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TriatoIndex: a composite indicator for triatomine surveillance

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41 **Abstract**

42 **Background:** Entomological indicators are essential to guide surveillance and control
43 of vector-borne diseases. Indicators of Chagas disease vector surveillance such as
44 infestation, colonization, and density depend on wide surveys performed by trained
45 health agents that are difficult to maintain in endemic countries; now, surveillance is
46 mainly based on community participation. Thus, the development of an index that
47 aggregates variables of vectorial potential and occurrence and triatomine species may be
48 useful.

49 **Objective:** To develop an index for triatomine bug surveillance.

50 **Methods:** The index was developed based on entomological surveillance data from the
51 State of Bahia, Brazil, between 2006 and 2019. For each triatomine species, the
52 following data were analyzed: a) relative abundance; b) geographic distribution, c)
53 proportion of nymphs; d) *Trypanosoma cruzi* infection; e) human contact/ blood meal
54 sources. Values were assigned to each of these variables and the sum of the values
55 generated the index (TriatoIndex = T_i) that ranged from 0 to 15. Subsequently, the
56 municipalities' T_i value was calculated, based on the sum of the T_i values of the species
57 registered in each municipality. **RESULTS:** From the 26 species of triatomines in

Bahia, 20 (77%) presented $T_i < 10$. *Triatoma infestans* (15), *T. sordida* (14), *T. brasiliensis* (13), *T. pseudomaculata* (12), *T. melanica* (10), and *T. juazeirensis* (10) presented the highest values of T_i in the studied area. The T_i values in the municipalities in the central and northeastern regions of Bahia were high; these areas were considered hotspots for the occurrence of the main important vectors.

Conclusions: The index presented takes into account the geographical distribution and vectorial potential of triatomines within the region. TriatoIndex is a promising tool for targeted surveillance of *T. cruzi* vectors.

Keywords: Triatominae, transmission, *Trypanosoma cruzi*, Chagas disease, Vector surveillance.

Background

Health indicators are summary measures containing relevant information on the performance of a health system and/or aspects of the health-disease situation in a given location over a period [1, 2]. Indicators can vary from the simple direct counting of cases of diseases to the calculation of proportions, rates, or indices, such as life expectancy and socioeconomic deprivation. An index is composed of measures of different nature, which represents the sum of elements of different magnitudes and dimensions (qualitative or quantitative), resulting in a scale of scores that are used to assess a given health situation [3].

Entomological indicators are essential to guide surveillance and control of vector-borne diseases because they indicate biological aspects of vectors and environmental situations that may favor the transmission [4]. Indicators of Chagas disease vector surveillance were: (i) infestation: $100 \times \text{number of domiciles infested} / \text{number of domiciles examined}$; (ii) colonization: $100 \times \text{number of domiciles}$

with nymphs/number of domiciles infested; (iii) density: number of triatomines collected/number of domiciles examined; (iv) natural infection: $100 \times$ number of triatomines infected with *T. cruzi*/number of triatomines examined [5, 6]. Such indicators depend on wide surveys performed by trained health agents that are difficult to maintain in endemic countries. Moreover, they generate biased vector classifications based on data from surveillance carried out in past decades. For example, triatomine species have been classified as 'primary' (e.g. *Triatoma infestans*), 'secondary' (e.g. *T. sordida*), 'domestic' (e.g. *Rhodnius prolixus*), 'wild' (*R. robustus*), 'intrusive' (e.g. *T. mexicana*), and other variations [7, 8]; these classifications are based on a biased mix-up of biological and operational matters that makes them potentially ineffective [9].

