Geographical distribution of the vector species Trypanosoma cruzi for Chagas disease in Ecuador: A narrative review

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ABSTRACT
Chagas disease is a complex clinical entity caused by a protozoan parasite, Trypanosoma cruzi, transmitted by the bite of infected triatomines. The objective of this study was to establish the distribution of vector species of *T. cruzi* according to all the geopolitical regions of Ecuador. This narrative review was conducted from December 2022 to July 2023 by searching the following databases: PubMed, Elsevier, Google Scholar, Scielo, Latindex, and Dialnet. Also, websites of international and national health organizations: WHO and PAHO, Epidemiological Gazette of Ecuador, SIVE-ALERTA, Ministry of Public Health of Ecuador, and national repositories of theses generated by Ecuadorian universities. In the Coastal region, *T. dimidiata* was found as the predominant vector (83%), followed by *Panstrongylus howardi, P. chinai and P. geniculatus,* all with the same percentage of circulation (33%) and *Rhodnius ecuadoriensis* (17%). In the Andean region, the most important species was *R. ecuadoriensis* in the Province of Loja (59%). The province of Orellana (Amazon region) had the highest value of R=0.471 and greater species diversity *(P. geniculatus, P. lignarius, R. robustus, R. pictipes, R. pallences, R. barreti, E. cuspidatus, E. mucronatu)*. Currently, the circulation of 4 genera and 17 species of triatomines is reported in Ecuador. It is necessary to expand the collection sites in different regions to update the geographical distribution of triatomine species circulating in Ecuadorian territory.

INTRODUCTION
According to the Vectorial Gazette of the 52nd Epidemiological Week of the year 2022, issued by the Ministry of Public Health of Ecuador, 99 cases of Chagas Disease (CHD) were reported during that year. The highest number of cases were reported in the province of Guayas[1].

Current estimates indicate that there are approximately 6 to 8 million people infected, with an additional 65 to 100 million individuals having risk factors, with almost 12000 deaths annually worldwide[2]. Over 170 species of blood-feeding triatomine insects belonging to the family Reduvidae, subfamily Triatominae, have been identified as vectors of the disease. The Triatominae subfamily groups a variety of species as a result of adaptation to diverse ecosystems, both natural and artificial.

Among the countries in the region considered endemic for CHD are those primarily located in the southern part of Latin America, such as Argentina, Brazil, Chile, Paraguay, and Uruguay. All those countries have experienced a considerable reduction in the circulation of the vector. In contrast, Central America faces a higher infection rate, with approximately 11% of the population affected[3].

In epidemiological terms, 17 species from the four most significant genus of vectors transmitting CHD in Ecuador have been documented. It is important to note that depending on the country, these vectors may be referred to by different names. In the case of Ecuador, they are commonly known as 'chinches', 'vinchucas', 'chinchorros', or 'guaros'[4].

In Ecuador, 19 of the 24 provinces of the country report cases of CHD, in which the prevalence from highest to lowest include Manabí, El Oro, Los Ríos, Guayas, Esmeraldas and Santa Elena (Coastal region); Pichincha, Loja, Cañar, Azuay, Chimborazo, Cotopaxi and Imbabura (Sierra region); Orellana, Napo, Morona Santiago, Sucumbíos and Pastaza (Amazon region). No cases have been reported in the Insular region, which is the fourth geopolitical region of the country. When evaluating the prevalence of infection, the Sierra region shows a prevalence of 0.65% of the disease, while the Coastal region has a prevalence of 1.99%, and the Amazon region has a prevalence of 1.75%[4]. Historically, provinces of El Oro, Manabí, Santa Elena, Guayas and Loja, have a higher rate of *Trypanosoma cruzi* infection[4].

American trypanosomiasis or Chagas Disease is a parasitic disease transmitted by a hemoflagellate protozoan called *T. cruzi*[2]. Transmission through an insect bite is the most frequent way of acquiring the disease through insect feces and subsequent inoculation by scratching people who experience intense itching. There are also other less frequent routes of infection, such as transmission through blood transfusions, vertical transmission, organ transplantation, and oral transmission[5].

In humans, it manifests itself in three phases: acute, intermediate, and chronic. The first is characterized by non-specific symptoms and the appearance of signs depending on the route of entry, such as the Romaña sign or inoculation chagoma; the second phase is clinically silent, and in the third phase, organic affectations appear, such as chagasic heart disease, or megasyndromes, such as megaesophagus or megacolon[6].

