Field Trials of an Improved Cost-effective Device for Detecting Peridomestic Populations of *Triatoma infestans* (Hemiptera: Reduviidae) in Rural Argentina

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An improved device for detecting peridomestic Triatoma infestans *consisting of one-liter recycled Tetra Brik milk boxes with a central structure was tested using a matched-pair study design in two rural areas in Argentina. In Olta (La Rioja), the boxes were installed beneath the thatched roofs and on the vertical wooden posts of each peridomestic structure. After a 5-month exposure, at least one of the recovered boxes detected 88% of the 24* T. infestans*-positive sites, and 86% of the 7 negative sites by timed manual collections at baseline. In Amamá (Santiago del Estero), the boxes were paired with the best performing prototype tested before (shelter unit). After 3 months, some evidence of infestation was detected in 89% (boxes) and 79% (shelters) of 18-19 sites positive by timed collections, whereas 19% and 16% of 32 negative sites were positive, respectively. Neither device differed significantly in the qualitative or quantitative collection of every sign of infestation. The installation site did not modify significantly the boxes' sampling efficiency in both study areas. As the total cost of each box was half as expensive as each shelter unit, the boxes are thus the most cost-effective and easy-to-use tool for detecting peridomestic* T. infestans *currently available.*

Key words: *Triatoma infestans* - Chagas disease - surveillance - sampling - vector control - Argentina

Triatoma infestans (Klug), the main vector of Chagas disease in Argentina, Bolivia, Brazil, Paraguay, Peru and Uruguay, is the target of an elimination program called The Southern Cone Initiative (Schmunis et al. 1996). *T. infestans* infests domestic and peridomestic habitats almost exclusively (Zeledón & Ravinovich 1981, Dias 1991), with sylvatic foci apparently existing only in Bolivia (Dujardin et al. 1987, Noireau et al. 2000). Although the transmission of *Trypanosoma cruzi* (Kinetoplastida: Tripanosomatidae) to humans mostly occurs in human habitations (the domestic environment)(Cecere et al. 1999, Cohen & Gürtler 2001), peridomestic foci of *T. infestans* are very frequent and the most likely source of the bugs that reinfest human habitations after insecticide spraying (Dujardin et al. 1996, Cecere et al. 1997). Early detection of peridomestic sites reinfested by triatomine bugs is thus essential to assess the effects of control actions and to establish the need for additional operations.

The standard method to assess the occurrence and intensity of infestation by triatomine bugs in domestic and peridomestic sites has been timed manual collections using an irritant spray (the “flushing-out” method) (Schofield 1978, Rabinovich et al. 1995). However, this method is costly, requires skilled staff, and lacks sensitivity and precision. An artificial shelter unit proved to be more sensitive in the detection of peridomestic foci of *T. infestans* than segments of bamboo cane lined with pleated paper or timed manual collections with an irritant (De Marco et al. 1999, Gürtler et al. 2001b). The shelter units accounted for several features of triatomine behavior (negative phototaxis, thigmotaxis, and preference for dry sites) and were resistant to weather conditions. However, they were expensive for large-scale triatomine surveillance programs, and because of the rigid plastic structure, the shelter units were not easily adaptable to many peridomestic sites differing in physical structure. Our general aim has been to improve the cost-effectiveness of the sensitive shelter units by using recycled, appropriate materials that could be easily handled by the affected rural populations. Such a tool is also indispensable to study the spatial and temporal dynamics of reinfestation at a community-wide scale.

In this study, we describe a simpler, equally sensitive and less expensive device than the shelter unit for detecting peridomestic triatomine foci. In two different rural areas in Argentina, we conducted matched-paired trials to assess the devices' effectiveness at peridomestic sites determined to be positive and negative for *T. infestans* by timed manual collections, and whether the installation site modified their sensitivity.

MATERIALS AND METHODS

Devices - The new devices were one-liter, recycled Tetra Brik™ (Tetra Pak Corp.) milk boxes measuring 16 x 9.5 x 6 cm (length, width, depth), hereafter called ‘box’. Two versions of these boxes, which differed only in the

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location of the entrances, were designed for installation beneath the beams supporting the thatched roof, or on the vertical wooden posts of each structure (Fig. 1). Internally, the boxes contained a central column (20 cm long and 4.5 cm in section) of accordion-folded corrugated paper (Fig. 1C), and a piece of corrugated paper lining the internal walls. All boxes had been washed with diluted detergent before field use, whereas other component materials had not been used or treated with any bug insecticide or attractant.

