RESEARCH ARTICLE

Triatominae fauna (Hemiptera: Reduviidae) in Mato Grosso do Sul, Brazil, and the influence of climatic elements on their populations.

Triatominae Fauna: Influence of Climatic Elements

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Abstract
Introduction: The objective of this work was to study Triatomine fauna captured during the period from 2006–2014 in Mato Grosso do Sul and to investigate the influence of climatic elements on these populations by providing subsidies to guide vector control work in the state.
Methods: We verified the natural infection rate, the abundance of classes, constancy, frequency and dominance, and the influence of climatic factors on the frequency of triatomine.
Results: Of the 14,178 specimens collected, 2,118 (14.94%) were domiciliary, and 12,060 (85.06%) were peridomiciles. The rate of natural infection in *Triatoma matogrossensis* was 18.18%, followed by *Rhodnius neglectus* (0.46%) and *Triatoma sordida* (0.27%). *Triatoma sordida* was the most frequent species: constant, abundant and dominant. We observed the influence of climatic factors on the encounter of insects during the period from January to December and throughout the eight years of the study period. Climatic factors such as relative humidity affect the frequency of insects.
Conclusions: Although Mato Grosso do Sul is considered free of endemic vector transmission by *Triatoma infestans*, the persistent encounter vectors naturally infected by *Trypanosoma cruzi* remain worthy of attention, and the information in this work may improve actions to combat the vector in the state better selecting the periods and favorable environmental conditions for control using insecticides, ensuring greater efficiency and decreasing the possibilities of the vector triatomine becoming resistant to the chemical agent.

Keywords: Triatomine, *Trypanosoma cruzi*, climatic elements.

INTRODUCTION

Trypanosoma cruzi, etiologic agent of Chagas disease, complex anthropozoonosis with mammals serving as reservoirs and hosts,[1] is classified into seven strains (TcI to TcVII)[2,3] with discrete typing units (DTU) and uses triatomine insects of the Hemiptera Reduviidae family for transmission.

Although a total of 142 triatomine species, grouped into five tribes formed by 18 genera,[4-6] only three genera have epidemiological importance in the transmission chain of the parasite (*Panstrongylus*, *Triatoma* and *Rhodnius*)[4] and no more than four species are directly involved: *Triatoma brasiliensis*, *Panstrongylus megistus*, *Triatoma pseudomaculata* and *Triatoma sordida*.

The presence of three main types of vectors were confirmed in Mato Grosso do Sul-MS: *T. brasiliensis*, *P. megistus* and *T. sordida*, latter being the only one with significant levels of household and peridomiciliary infestation (9.3% and 86.6%, respectively). *T. sordida* is the specie captured most frequently[7-10] and has the highest number of specimens naturally infected by *T. cruzi*.[8-10] *T. brasiliensis* and *P. megistus* have low rates (<0.2%) infestation.[7] However, these values may be underestimated.[9]

