Small-Scale Field Trial of a Sensing Device for Detecting Peridomestic Populations of *Triatoma infestans* (Hemiptera: Reduviidae) in Northwestern Argentina

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ABSTRACT Two prototypes of sensing devices for detecting peridomestic populations of *Triatoma infestans* Klug were tested in paired trials with bamboo canes in Amamá and nearby rural villages under triatomine surveillance. In infested peridomestic structures housing domestic animals, 1–2 pairs of numbered devices were placed per test site, left for 3–9 nights, and inspected for evidence of infestation. Prototype A was a black plastic cylinder 19 cm high and 10 cm diameter, with a screw cap on the top, 2 openings in the bottom, and a removable central structure made of resistant plastic coated with leather. Prototype B had square leather pieces rolled into cylinders instead of the central structure. Prototype A was significantly more sensitive than the bamboo cane with pleated paper inside in 13 test sites in which 20 pairs were tried. In a smaller series involving 7 pairs, prototype B also detected infestations more frequently than the cane. Triatomine feces were the signs most frequently recorded by both prototypes, whereas the bamboo canes recorded no feces. Ten *T. infestans* and 1 *Triatoma guasayana* Wygodzinsky & Avalos were collected from the prototypes placed on the ground or walls, not beneath the thatched roofs of the animal shelters, whereas only 3 *T. infestans* were collected from the canes. This study describes an effective sensing device for detecting *T. infestans* populations in outdoor animal shelters and provides quantitative field data on its performance.

KEY WORDS *Triatoma infestans*, Chagas disease, Argentina, detection, sampling, vector control

PERIDOMESTIC STRUCTURES HOUSING domestic animals are important sources of triatomines (Ronderos et al. 1980, Dias 1991). After thorough application of deltamethrin, residual foci of *Triatoma infestans* Klug in peridomestic sites initiated the reinfestation of human habitations in rural villages from northwestern Argentina (Cecere et al. 1997). Elimination of *T. infestans,* as supported by the Southern Cone Initiative under the aegis of the Pan American Health Organization (Schmunis et al. 1996), requires a sensitive, simple, and widely applicable method for detecting infested peridomestic sites that can be handled by the affected communities.

Detecting triatomine infestations is a difficult task when bug densities are low. In human sleeping quarters, timed manual captures using a flushing-out spray has usually been considered the method of preference for assessing house infestations by triatomines, but it has various limitations (Schofield 1978, Rabinovich et al. 1995). Therefore, other methods involving cardboard boxes (Gómez-Núñez 1965, Wisnivesky-Colli et al. 1988) and sheets of paper or calendars (García-Zapata et al. 1985) have been developed for triatomine surveillance. These devices are tacked to bedroom walls for long periods and reveal infestations through the presence of triatomine fecal streaks, exuviae, eggs, or bugs. In northwestern Argentina, sensor boxes had a higher sensitivity than matched paper sheets at low bug densities, and both devices were more sensitive than the flushing-out method for detecting domiciliary infestations (Gürtler et al. 1995, 1999).

In peridomestic areas, triatomines are usually searched for by flushing-out and microhabitat dissection. However, because of the intricate structure of some peridomestic ecotopes, such as corrals, the flushing-out method has a much lower capture efficiency there than in bedroom areas. In addition, domiciliary triatomine sensing devices made of cardboard or paper are inappropriate for outdoor sites because their shape is not adequate and they deteriorate easily because of climatic agents. An early design of a triatomine sensing device suitable for outdoor sites consisted in a bamboo cane with pleated paper inside (Tonn et al. 1976). In long-term field trials, the bamboo cane was not effective for sampling sylvatic tri-

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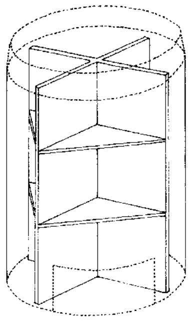

Fig. 1. Diagram of prototype A used to detect peridomestic triatomine populations.

atomines in Venezuela (Tonn et al. 1976) or peridomestic *T. infestans* in northwestern Argentina (O.D.S. and R.C., unpublished data), but it was apparently effective in central Brazil (García-Zapata and Marsden 1993), although no supportive data have been published to date. The sensitivity and limitations of the bamboo device for detecting peridomestic triatomine populations remain unknown.

Simultaneous discriminant assays in the laboratory were carried out to identify factors affecting refuge selection by *T. infestans* nymphs and preference for different types of substrate that could be used in the peridomestic sensing devices (De Marco et al. 1997). These trials, held under controlled conditions of temperature and light, showed that rough leather was significantly preferred to bamboo canes by *T. infestans* nymphs, which laid the basis for the design of 2 prototypes of peridomestic sensing devices. In this study we describe both prototypes and the results of a paired trial between them and the bamboo cane in a rural community under triatomine surveillance.

