Triatoma *Williami Galvão*, Souza e Lima, 1965 (Hemiptera, Triatominae) in Intradomiciliary Environments of Urban Area in Mato Grosso State, Brazil Domiciliation Process of a Wild Species?

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Research Article

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Abstract

Background: Triatomines found throughout Latin America are natural Chagas disease vectors (ChD). The domiciliation of triatomines is one of the main factors increasing the occurrence risk of human cases of this disease. There are 66 species of triatomine in Brazil, with three genera of significant epidemiological importance: *Panstrongylus*, *Rhodnius,* and *Triatoma*. Among the *Triatoma* species, *Triatoma williami,* a wild species, has been reported in the Brazilian states of Goiás, Mato Grosso, and Mato Grosso do Sul. In the city of Barra do Garças, Mato Grosso, the invasion by triatomines has been reported, with *T. williami* being the most common species.

Methods: Triatomine specimens were collected by passive surveillance or by active search by agents combating endemic diseases. After taxonomic identification, a parasitological feces diagnosis was performed to detect the presence of *Trypanosoma cruzi*. Concerning *T. cruzi* identification, molecular diagnosis and genetic sequencing were performed to identify the strain, also called discrete typing units (DTUs).

Results: In 2019, several triatomine specimens were collected in the urban area of Barra do Garças, Mato Grosso. Among them, 155 specimens were *T. williami*, *P. geniculatus*, and *R. neglectus*. In 2020, the sampled triatomine specimens were 56 *T. williami*, *Panstrongylus diasi*, and *R. neglectus*. For these years, *T. williami* has been the most frequent species. Between 2019 and 2020, 137 *T. williami* were collected (61% of them inside houses). In two triatomine colonies were found and morphological analyses, indicated were *T. williami*. These insects were collected inside houses in an urban area, on a neighborhood from Jardim Pitaluga (15°51’57.7” N, 052°16’04.5E). The records were sampled in September/2019 and January/2021. The rate of natural infection was 30.3% and 73.5% for 2019 to 2020. Two *T. williami* specimens belonging to one of colonies were positive for *T. cruzi* strain DTU IV,

Conclusions: This is the first time that the occurrence of domiciliation of *T. williami* has been confirmed in an urban area of Barra do Garças, Mato Grosso, Brazil. Further studies are needed for a clearer understanding of the ecology of this species for prevention and control mechanisms, since its sampled specimens had a high rate of natural infection by *T. cruzi*.

Introduction

The blood-sucking insects of the Triatominae subfamily are vectors of Chagas disease (ChD), an infection caused by the protozoan *Trypanosoma cruzi* (Chagas, 1909). The subfamily comprises 154 extant and three fossil species within five tribes and 18 genera (GALVÃO et al. 2020). In Brazil, 66 triatomine species have been previously recorded (GALVÃO, 2014; SOUZA et al., 2016; ALEVI et al., 2020; ZHAO et al., 2021).

Three genera have special significant sanitary importance and are related to the transmission of *T. cruzi* to humans: *Panstrongylus* Berg, 1879, *Rhodnius* Stål, 1859 and *Triatoma* Laporte, 1832 (GALVÃO *et al.*, 2014; MONTEIRO *et al.*, 2018; MS, 2015; OLIVEIRA and ALEVI, 2017; SILVA *et al.*, 2015).

Vectorial transmission by *Triatoma infestans* (Klug, 1834) was officially eliminated from Brazil in 2006 representing the enormous efforts to halt the transmission of ChD by non-native vectors (ABAD-FRANCH *et al.*, 2013). Despite this significant achievement, this “certification” may give a false idea that the disease transmission does not exist (BRANDÃO *et al.*, 2015). However, native triatomine species are potential vectors of *T. cruzi* and can invade and colonize artificial environments (VINHAES *et al.*, 2014). The domiciliation of triatomines is one of the main factors in the increasing transmission risk of *T. cruzi* to humans (LENT AND WYGODZINSKY, 1979). Anthropogenic morphoclimatic alterations propel the domiciliation process and dispersal of triatomines and can be interpreted as a survival strategy for the species (Forattini 1980). Silveira (2000) reported that the domiciliation process results from factors that may promote the invasion and progressive adaptation of triatomines to human households and may be related to the environment and the characteristics inherent in the vector. The domiciliation could be accelerated by the opportunism of wild triatomine species in the scenario of natural food sources scarcity. The human demographic shift is partially responsible for the changes in vectorial transmission. Such a shift promoted unfavorable environmental changes and subsequent rarefaction in wild fauna, leading triatomines to move to highly stable artificial habitats that offer a variety of hiding places and an abundance of food throughout the year (WHO, 2002).

The trends toward domesticity seem to be associated with behavioral plasticity (Carbajal de la Fuente *et al.* 2008), reducing the genetic repertoire of specimens, and increasing developmental instability. These conditions make triatomine species/populations more efficient vectors.

For a long time, Triatomine species have been classified according to their adaptation to human dwellings. Such a classification usually occurs in three groups, with Triatomine species classified as domiciliary, peridomiciliary, and wild. Noireau and Dujardin (2010) proposed four categories: sylvatic, intrusive, domiciliary, and domestic species. Such definitions have been the most widely accepted and are used in the literature to classify many triatomine species (WALECKYX *et al.*, 2015).

From the vector control perspective, it is of significant importance to precisely determine three aspects of the relationship between triatomines and humans: (i) the prevalence of sylvatic populations of triatomines, (ii) the level of intrusion of these sylvatic populations in peridomiciles and inside domiciles, and (i) the level of domiciliation or domestication in peridomiciles and houses (WALECKYX *et al.*, 2015). Nowadays, the attention is focused on the domiciliation of species, which were, until then, considered sylvatic because of increasing reports of wild species invading human and peridomestic dwellings in South American countries (GALVÃO *et al.*, 2001; SOTO-VIVAS *et al.*, 2001; VALENTE, 1999). In the last few decades, the literature has reported invasions by at least 10 species, increasing the risk of intradomiciliary colonies in Brazil, Bolivia, Colombia, and Venezuela (Table 1).

Triatoma williami Galvão, Souza e Lima, 1965 is a wild species that has been reported in the Brazilian states of Goiás, Mato Grosso, and Mato Grosso do Sul (ALMEIDA et al 2008; ARRAIS-SILVA *et al.*, 2011, GALVÃO 2014). The risk of domiciliation of this species was previously hypothesized by Andrade-Neto et al. (2012) through interviews with residents. Here, the domiciliation of this species was demonstrated through observing all of its life stages, including eggs, within a human dwelling.

Table 1
Species of triatomines already recorded to be domiciliated in human dwellings.