To install the boxes on the vertical posts, a single strand of wire was passed through each of two holes made on the two folded triangles located at the base and top of the box (Fig. 1A). The wire also held in place a 10 x 12 cm piece of commercially available bovine leather (the languet), with the rough surface facing upwards and covering the 10 x 1 cm entrance. The entrance was located at the bottom to intercept the bugs when they returned to the refuges after feeding or host-seeking activities (Fig. 1A). When the box was placed beneath and parallel to the horizontal beams supporting the thatched roof (Fig. 1B), the two entrances on the sides were also coated with a 10 x 12 cm piece of leather bounded flush to the beams with wire.

De Marco et al. (1999) described the shelter units. They consisted of a black plastic, wide-mouthed jar (19 cm high and 10 cm diameter) with a screw cap at the top and two openings at the bottom, from which a languet of leather coating the floor extended to the outside. Internally, the shelter units contained a removable central column (Fig. 1C) and the walls were lined with corrugated paper.

Study sites - As part of a larger research project on the ecology and control of *T. infestans*, we first conducted a trial of the boxes in rural houses around Olta (30.3ºS, 66.2ºW), La Rioja, Argentina, from late April 1999 to November 1999. The area belongs to the Monte province of the phytogeographic Chaco region, and is semi-arid with a thorn forest (Cabrera & Willink 1980). Olta is 471 m above sea level, and has a mean annual temperature of 19.3ºC, and the average annual rainfall is about 450 mm. The houses had been sprayed with beta-cyfluthrin approximately 5-6 years before this trial. In view of the positive results obtained in Olta, we conducted a matched-pair field trial of boxes and shelter units in Amamá and nearby villages (27.1ºS, 63ºW), Santiago del Estero, Argentina, between December 1999 and March 2000. The area belongs to the Chaco province of the phytogeographic Chaco region (Cabrera & Willink 1980). Its environmental characteristics and history of infestation by *T. infestans* were described previously (Gürtler et al. 1999).

Study design - In Olta, two skilled bug collectors from the National Vector Control Program (NVCP) assessed the intensity of peridomestic infestation by *T. infestans* and other triatomine species from 20 April to 6 May 1999. The search was made using an irritant agent (0.2% tetramethrin, Icona, Argentina) for 30 min per house, as described by Gürtler et al. (1995). All triatomine bugs were removed, identified to species and counted by stage, as described by Canale et al. (2000). Another person placed one or two pairs of numbered boxes per site in late June 1999. In total, 39 pairs of boxes were installed beneath the roofs and on the posts in 34 peridomestic sites at 26 houses. The peridomestic sites included 23 goat corrals and 2 chicken coops in which *T. infestans* had just been captured by timed manual collections, and 9 apparently uninfested sites (4 goat corrals, 1 pig pen, and 4 chicken coops).