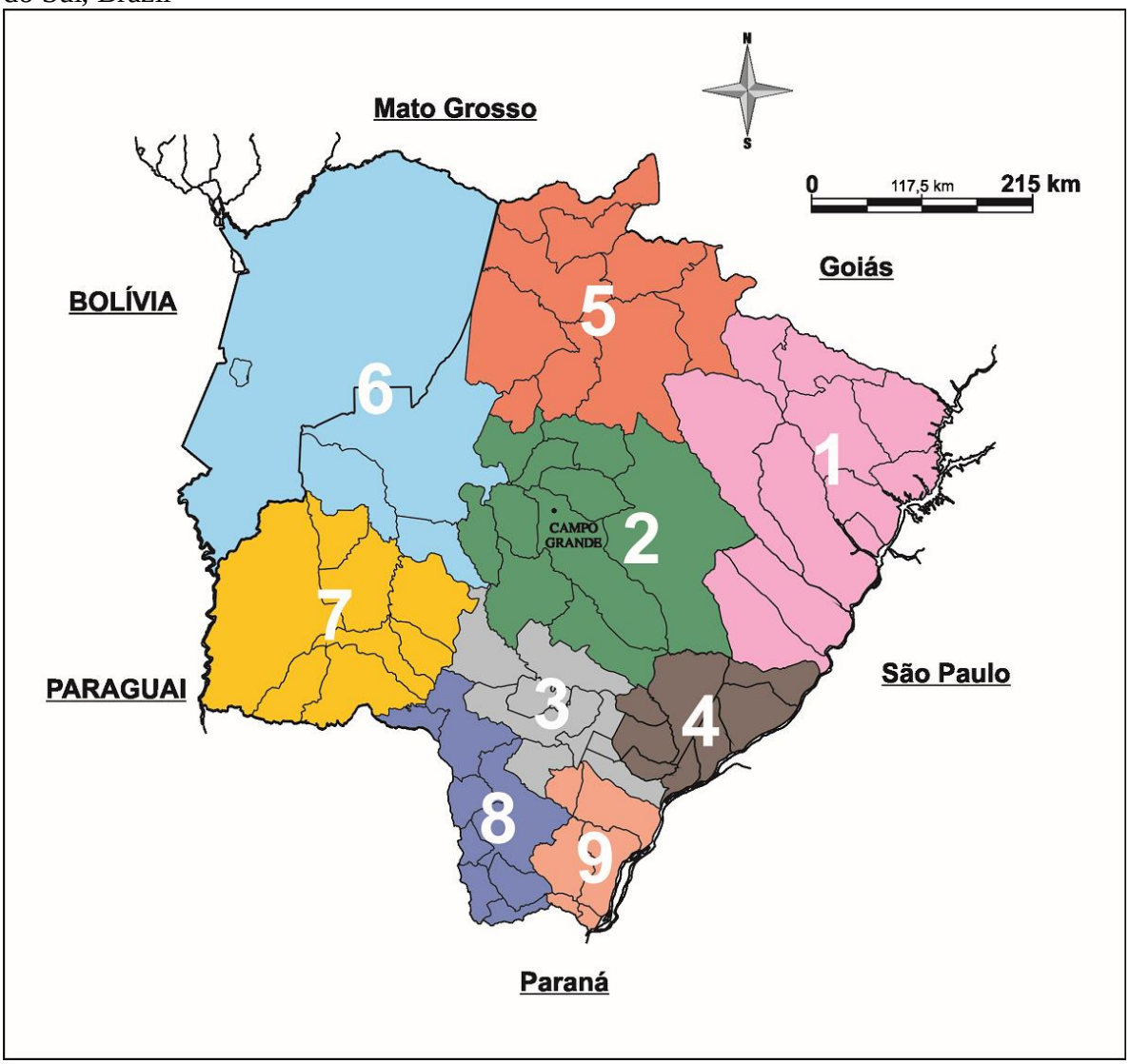
Cominetti *et al.*,[10] reported the circulation of three DTU in triatomine in MS and in *T. sordida* were found TCI, TCII and TcBat / TcVII and *Triatoma matogrossensis* the TCII.

The objective of this work was to study the captured Triatomine fauna in the state during the period 2006-2014, and the influence of climatic elements on their populations by providing subsidies to orient the vector control work in Mato Grosso do Sul.