Currently, most Chagas disease vector surveillance services in Latin America are based on community participation, generating information such as (i) list of species detected in the municipality, (ii) vector environment (intra/ peri domicile), (iii) frequency of notifications of the vector. In some cases, depending on the structure of the region's entomology laboratory, information about *T. cruzi* natural infection and blood meal sources of triatomines are obtained. Considering this surveillance scenario, we developed an index that aggregates occurrence variables (geographical distribution and relative abundance) and vectorial potential (proportion of nymphs, infection by *T. cruzi* and human contact/blood meal sources) of triatomine species to assist regional managers (states/provinces/departments) to prioritize municipalities for carrying out entomological surveillance activities. Thus, the objective of the study was to develop a composed indicator for triatomine surveillance in Bahia, a Brazilian state with the highest number of triatomine species and mortality rate of Chagas disease in Northeastern Brazil [10].

Methods

Triatomine data

Data were obtained with support from the State of Bahia Health Department (SESAB) between 2006 and 2019, from three different sources: (i) vector detection by the community, which takes the suspect insect to health agents in strategic locations in the municipalities, such as schools and health centers; (ii) vector detection by health agents after a survey in domiciles where triatomines were detected by inhabitants; (iii) routine vector sampling by health agents at domiciles in the municipality where *T. infestans*, *Panstrongylus megistus*, *T. brasiliensis*, and *T. pseudomaculata* species were already detected in past surveys, performed once a year or every two years, depending on transmission risk classification [10]. Triatomine detection and identification were carried out as established by the National Programme for the Control of Chagas disease and the manual of triatomines of Bahia [10]. Between 2006 and 2019, 66% of municipalities in Bahia (275/417) reported the occurrence of triatomines.

Data were also obtained through a bibliographic search between 2006 and 2019. The bibliographic searches were performed with the ReadCube® software in the databases of PubMed, Google scholar, and readcube and using the following indexes: “Triatominae”, “Triatoma”, “Panstrongylus”, “Rhodnius”, “Psammolestes” and “Bahia”. The databases used in the study were organized with information from entomological surveillance, obtained at the state level. Each row of the worksheet represents a triatomine registered with the following information: species, development stages, sex, municipality, year of collection, locality, geographic co-ordinates, environment of collection (intradomicile, peridomicile wild), natural infection and blood meal source.

TriatoIndex development

The TriatoIndex was obtained from five criteria: a) relative abundance, b) geographic distribution/occurrence in the municipalities, c) proportion of nymphs, d) natural infection by *T. cruzi*, and, e) human contact/triatomine blood meal sources. The relative abundance was calculated for each species [11, 12], according to the number of individuals of a species divided by the total number of individuals collected in Bahia between 2006 and 2019, following the formula below:

$$A_i = \frac{n_i}{N}$$

Where A_i represents the relative abundance of a given species in a given area; n_i : the total number of individuals of the species evaluated in the study area; N : the total of triatomines in the study area. The values obtained were stratified and values were assigned to each of these strata (Table 1).

The occurrence of triatomine species was calculated according to the number of municipalities with triatomine notification, divided by the total number of municipalities in Bahia that reported triatomines in the study period (between 2006 and 2019), following the formula below:

$$O_i = \frac{m_i}{M}$$

Where O_i represents the relative occurrence of a species in a given area; m_i : the number of municipalities registered for a species available in the study area; M : the total number of municipalities in the studied area.

Subsequently, triatomine occurrence was stratified into undetected, restricted, moderate, and wide; *T. infestans*, a non-native species, introduced into the study area and which has proven potential for house infestation in Bahia [10] received a maximum value in this criterion (Table 1).

The proportion of nymphs was calculated according to the number of nymphs detected in domiciles in the municipalities following the formula below:

$$C_i = \left(\frac{Nni}{Mi} \right)$$

Where C_i represents the proportion of nymphs detected of a species in a municipality; Nni : number of nymphs collected from a given species; Mi : total number of municipalities where the species was detected in the period. The obtained values from the species colonization level were stratified and values were assigned to each of the strata (Table 1).

