A survey on *Triatoma dimidiata* in an urban area of the province of Heredia, Costa Rica

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Triatoma dimidiata *has been found in several cities and towns of those countries where the insect is a domestic or peridomestic pest. In Central America, urban infestations occur in the capitals of at least five countries.*

During 2001 and 2002 a survey was carried out in the county of San Rafael, Heredia province, located 15 km northwest of San José, capital of Costa Rica, in order to determine the degree of infestation by T. dimidiata *in an entire city block.*

Six peridomestic colonies of the insect were detected in the backyards of eight households. The ecotopes occupied by the insects consisted of store rooms with old objects, wood piles or firewood, and chicken coops.

A total of 1917 insects were found in the six foci, during two sampling periods, and a mean infection rate by Trypanosoma cruzi *of 28.4% was found in 1718 insects examined. The largest colony found in one of the households yielded 872 insects that were thriving mainly at the expenses of two dogs.*

Opossums and adult insects were common visitors of the houses and it became evident that this marsupial is closely related to the peridomestic cycle of the Chagas disease agent. Lack of colonization of the insect inside the human dwellings is explained by the type of construction and good sanitary conditions of the houses, in contrast to the situation in most peridomiciliary areas.

Stomach blood samples from the insects showed that the main hosts were, in order of decreasing frequency: rodents, dogs, fowl, humans, opossums, and cats.

The fact that no indication of infection with Chagas disease could be detected in the human occupants of the infested houses, vis a vis the high infection rate in dogs, is discussed.

Key words: *Triatoma dimidiate* - urban infestation - Chagas disease - opossums - Costa Rica

The urban condition of *Triatoma dimidiata* in several countries of Latin America is a well known fact since the XIX century. The first reference to the finding of this species in the city of Guayaquil, Ecuador, was made by Stal (1859) and the second by Pittier and Biolley (1895) who encountered the insect in some urban districts of the city of San José, the capital of Costa Rica. This situation was confirmed later on by others (Büllow 1945, Céspedes & Aguilar 1955, Zeledón 1981).

The presence of the insect in other Central American capitals is also well documented. Dias (1952) pointed out its existence in Managua, Nicaragua, and in San Salvador, El Salvador. Its presence in Guatemala City and in Tegucigalpa, Honduras, has also been recorded (Peñalver et al. 1965, Ponce & Zeledón 1973).

T. dimidiata was found in houses in the city of Mérida, Mexico (Palomo 1940) and its highest urban expression is reached in Guayaquil, the second most important city of Ecuador, where this condition has been observed and studied by several authors (Campos 1923, 1931, Alvarez-Crespo 1944, Rodríguez 1959, Gómez-Lince 1968).

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In Central America the finding of *T. dimidiata* in cities has been fortuitous or the product of general surveys. Little attention has been paid to this situation and to the ecological conditions under which the insect thrives in or around an urban area.

In light of the Central American Initiative for the control of Chagas disease, and following its recommendations and objectives, we decided to study some of the factors that allow this insect to occur in an entire block of an urban area, in the province of Heredia, Costa Rica. The results of this field research are the object of this report.

MATERIALS AND METHODS

Study area - The chosen block is part of a town that corresponds to the county of San Rafael in the province of Heredia, 300 m from the local catholic church (Fig. 1A), 3 km northeast of the city of Heredia, and about 15 km northwest of San José, the capital of Costa Rica. San Rafael is located at 10º 00' N, 84º 06' W and at an altitude of 1264 m.

Procedure - During 2001, a person from one of the houses found some specimens of *T. dimidiata* in a store room located in the backyard, and took them to the clinical laboratory of the Heredia Hospital. We were alerted by the director of the laboratory to this finding and decided to carry out a survey during June and July, in the mentioned household plus a group of 11 additional houses located on the same side of the block. In view of the finding of some

colonies of the insect under peridomiciliary conditions in four of the houses during this first phase of 2001, in July of 2002 we decided to carry out another survey to include all the houses in the block (Fig. 1B).

Six well trained senior or graduate university students were in charge of the revision inside and outside of 68 houses of the 70 that made up the block (in two houses the householders were absent at the time). We used the man/hour method with at least two team members searching simultaneously with the help of forceps and a flashlight. The minimum time indoors was 15 min, taking between 15 min to 1 h to search the peridomestic areas. Once colonies were discovered, all surrounding objects were removed and all insects found were captured. This operation had a mean duration of 6 h.