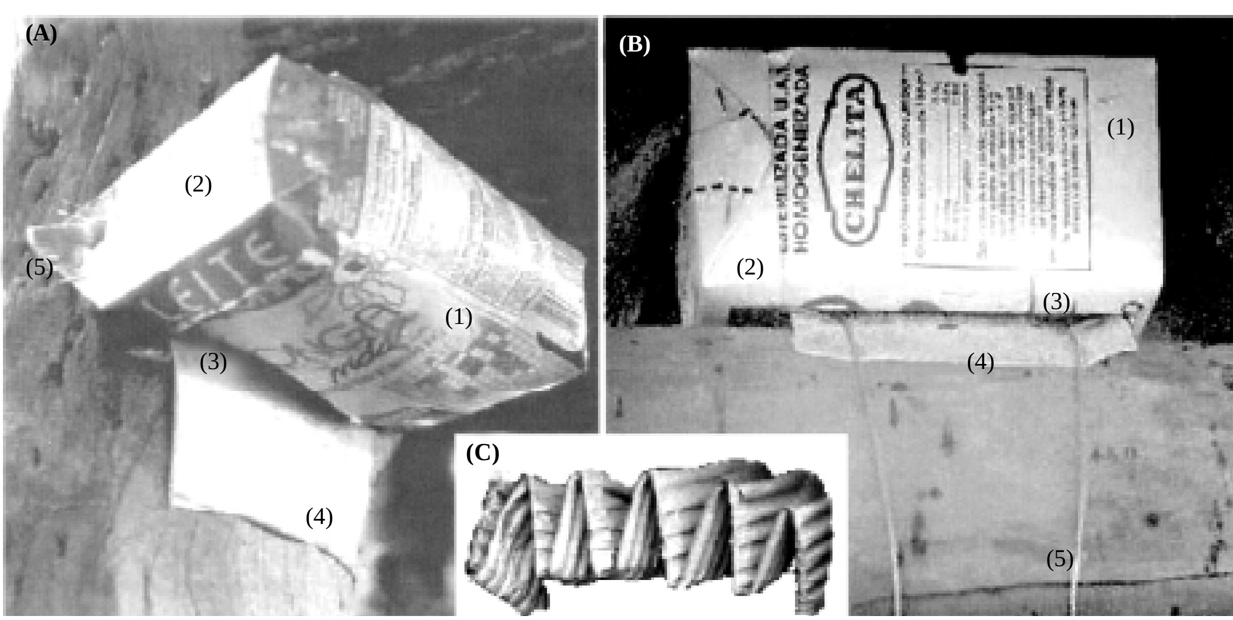

Fig. 1: Tetra Brik milk boxes used for detecting peridomestic *Triatoma infestans* and installed on the vertical wooden posts (A) or beneath the thatched roof (B) of each structure. The materials are: (1) Tetra Brik milk box cut on one end (2) to allow the introduction of the corrugated paper; (3) entrances; (4) leather languet; (5) wire that holds the box and the languet to the poles. (C) internal central column of accordion-folded corrugated paper. Black smears on the pole in B are triatomine dejecta.

All boxes were inspected for evidence of infestation following standard procedures between 14 and 18 November 1999 (Gürtler et al. 2001b). Briefly, the boxes were handled inside a deep plastic tray to minimize the loss of eggs or other signs, and the number of triatomine bugs, exuviae, eggs and dejecta in the interior and exterior of each device were counted and recorded. Triatomine-like dejecta from the boxes were tested by the phenolphthalin (Kastle-Meyer) test (Gürtler et al. 2001a) to confirm the presence of heme (which is absent from other non-hematophagous arthropods' feces). A maximum of 10 dejecta per device was tested to verify that at least one was phenolphthalin-positive.

In Amamá, one or two matched pairs of shelter units and boxes were installed between 10 and 16 December 1999. A total of 79 pairs (37 beneath the roofs and 42 on the posts) were installed in 56 peridomestic sites at 40 houses. The 24 infested sites included 6 goat corrals, 4 pig pens, 9 storerooms, 1 oven, and 4 chicken coops in which *T. infestans* had been collected by timed manual collections in April 1999. The 32 negative sites included 9 goat or sheep corrals, 12 pig pens, 2 storerooms, 2 ovens, 6 chicken coops, and 1 pile of wood. Whenever possible, a pair of shelter units and boxes was installed beneath the roof and another pair on the posts, but in sites that did not allow a double installation, the pair that adapted best was chosen. Between 14 and 27 March 2000, two skilled bug collectors from NVCP searched for triatomines in all bedrooms and peridomestic areas of 114 houses using 0.2% tetramethrin (Icona, Argentina) for 30 min per house. All triatomine bugs were processed as in Olta. Simultaneously with the timed manual collections, all boxes and shelter units were inspected for evidence of triatomine infestation by another team. For timed manual collections, the term "infested" or "positive" meant finding at least one live or moribund *T. infestans*. For the devices, these terms meant that at least one sign of infestation (i.e., *T. infestans* bugs, eggs or exuvie, or triatomine fecal smears) was detected.

Data analysis - Given the matched-pairs study design, each pair of devices was taken as the sampling unit to test their relative effectiveness. Pairs with one missing device were excluded from analysis. In the absence of prior evidence, the sensitivity of devices was tested by the two-tailed binomial test (Zar 1996). The recovery rate of each device was tested by the McNemar test for paired data (Zar 1996). In Olta, the sampling efficiency of the boxes according to installation site was measured by the log-transformed ratios of the numbers of bugs or each sign of infestation recovered from each box placed on the post (x) to those in the matched box beneath the roof (y) of each peridomestic site $\{\log_{10}[(x + 1)/(y + 1)]\}$. The antilog of the mean log ratio is the geometric mean ratio. Using a similar procedure for data collected in Amamá, the relative sampling efficiency of the devices was measured by the log-transformed ratios of the numbers of bugs or each sign of infestation recovered from each box (x) to those in the matched shelter unit (y) at each installation site $\{\log_{10}[(x + 1)/(y + 1)]\}$. Variations in the density of triatomine dejecta among component materials were studied by Kruskal-Wallis test (Zar 1996).