The criteria for natural infection by *T. cruzi* and triatomine blood meal sources were based on molecular detection studies between 2013 and 2014 in 127 municipalities in Bahia, in which a random sample of 695 triatomines was selected to the detection of *T. cruzi* and determination of blood meals (dog, cat, man, bird) using previously standardized molecular procedures [13]. Natural infection by *T. cruzi* was stratified as undetected and detected (Table 1). Triatomine blood meals were used to indicate the contact of vectors with humans according to the following strata: confirmed contact (man), close contact (domestic animals), potential contact (wild animals). In the case of the absence of data for some species of native triatomine recorded in the period, we considered the value as 1, as if these triatomines essentially feed on wild animals (Table 1).

Each of the 26 triatomine species in the state of Bahia was classified according to the five evaluated criteria (Tables 1 and 2). Subsequently, the values of each criterion were added to generate the final index for each of triatomine species (Table 3). From this classification, the municipalities of Bahia were ranked based on the sum of the TriatoIndex values of the species that occur in their territorial space. For example, if a municipality presents a species with a wide distribution (3), high relative abundance (3),

nymphs in domiciles (3), infected triatomines (3) that feed on man (3), the indicator value would be 15. If this municipality presents yet another species with restricted abundance (1), restricted distribution (1), undetected nymphs (0), undetected infection (0) and feeding on wild animals (1) the value “3” would be added to “15” and the TriatoIndex of the municipality would be “18”. Thus, the greater the number of species, the greater the value of the municipality's TriatoIndex.

TriatoIndex mapping

We use the ArcGis® software version 10.5 to view maps and perform geospatial analyzes [14]. The spatial unit used for georeferencing was, the name of the municipality and the geocode of IBGE. The vector layers (.shp) used as the basis for the maps were obtained directly from IBGE [15]. In ArcGis® 10.5 we use the Hot Spot Analysis tool (Getis-Ord Gi Statistic) to demonstrate the areas with high and low TriatoIndex values, considering different intervals of confidence [16].

Results

Criteria and values used to develop the TriatoIndex and classification of triatomines in Bahia, are described in Tables 2 and 3 respectively. Between 2006 and 2019, the most abundant species was *T. sordida*; *T. pseudomaculata* was classified with moderate abundance and wide distribution and *T. brasiliensis* presented moderate abundance and distribution. The other species showed lower values of abundance and occurrence. Four out of the 26 triatomine species were not detected in the period; nymphs of nine species were detected, among them *T. brasiliensis* and *T. infestans* (Table 2). Regarding the infection criterion, ten were detected infected with *T. cruzi* (Table 3). The species with proven contact with humans were *T. brasiliensis*, *T. juazeirensis*, *T. pseudomaculata*, and *T. infestans* (Tables 2 and 3).

The index for the species of triatomines in Bahia (TriatoIndex = Ti) ranged from 0 to 15 (Table 3). From 26 species of triatomines in Bahia, 20 (77%) presented values of Ti <10. *T. infestans* (15), *T. sordida* (14), *T. brasiliensis* (13), *T. pseudomaculata* (12), *T. melanica* (10) and *T. juazeirensis* (10) presented the highest values of Ti in the studied area, followed by *T. tibiamaculata*, *T. lenti* and *P. megistus*, that presented intermediate values (8) (Table 2).

The municipalities in southeastern Bahia showed very low values for TriatoIndex while the value for some municipalities in the central and northeastern regions of Bahia ranged from 40 to 68; these municipalities were considered hotspots of occurrence of relevant vectors in the transmission of *T. cruzi* (Figure 1).

Discussion

We developed a new composite indicator for the surveillance of triatomines based on five criteria: (a) relative abundance, (b) geographical distribution/occurrence in the municipalities, (c) proportion of nymphs, (d) infection by *T. cruzi* and (e) human contact/blood meal sources, using the data available in the health surveillance system in the State of Bahia, Brazil. *T. infestans*, the main target of Chagas disease vector surveillance in Bahia, presented the highest value for TriatoIndex, followed by *T. sordida*, *T. brasiliensis*, and *T. pseudomaculata*. We suggest the prioritization of the municipalities that present high values of the TriatoIndex to develop surveillance and controlling activities.

