Attraction of Chagas disease vectors (Triatominae) to artificial light sources in the canopy of primary Amazon rainforest

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Adult triatomines occasionally fly into artificially lit premises in Amazonia. This can result in Trypanosoma cruzi *transmission to humans either by direct contact or via foodstuff contamination, but the frequency of such behaviour has not been quantified. To address this issue, a light-trap was set 45 m above ground in primary rainforest near Manaus, state of Amazonas, Brazil and operated monthly for three consecutive nights over the course of one year (432 trap-hours). The most commonly caught reduviids were triatomines, including 38* Panstrongylus geniculatus, *nine* Panstrongylus lignarius, *three* Panstrongylus rufotuberculatus, *five* Rhodnius robustus, *two* Rhodnius pictipes, *one* Rhodnius amazonicus *and 17* Eratyrus mucronatus. *Males were collected more frequently than females. The only month without any catches was May. Attraction of most of the known local* T. cruzi *vectors to artificial light sources is common and year-round in the Amazon rainforest, implying that they may often invade premises built near forest edges and thus become involved in disease transmission. Consequently, effective Chagas disease prevention in Amazonia will require integrating entomological surveillance with the currently used epidemiological surveillance.*

Key words: Triatominae - light-trapping - Amazon rainforest - Chagas disease

Chagas disease is thought to be hypoendemic across Amazon rainforest ecoregions (Aguilar et al. 2007); transmission of the disease agent, *Trypanosoma cruzi*, is mediated by sylvatic triatomine bugs that occasionally invade houses or other premises and either come into direct contact with humans or contaminate their foodstuffs (Coura et al. 2002, Aguilar et al. 2007, Nóbrega et al. 2009, Valente et al. 2009). Such invasive behaviour is believed to be fairly common in Amazonia and has been linked to the attraction of adult (i.e., winged) triatomines to artificial light sources (Miles et al. 2003, Valente et al. 2009). However, this beliefs are largely based on anecdotal observations, and have to be interpreted with caution. The true epidemiological importance of triatomine attraction to artificial light sources in Amazonia remains unclear; in fact, even the frequency of such events is yet to be suitably quantified. To address this basic issue, we performed systematic nocturnal light-trapping in an uninhabited forest environment over the course of one year. The results of this unprecedented trapping effort show that several known *T. cruzi* vector species are commonly attracted to artificial light sources in central Amazonia. This suggests that adventitious triatomines may often reach artificially lit households near forest edges and may thereby become involved in Chagas disease transmission in the region.

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Triatomine collections were made at the Tropical Silviculture Station of the Brazilian National Institute of Amazonian Research (INPA) (2°35'S 60°06'W), a region mainly composed of primary *terra firme* rainforest. Within the context of a broader study on forest canopy insect diversity, a light-trap, consisting of a vertical white sheet simultaneously lit by a 250-watt mercury vapour lamp, a 20-watt black light and a 20-watt black light bulb, was set 45 m above ground on a tower platform. The trap was operated monthly from January-December 2004 for three consecutive nights from 6:00 pm-6:00 am during the waning moon-new moon transition, resulting in a total of 432 trap-hours. Specimens landing on the sheet were collected, placed in standard killing jars and brought to the laboratory for species determination (Lent & Wygodzinsky 1979). All specimens, including triatomines and other Reduviidae, were deposited at the INPA Invertebrate Collection in Manaus, state of Amazonas, Brazil.

A total of 230 Reduviidae specimens belonging to eight subfamilies were collected (MCM Castro & JA Rafael, unpublished observations). The most abundant subfamily was Triatominae, accounting for 32.6% of the total catch with 75 specimens representing seven species and three genera (Table). Triatomine catches were fairly well distributed throughout the sampling period, with a trend towards higher trapping productivity over the second half of the year and an apparent peak in October (Figure). The only month without any catches was May. Overall, male triatomine bugs were 3.4 times as likely as females to be caught in the canopy-level light-trap.