The sources of blood meals of 100 insects (77 nymphs and 23 adults), from five of the six foci, were identified by two tests. The capillary tube precipitin test with antisera from 14 hosts (human, fowl, dog, cat, horse, goat, cow, pig, sheep, rodent, opossum, armadillo, toad, and lizard) were used following the procedure of Lorosa et al. (1998). The Outchterlony double diffusion agar test (Crowle 1980) was also used with only five antisera (human, fowl, dog, rodent, and opossum). The antigens were obtained from the stomach of the insects and preserved at 5ºC of saline solution plus merthiolate 1/10,000.

A serological survey was made in 24 persons (11 females and 13 males with a mean age of 30.8 years) of the 30 living in the eight houses with peridomiciliary infestation, and in ten dogs out of the 13 belonging to the same householders, by using one or two ELISA commercial kits (crude and recombinant antigens from Wiener); in both cases positive dogs were confirmed with two additional tests (Montenegro et al. 2002).

RESULTS

In eight out of the 68 houses searched, we found colonies of *T. dimidiata* in artificial ecotopes around the houses. We divided these colonies in six foci (F1-F6), due to the fact that houses 1 and 2 and houses 34 and 35 shared the back yard. Three of the foci were located on the east side of the block (F1, F2, and F3), one on the south (F6), one on the west (F5) and one was in a central position (F4) (Fig. 1B).

Most of the houses were built of cement or blocks. In 56 of them, the inside sanitary conditions were good; in the other 12 houses these conditions were fair (Fig. 2 A, B, C).

In Table I, we show the types of ecotopes where the foci (F1-F6) were located, and the number of insects found in each of them during the two phases of the work. The main types of ecotopes were store rooms with old objects inside, wood piles or fire wood, and chicken coops.

In F1, F2, and F3 the colonies were close to dogs which evidently were important sources of blood for the insects even though rats and mice were also part of the biocenosis; in F4 and F5, the insects were in or close to the chicken coops, and in F6, they were found close to an abandoned nest inside an old store room with many wood pieces.

After showing samples of dead *T. dimidiata* specimens to all the householders, the ones belonging to 23 of them (33.8%) recognized the adults and stated that they had seen them frequently inside their houses. On at least two occasions this fact was confirmed by us.

In one of the empty lots in the east part of the block, it was possible to locate two abandoned opossum nests and the inhabitants of 22 houses (32.4%) recognized that their places were visited rather often by the marsupial and sometimes they used to live in the roofs of their houses.

Out of the 1917 insects captured during the two periods, 1718 were examined for *Trypanosoma cruzi* and the mean infection rate was 28.5% (Table I).

The largest colony was obtained from house No. 3 (F2) which had a pile of wood pieces on a raised platform made of wood and with numerous cracks, at a short distance from the dirt floor in an open store room located in the backyard, where a dog house for two dogs was also based (Fig. 2D). In this place we found 872 insects which represent 45.5% of the total found; 199 first and second instar nymphs from this house were not examined for *T. cruzi*.

TABLE I

Entomological survey for the presence of *Triatoma dimidiata* in 68 households from a complete block of the urban area of San Rafael county, province of Heredia

Focus (House No.)	Place [a]	No. of insects examined and year			No. of positive insects (%)		
		2001	2002	Total	2001	2002	Total (%)
F1(1 y 2) [b]	Store room and dog house	107	146 [c]	253	19(17.8)	41(28.1)	60(23.7)
F2(3) 231(34.4)	Store room (wood piles)	462 [d]	210	672	194(42.0)	37(17.6)	
F3(4)	Backyard	4	4	8	1(25.0)	0	1(12.5)
F4(34 y 35) [b]	Chicken coop (wood piles)	371	95	466	0	0	0
F5(44) 10(16.1)	Chicken coop (wood piles)	3	59	62	0	10(16.9)	
F6(50) 188(73.2)	Store room (wood and fire wood)	172	85	257	141(82.0)	47(55.3)	
Total		1119	599	1718	355(31.4)	135(22.5)	490(28.5)

a: in all cases the insects were found in peridomiciliary structures; *b*: these households share the backyard; *c*: an adult was found on a bed of house Nº 1; *d*: from a total of 661 insects captured.