Materials and Methods

Sensing Devices. The bamboo device consisted of fragments of bamboo cane, *Guadua trinii* (12 cm long and 2.5 cm i.d.) with pleated filter paper inside. These bamboo canes were selected randomly among 3 groups that differed in age, size, and source, which were similarly preferred by the bugs in previous laboratory trials.

Prototype A was a commercially available black plastic cylinder 19 cm high and 10 cm diameter, with a screw cap at the top and 2 openings in the bottom, each 1 measuring 3 cm high and 7 cm wide (Fig. 1). The internal wall surface and floor was coated with leather; the rough leather surface faced the inside. Commercially available brown (3 mm thick) bovine leather that had been subjected to a normal tanning process, with homogeneous rough and smooth surfaces, was used. The cylinder contained a removable central structure made of resistant plastic (alto impacto) that had 3 floors, each 1 divided into 4 compartments. The central structure was coated with leather glued to the plastic surface. Prototype B differed from prototype A in size and internal structure. It was 10 cm high and 10 cm in diameter and had 4 square leather pieces (10 by 10 cm) rolled into cylinders instead of the central structure. All devices and materials had not been used previously.

Study Site. Fieldwork was carried out in Amamá and nearby villages (27° S, 63° W), Province of Santiago del Estero, Argentina. As part of an ongoing surveillance program, 3 skilled bug collectors from the National Chagas Service searched for triatomines in all bedroom and peridomestic areas using 0.2% tetramethrin (Icona, Argentina) to dislodge the insects in December 1997 (Gürtler et al. 1995). During 30 min per house, 2 men searched bedrooms (1 person-hour) while another man searched peridomestic sites such as goat, pig, or horse corrals, tool sheds, chicken houses, kitchens, situated within the area of human activity (0.5 person-hour per house). All bugs collected were removed, identified to species, counted by stage, and stored for other purposes.

In peridomestic structures where *T. infestans* had just been collected by flushing-out, we placed 1–2 matched pairs of numbered sensing devices per test site. The test sites were located in 13 houses and included 8 goat corrals, 2 pig corrals, a chicken corral, a tool shed, and a chicken nest. *T. infestans* densities per infested peridomestic compound ranged from 1 to 50 bugs per 0.5 person-hour (mean, 15; median, 7 bugs). The devices were secured using wire and placed beneath the thatched roof (usually measuring <2 by 2 m^2, 1–1.6 m high), at ground level, on the walls or wooden poles that supported the roof, or in the corral fence composed of piled thorny shrubs. After an average of 4.3 (range, 3–9) nights of exposure, all devices were inspected for evidence of infestation. During the exposure nights, in a typical corral fence and a hollow branch infested by *T. infestans*, temperature was recorded by means of temperature dataloggers (Tinytalk II, Gemini Dataloggers, UK). The minimum temperature range (18–30°C) recorded (Lazzari et al. 1998) was above the temperature range at which *T. infestans* was captured by yeast-baited traps under natural climatic conditions (Lorenzo et al. 1998). For statistical analysis, we used the binomial test (Zar 1996), considering each pair of sensing devices as the sampling unit on the assumption that each pair within a given test site performed independently of others. In the absence of a previous paired trial of the sensing devices, either in an experimental arena or in the field, we carried two-tailed instead of one-tailed tests; the former are also more conservative.

Results

In total, 119 houses were inspected; *T. infestans* was collected in human sleeping quarters of 27 houses and in peridomestic sites of 35 houses. Goat and pig corrals were the peridomestic ecotopes most frequently colonized by *T. infestans.*

Both prototypes yielded some evidence of infestation in 70% (19 of 27) of units, whereas only 11% (3 of 27) of bamboo canes were positive (Table 1). Prototype A was significantly more sensitive than the bam-

Table 1. Detection of peridomestic infestations by *T. infestans* using 1–2 pairs of prototypes and bamboo canes exposed for 3–9 d, Amamá and nearby villages, December 1997

Prototype	Positive[a] by both devices	Negative by both devices	Positive only by prototype	Positive only by bamboo cane	Total	Two-tailed binomial test
A	1	5	13	1	20	$P = 0.0018$
B	1	2	4	0	7	$P = 0.125$
Total	2	7	17	1	27	—

[a] Any type of evidence of infestation (triatomine fecal smears, eggs, exuviae, or bugs).

boo cane (2-tailed binomial test, $P = 0.0018$), detecting infestations that were missed by the paired cane on 13 occasions, whereas the opposite occurred only once. Five pairs did not reveal any sign of infestation, and the devices were both positive only once.