Several risk factors related to transmission are linked to the conditions and construction materials of homes in rural or remote areas of the city. These factors include wooden walls, adobe, straw, palm leaves, the accumulation of firewood, and the presence of breeding sites, animal nests, or agglomeration of sparrows, squirrels, dogs, and pigeons around houses. These conditions create an environment that closely resembles the natural habitat of triatomines[5].

In the last 20 years, the region of the Americas has been the first continent to initiate efforts to eliminate communicable diseases, especially CHD[7]. Recognizing that transmitting species in regions that have historically shown high rates of vector infestation is crucial. This recognition should involve not only researchers and health teams but also communities facing daily problems. Therefore, the significance of this review lies in identifying vectors impacting Ecuador's regions with neglected tropical diseases such as CHD. Notably, in Ecuador, from 2013 to 2019, 439 reported cases highlighted the chronic presentation of the disease (75.4%)[8]. Social and economic situations, especially in rural sectors, and the neglect of health determinants such as lack of education, low income, and poor nutritional and sanitary conditions, contribute to delays in diagnosis and obtaining timely treatment, turning CHD into a serious public health problem.

The main aim of this research was to establish the distribution of *T. cruzi* vector species according to the geopolitical regions of Ecuador over the last ten years, considering places and collection sites. The goal was to determine the ratio of identified species to the total described for the country and assess the prevalence of species across regions and provinces. This information is crucial for understanding the transmission and natural history of CHD, an endemic pathology in the Ecuadorian territory.

This study is a narrative review. The inclusion criteria were primary studies published in indexed journals during the period of 8 years (2013–2022), belonging to qualitative and quantitative studies in English and Spanish. Exclusion criteria were considered studies carried out before 2013 or after 2022 and in the Portuguese language, literature reviews, absence of the methodological design of the research, chapters, letters, editorials, experience reports, and case studies. The academic databases searched were PubMed, Elsevier, Google Scholar, Scielo, Latindex 2.0, and Dialnet. The websites were also searched of international and national health organizations: WHO and PAHO, Epidemiological Gazette of Ecuador, SIVE-ALERTA, Ministry of Public Health of Ecuador, and national repositories of theses generated by Ecuadorian universities.

In each database, the following search terms were used as filters for article retrieval within the DeCS/MeSH descriptors: 'Triatominos' AND 'Distribución geográfica', 'Chagas AND Ecuador', 'Enfermedad de Chagas OR regiones del Ecuador', 'Vector species NOT Trypanosoma cruzi', 'Ecuador NOT Latin America', and 'vinchucas NOT chinchorros'. These terms were combined using the operators AND, OR, and NOT.

Subsequently, the collected data were organized and distributed using Microsoft Excel 2016. The information was categorized into journal details, article title, author, year, research objectives, research type, methodology, description, sample size, instruments used, results, and findings obtained.

Following the organization and tabulation of information, the documents were grouped into four thematic nuclei: geographical distribution of *T. cruzi* at both regional and national levels, vector presence based on geopolitical regions in the country, prevalence of CHD by provinces and regions, and the relationship (R) indicating the strength and direction of the relationship between the probability of CHD infection and infestation by the parasite's vectors (Figure 1). The functional R was expressed by the formula $f = X/Y$, where X represents the independent variable (number of identified species), and Y represents the dependent variable (17), representing the total number of species circulating in the national territory to date.

A total of 82 publications were identified with the search terms, of which 36 articles were used in the present investigation, and of those, eight were finally chosen using the selection criteria. (Figure 2)