Specie	City/State/Country	Reference
Panstrongylus megistus	São Paulo, Brazil	Silva e*t al.* (2021)
P. rufotuberculatus	La Gardenia, Colombia	Wolf and Castillo (2002) Depickère *et al.* (2011)
P. geniculatus	Munecas, La Paz, Bolivia	Reyes-Lugo and Rodriguez-Acosta, (2000)
Rhodnius stali	Alto Bebi, Bolivia	Matias *et al.* (2003)
Triatoma brasiliensis macromelasoma	São João do Piauí, Piauí, Brazil	Santos *et al.* (2017)
T. rubrovaria	Rio Grande do Sul, Brazil	Almeida *et al.* (2000) CEVS/RS (2009)
T. maculata	Pitahaya, Venezuela	Reyes-Lugo and Reyes-Contreras (2011)
	Boa Vista, RO, Brazil	Luitgards-Moura (2005) Ricardo-Silva *et al.* (2016)
T. nigromaculata	Merida, Venezuela	Añez *et al.* (2005)
T. pseudomaculata	Minas Gerais, Brazil	Assis *et al.* (2007)
T. sherlocki	Bahia, Brasil	Almeida *et al.* (2009)

Material And Methods

The municipality of Barra do Garças, in the state of Mato Grosso, has a population of 56,423 inhabitants and a territorial area of 9,079 km^2 (IBGE 2017) (Fig. 1). It is located at the margins of the Garças and Araguaia rivers, forming an essential touristic complex. The biome is the Brazilian Cerrado, characterized by spatial heterogeneity and high endemism of plants and insects (MMA 2002; SILVA AND BATES, 2002), and is considered a biodiversity hotspot. The climate of this region is characterized by two seasons, dry winter and rainy summer, and corresponds to the Aw climatic type, according to Köppen’s classification (KÖPPEN, 1948). The climate of this region has an annual average humidity of 60% and an annual average temperature of 20–27 ºC.

The headquarters of the municipality is organized in 53 neighborhoods. The city health secretariat (Secretaria Municipal de Saúde) has 45 endemic control field agents to perform health surveillance and vector control activities. Three of these agents work in the surveillance and control of ChD vectors.

The inhabitants usually collect the triatomines found in the human dwellings. These people inform the health workers or deliver the specimens directly to the Entomology Laboratory at the Regional Health Office of Barra do Garças (ERSBG abbreviation in Portuguese) from the State Health Secretariat of Mato Grosso (SESMT abbreviation in Portuguese), Brazil. All of the sampled material was analyzed in this facility. The identification of the specimens was made through the use of dichotomous keys from Lent and Wygodzinsky (1979) and Galvão (2014). The identification of these insects as *T. williami* was carried out based on the external morphological characteristics of the head, wing, abdomen, and external female genitalia (Fig. 2A–E). Such analyses confirmed the importance of these structures, as previously discussed by Teves *et al.* (2020). Based on this information, the activities of the ChD surveillance team are triggered.

For the analysis of natural infection by *T. cruzi*, the conventional polymerase chain reaction (cPCR) was performed as previously described by Brígido, et al (2017) using oligonucleotides P21 fw (5'-AACGCACCATCAATCTTTTG-3') and P21 rv (5'-CGTCGCATTCCTCATTTCTTC-3') that amplify a 65bp fragment from the genomic region of the parasite. For *T. cruzi* DTUs identification, cPCR was performed according to Cosentino and Agüero (2012) using the oligonucleotides TcSC5D-forward 5'-GGACGTGGCGTTTGATTTAT-3' and TcSC5D-reverse 5'-TCCCATCTTCTTCGTTGACT-3' that produce a amplicon of 832bp from TcSC5D gene. The amplicons were sequenced at ABI3730xl Genetic Analyzer (Applied Biosystems). The sequences of the *T. cruzi* TcSC5D gene were analyzed on Clustal Omega tool (Sievers and Higgins, 2014) to discriminate the DTUs TcI to TcVI using the polymorphic sites described by Cosentino and Agüero (2012).

Results

The invasion of wild triatomines has been reported in urban housing units from the municipality of Barra do Garças, Mato Grosso, Brazil, and a ten-year historical series confirmed it. During this series, the species collected were: *Triatoma williami* Galvão, Souza and Lima (1965), *Panstrongylus diasi* Pinto & Lent 1946, *Panstrongylus geniculatus* (Latreille, 1811), and *Rhodnius neglectus* Lent, 1954.

In 2019, 155 specimens of *T. williami*, *P. geniculatus*, and *R. neglectus* were collected. In 2020, 56 specimens of *T. williami*, *P. diasi*, and *R. neglectus* were collected. During all of the analyzed years, *T. williami* was the most frequent species (Fig. 3).

In the urban area of Barra do Garças, Mato Grosso, Brazil, the presence of *T. williami* has been registered in eight neighborhoods. In 2019 and 2020 (Table 2), the highest infestation recorded were found at boundaries of the Serra Azul State Park (PESA abbreviation in Portuguese) (Fig. 4).

Table 2
Distribution of the collected *Triatoma williami* specimens by neighborhood in Barra do Garças, Mato Grosso, Brazil, in 2019 and 2020.

***T. williami* abundance by neighborhood**	**2019**		**2020**	
	AF	**RF (%)**	**AF**	**RF (%)**
Jd Amazônia I - BNH	57	41.6	32	78.0
Jd Pitaluga	72	52.6	9	22.0
Jd Araguaia	2	1.5	0	0.0
Santo Antônio	2	1.5	0	0.0
Monte Sinai	1	0.7	0	0.0
Jd Amazônia II	1	0.7	0	0.0
Jd Piracema	1	0.7	0	0.0
São Sebastião	1	0.7	0	0.0
Total	**137**	**100.0**	**41**	**100.0**

AF: Absolute frequency; RF: Relative frequency.

For *T. williami*, the number of females collected was larger than that of the males. During 2019 and 2020, the females/males ratio was not within the expected 1:1 pattern. It was 0.79 in 2019 and 0.75 in 2020 (Fig. 5).

From 2019 to 2020, 137 specimens of *T. williami* were collected, with 61% found inside houses. In 102 of these locations, these specimens were found in the three common environments in which they usually occur: indoor, peridomicile and no information (Fig. 6).

From a monthly density analysis of the sampled triatomines from 2019 to 2020, it is possible to observe that environmental seasonality was more significant during the third quarter of the year. This period is recorded as the driest climatic season in the region (Fig. 7)

In 2019, three species of triatomines, from three significant genera to the epidemiological context of ChD, were naturally infected by *T. cruzi* in the urban area of Barra do Garças: *T. williami*, *P. geniculatus*, and *R. neglectus.* In 2020, specimens from the species *T. williami*, *R. neglectus*, and *P. diasi* were positively infected with *T. cruzi*. From 2019 to 2020, of the 155 and 56 triatomines collected and analyzed, 90 and 42 had a parasitological diagnosis for *T. cruzi* infection, respectively.

Table 3
The rate of natural infection analysis for *Trypanosoma cruzi* in triatomines collected in Barra do Garças, Mato Grosso, Brazil, for 2019 to 2020.

	2019			**2020**		
Species/ Infection rate	**Analyzed**	**Positive**	**Infection rate**	**Analyzed**	**Positive**	**Infection rate**
Triatoma williami	76	23	30.3	34	25	73.5
Rhodnius neglectus	12	1	8.3	4	1	25.0
Panstrongylus diasi	0	0	0.0	3	1	33.3
P. geniculatus	2	1	50.0	1	0	0.0
Total	90	25	-	42	-	-

Source: Data recorded in the monthly sheet of the ChD Control Program, State Health Secretariat of Mato Grosso, Brazil.