Panstrongylus geniculatus was the most commonly caught species: it was represented by 1-9 individuals in all monthly catches except for May (Table); the sex

TABLE

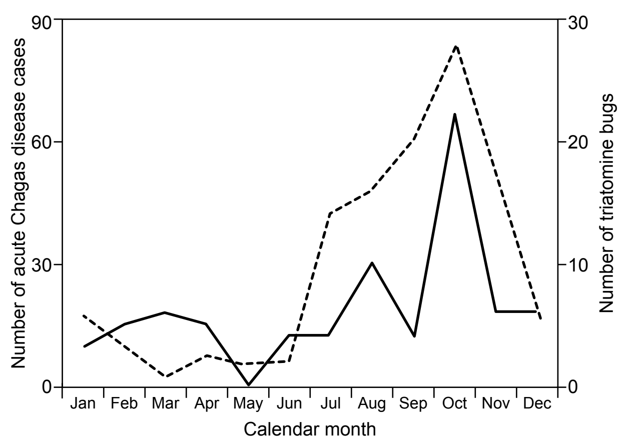
Monthly triatomine catches using a canopy-level light-trap in primary Amazon rainforest at the Tropical Silviculture Station, Brazilian National Institute of Amazonian Research, state of Amazonas, Brazil, 2004

	Months														
Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Male	Female	Total
Panstrongylus geniculatus	1	4	2	3	-	2	2	3	3	9	4	5	28	10	38
Panstrongylus lignarius	-	-	1	-	-	-	-	3	-	3	1	1	6	3	9
Panstrongylus rufotuberculatus	-	-	-	-	-	1	-	-	-	2	-	-	3	-	3
Rhodnius robustus	-	-	1	-	-	-	1	-	-	3	-	-	3	2	5
Rhodnius pictipes	-	-	-	-	-	-	-	1	1	-	-	-	1	1	2
Rhodnius amazonicus	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1
Eratyrus mucronatus	2	1	2	2	-	-	1	3	-	5	1	-	16	1	17
Total	3	5	6	5	-	4	4	10	4	22	6	6	58	17	75

ratio (♂:♀) for this species, and generally for the genus *Panstrongylus*, was close to 3:1. Most *P. geniculatus* and *Panstrongylus lignarius*, as well as all three *Panstrongylus rufotuberculatus* specimens, were collected in the second half of the year. *Eratyrus mucronatus*, a relatively little-studied species, was consistently caught across seasons in the light-trap; the ♂:♀ ratio was as high as 16:1 for this species (Table). The genus *Rhodnius* was represented by three species. Two of them, *Rhodnius robustus* and *Rhodnius pictipes*, are common in Amazonia and have been implicated in Chagas disease transmission (Abad-Franch & Monteiro 2007, Valente et al. 2009), whereas *Rhodnius amazonicus* is a rare species hitherto known only from type specimens and a few additional collections in French Guiana (Bérenger & Pluot-Sigwalt 2002, Bérenger et al. 2009).

Twenty-seven triatomine species in nine genera and five tribes have been recorded to date in Amazonia. Except for spatially discrete foci of true domestic (i.e., household-breeding) populations, Amazonian triatomines are essentially sylvatic (Abad-Franch & Monteiro 2007, Aguilar et al. 2007). They exploit a variety of forest ecotopes, including palm tree crowns, hollow trees and vertebrate nests and burrows (Lent & Wygodzinsky 1979, Barrett 1991). Flying from such ecotopes, adult specimens may enter a house or fall into a food-processing device; this is currently regarded as the main mechanism underlying Chagas disease epidemiology in Amazonia (Coura et al. 2002, Aguilar et al. 2007, Valente et al. 2009). For instance, large peridomestic palm trees are often infested and can act as a major source of adventitious *Rhodnius* specimens in several Latin American biomes, including Amazonia (Romaña et al. 1999, Fitzpatrick et al. 2008, Gurgel-Gonçalves et al. 2008, Abad-Franch et al. 2010, Calzada et al. 2010).

Attraction of adult triatomine bugs to artificial light sources can enhance the risk of Chagas disease transmission under such circumstances (Coura et al. 2002, Miles et al. 2003). Both field (Noireau & Dujardin 2001, Zeledón et al. 2001, Carbajal de la Fuente et al. 2007) and laboratory studies (e.g., Minoli & Lazzari 2006) suggest that triatomine bugs make use of artificial light cues while actively dispersing; our results lend further support to this view by showing that forest triatomines can be routinely collected in light-traps in primary rainforest environments. Electric light, a trait that is typical of human residences, may therefore play a key role also in household invasion by adult sylvatic triatomines. Other potential attractors that might be used by dispersing triatomines as guiding cues, such as radiant heat or human odors (Minoli & Lazzari 2006), are typical of households too.