MATERIAL AND METHODS

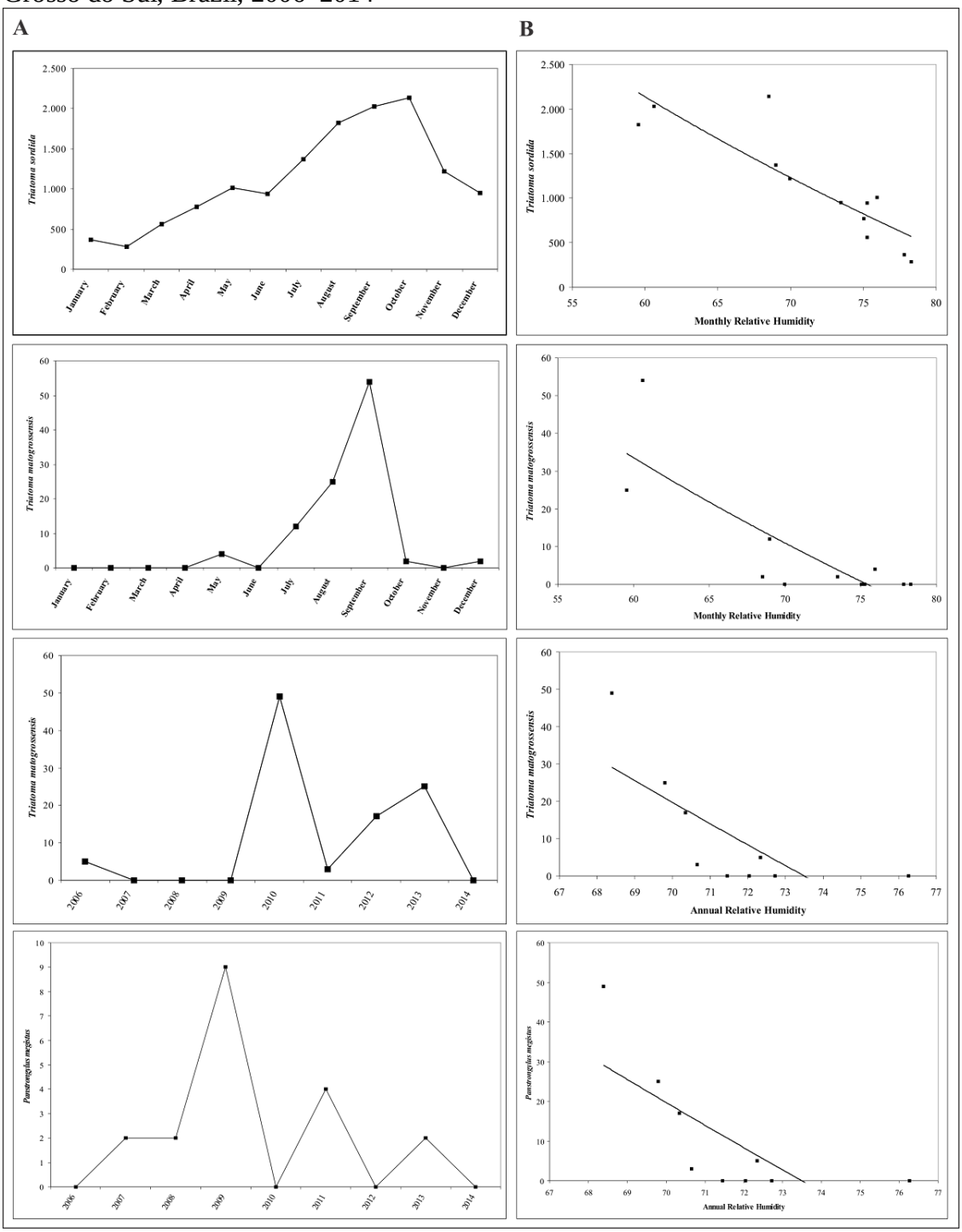
The State of Mato Grosso do Sul (MS) has 79 municipalities in an area of 357,145,534 km² and an estimated population of 2,619,657 inhabitants.[11] It is bordered on the east by the states of Minas Gerais and São Paulo, to the north with the states of Mato Grosso and Goiás, to the south with the State of Parana and Paraguay and to the west with Bolivia (Fig. 1). It is divided into nine Planning Regions (PR) as the Study of State Territorial Dimension of Mato Grosso do Sul[12] which are: Bolsão, Campo Grande, Grande Dourados, Leste, Norte, Pantanal, Sudoeste, Sul-fronteira and Cone-Sul (Fig. 1).

Fig. 1. Planning regions as the study of the territorial dimension of the State of Mato Grosso do Sul, Brazil



1: Bolsão; 2: Campo Grande; 3: Grande Dourados; 4: Leste; 5: Norte; 6: Pantanal; 7: Sudoeste; 8: Sul-fronteira; 9: Cone-Sul.
Fonte: COMINETTI (2015)

Fig 2. Triatominae frequency and influence of relative humidity in their populations in Mato Grosso do Sul, Brazil, 2006–2014



A. Frequency of triatomine for month / year. B. Influence of relative humidity in triatomine for month / year. Progression in natural logarithm.
Note: other species were not entered due to: less importance in the epidemiological chain, small number of captured specimens and / or absence of statistical correlation.

To study the fauna of triatomine vectors of *T. cruzi* in the state of MS during the period 2006-2014 in 50 municipalities of the state, analyzed the information databases Control of Chagas Disease (PCDCh) developed by Coordination Vector control (CCV). The identification of the insects was performed according to Carcavallo *et al.*.[13] The monthly distribution of species of triatomines, natural infection rate[14] and fauna analyzes were determined to define the abundance of classes, constancy, frequency and dominance.[15] Then, the same procedure was applied from the annual distribution.