In September 2019, the ChD surveillance team attended to a request from the resident and went to that human dwelling to carry out an entomological survey for triatomines. After one bed was searched, the field agents found adult specimens, eggs, and nymphs on the wooden bed frame (Fig. 8A–C). Signs of feces were also observed. These findings were the first evidence of colonization of *T. williami*, which was also characterized by four sampled adults (one male and three female), 41 nymphs in the first developmental stage, and 34 eggs (Fig. 9A–B).

After these triatomines were found, the endemic control agents of the City Health Secretariat of Barra do Garças performed a residual chemical control in that house. In 2020 the agents did not carry out entomological research and chemical control in this house.

In January 2021, more specimens were caught inside human dwellings by the residents. These specimens were handed over to the ERSBG from the SESMT. This was the second record of compound domiciliation with eight sampled specimens: two males, one female, and five nymphs (one nymph in the N1, one in the N2, two in the N4, and one in the N5 stages).

In February 2021, the field agents carried out residual chemical control in the infested house again. In June 2021, the resident on that infested house collected and delivered two additional *T. williami* nymphs to the ERSBG from the SESMT: one nymph in the N1 stage, one dead male, and one exuviae (Fig. 10).

Both colonies of *T. williami* were found indoors, in beds, in an urban area on the neighborhood Jardim Pitaluga (S15°51’57.7” W052°16’04.5) in Barra do Garças, Mato Grosso, Brazil. The voucher specimens from the first colony were deposited in the Herman Lent Collection of the Instituto Oswaldo Cruz in Rio de

Janeiro. Two of the sampled specimens were adults, one female (CTIOC 13005) and one male (CTIOC13006), whereas three were nymphs (CTIOC13007 to CTIOC13009), and there were five eggs.

The molecular diagnoses for natural *T. cruzi* infections in two adult male specimens were positive. Given these results, the molecular content was sent to the genetic sequencing of *T. cruzi* strain, which was identified as discrete typing unit (DTU) type IV.

For the second *T. williami* colony, the feces from the three specimens were analyzed with a parasitological test and were infected by *T. cruzi*, whereas the other specimens were not infected. Two adult specimens, one female and one male, and two nymphs were deposited in "Collection Entomological Prof° Dr. José Maria Soares Barata." in Faculty of Pharmaceutical Sciences UNESP - Araraquara - São Paulo Brazil.

Discussion

We reported a systematic collection of adults, nymphs, and eggs of *T. williami* inside human dwellings from Barra do Garças, Mato Grosso, Brazil, during two different years. In the second year, we found nymphs in the last developmental stage, suggesting early stages in the domestication of this sylvatic species. The domiciliation of wild triatomine species is a risk factor for reestablishing the vectorial transmission of ChD (SILVEIRA and DIAS, 2011; WALECKX *et al.* 2015). Surveillance for species, considering the domiciliation principle and the development of actions to interrupt this process, is paramount in preventing ChD. For Berenger and Pages (2007), the process of domestication seems irreversible.

Lunardi *et al.* (2017) discussed that morphological plasticity in the shape of *T. williami* is associated with blood source, but they did not test whether plasticity confers a fitness advantage to culminate in domiciliation by this species. However, in a previous study, Lunardi *et al.* (2015) recorded a high potential vector for nymphs of this species.

So far, *T. williami* has been considered a secondary *T. cruzi* vector because it maintains its wild condition and shows synanthropic potential, colonizing peridomiciles and, frequently, invading households. The synanthropy represents a secondary adaptation by sylvatic species in response to environmental changes. Such adaptability to human dwellings depends on triatomine plasticity (FORATTINI, 1980).

Given the increasing importance of secondary triatomine species and their frequency of occurrence within domiciliary environments, further eco-epidemiological studies should be stimulated to monitor changes in the behavior of these species. The behavioral characteristics of the different species of triatomines allow them to adapt to environmental changes, directly reflecting the population dynamics of these vectors. Thus, natural or anthropogenic environmental factors interfere with species density, dispersal, reproduction, and domiciliation (VAZQUEZ-PROKOPEC *et al.*, 2006; GRIJALVA e*t al.*, 2014; CORASSA *et al.*, 2016; VIANNA *et al.*, 2017).

The first *T. williami* specimen in Nova Xavantina, Mato Grosso, Brazil, was recorded by Travassos-Filho (1972). This specimen was collected inside the house of a worker and was infected by *T. cruzi*. Then, Arrais-Silva *et al.* (2011) and Andrade-Neto (2012), using molecular biology, found that the natural infection rate of this species by *T. cruzi* was 30% in Barra do Garças, Mato Grosso, Brazil. In our parasitological feces diagnosis, we observed an elevated infection rate of *T. williami* by *T. cruzi* in 2019 and 2020, indicating the transmission risk of the parasite by this vector.

The finding of the TcIV DTU of *T. cruzi* in *T. williami* collected in the home is an unprecedented record for Mato Grosso, Brazil, and it is concerning. The distribution of DTU TcIV is more significant in Central and South America, with greater density in the Amazon region. In the Western Brazilian Amazon region, this is the leading cause of human infections, resulting from oral transmission outbreaks of the parasite in the region (MONTEIRO et al., 2012; TESTON et al., 2017; SANTANA et al., 2019). The origin of this DTU is derived as a wild cycle, but studies have already demonstrated its participation in domestic cycles (ZINGALES et al., 2012; BRENIÈRE et al., 2016), which are frequently correlated to acute ChD infections in humans. Studies analyzing triatomines from different biomes have not recorded this DTU for the Cerrado (BARROS et al., 2017). Therefore, this unprecedented record for Cerrado, the predominant biome in our study area. Izeta-Alberdi et al. (2016) found no correlation between TcIV and any vector species. Barros et al. (2017) found a predominance of this DTU for the *Triatoma* genus, corroborating the record of our study of this strain in *T. williami*. Regarding the potential reservoirs that participate in the transmission cycle of this parasite, the main mammals are carnivores, primates, and rodents (ZINGALES et al., 2012; IZETA-ALBERDI et al., 2016; BARROS et al., 2017).

The characteristics found for *T. williami* seem similar to those of *T. infestans.* According to Vinhaes *et al.* (2014), the protagonism of *T. infestans* can be justified due to its high degree of anthropophily, a large capacity to colonize human domiciles, and high rates of natural infection. The record of *T. williami* in the domiciliation process lights up an alert because there is a record of this species naturally infected by *T. cruzi*, with a high infection rate.

It is necessary to carry out immediate intervention measures to interrupt this process of domiciliation of T. williami in the urban area of Barra do Garças, Mato Grosso, Brazil. The approximation of vectors with human living spaces increases the risk of transmission of Chagas disease (CARVALHO and GOMES, 2014).