GEOGRAPHICAL DISTRIBUTION OF VECTOR SPECIES

Coastal region

The vectors found in the Coastal region are as follows: In

Figure 1. Search strategy and data collection diagram

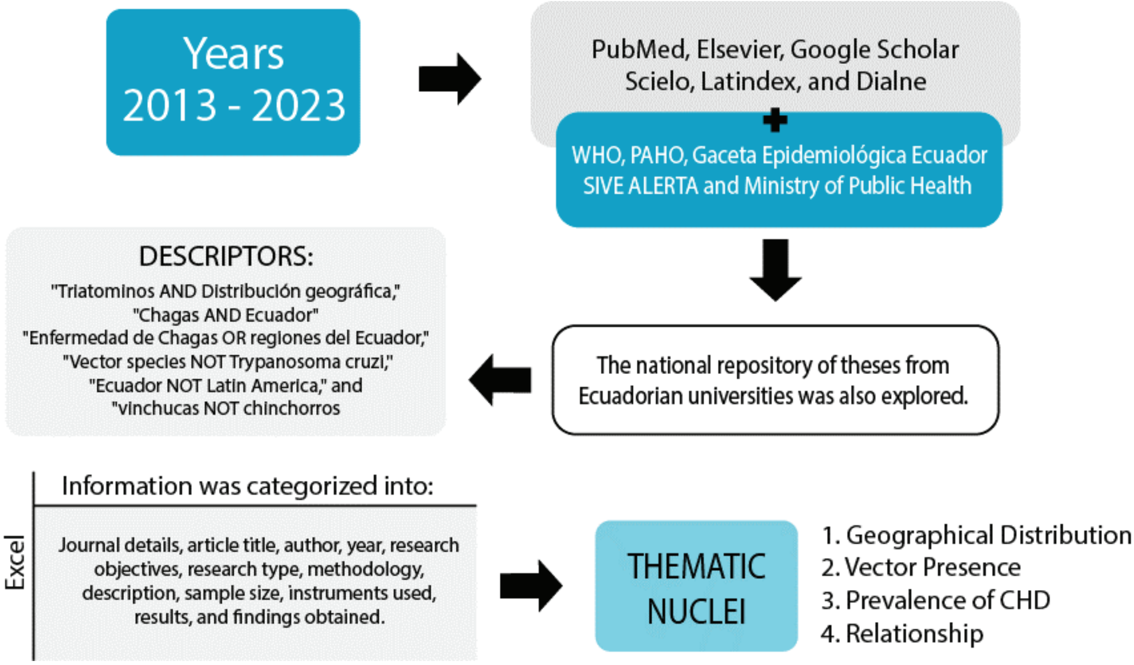
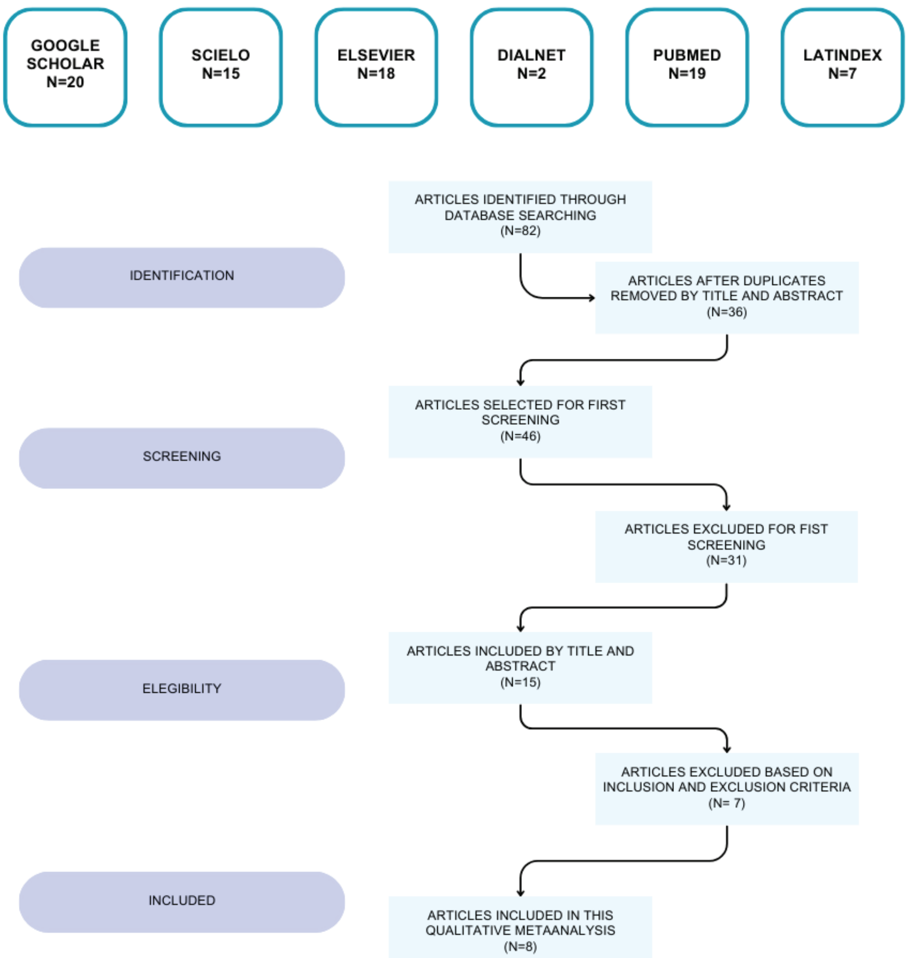