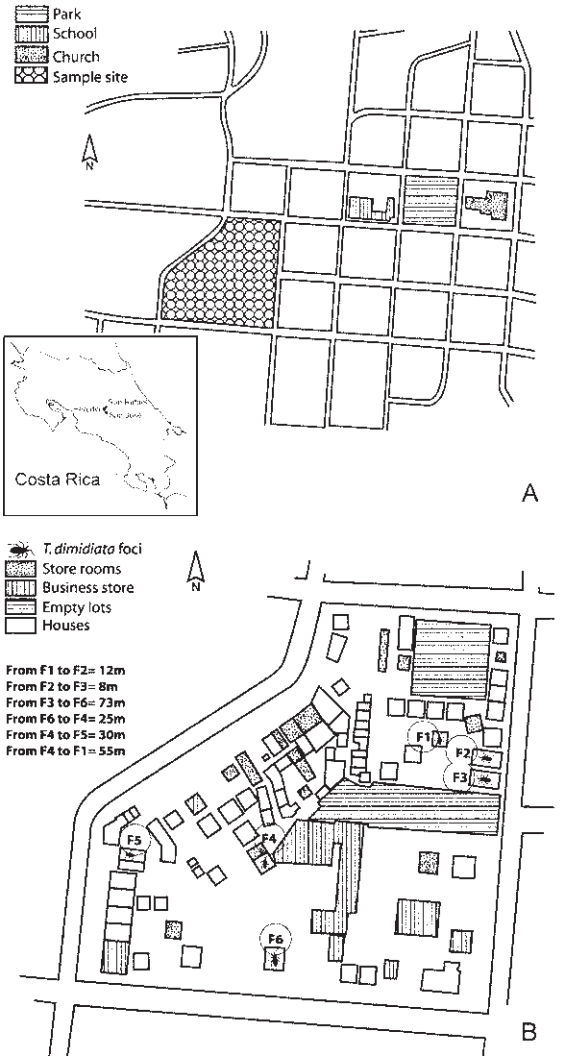

Fig. 1A: partial map of San Rafael, Heredia, showing the block where the survey for *Triatoma dimidiata* was carried out. A Costa Rican map showing the relative location of San Rafael in relation to San José and Heredia. B: map of the block showing the sites where *T. dimidiata* was found in San Rafael, Heredia.

In Table II we show the rate of *T. cruzi* infections in each of the foci, discriminating by insect stages. In Table III we present the details of the infection rates by sex and by nymphal stages.

The differences in degree of *T. cruzi* infections among the groups of insects are probably related to the type of host available in a certain moment. There were more nymphs (87.7%) than adults (12.3%) in the entire population.

In the eight infested houses there were 13 dogs (1.6 dogs/house) whereas in the other 60 houses the number of dogs was 73 (1.2 dogs/house) ($p = 0.5$). In five of the eight houses, there were chicken coops with a total of 51 animals among them (6.4 chickens/house) whereas in the other 60 houses there were only two chicken coops with a total of 15 (0.25 chickens/house) ($p = 0.01$).

In Table IV we present the results obtained by combining the precipitin and diffusion tests for the identification of the hosts used by the insects. Six different blood sources were recognized. The most common blood sources were rodent and dog followed by fowl, human, opossum, and cat. In 26 nymphs and six adults from houses Nº 1, 2, 3, 34, and 35, human blood was detected indicating a constant entrance of nymphs and adults into the houses without remaining inside. Also, 13 nymphs and two adults from the houses formerly mentioned, plus house Nº 44, presented opossum blood, showing the close relationship of this animal with humans under urban conditions. In five nymphs with three or four different types of blood, human, and opossum bloods coincided.

All 24 persons examined by the ELISA test were serologically negative; four of the ten dogs examined by the same test, yielded a positive result, confirmed by indirect immunoflorescence and indirect hemagglutination tests.

DISCUSSION

The finding of six peridomiciliary colonies of *T. dimidiata* in one entire block of the town of San Rafael de Heredia, Costa Rica, confirms the tendency of this bug to infest urban areas when the ecological conditions allow the insect to thrive in artificial ecotopes if they are present.