When we analyzed the records of the locations with triatomines in Barra do Garças over ten years, we identified a higher occurrence in households in the four neighborhoods bordering PESA. Thus, the presence of a green belt associated to the artificial light of these households might be supporting and promoting dispersion of the triatomines. Martins *et al.* (2019) reported that Barra do Garças, Mato Grosso, has a different ecological context, given its proximity to PESA. This state park may facilitate human contact with wild triatomines, which are potential vectors of ChD, especially in PESA neighborhoods.

The occurrence of wild triatomine species sporadically invading human houses is a significant difficulty in vector surveillance programs (CARANHA *et al.*, 2011). A study in a similar area, by Jácome-Pinilla *et al.* (2015), proved an actively dispersing area and triatomines highly attracted to artificial lights. Furthermore, the environmental parameters encountered during this study, particularly during the first hours after sunset, are favorable for the active dispersal of sylvatic triatomines. One immediate recommendation is that external artificial lights on walls must remain turned off during the first hours after sunset, the period when most sylvatic triatomines find favorable atmospheric and environmental conditions for dispersal.

Entomological surveillance for triatomines in Barra do Garças has been done mainly by the population, showing the importance of passive surveillance by residents to detect foci of the triatomines. Thus, we reinforce the importance of health education for ChD prevention. The passive surveillance improved risk management by the city health system, favoring timely intervention in the ChD transmission chain. This process corroborates that entomological surveillance has been supported by community referees responsible for the Triatomine Information Post Network (IPN), which has been established for a long time (SILVEIRA and DIAS, 2011). The knowledge of the population about triatomines and ChD is paramount to promoting collaboration in vector control and reducing vector transmission (VILLELA *et al.*, 2009a, 2009b; COURA; JUNQUEIRA, 2012). Thus, the better the understanding, the greater the chance of intervening positively, preventing health problems and favoring healthier ways of life (AYRES, 2009).

Analysis of the triatomines collected in Barra do Garças in a historical ten-year series showed earlier demonstrates the increase in vector density in 2019. The results indicate periods with a peak incidence of triatomines in the third quarter of the year. Seasonality is also observed in Chagas vector populations and transmission. In combination with density-dependent regulation, these characteristics have led to the belief that insecticide control of these vectors can be improved if seasonally timed (GORLA, 1988; SCHOFIELD, 1991).

Thus, studies are needed to investigate the mammal fauna and triatomines in urban areas and adjoining neighborhoods of PESA to evaluate the dimensions and degrees of trypanosomal infection. These new studies will allow us to assess the infection risks of humans around the park, considering the presence of the etiological agent of ChD.

The finding of *T. williami* colonies inside homes and the high rate of natural infection for this species reinforces the need to study reservoirs and their role in maintaining and or dispersing *T. cruzi*. The main determinants for establishing human infection by *T. cruzi* involve the adaptation of triatomines to the domicile and peridomicile and the *T. cruzi* circulation between wild and domestic animals in these environments (COURA, 2007).

However, understanding variation in vector infection prevalence alone is not enough to understand the risk to humans from the vector-related transmission. Several factors affect the relationship between vectors and the prevalence of human infection (BROWNE et al., 2016). The maintenance of sustainable surveillance activities is possible only if all transmission network components are identified (NOIREAU et al., 2009). These measures are essential for the sustainability of the control of ChD, since the re-infestation of homes by native triatomines occurs continuously, and as there are wild foci of vector species of *T. cruzi*, there is a risk of infection of the reservoirs (PRIOTTO, 2012).

The detection of possible triatomine domiciliation in the urban area of Barra do Garças, Mato Grosso, Brazil, demonstrates the importance of entomological surveillance and underscores the importance of strengthening prevention programs and controlling ChD infections. Our results reinforce the importance of and need for entomological surveillance in routine home visits by health field agents. Therefore, maintaining and systematizing chemical control measures and following the Brazilian Ministry of Health protocol and environmental management in households to reduce the risk of ChD infection in endemic areas of the state of Mato Grosso, Brazil, is of utmost importance.

Conclusion

As far as we know, this study is the first to confirm the domiciliation of *T. williami* in urban areas of Barra do Garças, Mato Grosso, Brazil. This record occurred after sporadic invasions by this species in domiciles near an environmental conservation unit. This park is composed of native vegetation and wild animals, which are possible reservoirs for *T. cruzi*. These conditions reinforce the importance of entomological surveillance for the sanitary control of triatomines. Further studies are need to understand better the ecology of these species for their prevention and control mechanisms, since they have a high natural infection rate by *T. cruzi*.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing Interests

The authors declare that they have no competing interests.

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Authors’ contributions

MFM, JCS, and JO contributed to the preparation of the manuscript; CG was responsible for identifying the studied specimens and text review; SCM organized, prepared, and analyzed data; and LKSS realized textual revision.