Figure 2. PRISMA flowchart for systematic literature review and inclusion of articles



the Province of Manabi, *Triatoma dimidiata* stands out in first place (83%), followed by *Panstrongylus howardi*, *P. chinai* and *P. geniculatus*, all with the same percentage of circulation (33%), respectively, and *Rhodnius ecuadoriensis* (17%). In El Oro Province, 23.53% of vector presence is reported, where prevalent species of triatomines represent about 17% and include: *P. howardi, P. chinai and P. rufotuberculatus*. The provinces of Los Ríos and Esmeraldas show an 11.76% infestation. In the first province, vectors such as *T. dimidiata* and *T. dispar* have been found (33%), while in the second, *T. dispar* and *P. geniculatus* stand out in communities such as Pambilar and Balsareño[9,10]. Finally, in the provinces of Guayas and Santa Elena, there is 5.88% of circulation of vectors associated with the transmission of CHD, in which only the presence of *T. dimidiata* as the main vector has been reported[9,10] (Supplementary file Figure S1).

Andean region

In the Andean region, the most relevant species is *R. ecuadoriensis*. In the Province of Loja, it was located (59%) in 63 infested communities out of about 92 examined; in addition, most of them are associated with poor sanitary conditions[11]. In this regard, it is the province with the highest number of cases reported (23.53%) of the total number of species described in Ecuador[11]. The vectors found in ascending order of prevalence are: *T. carrioni (*63%), *R. ecuadoriensis* (25%), *P. howardi* and *P. chinai* (13%)[12,13].

In Pichincha, as in Loja, 23.53% of the vector species of CHD are located, with the following species: *R. ecuadoriensis, T. carrioni, T. venosa and T. dispar* (50%), all with the same level of circulation. There are biogeographical analyses that consider that these species are potentially present in the cantons of Pedro Vicente Maldonado and Milpe at 90 km, belonging to the canton of San Miguel de los Bancos, limiting

Table 1. Selection of the final studies for analysis in the narrative review, 2022

Authors	Year/Country	Study type	Evidence level	Main conclusions
Arteaga-Chávez and Hurtado[4]	2019/Ecuador	Community-based, descriptive, longitudinal, random assignment	II-2	The predominant vector found corresponded to *T. dimidiata* in peridomestic and domestic environments, without natural infection with *T. cruzi*. In the intervention areas of Arrastradero and El Limón, the prevalence was: 8.59% and 11.23%.
Vaca-Moyano et al.[14]	2017/ Colombia	Field study, descriptive, longitudinal	IV	*T. dispar* is identified in the western foothills of the Andes Mountains (300–1800 m above sea level) and extends to the lowlands of the North Coast (0–300 m above sea level).
Grijalva et al.[11]	2015/USA	Entomological, descriptive, transversal study	III	Four species of triatomines (*R. ecuadoriensis*, *T. carrioni*, *P. chinai* and *P. rufotuberculatus*) infested dwellings in 68% of the 92 rural communities examined.
Grijalva et al.[10]	2014/Ecuador	Field study	II-III	99% of the specimens collected were *R. ecuadoriensis*. The remaining specimens corresponded to: *P. howardi*, *P. geniculatus* and *P. rufotuberculatus.*
Guevara et al.[9]	2014/Brazil	Letter to editor, descriptive, transversal study	IV	96% of triatomines collected in the northwest province of Esmeraldas corresponded to *T. dispar.*
Abad-Franch et al.[12]	2013/Brazil	Systematic, descriptive, longitudinal review	I	*R. barretti* is emerging as an endemic species of the humid Napo forests in western Amazonia.
Soto-Vivas et al.[13]	2018/Ecuador	Entomological, descriptive, transversal study	III	New species are reported in Ecuador in the updated distribution: *E. mucronatus*: Esmeraldas, Loja, Napo, Orellana, Sucumbíos; *P. geniculatus*: Esmeraldas, Imbabura, Manabí, Napo, Orellana, Pastaza, Pichincha and Sucumbíos; *R. pictipes*: Azuay, Morona Santiago, Napo, Orellana, Sucumbíos; *R. robustus*: Napo, Morona Santiago, Sucumbíos, Orellana.
Robles et al.[15]	2019/Ecuador	Community intervention, descriptive, cross-sectional study	III	No significant differences were found between infestations inside and outside the home for the species *P. diasi*, *T. costalimai* and *T. williami*. In Guayaquil - Ecuador the common triatomid is *T. dimidiata*.