The predominant species are those that achieved the highest faunal indices of abundance, frequency, constancy, and dominance.[16] We calculated the average of temperature (T), average of relative humidity (RH) and average of precipitation (P), in millimeters (mm), using data from the Embrapa West Station[17] database for months (January to December) and for years (2006 to 2014).

To verify the relationship between bugs collected with the Planning Regions, ecotope, positivity and frequency of species over months and over years, we used the nonparametric Friedman test. To check the influence of climatic factors on the frequency of insect vectors and their distribution along the Planning Regions was used multiple linear regression analysis. All statistical analyzes were performed using SPSS software, version 20, as described by Norusis, 1990.[18]

RESULTS

They were collected and identified 14,178 species of insects in 50 municipalities of MS, divided in eight PR (Fig. 1). In the Southern Cone region there was no collection of insects being discarded from the work. Species were identified *T. sordida*, *T. matogrossenssis*, *T. baratai*, *Panstrongylus diasi*, *P. megistus*, *P. geniculatus* and *Rhodnius neglectus*.

T. sordida was the most abundant (13,642 to 96.22%), followed by *R. neglectus* (217 – 1.53%), *P. geniculatus* (158 – 1.11%) and *T. matogrossensis* (99 – 0.70%). The other species gives a total of 62 specimens (0.44%) (Table 1).

Table 1. Triatomines captured per Planning Region of Mato Grosso do Sul, Brazil, 2006–2014

Species	Planning Region																Total	
	Bolsão		Campo Grande		Grande Dourados		Leste		Norte		Pantanal		Sudoeste		Sul-fronteira			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
T. sordida	6,268	45.95	2,957	21.68	211	1.55	31	0.23	157	1.15	3,730	27.34	239	1.75	49	0.35	**13,642**	**96.22**
T. matogrossenssis	-	-	1	1.01	-	-	-	-	34	34.34	63	63.64	1	1.01	-	-	**99**	**0.70**
T. baratai	-	-	-	-	-	-	-	-	-	-	4	12.12	29	87.88	-	-	**33**	**0.23**
P. diasi	7	70	-	-	2	20	1	10	-	-	-	-	-	-	-	-	**10**	**0.07**
P. megistus	9	47.37	-	-	8	42.11	-	-	-	-	1	5.26	1	5.26	-	-	**19**	**0.13**
P. geniculatus	1	0.63	4	2.53	149	94.30	-	-	-	-	4	2.53	-	-	-	-	**158**	**1.11**
R. neglectus	83	38.25	1	0.46	109	50.23	11	5.07	-	-	5	2.30	8	3.69	-	-	**217**	**1.53**
Total	**6,368**	**44.91**	**2,963**	**20.90**	**479**	**3.38**	**43**	**0.30**	**191**	**1.35**	**3,807**	**26.85**	**278**	**1.96**	**49**	**0.35**		**14,178**

Note: There were no collections in the Cone–Sul region.

When data were examined for each species, there was correlation between the number of insects caught and planning region (p = 0.025). *T. sordida* was the species that occurred more frequently in all regions. The other species presented below 2% (Table 1).

Of the total samples collected, 2,118 (14.94%) were in domiciliary and 12,060 (85.06%) in peridomicile environments (Table 2). There was a significant relationship between the frequency of catches of triatomine and the type of ecotope over the months (p = 0.002).

T. sordida was characterized as very abundant, while the other species were characterized as rare. In the evaluation of constancy (the number of times a particular species recovered in total collections performed), it was observed the species characterized as more constant was *T. sordida*. No species was regarded as ancillary. The species *T. matogrossensis, T. baratai, P. diasi, P. megistus, P. geniculatus and R. neglectus* were characterized as accidental (Table 3).

T. sordida was characterized as quite common species and dominant in MS (Table 3), while the others were characterized infrequent. It was verified correlation between the number of insects caught by species and frequency of positivity for *T. cruzi* (p = 0.008). The highest obtained ratio refers to *T. matogrossensis* (18.18%), followed by *R. neglectus* (0.46%) and *T. sordida* (0.27%) (Table 2).