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Figures

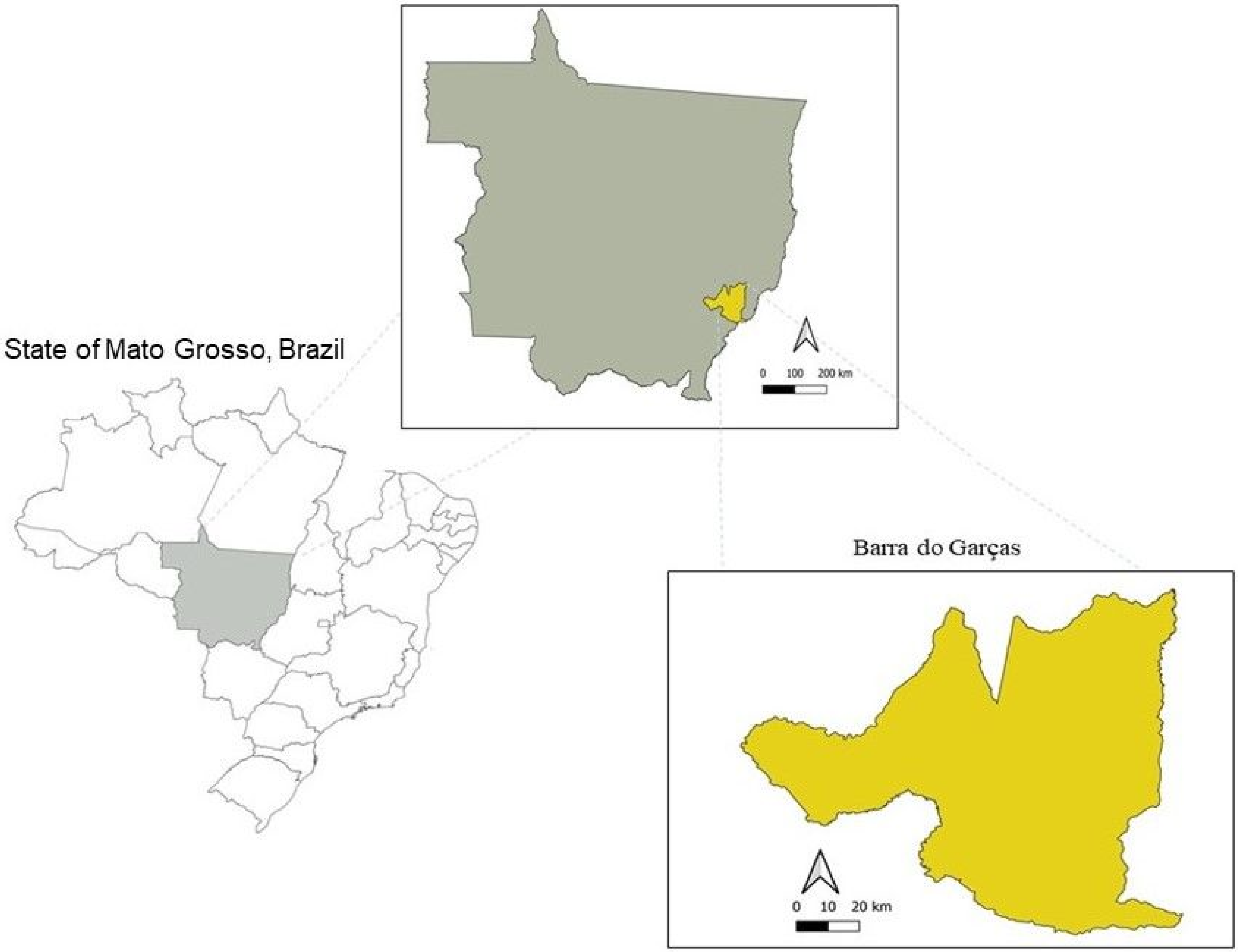

Figure 1

Municipality of Barra do Garças, Mato Grosso, Brazil. Adapted from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE).

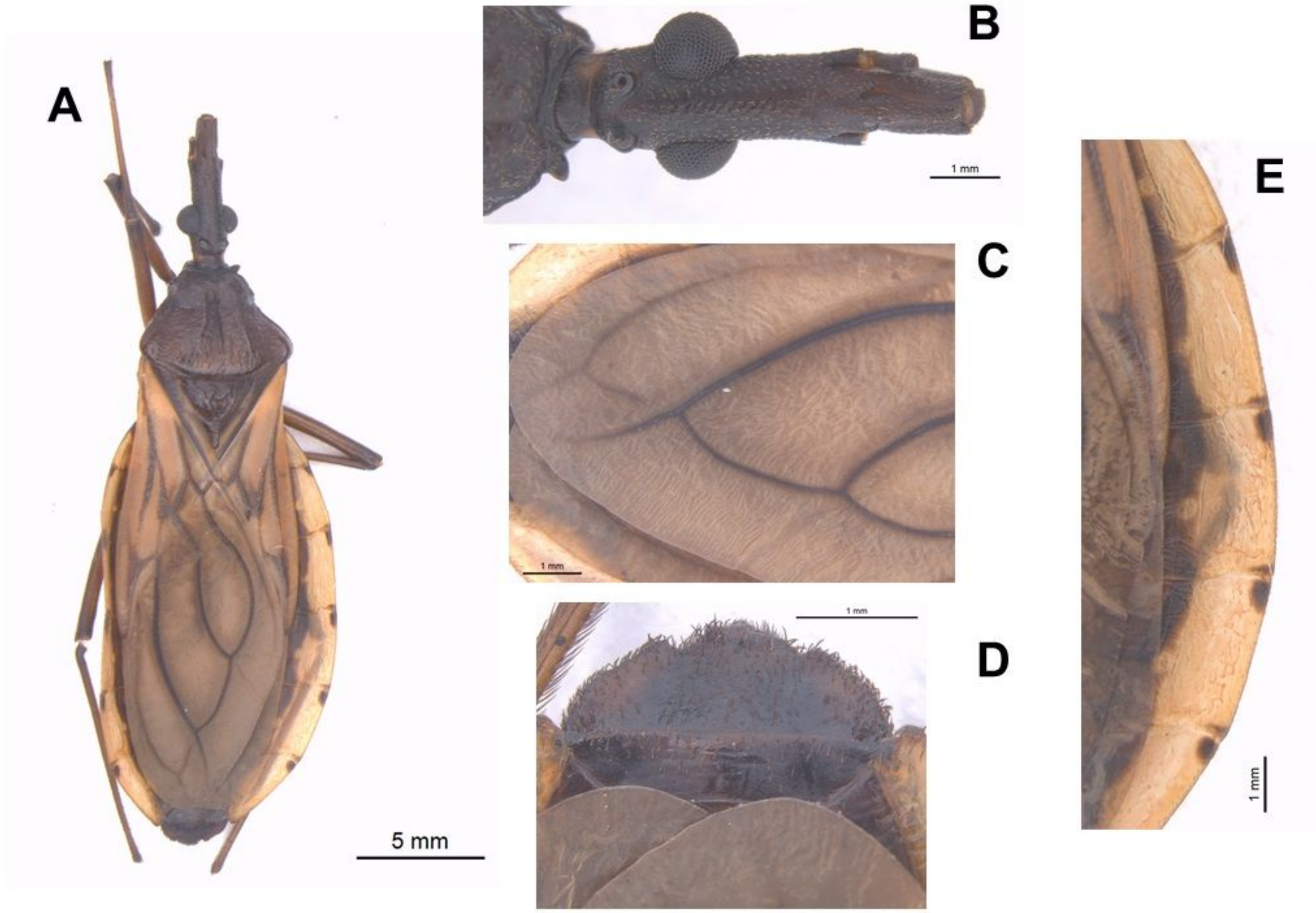

Figure 2

A. Adult female of Triatoma williami; B. Head detail in the dorsal view of the specimens; C. wing venation pattern detail of the specimens; D. External female genitalia by dorsal view; E. General appearance of the connexivum chromatic pattern.