their distribution to the northern and central zone of the western foothills of the Andes Mountains[4,13]. In Imbabura, there is about 17.65% presence of these species in which, according to studies, there are also: *T. venosa, T. dispar* and *P. geniculatus.* In Cotopaxi and Chimborazo, it has been reported (11.76%) of location of: *T. venosa and T. dispar*. Finally, in Azuay, Cañar and Bolivar, these vectors have been found (5.88%), where also, in these last three provinces, the existence of *T. carrioni* has been documented as a species endemic to the provinces of the Sierra[12]. In the case of *T. venosa*, although it is found in the provinces described above, this species has no potential risk of transmission to humans[14] (Supplementary file Figure S2).

Amazon region

In eastern Ecuador, the provinces with the highest number of *T. cruzi* infestations are Orellana and Napo. Both represent 47.06% of the presence of triatomines out of the total number of species described for Ecuador[15]. The vectors found in these provinces, in order of importance, are: *Rhodnius robustus* (100%), followed by *Eratyrus cuspidatus*, *E. mucronatus*, *P. lignarius*, *P. geniculatus* and *R. pictipes,* all with equal prevalence of infection (80%)[12]. Similarly, *R. pallences* and *R. barreti* (40%) were found reciprocally. The latter species is considered to be entirely wild and has been reported mainly in the provinces of Orellana, Napo and Sucumbíos[15]. *R. barreti* has been indicated as a new candidate vector of CHD, due to its biological and behavioral characteristics[12].

On the other hand, Sucumbíos is the third province where triatomines have been found in the Amazon (41.18%), and their reported vectors are the same as those recorded in Napo and Orellana, with the exception of *R. pallences*, a species that has not been documented[13].

Lastly, the provinces of Morona Santiago and Pastaza have prevalences of 23.53% and 11.65%, respectively[13,15] (Supplementary file Figure S3).

Table 2, shows the ratio of triatomine species in the

Table 2. List of triatomine species according to collection sites, Coastal region, Ecuador, 2022

Provinces	R[a]	P[b] (%)	Species	References
Manabí	5/17	29.41	*T. dimidiata, P. howardi, P. chinai, P. geniculatus, R. ecuadoriensis*	Grijalva et al.[10] Guevara et al.[9]
El Oro	4/17	23.53	*T. dimidiata, P. howardi, P. chinai, P. rufotuberculatus*	
Emeralds	2/17	11.76	*T. dispar, P. geniculatus*	
Los Rios	2/17	11.76	*T. dimidiata, T. dispar*	
Guayas	1/17	6	*T. dimidiata*	
St. Helena	1/17	6	*T. dimidiata*	

a Relationship between the number of vectors found in each province with respect to the total number of species found in Ecuador. b The percentage of vector species found is obtained between the number of species present in each province divided by the total number of species in Ecuador.

Table 3. List of triatomine species according to collection sites, Sierra region, Ecuador, 2022

Provinces	R[a]	P[b] (%)	Species	References
Pichincha	4/17	24	*T. dispar, T. carrioni, T. venosa, R. ecuadoriensis*	Arteaga-Chavez et al.[4] Grijalva et al.[10] Abad-Franch et al.[12] Soto-Vivas et al.[13]
Loja	4/17	24	*R. ecuadoriensis, T. carrioni, P. chinai, P. howardi*	Grijalva et al.[10] Abad-Franch et al.[12] Soto-Vivas et al.[13]
Imbabura	3/17	18	*P. geniculatus, T. dispar, T. venosa*	Abad-Franch et al.[12]
Chimborazo	2/17	12	*T. dispar, T. venosa*	Vaca-Moyano et al.[14] Abad-Franch et al.[12]
Cotopaxi	2/17	12	*T. carrioni*	Abad-Franch et al.[12]
Bolivar	1/17	6	*T. carrioni*	
Cañar	1/17	6	*T. carrioni*	
Azuay	1/17	6	*T. carrioni*	