The analysis of the data of the climatic elements (T, RH and P) revealed a correlation between the number of insects captured and the month of capture (p <0.01) for *T. sordida* and *T. matogrossensis* and correlation between the number of insects captured and the years of capture (p <0.03) for *P. megistus* and *T. matogrossensis*. Multiple linear regression analysis was performed to

verify the correlation between the climatic elements, catches of triatomine insects and their distribution in MS and showed only the influence of UR on the frequency of catches of triatomines in MS (Fig. 2).

DISCUSSION

The most common species in this study, as well as in other developed MS,[7-10] was *Triatoma sordida*. It is a native species of the Cerrado, predominant of the state biome and extends over an area of 2.04 million km^2 encompassing the state of Goiás, the Distrito Federal and part of Minas Gerais, Rondonia, Mato Grosso, Bahia, Tocantins, Maranhão, Piauí and Pará.[19-22] Triatomine exhibited low intradomiciliary frequency (12.97%), in agreement with other studies that have shown that *T. sordida* is predominantly peridomiciliary in MS.[7,8] The simple encounter of infected triatomine, even at low frequency, such as the case of *T. sordida* (0.24%), should be treated as a warning sign since the vector transmission is likely to occur.[23] However, food preference may be more related to opportunity than a tendency to a particular food source.[24] This feature could explain the low rate of infection in humans in community Furnas of Dionysius (0.6%).[25] However, another explanation for this value may be the improvements made over the years in the community's homes, as well as the preservation of the local fauna and flora, keeping wild hosts away from humans.

In a recent survey, *T. sordida* was found with the widest range of DTU (TcI, TcII and TcBat/TcVII).[10] This points to their ability to accommodate different types of *T. cruzi* and their distribution is wide and capturing almost constant throughout the year (Fig. 3), the species of triatomine becomes an important sentinel parasite movement, in addition to increasing its potential as *T. cruzi* vector.

T. sordida was the predominant species. Ecologically, the dominant term refers to the body which suffers environmental impact changing it so, may cause the disappearance (or appearance) of other taxa.[26] Thus, the predominant species can prevail over the other in the search for resources. In fact, after the elimination of domiciled populations of *T. infestans*, *T. sordida* was the most abundant in the state. After the increase of niches left vacant by *T. infestans*, secondary species assumed prominent position in frequency captures.[27-29] Among these, *T. sordida* have great capacity of occupancy of domestic ecotopes and peridomestic.

Its value as *T. cruzi* vector has been treated as of little relevance in the state. It is explained that due to its predominantly ornithophilic habits and their reduced rate of natural infection. However, Cominetti *et al*.[9] suggest that the rates may be underestimated. If the same data presented in Table 2 for the level of natural infection are treated as found by Cominetti *et al*.,[9] we would have *T. sordida* with 1,118 (8.2%) were positive, compared with 37 (0.27%), showing that it cannot be as

irrelevant their vectorial capacity when taking into account the frequency of individuals infected. Moreover, the fact should be considered to be secondary data and many samples collected were not analyzed for various reasons, for example, dead insects and/or without intestinal content as well as involuntary flaws in the data record. So many of these values may fall short of reality and be more expressive than presented in this paper as to their infection rates.

T. matogrossensis has invades the home environment and presents a tendency to domiciliation.[30,31] In a previous work,[14] this species was not found naturally infected, but its infection rate (18.18%) in this study draws attention and is cause for concern. Despite being a kind of rocky environment and wild breeding sites, 32.32% of these insects were captured in the home environment, which is of concern because it is a species with good capacity vector for *T. cruzi*.[32] *R. neglectus* is predominantly wild, occurring in palm trees[29,30] and with low rates of *T. cruzi* infection.[33]