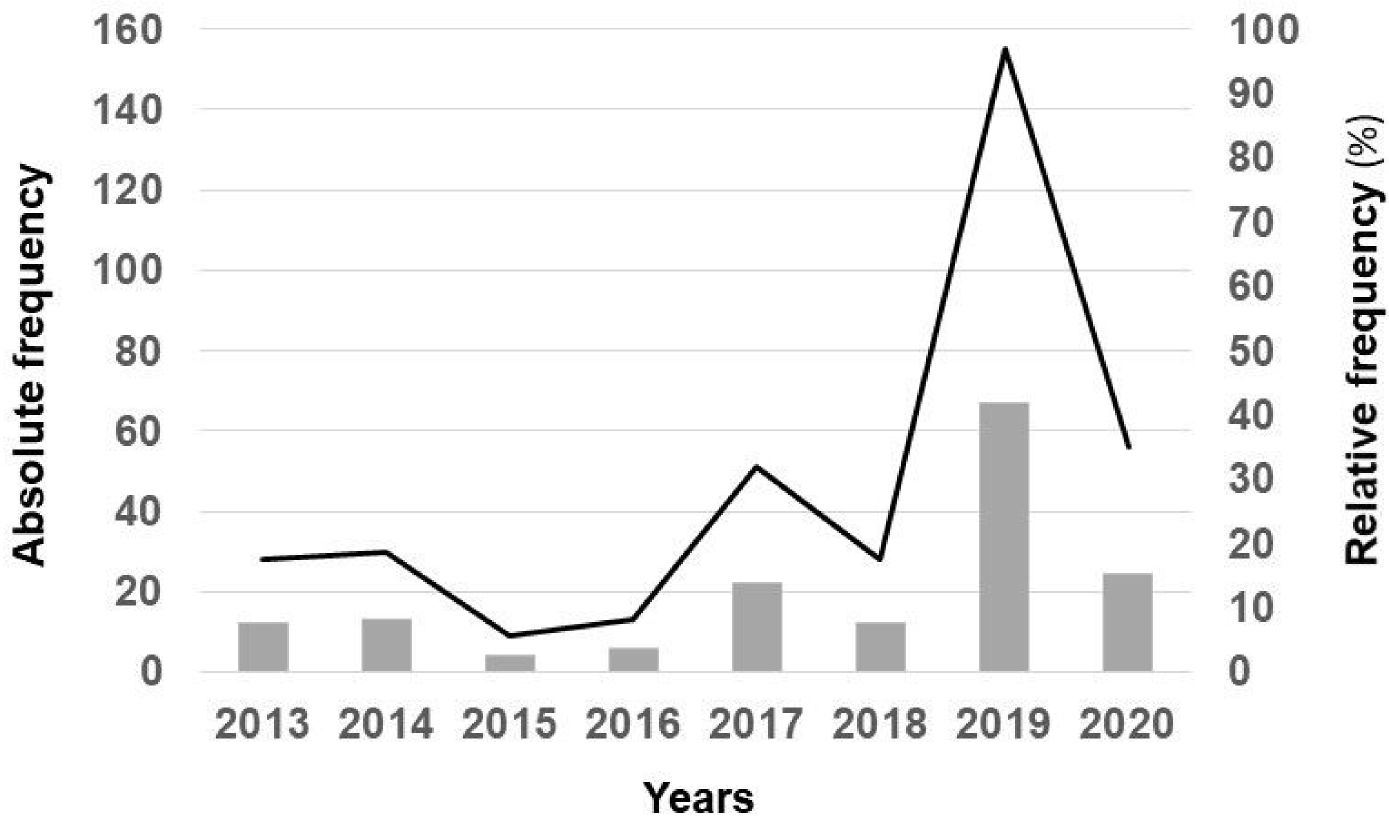

Figure 3

The absolute and relative frequencies of triatomines collected in Barra do Garças, Mato Grosso, Brazil, from 2013 to 2020.

Figure 4

Panoramic view of the Barra do Garças municipality and the Parque estadual da Serra Azul (PESA), Mato Grosso, Brazil.

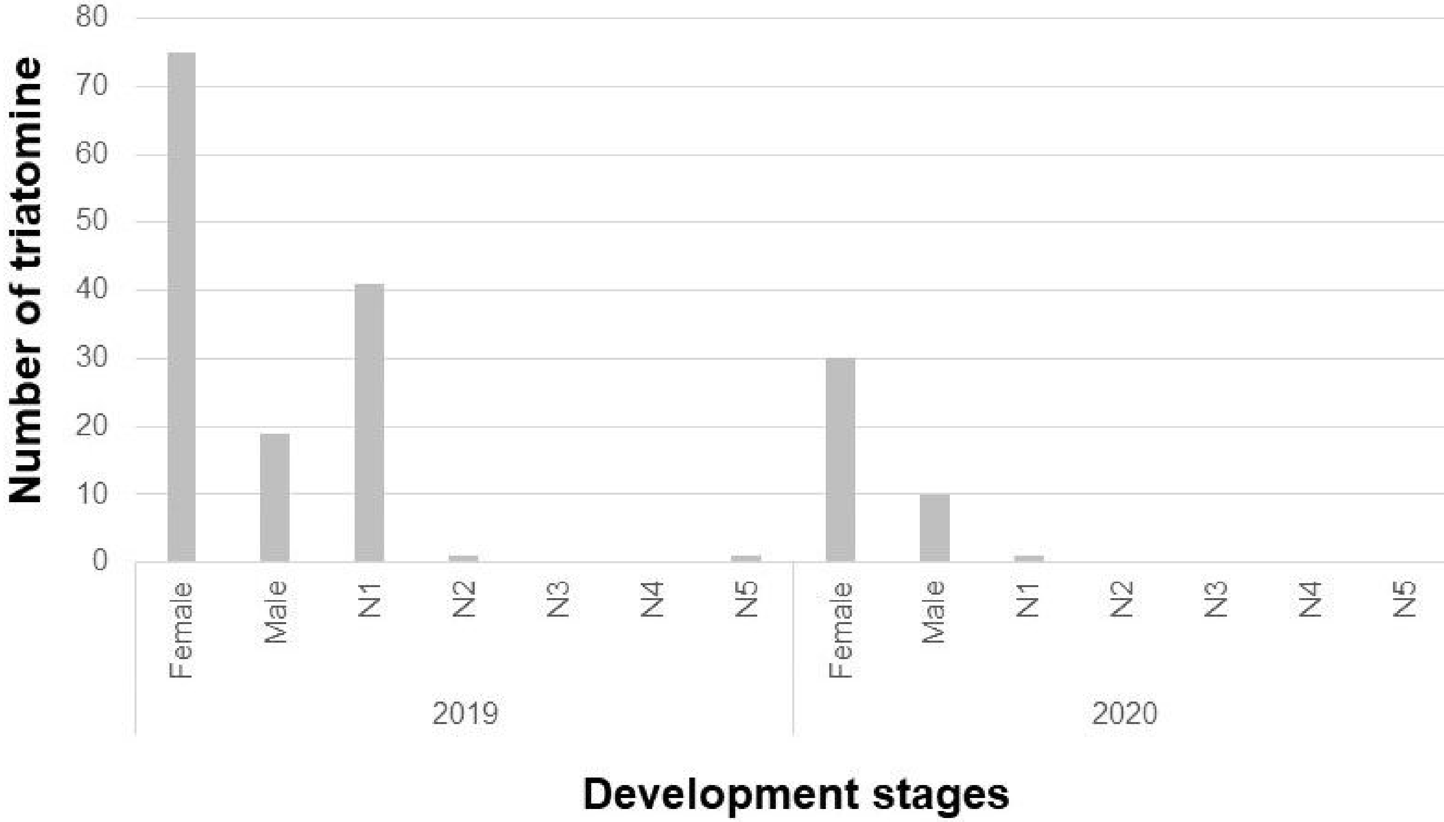

Figure 5

The density of adults and nymphs of Triatoma williami sampled in Barra do Garças, Mato Grosso State, Brazil from 2019 to 2020, according to sex and life developmental stage. N1: first stage nymph; N2: second stage nymph; N3: third stage nymph; N4: fourth stage nymph; N5: fifth stage nymph.