RESULTS

In Olta, the total catch of *T. infestans* by timed manual collections from 25 infested peridomestic sites was 199 bugs (median, 3 bugs per site; first and third quartiles, Q1-Q3, 2-9.3) in late April 1999. In November 1999, the boxes that had been installed beneath the roofs were recovered significantly more frequently than those on the vertical posts (90% to 69%, respectively; McNemar χ^2 = 6.13; degrees of freedom, df = 1, P = 0.013). All of the missing devices had been placed in goat or sheep corrals.

At least one of the recovered boxes detected some evidence of triatomine infestation in 88% of the positive sites, and in 86% of the sites that had been negative by timed collections in late April 1999 (Fig. 2). Both in positive and negative sites, the boxes on the posts were qualitatively more sensitive in detecting *T. infestans* bugs or

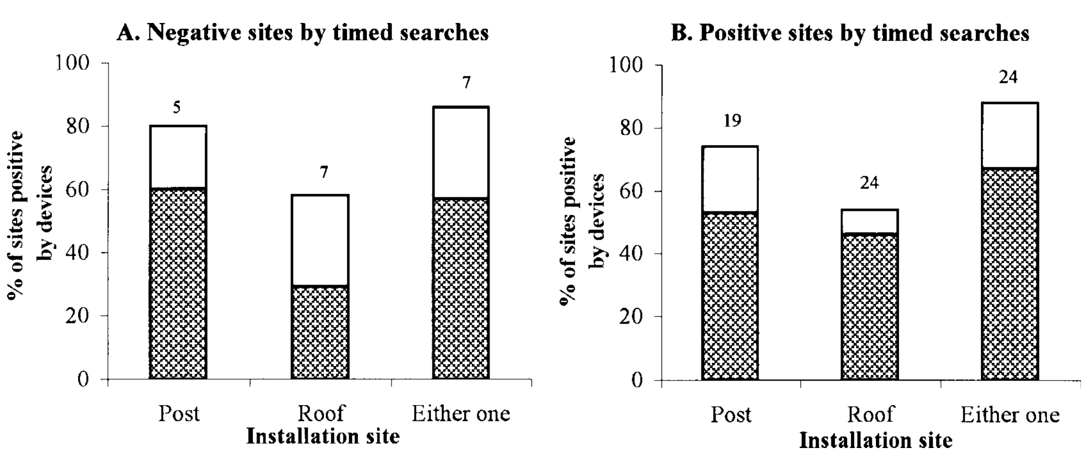

Fig. 2: infestations by *Triatoma infestans* detected in November 1999 using 1-2 Tetra Brik boxes according to installation site (on vertical posts and beneath the thatched roof) in peridomestic sites that had been negative (A) or positive (B) by timed manual collections in late April 1999, Olta and nearby villages, April 1999-November 1999. Empty bars are based on the finding of any sign of infestation, excluding *T. garciabesi* or *T. guasayana*; hatched bars are based on the finding of *T. infestans* bugs, exuviae or eggs. Numbers on top of each bar represent the total number of sites inspected for infestation by the recovered devices.

any sign of infestation than those beneath the thatched roofs, although not significantly so (two-tailed binomial tests, $P > 0.2$).

The frequency distribution of every sign in the positive devices was significantly different from a random distribution: *T. infestans* bugs ($\chi^2 = 58.5$, $df = 16$, $P < 0.005$), exuviae ($\chi^2 = 27.3$, $df = 9$, $P < 0.005$), eggs ($\chi^2 = 296.6$, $df = 19$, $P < 0.005$) or triatomine dejecta ($\chi^2 = 240.0$, $df = 30$, $P < 0.005$); the variance to mean ratios (11, 2, 18, and 10, respectively) indicated strong aggregation. The boxes collected a similar total number of signs of infestation when placed beneath the roofs (443) or on the posts (393). When placed beneath the roofs rather than on the posts, the boxes' sampling efficiency did not differ significantly for *T. infestans* bugs (mean log ratio ± 95% confidence limits (C.L.), 0.03 ± 0.29), exuviae (0.18 ± 0.43), eggs (0.09 ± 0.39) or triatomine dejecta (0.17 ± 0.25). The 67 bugs collected from the boxes in five negative sites were 76% I-II instar nymphs, 3% III-IV, 9% V, and 12% adults, whereas in the positive sites the stage structure of the 78 bugs collected was 49% I-II, 13% III-IV, 17% V, and 21% adults. Both stage structures were significantly different ($\chi^2 = 32.6$; $df = 3$; $P < 0.001$). The density of triatomine dejecta per 100 cm^2 in the languet (median, 1.6; Q1-Q3, 0.8-2.5) was significantly larger by at least one order of magnitude than in the accordion (median, 0.4; Q1-Q3, 0.2-0.8), wall lining (median, 0.4; Q1-Q3, 0.2-1.1) and the external surface (median, 0.6; Q1-Q3, 0.2-1.5)(Kruskal-Wallis, $\chi^2 = 10.1$; $df = 3$; $P = 0.018$).