Surveillance of Chagas disease vectors in Brazil has been carried out actively with health agent surveys in domiciles and mainly with community participation. Collected triatomines were sent to a referenced laboratory at the municipal or state level for identification and parasitological examination. In some situations (e.g. the

occurrence of *T. infestans* in the municipalities), active surveillance by health agents is carried out once or twice a year [10]. We suggest that the municipalities with the highest values of TriatoIndex be a priority for carrying out active surveillance activities to promote the sustainability of the interruption of transmission by *T. infestans* and the control of vector transmission by other species with relevant vector potential.

In the State of Bahia, 26 species of triatomines are known. These species have different potential to transmit *T. cruzi* to man and his domestic animals and this variation was considered in the development of TriatoIndex. This integrated approach allows classifications to be generated from the triatomine geographic distribution database obtained from entomological surveillance services in different regions. The frequency of the occurrence of infected vectors in different municipalities and their blood meal sources are also important indicators to understand the risk of transmission of *T. cruzi* and several studies carried out in partnership with the state or municipal health system demonstrate that these entomological indicators are relevant [17-22].

In the present study, we observed that the municipalities with the highest value for TriatoIndex were grouped along the hydrographic basin of the São Francisco River, in the central and northeastern region of Bahia, also coinciding with the transition area between the Cerrado and Caatinga biomes. A hypothesis to explain this result would be the fact that a greater diversity of species of triatomines is found in this range [21] and consequently, a higher probability of detecting synanthropic triatomines would be expected in the domiciles of municipalities in that region. Also, a greater diversity of species is generally observed in ecotone areas where biomes meet due to the environmental heterogeneity that favors speciation [23].

Another important piece of information that TriatoIndex adds for entomological surveillance is the potential contact of triatomines with humans [24]. The evaluation of

triatomine blood meals using molecular biology techniques to detect DNA from humans and domestic animals, added another relevant variable for entomological surveillance [25-29]. This information reveals how close the vector's association with humans is in that environment, and consequently a better assessment of the risk of *T. cruzi* transmission [13, 30-35].

The study had some limitations: Firstly, the proposal is based on the use of data from municipal and state surveillance systems that depend on the quality of information recorded. For example, it was not possible to obtain the proportion of nymphs for the entire period due to data recording problems; only 10% of all specimens captured from *T. brasiliensis* were analyzed according to this criterion (Table 3). This illustrates the importance of recording data from the place of capture, especially when referring to the peri and intra-household environment. We suggest that the registration of information in the municipalities follows the spreadsheet pattern used in our study. Secondly, the molecular surveillance data for *T. cruzi*-infected triatomines were not widely applied throughout the study and not even in all the municipalities in the studied area.

Originally, we believe that the prevalence of *T. cruzi* infection (continuous quantitative variable: 0-100%) would be the best way to quantify this information, however, given the limitations observed in the data, we adjusted the form of analysis to a qualitative variable (detected/undetected species infected with *T. cruzi*). Thus, it would be relevant to implement molecular biology techniques in referenced laboratories at the central level, for the molecular detection of *T. cruzi* and triatomine blood meals. An alternative would be the development of partnerships with research institutions to make these molecular analyzes feasible.

We also emphasize the importance of the correct taxonomic identification of triatomines collected for the success of this approach. For example, *T. brasiliensis* is

morphologically similar to *T. petrocchiae*, however, these species have different vector potential for transmission of *T. cruzi* in the northeast region of Brazil. Thus, the training of municipal and state teams for taxonomic determination of triatomines should be reinforced, as well as the use of teaching materials dedicated to this purpose [10].

Our perspective is that the surveillance services use the TriatoIndex in prioritizing the control actions for triatomines in Brazil. Currently, the indication of chemical control is based only on the occurrence of triatomines in the domicile environment, not taking into account other criteria now included in the TriatoIndex. Additionally, the use of TriatoIndex allows the generation of maps to indicate the areas that deserve more attention from surveillance. The entomological surveillance service can also use the mapping of the hotspots indicated by TriatoIndex to guide the distribution of insecticides or coverage of the areas for housing improvement. For example, with the use of TriatoIndex, we demonstrated that the species *T. infestans*, *T. brasiliensis*, *T. sordida*, and *T. pseudomaculata* were the ones that presented the greatest vectorial potential to transmit *T. cruzi* to man in Bahia. Colonies of these species within domiciles have been recorded in different regions of the state of Bahia, as well as the presence of some of them in outbreaks of acute Chagas disease [36-38].