TABLE II

Details of *Trypanosoma cruzi* infection in adults and nymphs of *Triatoma dimidiata,* from eight houses of a complete block of San Rafael county, province of Heredia

Focus (House No.)	Adults		No. of positives (%)		Nymphs		No. of positives (%)	
	2001	2002	2001	2002	2001	2002	2001	2002
F1 (1 y 2) (29.6)	40	11	10 (25.0)	1 (9.1)	67	135	9 (13.4)	40
F2 (3) (14.4)	67	50	47 (70.1)	14 (28.0)	395	160	147 (37.2)	23
F3 (4)	0	0	0	0	4	4	1 (25.0)	0
F4 (34 y 35)	39	8	0	0	332	87	0	0
F5 (44) 6 (11.5)		0	7	0	4 (57.1)	3	52	0
F6 (50)	13	0	11 (84.6)	0	159	85	130 (81.8)	47 (55.3)
Total	159	76	68 (42.8)	19 (25.0)	960	523	287 (29.9)	116 (22.2)

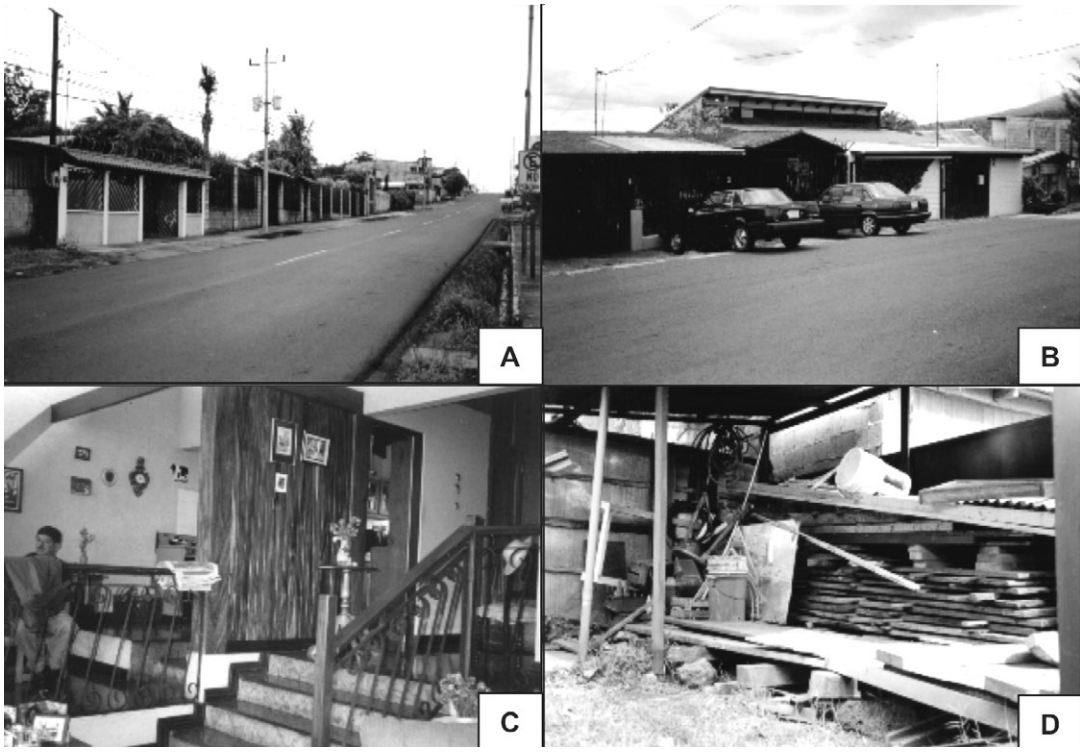

Fig. 2A: some of the houses surveyed for *Triatoma dimidiata* in San Rafael, Heredia. These houses are located on the southern side of the surveyed block. B: a two-story house (No. 3), where F2 was found. This house is located on the eastern side of the block shown in Fig 1. C: interiors of the two-story house No. 3, showing excellent construction and sanitary conditions. D: woodpile located in the backyard of the same two-story house (No. 3), where 872 specimens of *T. dimidiata* were found. A dog house is located next to the woodpile (not shown in the picture), where two dogs dwell.

TABLE III

Triatoma dimidiata infected with *Trypanosoma cruzi,* according to sex and nymphal instar, found in eight households of a complete block of San Rafael county, province of Heredia

Sex	Positive insects (%)		Negative insects (%)			Totals	Consolidated	Positives (%)
or instar	2001	2002	2001	2002	2001	2002	Total	
Female adults	31(45.6)	7(18.4)	37(54.4)	31(81.6)	68	38	106	38(35.8)
Male adults	37(40.7)	12(31.6)	54(59.3)	26(68.4)	91	38	129	49(38.0)
Nymphs 5º	174(46.2)	62(27.4)	203(53.9)	164(72.6)	377	226	603	236(39.1)
Nymphs 4º	50(27.0)	23(30.7)	135(73.0)	52(69.3)	185	75	260	73(28.1)
Nymphs 3º	46(23.4)	20(24.7)	151(76.7)	61(75.3)	197	81	278	66(23.7)
Nymphs 2º	13(10.7)	11(13.3)	109(89.3)	72(86.8)	122	83	205	24(11.7)
Nymphs 1º	4(5.1)	0	75(94.9)	58(100.0)	79	58	137	4(2.9)
Total	355(31.7)	135(22.5)	764(68.3)	464(77.5)	1119	599	1718	490(28.5)