In Amamá, the total timed manual catch of *T. infestans* from 24 infested peridomestic sites was 194 bugs in March 2000 (median per site, 5 bugs; Q1-Q3, 2-14). There were no significant differences in the recovery rate of the 79 pairs of boxes and shelter units when placed either beneath the thatched roof (84% and 92%, respectively; McNemar $\chi^2 = 0.57$; $df = 1$; $P = 0.45$), or on the vertical posts (93% and 88%, respectively; McNemar $\chi^2 = 0.50$; $df = 1$; $P = 0.48$). After a three-month exposure, at least one of the recovered devices detected some evidence of triatomine infestation in 89% (boxes) and 79% (shelters) of positive sites, and in 19% (boxes) and 16% (shelters) of negative sites (Fig. 3)(two-tailed binomial tests, $P > 0.5$).

A total of 1,361 and 1,265 signs of infestation (including 137 and 140 bugs) was recovered from the shelter units and boxes, respectively (Table I). The frequency distribution of every sign of infestation in the positive devices also was significantly different from a random distribution: *T. infestans* bugs ($\chi^2 = 530.9$, $df = 14$, $P < 0.005$), exuviae ($\chi^2 = 615.6$, $df = 28$, $P < 0.005$), eggs ($\chi^2 = 1676.9$, $df = 26$, $P < 0.005$) and triatomine dejecta ($\chi^2 = 3689.35$, $df = 47$, $P < 0.005$); the variance to mean ratios (14, 18, 24 and 66, respectively) again indicated strong aggregation. The boxes were as efficient as the shelters in the collection of every sign in either installation site (Fig. 4). When all signs of infestation were pooled, the relative sampling efficiency of the devices installed on the posts (mean log ratio ± 95% C.L., -0.13 ± 0.15) or beneath the roofs (0.02 ± 0.31) was not significantly different. None of the correlation coefficients between the log ratios for each type of sign and bug catches by timed manual collection was statistically significant in either installation site (for all cases, $P > 0.1$).