In a smaller series, prototype B also detected signs of infestations more frequently than the bamboo cane (Table 1). Prototype B detected infestations that were missed by the bamboo cane on 4 occasions; the opposite result was not observed (2-tailed binomial test, $P = 0.125$). Given these results, the binomial test has no power to detect a significant difference (Zar 1996).

Triatomine feces were the signs most frequently recorded by both prototypes, totaling 86 fecal spots; of these, 40% were on the inside. The bamboo canes did not record any triatomine feces. Both prototypes yielded 10 *T. infestans* (9 nymphs), one 3rd-instar *Triatoma guasayana,* and 1 *T. infestans* exuvia. The bamboo canes yielded 3 *T. infestans* (1 nymph). All bugs were collected from devices placed on the floor or walls, not beneath the thatched roofs of animal shelters, and nearly all of them had recently engorged. No eggs were collected.

Discussion

This study describes an effective sensing device for detecting *T. infestans* populations in outdoor animal shelters and provides quantitative field data on its performance. Both prototypes were sensitive for detecting peridomestic *T. infestans* populations, and moreover, prototype A was significantly more sensitive than the bamboo canes in paired trials. Although our study was limited in the number of test sites, the results are very promising in face of the much more limited length of exposure of all devices. The temporal scale in which triatomine surveillance operates undoubtedly is much larger than the 3–9 d of exposure, which makes likely that the performance of these devices would improve if longer times were used. However, we cannot exclude that longer exposure periods would negatively affect the properties of the materials used in the sensing devices, or the devices would turn into refugia suitable for other arthropods that may interfere with the triatomines' presence. Therefore, longer and larger studies would allow the evaluation of factors that affect the performance of sensing devices, such as exposure periods, installation site, type and number of entrances, color, and so on.

The design of the present prototypes considered several features of triatomine behavior (Wiesinger 1956, Schofield 1979, Nuñez 1987). The black plastic cylinder ensured resistance to weather conditions, and a dark, dry inside respecting the negative phototactic response (Reisenman et al. 1998) and xeropreference of *T. infestans* (Roca and Lazzari 1994). The rough leather surface provided an adequate substrate for the bugs' thigmotactic response. This and the internal structure with many compartments and angles likely favored the triatomines' characteristic state of akinesis, which may have increased the bugs' residence period in the interior and the likelihood of finding triatomine feces, bugs, and exuvia. In contrast, the lack of triatomine feces or exuviae inside the bamboo canes suggests that these worked as a more transient, less suitable refuge. In addition, the larger external surface of the cylinders in comparison with the bamboo canes increased the likelihood of detecting triatomine feces, which were the most frequent sign of infestation detected. The screw cap allowed removal of the internal structure for inspection. Attending the above-mentioned features of triatomine behavior, the design of the prototypes may be simplified to reduce its cost and the labor involved in its construction.

There are conceptual differences between the cardboard sensing devices used in human sleeping areas (e.g., sensor boxes), the bamboo cane, and both prototypes. Sensor boxes were conceived as mazes working as a triatomine slow-down in the pathway between their natural refuges and the hosts (Wisnivesky-Colli et al. 1988). However, in peridomestic sites, the effectiveness of a sensing device depends precisely on its suitability as an alternative refuge because it is difficult to identify the bugs' pathway from the refuge to the host where there are multiple natural refuges and inconstancy of host resting places. The bamboo cane may resemble some of the materials usually found in the bugs' natural refuges, but its internal structure is qualitatively different from both prototypes; the canes may therefore compete with the prototypes on the basis of its relative number. Prototypes A and B likely provide better conditions of roughness, dryness, darkness, protection from weather changes, and so on than the bamboo canes; therefore, the prototypes may compete with them on the basis of their quality and quantity. Because all the bugs collected came from devices located on the floor or on the walls close to the hosts' resting places and most of these bugs were engorged, we conclude that the devices intercepted the bugs' way back to their prior refuges. Therefore, the precise location of the artificial resting shelters may greatly affect the outcome.

Artificial resting shelters or boxes have been used successfully for sampling adult mosquito populations (Service 1976). For triatomine surveillance, resting-site refuges or boxes, such as these prototypes or any other related development, have proved effective for detecting peridomestic *T. infestans* populations in known key sites where they occur. Basic information on the preferred ecotopes of each target triatomine species is crucial for effective surveillance. These sites must be typified in each region and monitored with adequate frequency. For the sustained elimination of *T. infestans* on a regional scale, sensitive detection methods that may be handled by the affected people are a requisite.

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