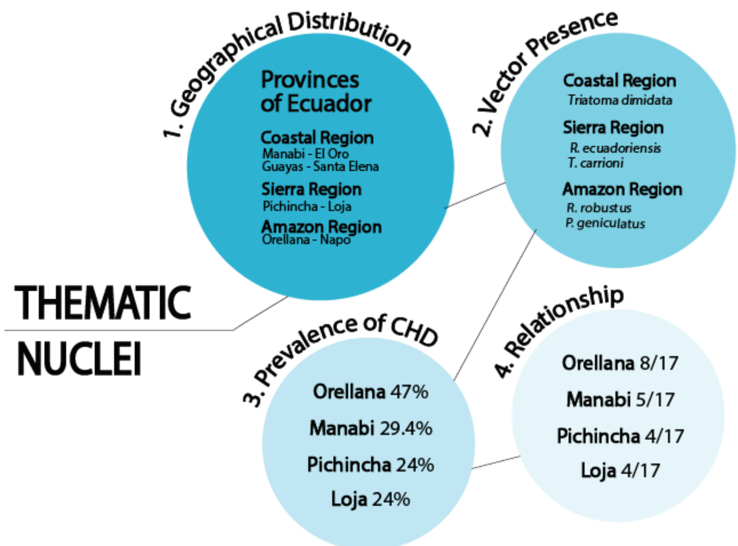
a Relationship between the number of vectors found in each province with respect to the total number of species found in Ecuador. b The percentage of vector species found is obtained between the number of species present in each province divided by the total number of species in Ecuador.

Table 4. List of triatomine species according to collection sites, Amazon region, Ecuador, 2022

Provinces	R[a]	P[b] (%)	Species	References
Orellana	8/17	47	*P. geniculatus, P. lignarius, R. robustus, R. pictipes, R. pallences, R. barreti, E. cuspidatus, E. mucronatus*	Abad-Franch et al.[12] Soto-Vivas et al.[13] Robles et al.[15]
Sucumbíos	7/17	41.1	*P. geniculatus, P. lignarius, R. robustus, R. pictipes, R. barreti, E. cuspidatus, E.mucronatus*	Soto-Vivas et al.[13] Robles et al.[15]
Napo	7/17	41.1	*R. robustus, R. pictipes, R. pallences, P. geniculatus, P. lignarius, E. cuspidatus, E. mucronatus*	Soto-Vivas et al.[13] Robles et al.[15] Abad-Franch et al.[12]
Morona Santiago	4/17	24	*R. robustus, R. pictipes, E. cuspidatus, E. mucronatus*	Soto-Vivas et al.[13] Robles et al.[15]
Pastaza	3/17	18	*P. geniculatus, P. lignarius, R. robustus*	

a Relationship between the number of vectors found in each province with respect to the total number of species found in Ecuador. b The percentage of vector species found is obtained between the number of species present in each province divided by the total number of species in Ecuador.

Figure 3. Relevant results, thematic nuclei, Chagas disease, Ecuador



Coastal region. The province of Manabi was identified as having the highest ratio, with R=5/17 (R=0.294), with five species circulating primarily: *T. dimidiata, P. howardi, P. chinai, P. geniculatus*, and *R. ecuadoriensis* in which case, prevalences of 29.41% were obtained. This was followed by the province of El Oro, 4/17 (R=0.235) in which the species *T. dimidiata, P. howardi, P. chinai, P. rufotuberculatus* were found to have a prevalence of 23.53%. Finally, the provinces of Esmeraldas and Los Ríos, with R= 2/17 (R=0.117), in which the species *T. dispar, P. geniculatus, and T. dimidiata* predominate, show the same prevalence records (11.76%).

Table 3 shows the list of species according to the places where they were collected in the Sierra region. The following was observed in order of frequency: the province of Pichincha and Loja was predominant, R= 4/17 (R=0.235) with the following species: *T. dispar, T. carrioni, T. venosa, R. ecuadoriensis, P. chinai and P. howardi* with a prevalence of 24%. This was followed by Imbabura, R=3/17 (R=0.176) with the following species*: P. geniculatus, T. dispar and T. venosa.* The prevalence obtained in this case was 18%. Finally, Chimborazo and Cotopaxi R=2/17 (R=0.118) in which *T. carrioni* stood out, with prevalences of (12%).

The species of triatomines present in the Amazon region by collection sites are shown in Table 4. In the first place, the province of Orellana stood out, R= 8/17 (R=0.471) with the following species: *P. geniculatus, P. lignarius, R. robustus, R. pictipes, R. pallences, R. barreti, E. cuspidatus, E. mucronatus*, whose prevalence figures obtained were 47%. In second place, Sucumbíos and Napo predominate, where R=7/17 (R=0.412) respectively, with the following species reported: *P. geniculatus, P. lignarius, R. robustus, R. pictipes, R. barreti, E. cuspidatus, E. mucronatus and R. pallences*, obtaining the same percentage of prevalence, 41.7%. Finally, in the province of Morona Santiago, R=4/17 (R=0.235), the species identified were *R. robustus, R. pictipes, E. cuspidatus and E. mucronatus*, registering 24% prevalence.