The use of entomological indicators to classify triatomines using variables incorporated into an index for the surveillance and control of triatomines is an important initiative to monitor the potential for vector transmission in municipalities. The presented approach can become an alternative way to classify triatomines from the available information of the entomological surveillance service, in a value system, to direct vector control actions. The use of TriatoIndex is promising, as it takes into account several important pieces of information for the transmission of *T. cruzi* to man.

We hope that the use of TriatoIndex will be a relevant tool for making political decisions related to the control of Chagas disease vectors.

Additional files

No additional files

Abbreviations

PCR: Polymerase Chain Reaction; SESAB: Epidemiologic Surveillance team of Bahia State Health Service; DNA: Deoxyribonucleic acid; GPS: Global Position System; GIS: Geographic Information System; qPCR: quantitative Polymerase Chain Reaction; SINAN - Notification Disease Information System.

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Declarations

Ethics approval and consent to participate

The adopted procedures were in accordance with the ethical standards of the Research Ethics Committee of the Gonçalo Moniz Institute (FIOCRUZ, Bahia, Brazil) nº 2.552.284 and with the Helsinki Declaration of 1964, revised in 1975, 1983, 1989, 1996, and 2000. The consent form was waived because the analysis was based on a state surveillance service of Bahia – Brazil. However, no personal identification data were

used to ensure the complete anonymity of participants. The research did not cause any physical, psychic, moral, intellectual, social, cultural, or religious risk to the residents and animals of studied areas.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that there are no conflicts of interest associated with this study.

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Author's Contribution

GR-Jr, RG-G, and MGR conceived the study. MGR raised funds and administered the project. GR-Jr, RG-G, MGR, contributed to the design of trial methods. GR-Jr, CMMC, GMC, OMFS, CGSS, EOLF and RFS performed research. GR-Jr and MGR supervised students involved in field and laboratory research. GR-Jr, CMMC, GMC, OMFS, CGSS, RFS obtain the databases, GR-Jr curated the dataset and analyzed the data. GR-Jr, RG-G and MGR drafted the first version of the manuscript. All authors contributed to the interpretation of results, read and commented on manuscript drafts, and approved the final version.

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Figure legend

Fig 1. a: Classification of municipalities in Bahia weighted by TriatoIndex. The municipalities of Bahia were ranked based on the sum of the TriatoIndex values of the species that occur in their territorial space (0 to 68). b: Hot Spot Analysis (Getis-Ord Gi Statistic) to identify the regions of high and low values of TriatoIndex at the municipal level. Municipalities in southeastern Bahia showed very low values for TriatoIndex

479 (blue colors) while the values for municipalities in the central and northeastern regions
480 of Bahia were high (red colors). CI: Confidence intervals.

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Table 1. Criteria and values used to determine the TriatoIndex of triatomine species from Bahia between 2006 and 2019.

Criteria		Value
(A) Relative abundance		
Rare	No registration in the period;	0
Restricted	Between 0.1% and 1%	1
Moderated	Between 2% and 50%	2
Dominant	More than 50%	3
(B) Occurrence		
Non-detected	There were no species records in the study area between 2006 and 2019	0
Restricted	Between 1% and 25%	1
Moderated	Between 26% and 50%	2
Wide	More than 50%	3
Non-native	Species with proven potential for the home occurrence	4
(C) Proportion of nymphs		
Non-detected	There were no records of nymphs of the species at home in the municipalities between 2006 and 2019	0
Rare	Between 0.1 and 0.99 nymph/municipality	1
Moderated	Between 1 e 10 nymphs/municipality	2
Common	More than 10 nymphs/municipality	3
(D) <i>T. cruzi</i> detection		
Non-detected	No record of infection in Bahia between 2006 and 2019	0
Detected	With a record of infection in Bahia between 2006 and 2019	3
(E) Human contact/bloodmeal		
Potential contact	Sylvatic animals	1
Close contact	Domestic animals	2
Proven contact	Man	3

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Table 2. Classification of triatomines in Bahia according to the criteria used to develop the TriatoIndex.