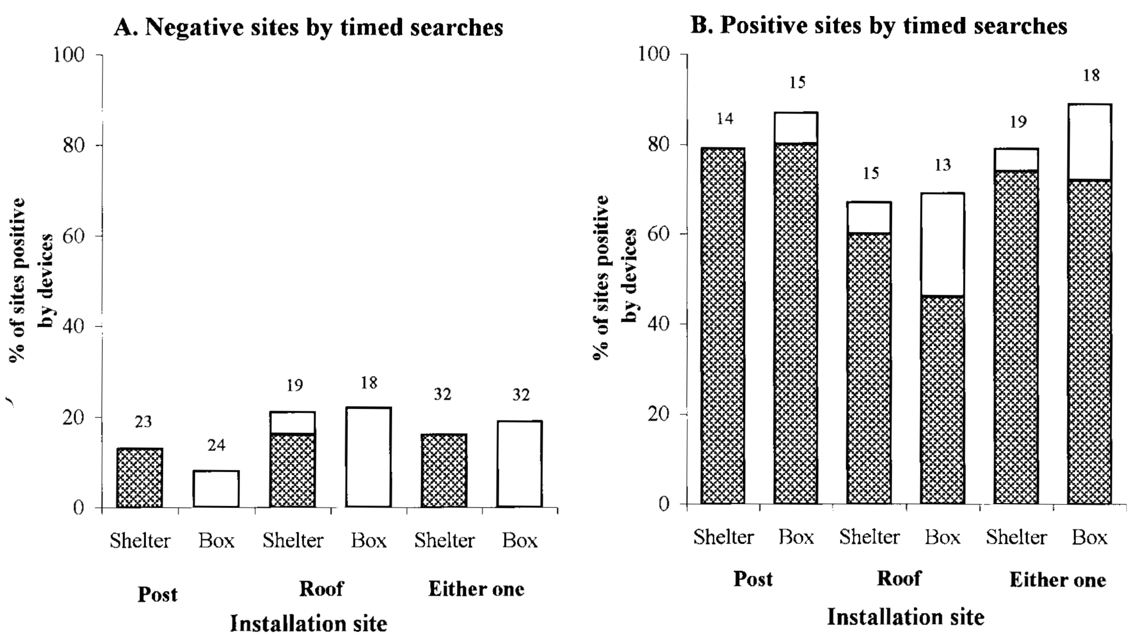

Fig. 3: infestations by *Triatoma infestans* detected in March 2000 using 1-2 matched pairs of shelter units and Tetra Brik boxes according to installation site (on vertical posts and beneath the thatched roof) in peridomestic sites that had been negative (A) or positive (B) by timed manual collections in March 2000, Amamá and nearby villages, December 1999-March 2000. Empty bars are based on the finding of any sign of infestation, excluding *T. garciabesi* or *T. guasayana*; hatched bars are based on the finding of *T. infestans* bugs, exuviae or eggs. Numbers on top of each bar represent the total number of sites inspected for infestation by the recovered devices.

TABLE I

Number of *Triatoma infestans* bugs and signs of infestation recovered from the matched Tetra Brik boxes and shelter units installed beneath thatched roofs or on vertical posts, Amamá and nearby villages, December 1999-March 2000

Installation site	Device	No. of *T. infestans* Bugs	Exuviae	Eggs	No. of triatomine dejecta	Total
Roof	Shelter	45	35	79	263	422
	Box	38	17	262	148	465
Post	Shelter	92	65	290	492	939
	Box	102	98	155	445	800
Total	Shelter	137	100	369	755	1,361
	Box	140	115	417	593	1,265

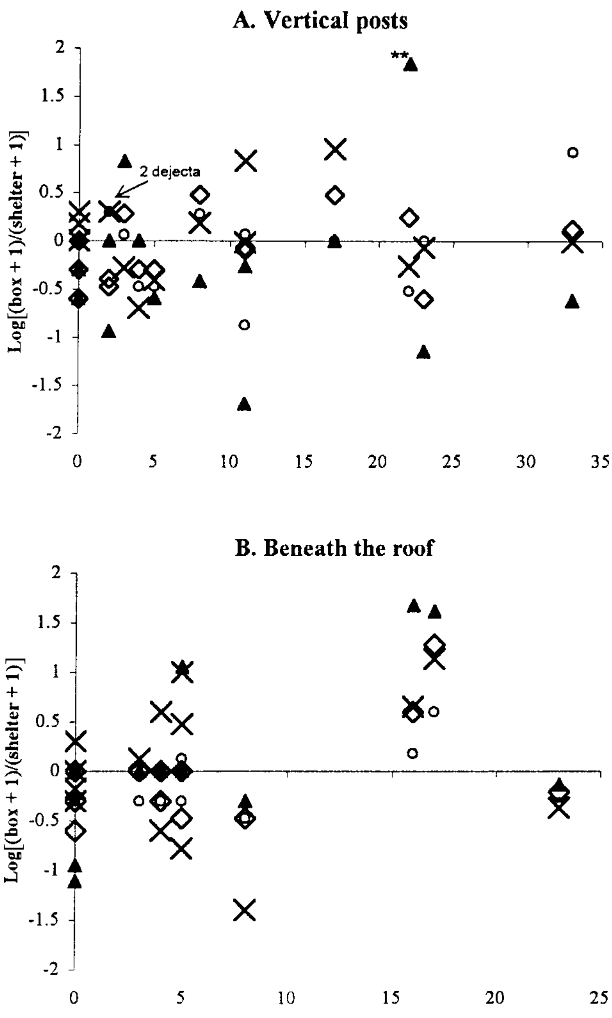

Fig. 4: log-ratios between the numbers of *Triatoma infestans* bugs (◊), exuviae (○), eggs (▲) and triatomine dejecta (X) collected by the Tetra Brik box and the shelter unit installed on vertical posts (A) or beneath the roofs (B), in the ordinate, and the total number of *T. infestans* bugs collected by timed manual searches in March 2000, in the abcissa. Amamá and nearby villages, December 1999-March 2000. Two overlapping points (X) in A are shown with an arrow.