Regarding the thematic cores considered in the study, information related to the habitat of the vectors was obtained with respect to the geographical location, with the triatomine species considered as a transmitter of CHD frequently found. The relationship and prevalence of infection according to geopolitical regions of the country are shown in Figure 3.

DISCUSSION

The present study indicates that at the present time, there is still a high rate of vectorial circulation, of the parasite that causes CHD in Ecuador[16]. This pathology is considered as re-emerging, probably due to the lack of epidemiological surveillance, social and demographic factors, such as the displacement of infected people to non-endemic areas, blood transfusions and organ donation in countries that do not perform screening tests, difficulties in timely diagnosis and proper therapeutic management of infected patients[17,18]. All this leads to the fact that homes are still infested with insects and, consequently, the increase in prevalence and contagion rates through the different forms of transmission of CHD in endemic countries, becoming a serious public health problem, underestimated, not solved due to multiple causes, affecting approximately 1.2 million people[19].

The primary vector for Ecuador, continues to be *T. dimidiata*[1]. Results from previous research in various collection sites in the country corresponding to the Coastal region coincide with various authors[20]. This area exhibits favorable environmental conditions that have allowed it to colonize even densely populated areas in marginal urban ecotopes, with similar patterns observed in Argentina, Bolivia, Colombia and Mexico[20]. Likewise, Touriz et al.[21] also reports the high presence of different vector species, mainly in the province of Guayas, but also differs in the number of species reported, in this case only *T. dimidiata*[22]. Similarly, it is important to mention that the case of *P. howardi* has been collected mostly in Manabí, which is also related to that reported by Villacís et al.[23] by pointing out the presence in great proportion (92.7%) of *R. ecuadoriensis* in the province of Manabí, being the main species also reported in other provinces such as Santo Domingo and Guayas. In the case of countries such as Argentina or Brazil, the most prevalent vector was *T. infestans*, which originated in Bolivia, and was distributed throughout the South American continent, until it was eradicated in countries such as Uruguay, Chile and Brazil more recently[5].

In Mexico, according to Salazar et al.[24] the predominant intradomiciliary vector species is *T. barberi,* which has been identified in: Colima, Guanajuato, Guerrero, Hidalgo, Jalisco, Michoacán, Michoacán, Morelos, Oaxaca, Puebla, Querétaro, Tlaxcala, and Veracruz. It caused 371 deaths due to CHD, most of them in the states of Oaxaca (54.7%) and Guerrero (15.4%). Likewise, in countries such as Guyana, the Antilles, and Suriname, vectors different from those found in Ecuador emerged, as in the case of *T. maculata* [5].

Regarding the background of similar studies, the research conducted by Ocana-Mayorga et al.[25] focused on the collection of vinchucas in Manabí and Loja. Subsequent analysis, specifically targeted specimens showing traces of human DNA, aiming to comprehend the transmission cycle depending on the vector's origin, whether domiciliary, peridomiciliary or in the forest. The identified species included *P. chinai*, *P. howardi*, *P. rufotuberculatus*, *R. ecuadoriensis*, and *T. carrioni*. Out of the 170 specimens collected, approximately 112 tested positive for *T. cruzi* infection. On the other hand, in an article by Grijalva et al.[26] about the distribution of triatomine species in both intra- and peri-domiciliary environments in the Coastal region of Ecuador, determined through an entomological survey, species such *as R. ecuadoriensis, P. rufotuberculatus*, and *P. howardi*, were identified as responsible for infestations in homes. Specifically, they found infestations in 47 out of 78 communities in Manabí. Similarly, in research conducted by Quinde-Calderón et al.[27], the results of the analysis of epidemiological surveillance led by the Ministry of Public Health over 10 years (2004–2014) in 11 provinces, were reported. Survey results indicated infestation mainly in coastal provinces, such as El Oro and Guayas, in the highlands, such as Loja and Pichincha, and in the Amazon, such as Orellana and Sucumbíos. The study also noted that *T. dimidiata* and *R. ecuadoriensis* were among the frequently found vector species.

