic items were sprayed with a commercial insecticide (Dinex®) containing 0·05% deltamethrin plus 0·04% esbiothrin. The house was then treated with a dislodgant spray (see PINCHIN *et al.*, 1978) by igniting in the interior a fumigant canister (Musal®) which liberates a smoke containing asymethrin, permethrin and dichlorvos. Two hours later, all knocked-down bugs were collected. Roof tiles were then removed for inspection, and the walls were progressively dismantled and checked for bugs. The dismantling of the house and collection of bugs involved a team of 6 people over a period of 4 days, after which the remains of the house were burned.

A total of 11 403 *R. prolixus* was collected (Table), the largest number of Triatominae collected from a single house. In Venezuela, using a similar technique of house dismantling, RABINOVICH *et al.* (1979) collected 7934 *R. prolixus* from a single house, while dissection of a house in the Francisco Morazán department of Honduras revealed 11 341 specimens (C. Ponce *et al.*, unpublished report, 1990). DIAS & ZELEDÓN (1955) collected 6034 *Triatoma infestans* by dismantling a house in central Brazil, and SCHOFIELD (1980) reported 1063 and 4923 *T. infestans* from 2 houses in Brazil based on mark–recapture estimates during house dissection.

Although the collected insects were not weighed in this study, we can use the data of RABINOVICH *et al.* (1979) to estimate the average blood loss attributable to *R. prolixus* in this house (Table). Assuming that the proportion fed of each stage in our collection was similar to that found by RABINOVICH *et al.* (1979), then each person in the house would have been suffering, on average, 98 bites per day, and losing in consequence around 8·8 mL of blood per day. Recalling the calculations of RABINOVICH *et al.* (1990) showing that the average probability of a new infection is equivalent to about 1 per 1000 bites from infected bugs, it was unsurprising to find that all 9 people in this house were seropositive for *Trypanosoma cruzi* infection.

Epidemiological surveys by ourselves and others indicate that heavy domestic infestations with *R. prolixus* are not uncommon in rural areas of Colombia, and the presence of this vector is the single most important risk factor for *T. cruzi* transmission (ANGULO *et al.*, 1999; GUHL *et al.*, 1999; RESTREPO *et al.*, 1999). These data fully endorse the need for control actions, not only to eliminate the risk of further transmission of *T. cruzi*, but also to reduce the substantial blood loss of people living in heavily infested houses.

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Table. Numbers of *Rhodnius prolixus* collected from the rural house in Colombia, and estimates of their average biting frequency and amount of blood taken

Stage	No. collected	Bites/day[a]	Estimated total blood taken[a]
1	1248	53·5	105·9
2	1265	147·2	1076·4
3	1675	154·8	3481·4
4	1759	118·5	9537·1
5	2446	182·8	36796·2
Adult	3010	225·8	32424·9
Total	11403	882·6	83421·9[b]

[a]Following the calculations of RABINOVICH *et al.* (1979), assuming that proportions of bugs feeding were the same in both cases.

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