The installation site modified the sampling efficiency of signs of infestation by shelter units but not by the boxes (Table I). Shelters installed on the posts collected significantly more *T. infestans* bugs (mean log ratio ± 95% C.L., 0.62 ± 0.39), exuviae (0.40 ± 0.38), eggs (0.57 ± 0.42), triatomine dejecta (0.61 ± 0.52), or any sign of infestation (0.67 ± 0.56) than the paired shelters beneath the roofs. Despite clear differences at the aggregate level, paired boxes installed on the posts and beneath the roofs did not differ significantly in the collection of *T. infestans* bugs (mean log ratio ± 95% C.L., 0.27 ± 0.98), exuviae (0.22 ± 0.82), eggs (-0.43 ± 1.43), triatomine dejecta (0.37 ± 0.60), or any sign of infestation (0.25 ± 0.71). The density of triatomine dejecta per 100 cm^2 in the languet (median, 5.8; Q1-Q3, 0.8-15) was significantly larger by at least one order of magnitude than in the accordion (median, 0.4; Q1-Q3, 0-0.8), wall lining (median, 0.9; Q1-Q3, 0.2-4.7) and the external surface (median, 0.9; Q1-Q3, 0.4-0.2)(Kruskal-Wallis, $\chi^2 = 10.73$; $df = 3$; $P = 0.013$).

Shelters or boxes exposed for three months and timed manual collections with an irritant did not differ significantly in their capacity to detect some evidence of triatomine infestation (Table II). Both devices and timed searches detected some infestations that were missed by the alternative method. Results for shelter units and timed collections in Table II differ from those published before (Table III in Gürtler et al. 2001b) because the present data series includes more peridomestic sites exposed for a different and shorter time period (December to March). The stage structure differed significantly among methods ($\chi^2 = 57.7$; $df = 2$; $P < 0.001$). Timed manual collections were biased toward large stages; from 194 bugs collected, 55% were adults, 17% V, 20% III-IV and 8% I-II. In contrast, the boxes collected 140 bugs, including 14% adults, 19% V, 48% III-IV and 18% I-II nymphs, whereas the shelter units collected 137 bugs, including 32% adults, 18% V, 22% III-IV, and 29% I-II. In negative sites, *T. infestans* bugs were found only in the shelters (6 I, 1 II and 1 V). The devices also detected 29 *T. garciabesi* bugs and one *T. guasayana* bug. Spiders, crickets, small lizards (*Gecko* sp.), known to prey on triatomines, and cockroaches were also recovered from the devices.

A previous cost estimate for each shelter unit was US$1.74 (Gürtler et al. 2001b), or US$0.50 at June 12, 2002 prices. For the box, the current cost estimate is US$0.26, and includes US$0.14 for materials (leather, corrugated paper and wire) and US$0.12 for 5 min of labor (cutting and assemblage, assuming US$1.43 per labor hour). Additional expenses related to fieldwork, which for the shelter unit were US$0.40 at 2002 prices, have been reduced to US$0.31 for the box. These include search for a suitable site and deployment of devices, US$0.12 or 5 min; and inspection and reinstallation of devices, US$0.19 or 8 min.

DISCUSSION

Tetra Brik boxes were consistently as sensitive as the shelter units or timed manual collections with an irritant in detecting foci of *T. infestans* in a great variety of peridomestic ecotopes differing in construction materials, resident hosts and intensity of infestation both in La Rioja and Santiago del Estero Provinces. This is consis-

TABLE II

Detection of peridomestic infestations by *Triatoma infestans* using 1-2 matched pairs of shelter units and Tetra Brik boxes exposed for three months, and timed manual collections with an irritant conducted in March 2000, Amamá and nearby villages. The numbers in the Table are for peridomestic sites

Device	Positive [a] only by devices	Positive only by timed collections	Positive by both methods	Negative by both methods	Missing devices	Two-tailed binomial test
Shelter	5	4	27	15	5	$P = 1.00$
Box	6	2	26	16	6	$P = 0.29$

a: positive means any sign of infestation: *T. infestans* bugs, exuviae or eggs, or triatomine fecal smears.

tent with previous results (Gürtler et al. 2001b) and supports the replacement of timed searches or shelter units by boxes for detecting and collecting peridomestic *T. infestans*.