N° / species	Criteria				
	Abundance	Occurrence	Nymphs	<i>T. cruzi</i>	Human contact/bloodmeal
<i>Cavernicola pilosa</i>	Rare	No occurrence	Non-detected	No data	No data
<i>Panstrongylus diasi</i>	Restricted	Restricted	Non-detected	No data	Potential / Wild Animals
<i>P. geniculatus</i>	Restricted	Restricted	Non-detected	No data	Potential / Wild Animals
<i>P. lenti</i>	Rare	No occurrence	Non-detected	No data	No data
<i>P. lutzi</i>	Restricted	Restricted	Non-detected	Non-detected	Close/Domestic animals
<i>P. megistus</i>	Moderated	Restricted	Common	Non-detected	Close/Domestic animals
<i>Parabelminus yurupucu</i>	Rare	No occurrence	Non-detected	No data	No data
<i>Psammolestes tertius</i>	Restricted	Restricted	Non-detected	Detected	Potential / Wild Animals
<i>Rhodnius domesticus</i>	Rare	No occurrence	Non-detected	No data	No data
<i>R. nasutus</i>	Restricted	Restricted	Rare	Non-detected	Potential / Wild Animals
<i>R. neglectus</i>	Restricted	Restricted	Non-detected	Non-detected	Potential / Wild Animals
<i>Triatoma bahiensis</i>	Restricted	No occurrence	Non-detected	No data	Potential / Wild Animals
<i>T. brasiliensis</i>	Moderated	Moderated	Common	Detected	Proven / Man and domestic animals
<i>T. costalimai</i>	Restricted	Restricted	Non-detected	Non-detected	Potential / Wild Animals
<i>T. infestans</i>	Restricted	Non native	Common	Detected	Proven / Man and domestic animals
<i>T. juazeirensis</i>	Restricted	Restricted	Common	Detected	Proven / Man and domestic animals
<i>T. lenti</i>	Restricted	Restricted	Non-detected	Detected	Potential / Wild Animals
<i>T. melanica</i>	Restricted	Restricted	Common	Detected	Close/Domestic animals
<i>T. melanocephala</i>	Restricted	Restricted	Non-detected	Non-detected	Close/Domestic animals
<i>T. petrocchiai</i>	Restricted	Restricted	Non-detected	No data	Close/Domestic animals
<i>T. pseudomaculata</i>	Moderated	Wide	Moderated	Detected	Proven / Man and domestic animals
<i>T. rubrofasciata</i>	Restricted	Restricted	Non-detected	No data	Close/Domestic animals
<i>T. sherlocki</i>	Restricted	Restricted	Non-detected	Detected	No data
<i>T. sordida</i>	Dominant	Wide	Common	Detected	Close/Domestic animals
<i>T. tibiamaculata</i>	Restricted	Restricted	Rare	Detected	Close/Domestic animals
<i>T. vitticeps</i>	Restricted	Restricted	Non-detected	No data	Potential / Wild Animals

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487 **Table 3.** Data on triatomine species in Bahia used for the development of TriatoIndex.