Although *P. diasi*, *R. neglectus*, *P. geniculatus* and *T. baratai* not present major epidemiological importance, studies show that *R. neglectus* can form colonies domiciliary[33,34] exposing synanthropy highlighted in the Brazilian Midwest,[33] besides being the most frequent indoors,[7,35] which can lead to increased transmission capacity. *P. geniculatus* is also described with low potential for *T. cruzi* transmission due to its small capacity domiciliation[36] and typically inhabit burrows of armadillos.[37-39] Only 1.11% of the specimens collected were *P. geniculatus*. This insect is most often encountered in the home environment insect, suggesting slight domiciliation, as reported for peridomiciles in the Amazon region[40,41] and indoors in Colombia and Venezuela.[42-44] *T. baratai* is considered wild, though their meeting in domestic and peridomicile in MS.[45] Its frequency was almost similar for both ecotopes and no samples were positive for *T. cruzi*. Moreover, their biology and vector potential are little known. *P. diasi* was the most frequent domestic ecotone, despite its almost negligible number and be a wild species, it has been observed in predominantly ecotope intradomiciliary.[35] His presence in the state has been highlighted[7] and its distribution includes the states of Bahia, Goiás, Maranhão, Minas Gerais, Rio Grande do Norte, São Paulo[4,13,46] and Tocantins.[47] Cannot categorically state these species have preference for intradomicile, given that *T. sordida* was found mainly in intradomiciliary ecotope in study of triatomines in the Federal District, Brazil,[35] which can be explained by his attraction to the artificial light of villas, while in Mato Grosso do Sul is mainly peridomiciliary. Moreover, most often triatomine in the state remains peridomiciliary (85.06%).

T. sordida presents increase in their catches over the months of the year, starting in February and extending to the month of October, when it begins its decline (Fig. 2). This more intense

increase occurs during the driest months, characteristic of winter in Mato Grosso do Sul. Multiple regression analysis showed that the average monthly variable RH affects the population of this insect causing decrease its frequency with increasing RH (Fig. 3). Thus, the increase in population in the dry season confirms the influence of RH on the distribution of *T. sordida* with this preferring less humid and with marked annual periods of dry and rainy seasons, as pointed out by Forattini *et al*..[48] The same inverse influence of UR on increasing the triatomine population was observed for *T. matogrossensis* and *P. diasi*. Studies have shown that the triatomine are influenced by environmental factors such as temperature and humidity.[49-51] This work shows that this is true, aside from *T. sordida*, *P. megistus* and *T. matogrossensis*. The change in monthly RH has greater effect on the population of *T. matogrossensis* and *T. sordida*, while the variation in RH over the years affects the population of *T. matogrossensis* and *P. megistus*. Research indicates that T directly affects the outbreak of *R. robustus* eggs,[51] *R. prolixus*[52] and *T. dimidiate*,[53], but this correlation was not observed in this study. One possible explanation for this is that only secondary data from collections were used in this study, and it may not be possible to have this association made.

P. megistus suffered direct influence of the variation in average annual RH (Fig. 2). The highest occurrence of this species was in the Grande Dourados and Bolsão (Table 1). Both regions have dry weather ranging from four to five months of the year, serving as a natural barrier to insect dispersal. Aragão[54] concluded that the species showed preference for humid and arid climate zones more limited dispersion. Forattini *et al*.[48] also reached similar conclusions by studying *P. megistus*, pointing to environmental degradation and RH indices resembling of the distribution of the vector, with preference for wetter and warmer regions. Despite its encounter in less disturbed areas, its frequency was much lower, suggesting its domiciliation in times when the RH and environmental degradation are bigger.

As the human impact (mainly agropastoral events, such as deforestation) modifies the microclimate of a location and destroy the natural environment of the insect, its low frequency in household breeding sites can be explained by their isolation in remaining areas of native or secondary forest these regions (Grande Dourados and Bolsão) dominated by agriculture. As there is a decrease of preserved areas, making these less humid ecotopes, the triatomine can search more favorable microclimates to its development and adopt a synanthropic behavior.

Another factor that may explain the constant triatomine catches over the years is the use of insecticides (pyrethroids) and the conditions under which these are applied to the environment. Factors such as T, RH and P may result in pesticide effectiveness loss.[55] Obara *et al*.[56]

observed that the *T. sordida* evaluated in three states of the region Brazilian Midwest had low to pyrethroid resistance levels. However, populations of some municipalities in the state were more likely to progress to resistance. Incipient levels of resistance to deltamethrin (pyrethroid) were observed in five populations from the state of Minas Gerais.[57] Thus, in the state, vector control may be being affected mainly by RH, since most sample correlated with this environmental variable, and the spraying of insecticide for population control of insects in the colder and dry months would be most appropriate to increase its residual effect.

CONCLUSIONS

Although Mato Grosso do Sul is considered free of endemic vector transmission, persistent encounters with vectors naturally infected by *T. cruzi* are worthy of attention. The relationship between *Triatomine* entomofauna and climatic factors may assist with actions to combat the vector in the state because it is possible to establish a control pattern for the species based on the temporal and environmental dynamics of the venues of triatomine.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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