Boxes and shelters revealed the presence of *T. infestans* bugs in sites where timed manual collections had been or were negative concurrently. This may be explained by 'false negative' results of timed collections or to recent bug colonization, because the bugs recovered from the devices installed in negative sites either were first-second instar nymphs and adults, or late instars and adults. Moreover, in Amamá both devices detected low-density infestations and other new foci missed by concurrent timed manual collections, in spite of all searches having been made by the same highly experienced bug collector. Clearly, rapid timed searches by skilled bug collectors may fail to detect many peridomestic foci of *T. infestans* that, in the absence of treatment, inevitably would increase in abundance and reinfest the treated areas.

Boxes and shelters apparently provided similarly suitable conditions that increased the bugs' residence time in the interior and the likelihood of leaving at least one sign of infestation, which is consistent with previous results (De Marco et al. 1999, Gürtler et al. 2001b). The aggregation behavior of several triatomine species is mediated by thigmotaxis and by volatiles present in their feces (Schofield & Paterson 1977, Lorenzo Figueiras et al. 1994). Under laboratory conditions, *T. infestans* bugs apparently used feces as chemical marks left just outside their refuges (Lorenzo & Lazzari 1996). Here we provide the first evidence that this pattern also occurs in the field, where the density of triatomine feces was significantly more abundant in the entrances (i.e., the leather languet) than inside the artificial refuges. Moreover, the large number of triatomine feces found in the devices could enhance both their attractiveness to *T. infestans* bugs and the chance of collecting more bugs, exuviae or eggs. Given the interspecific attraction of *T. infestans* bugs to feces of *T. garciabesi* and *T. guasayana* (Lorenzo Figueiras & Lazzari 1998), which also infest peridomestic habitats in the study area, their feces may further increase the attractiveness of the artificial refuges for *T. infestans*.

Inappropriate installation of the devices may expose them to damage by the resident animals, as occurred in Olta, or to sunlight and rainfall, or may block the entrances to the bugs. Heavy rainfall did not negatively affect the materials used in either device or the subsequent finding of signs of infestation during the dry and wet seasons. It is highly likely that the Tetra Brik box and leather components may be used for many years, but the less expensive central cardboard structure may need replacement perhaps every six months. Tetra Brik boxes that are no longer usable can be recycled in several ways (available at http://www.tetrapak.com).

The installation site of the shelter units significantly modified the likelihood of the bugs' leaving some sign of infestation, perhaps because the units' rigid plastic structure, size and shape did not fit adequately beneath the roof and may have restricted the access of bugs. Because the entrances and leather languets of shelters and boxes had the same size, other factors need to be invoked to explain variations in sampling efficiency related to installation site. In contrast, the installation site did not significantly modify the boxes' sampling efficiency of any sign of infestation in either study area, although the total number of signs collected on the vertical posts tended to be clearly larger than beneath the roof. We believe that this was caused by the boxes' effective interception of those bugs that returned back to the refuges in the thatch.

The box was as sensitive as the shelter in the collection of every sign of infestation in either installation site at a wide range of bug abundance. The frequency distribution of each type of sign of infestation within the boxes and shelters was aggregated, with most devices bearing few signs and a few devices showing many signs. This overdispersion may lead to confusion when overall ratios of signs, not ratios of individual pairs, are used to represent the devices' sampling efficiency. In contrast to light traps (Schweigmann et al. 1988) and yeast or mammal-baited traps (Lorenzo et al. 1998, Noireau et al. 1999), both shelters and boxes collected all nymphal stages and adults of *T. infestans*, including starved and recently fed *T. infestans* bugs (Leonardo A Ceballos et al. unpublished data).

The boxes have several advantages over the shelter unit regarding simplicity, ease for cutting, adaptability to the variable surface of wooden poles, and cost. The cost of the shelter units was reduced by nearly 50% because of the use of recycled milk boxes instead of plastic, and the reduction of labor time to assemble and set up the boxes in the field. Compared with the US$17 annual cost of triatomine surveillance per rural house using timed manual searches with an irritant in Argentina in the early 1990s (Chuit et al. 1992)(US$4.88 at 12 June 2002 prices), surveillance of peridomestic sites using boxes is clearly the most cost-effective tool currently available for large-scale control programs, which are in need to cover some one million rural houses throughout Argentina. If found acceptable by householders, the boxes might be incorporated into community-based control programs, in which the periodic replacement of the central cardboard column could be linked to the search for evidence of peridomestic infestation by local villagers.

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