Broken line: monthly numbers of acute Chagas disease cases notified from the Brazilian Amazon Region, 2007-2009 (www.datasus.gov.br); solid line: triatomine catches in a canopy-level light-trap in primary Amazon rainforest, 2004.

Our catches represent a large fraction of the triatomine species known to occur in central Amazonia. The study site lies within the Uatumã-Trombetas ecoregion, where 11 species (including 2 cryptic *R. robustus* forms) have been recorded. *Microtriatoma trinidadensis* and *R. brethesi* may also be present, but have not been collected to date (Abad-Franch & Monteiro 2007). Our catches therefore included ~70% of the locally recorded species; only *Cavernicola pilosa*, *Cavernicola lenti* and *Rhodnius paraensis* were not collected. This indicates that light-trapping can be used to sample most, if not all, of the epidemiologically relevant species present in Amazonian forests landscapes.

When compared with the results of surveys conducted in anthropic landscapes, our data suggest that the rich triatomine fauna of primary forests becomes heavily simplified following disturbance. For example, Naiff et al. (1998) reported only three species (*P. geniculatus*, *R. robustus* and *R. pictipes*) in an urban environment, and Valente et al. (2009) collected only two species (*R. pictipes* and *P. geniculatus*) in and around a rural settlement. Bérenger et al. (2009) reported similar results from French Guiana: 11 triatomine species were collected in forested areas, but only five (*P. geniculatus*, *P. lignarius*, *R. pictipes*, *R. robustus*, and *E. mucronatus*) were found in anthropic landscapes.

Why males of several triatomine species appear to fly more often than females to light-traps and houses remains difficult to explain. In fact, some laboratory and field studies suggest that female bugs are equally or more likely than males to start dispersive flights (Schofield et al. 1992, Gurevitz et al. 2006, Minoli & Lazzari 2006), but males are usually caught more often at light-traps (Noireau & Dujardin 2001, Zeledón et al. 2001, Vázquez-Prokopec et al. 2006). This is clearly of more importance for species capable of colonising human households, which has not been reported in our study area. However, *P. geniculatus* can colonise peridomestic pigsties in Amazonia (Valente et al. 1998), and *Eratyrus mucronatus*, *P. geniculatus*, *P. rufotuberculatus* and the *P. lignarius* population from the Marañón Valley, Peru (formerly known as *P. herreri*) have all been reported to breed within houses in other biomes (Barrett 1991, Noireau et al. 1995, Wolff & Castillo 2000, Abad-Franch et al. 2001, Cuba Cuba et al. 2002).

Triatomine trapping appeared to be more productive towards the end of the year, which coincides with the local dry season. Approximately 75% of catches occurred between July-December, when the monthly rainfall averaged ~95 mm. In contrast, the monthly rainfall from January-May averaged ~280 mm (www.inmet.gov.br). This trend, noted also by Naiff et al. (1998) for *P. geniculatus* specimens flying into houses in Manaus, needs obviously to be confirmed with more data. It is nonetheless worth highlighting that reports of acute Chagas disease cases are also strongly biased towards the second half of the year in the Brazilian Amazon (Figure). This observation is merely correlational, but hints at a potential link between increased vector flight activity and higher disease incidence in drier (and hotter) months; we believe that this possibility should be more thoroughly investigated.

The frequent and widespread attraction of Amazonian triatomines to artificial light sources poses a potentially serious health threat that is only beginning to be understood. Individual sylvatic triatomines are often infected by the time they reach the adult stage, and can transmit *T. cruzi* to humans either by direct contact or by contaminating food or food-processing equipment. The parasite is carried by triatomine bugs in both cases, and transmission must therefore be regarded as vector-borne. This raises concerns about current disease surveillance strategies, which in Amazonia strongly emphasise the detection, confirmation, and compulsory reporting of acute disease cases (SVS 2005, Aguilar et al. 2007). By overlooking the entomological aspects of surveillance, such schemes might be missing most transmission risk situations in the Amazon and, as a consequence, may drive public attention and resources away from primary disease prevention.

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