Most of the lands where these small towns are built were previously coffee plantations where the wild cycle of the insect, sharing the same places with opossums, has probably existed for a long time. This marsupial continues to be common in urbanized areas and in larger cities in many countries, where it easily becomes a synanthropic animal, linking the wild and the domestic cycles of *T. cruzi*, involving the same vector in both cases (Zeledón et al. 1970).

A clear relationship of these cycles based on blood source identification, as well as some evidences for the dispersion of nymphs from the outside to the inside of houses, were previously presented and discussed (Zeledón et al. 1973).

In the city of Guayaquil, Ecuador, the insect is found in buildings and houses, both inside and peridomestic, using wood piles, stone piles, chicken coops, and pigsties as shel-

TABLE IV
Precipitin and diffusion agar tests for identification of blood meals of *Triatoma dimidiata*

	Number of insects examined		Number of positive insects					
Focus (House No.)	Nymphs	Adults	H	D	R	C	F	0
F1 (1 - 2) [a]	27	3	2	2	17	4	11	7
F2(3)	41	11	29	40	20	1	18	6
F3(34 y 35) [b]	8	5	1	-	12	1	4	1
F5(44)	0	4	-	-	1	-	2	1
F6(50) [c]	1	0	-	1	1	-	-	-
Total	77	23	32	43	51	6	35	15

a: house No. 1 was constructed in the back yard of house No. 2; houses 34 and 35 shared the same backyards; *b*: five samples did not react, 31 reacted to two different hosts, 17 reacted to three and 4 reacted to four different hosts; *c*: most of the insects were in total starvation; H: human; D: dog; R: rodent; C: cat; F: fowl; O: opossum.

ters, sometimes in close association with opossums (Espinoza 1955, Arzube-Rodríguez 1966, Gómez-Lince 1968).

In our case, some domestic animals such as dogs and chickens were acting as the main source of blood, together with smaller animals such as rats and mice. These animals thus serve as a biological barrier in peridomicilary foci. Nevertheless, the detection of human blood in nymphs and adult insects in at least three foci (F1, F2, F3), indicates frequent penetrations of the bugs into the houses.

Some of the colonies of *T. dimidiata* produced under these circumstances were able to reach a considerable size, such as the case of F2 with almost 900 individuals, which showed a direct relation with the biomass available to the insects. In the case of F3 which was the smallest of all, the householders had remodeled the back yard and covered all the dirt parts with cement floor.

The infection rates by *T. cruzi* vary according to the type of host. If the insects have access to opossums the rate is going to be high but it could be nil if the blood source is fowl. Dogs are very often victims of infected bugs due to their habit of grabbing them with their mouth and becoming infected by this mechanism (Montenegro et al. 2002). In this research, dogs, rodents and opossums were probably the main source of infection of the insects by *T. cruzi*. All infected nymphs and adults had blood in their intestine from one of these animals or a mixture of them.

Adult insects can start new colonies by flying to houses, attracted to electric lights, but in many instances cannot thrive due to the type of construction and to the good sanitary conditions within the household. They remain in peridomestic sites where they may start a colony if the conditions allow it (Zeledón et al. 2001a). The attraction of this species to lights, either from the wild or even within cities, has been well documented (Campos 1931, Palomo 1940, Sousa et al. 1983, Zeledón et al. 2001b).

In our case, the inhabitants of San Rafael claimed that the visitation of adult insects is common all year round especially during the dry season (December to May). Occasionally, some of them are bitten by the insects though the rate of transmission of Chagas disease, as in this case, is low, probably due to the poor vectorial capacity of this particular species (Zeledón et al. 1977). Nonetheless, a fatal case of trypanosomiasis in a 17 year old boy from Cinco Esquinas de Tibás, about 1 km from downtown San José, has been reported (Céspedes & Aguilar 1955), and in Tegucigalpa, Honduras, at least 12 acute cases of urban infections have been detected (C Ponce, pers. commun.).

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