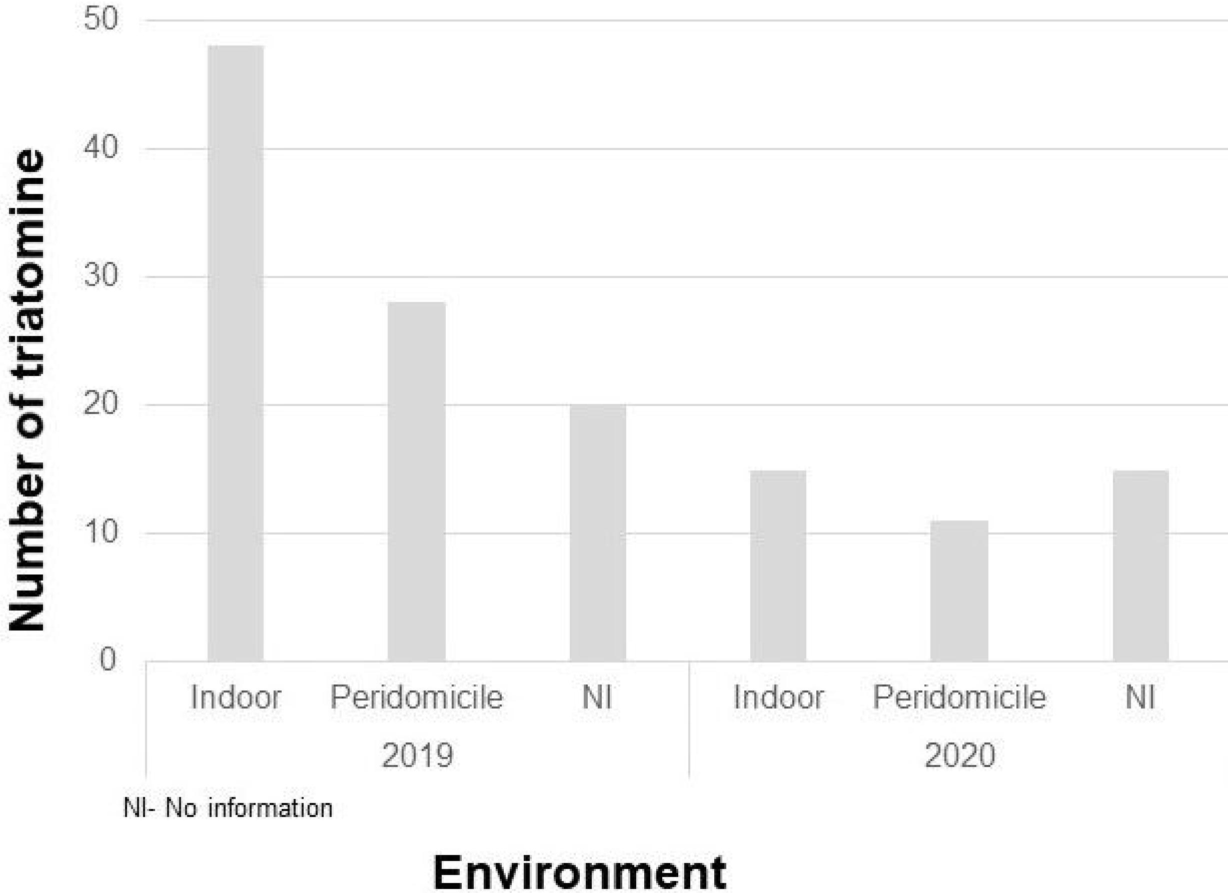

Figure 6

The density of Triatoma williami collected from 2019 to 2020 in Barra do Garças, Mato Grosso, Brazil, from 2019 to 2020 in each environment. Source: Data recorded on the monthly sheet related to the ChD Control Program, State Health Secretariat of Mato Grosso, Brazil.

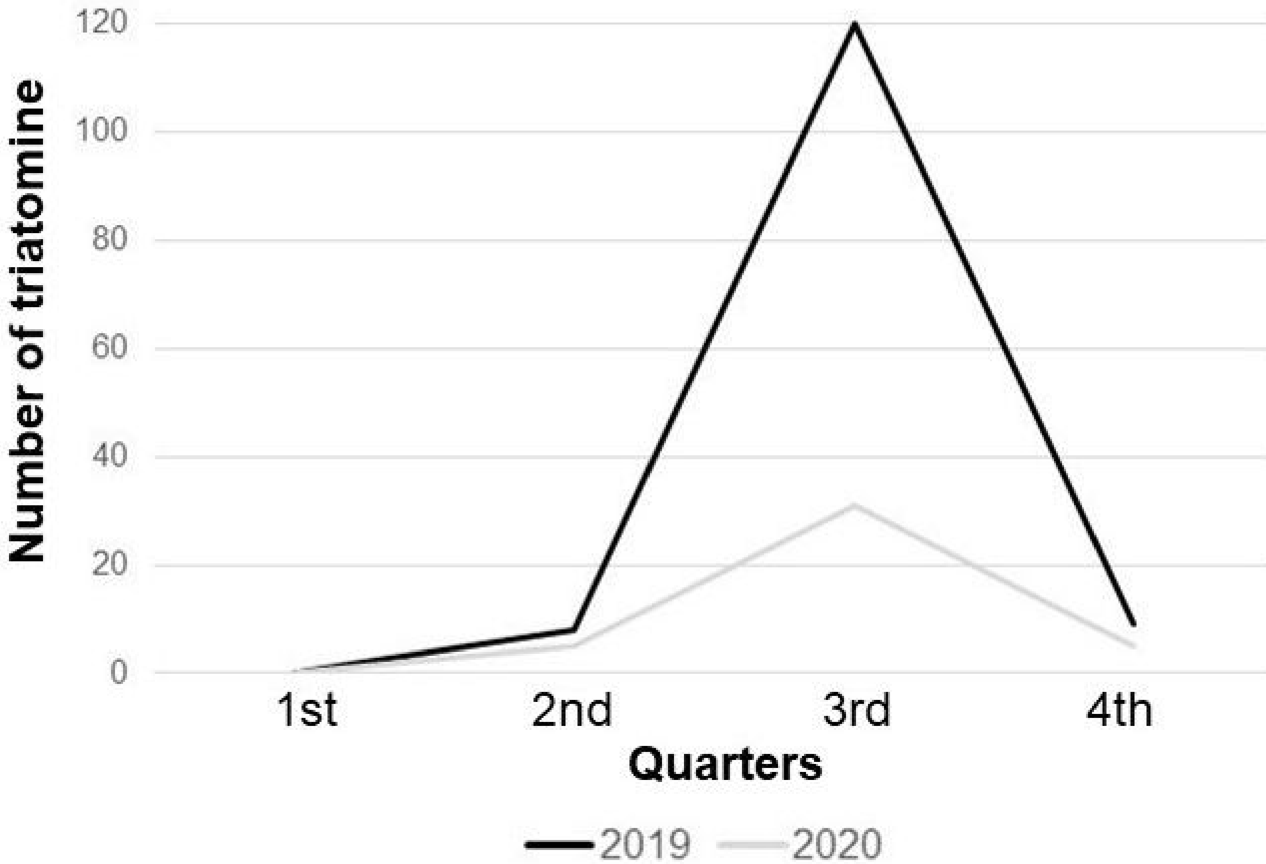

Figure 7

The monthly density of Triatoma williami collected (between 2019 and 2020) in Barra do Garças, Mato Grosso, Brazil.