Species	A. Abundance	B. Occurrence	C. Proportion of Nymphs ^b		D. <i>T. cruzi</i> infection		E. Triatomine Bloodmeal				Criteria					TriatoIndex
	N ^o Triatomines (2006-2019)	N ^o Municipalities	Adults	Nymphs	Examined	Infected	Man	Dog	Avian	Cat	A	B	C	D	E	Value
<i>Cavernicola pilosa</i> ^a	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-	0
<i>Panstrongylus diasi</i>	6	1	6	0	0	-	-	-	-	-	1	1	0	-	1	3
<i>P. geniculatus</i>	155	52	82	0	0	-	-	-	-	-	1	1	0	-	1	3
<i>P. lenti</i> ^a	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-	0
<i>P. lutzii</i>	370	66	355	0	3	0	N	Y	Y	N	1	1	0	0	2	4
<i>P. megistus</i>	1842	41	1335	36	6	0	N	Y	Y	N	2	1	3	0	2	8
<i>Parabelminius yurupucu</i> ^a	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-	0
<i>Psammolestes tertius</i>	39	26	22	0	8	2 ^c	N	N	Y	N	1	1	0	0	1	3
<i>Rhodnius domesticus</i> ^a	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-	0
<i>R. nasutus</i>	16	3	14	2	0	-	-	-	-	-	1	1	1	0	1	4
<i>R. neglectus</i>	100	23	100	0	0	-	-	-	-	-	1	1	0	0	1	3
<i>Triatoma bahiensis</i>	2	1	2	-	-	-	-	-	-	-	1	1	1	-	-	3
<i>T. brasiliensis</i>	11105	92	1108	72	51	9	Y	Y	Y	N	2	2	3	3	3	13
<i>T. costalimai</i>	2	1	2	0	0	0	-	-	-	-	1	1	1	0	1	4
<i>T. infestans</i>	763	8	363	294	80	0 ^d	Y	Y	Y	N	2	4	3	3	3	15
<i>T. juazeirensis</i>	228	8	105	123	89	6	Y	N	Y	N	1	1	3	3	2	10
<i>T. lenti</i>	239	2	230	9	0	0 ^e	-	-	-	-	1	1	2	3	1	8
<i>T. melanica</i>	19	1	7	12	7	2	N	N	Y	N	1	1	3	3	2	10
<i>T. melanocephala</i>	233	51	233	0	1	0 ^e	N	N	Y	N	1	1	1	0	1	4
<i>T. petrocchiae</i>	1	1	1	0	1	0	-	-	-	-	1	1	0	0	1	3
<i>T. pseudomaculata</i>	16717	174	415	282	83	10	Y	Y	Y	N	2	3	2	3	2	12
<i>T. rubrofasciata</i>	6	2	6	0	0	0	-	-	-	-	1	1	0	0	2	4
<i>T. sherlocki</i>	323	1	-	-	-	- ^f	N	N	Y	N	1	1	-	3	1	6
<i>T. sordida</i>	146901	159	1822	1493	290	11	N	Y	Y	N	3	3	3	3	2	14
<i>T. tibiamaculata</i>	1273	18	955	1	128	2	N	N	Y	N	1	1	1	3	2	8
<i>T. vitticeps</i>	38	4	24	2	0	0	-	-	-	-	1	1	0	0	1	3

488 ^aNot recorded in the period; the values were obtained from data in the literature. ^b The divergence between the total number of individuals (abundance) and the number of
489 registered adults and nymphs is due to problems in registering the data of the development stages by the service. ^c In a bird's nest on a tree. It was not considered for the
490 calculation of the TriatoIndex. ^d *T. cruzi* was detected in *T. infestans* in Bahia in 2011 [40]. ^e *T. cruzi* was detected in *T. lenti* and *T. melanocephala* [39]. ^f *T. cruzi* was
491 detected in *T. sherlocki* [41]. Abbreviations: Y=yes; N=no. "-" = no data.

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Figures

Figure 1

a: Classification of municipalities in Bahia weighted by TriatolIndex. The municipalities of Bahia were ranked based on the sum of the TriatolIndex values of the species that occur in their territorial space (0 to 68). b: Hot Spot Analysis (Getis-Ord Gi Statistic) to identify the regions of high and low values of TriatolIndex at the municipal level. Municipalities in southeastern Bahia showed very low values for TriatolIndex (blue colors) while the values for municipalities in the central and northeastern regions of Bahia were high (red colors). CI: Confidence intervals.