On the other hand, *R. ecuadoriensis, T. dispar*, and *T. carrioni* have consistently been found in the Sierra region across various sampling locations. This observation may be linked to the resilience of these species to high altitudes and specific climatic conditions, particularly evident in areas like Pichincha and Loja. *R. ecuadoriensis* tends to inhabit wild areas, especially those dominated by tagua palm species (*Phytelephas aequatorialis*)[28]. In contrast, *T. dispar* and *T. carrioni* have been implicated in the transmission of Chagas disease (CHD), accounting for 24% of cases, primarily in Loja – the province where most highland collection activities have been concentrated[28]. This finding aligns with Grijalva et al.[28] who emphasized the significant presence of the species *R. ecuadoriensis*. Additionally, *P. howardi* has been associated with materials such as adobe (clay) and earthen floors[22].

It should be noted that, in the case of Colombia, the vectors *T. dimidiata* and *R. prolixus*[29] are found in the neighboring country. The former, a primary vector in the neighboring country, also colonizes the inter-Andean region of the country[30].

The Amazon region, on the other hand, hosts a diverse range of triatomines. The findings in the eastern region of *R. robustus, E. cuspidatus, E. mucronatus, P. lignaris, P. geniculatus and R. pictipes, R. pallences and R. barretti*, are similar to those of the study conducted by Amunárriz et al.[31]

who found the presence of *P. geniculatus, R. pictipes and R. robustus* in the province of Orellana, being closely related to the environmental conditions of the place, creating a favorable habitat for maintenance, reproduction, and breeding[32]. In this context, it is necessary to evaluate the feasibility of vector migrations aided by the movement through the Amazonian strip shared with Colombia and Peru[32]. It is also important to evaluate the role of *P. geniculatus* found in the entire eastern region, except in Morona Santiago; it is important to continue gathering information about the role of this triatomine as a primary vector in the Amazon, which prevents it from establishing itself in certain neighboring provinces. Recent studies carried out in Alto Orinoco and Atures, Amazonas state, Venezuela, incriminate it as the main vector for the transmission of CHD, given its synanthropic, photophilic, and diverse habitat capacity due to large deforestations that reduce the population of other triatomines[33].

In terms of geographical distribution, by province, with the highest number of triatomines, according to different genera and species, according to regions and in descending order, were the following: Manabí, El Oro and Esmeraldas in the Coastal region of Ecuador; Pichincha, Loja and Imbabura in the inter-Andean or Sierra region; and Orellana, Sucumbíos and Napo, in the Amazon region. These results are similar to those obtained by Mantilla et al.[34] where most of the epidemiological studies carried out in the country were mainly in the provinces of Manabí, Guayas, El Oro and Loja, and who found a 3.03% seropositivity of the samples analyzed. They are also similar to the results obtained by Velásquez et al.[35] who indicated that the majority of patients with CHD were among blood donors when reviewing the record of donations, corresponded to the urban areas (n=105; 76.64%) of the provinces of El Oro and Los Ríos. Similarly, Morales-Viteri et al.[36] determined that CHD was in 20 of the 24 provinces of the country, with the provinces of El Oro (23.69%), Guayas (14.58%), Loja (13.67%), Sucumbíos (8.88%), Pichincha (36, 8.20%) and Manabí (7.74%) reporting the highest number of cases.

Limitations

This study had certain limitations, such as the lack of relevant bibliographic references that provided complete information about the variables considered in the study (thematic cores). On the other hand, the subjectivity regarding the results of the studies reviewed can lead to generating a selection bias in the articles considered in the study, given that they included the variables considered in the study. Furthermore, due to the COVID-19 pandemic, vector control teams limited their search activity, monitoring, and supervision of vectors, significantly reducing the number of active research and publications. Finally, no article was found in the reviewed literature that referred to the value of R, which could be used as an indicator for the implementation of future research.

CONCLUSION

CHD is a re-emerging and silent pathology. Currently, Ecuador reports the circulation of 17 species of triatomines; 4 genera with their respective species: Triatoma: (*dimidiata, carrioni, dispar and venosa*); Rhodnius (*robustus, ecuadoriensis, pictipes*, *barretti*); Eratyrus *(mucronatus, cuspidatus);* and Panstrongylus (*howardi, chinai, herreri, lignarius, geniculatus, rufotuberculatus*). In the Amazon region, the greatest diversity of genera and species in the country was found, as well as high levels of prevalence of infection.

The provinces with the most reports of triatomines were Manabí, El Oro, Esmeraldas and Los Ríos, Pichincha, Loja, Orellana, Sucumbíos and Napo. It is necessary to expand the collection sites to update the geographical distribution of triatomine species circulating in Ecuadorian territory.

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