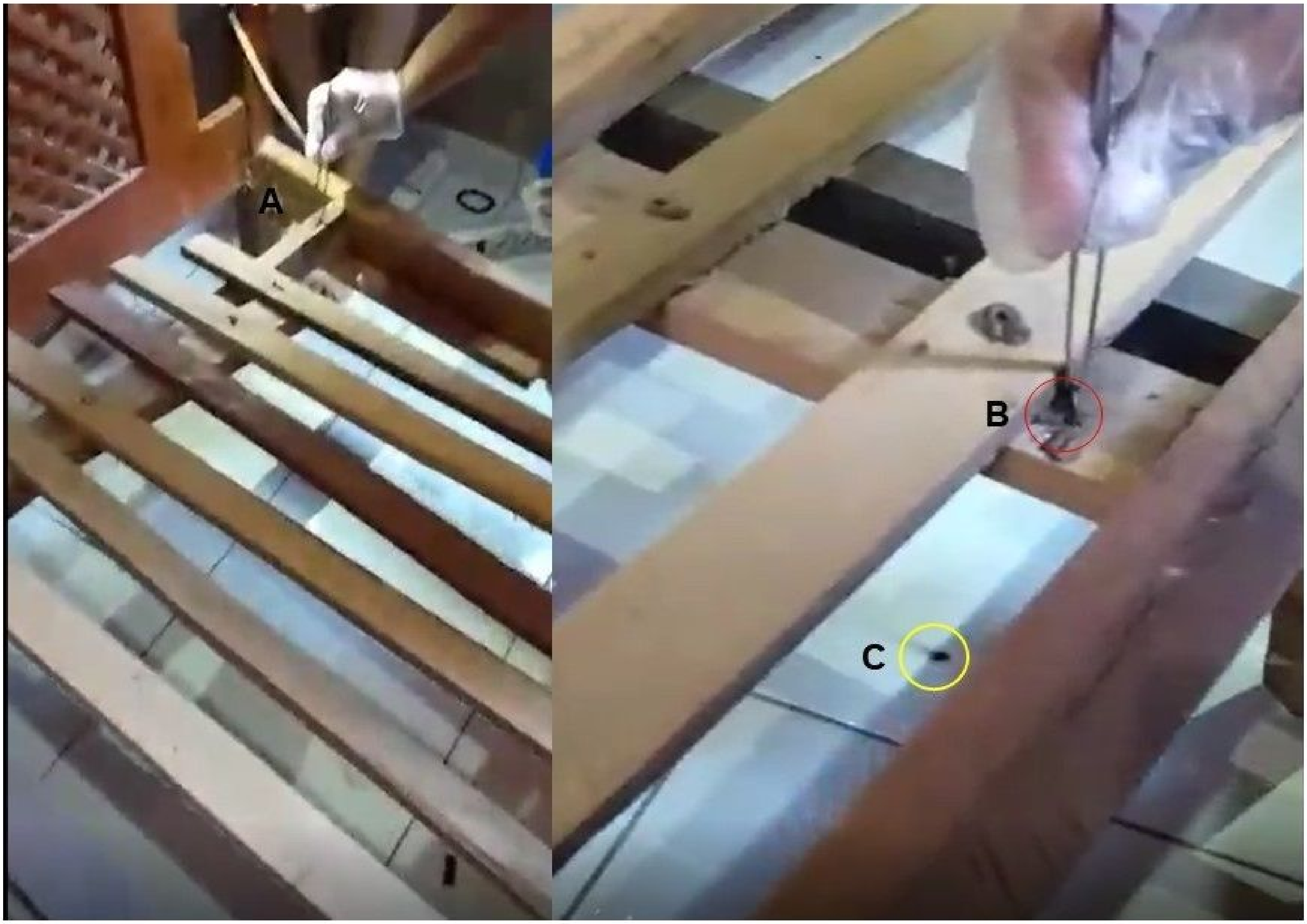

Figure 8

A. The field agents performed the entomological survey in the cracks of a bed of the resident. B. One adult of Triatoma williami collected in bed (red circle) in a residence from the Barra do Garças municipality, Mato Grosso, Brazil, in 2020. C. Traces of feces on the floor under the bed (yellow circle).

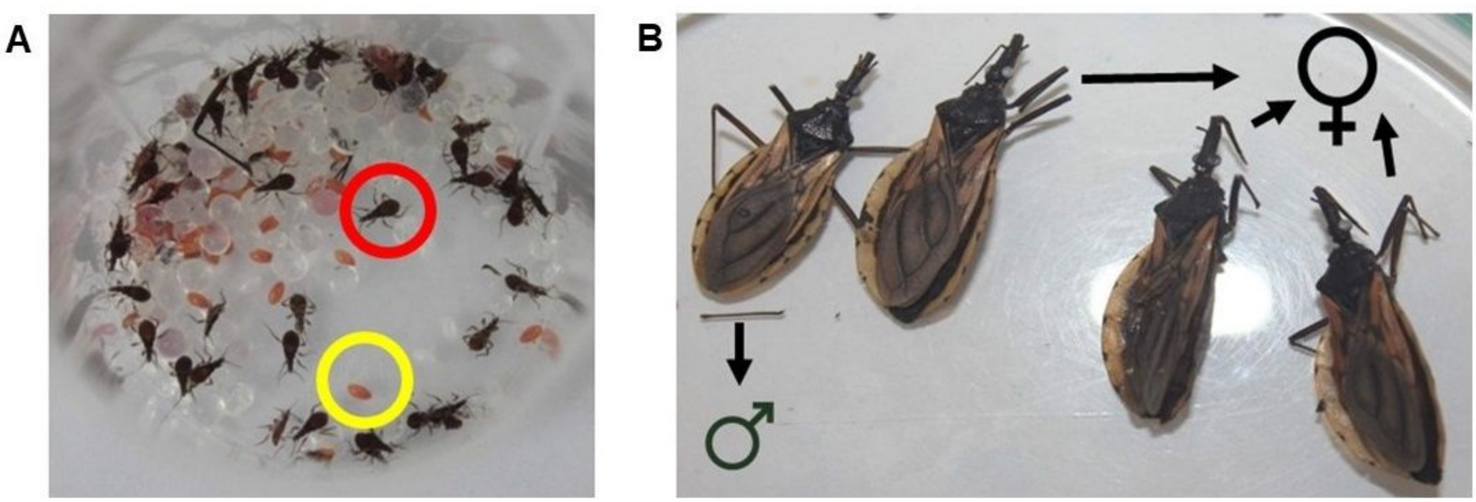

Figure 9

A. Eggs (yellow circle) and nymphs (red circle); B. One male and three female specimens of Triatoma williami collected in Barra do Garças, Mato Grosso, Brazil, in 2019.

Figure 10

The specimens of Triatoma williami sampled after the residual chemical control in Barra do Garças, Mato Grosso, Brazil, in 2021.