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Review article

Chagas disease in Ecuador: a systematic review of epidemiological and entomological aspects

Enfermedad de Chagas en el Ecuador: una revisión sistemática de los aspectos epidemiológicos y entomológicos

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Abstract

Chagas disease is a chronic and systemic parasitosis caused by the hemoflagellate protozoan Trypanosoma cruzi and transmitted mainly by insects of the Triatominae subfamily. Currently, at least 151 species of Triatominae are recognized, with species of the genera, Triatoma, Rhodnius and Panstrongylus, with an important epidemiological role in the transmission of the disease. In Ecuador it is difficult to know the true epidemiological situation of this disease, its implications and the situation regarding its prevention and control management. A review of the epidemiological data of Chagas disease, published in the Epidemiological Surveillance Subsystem of the Ministry of Public Health from 2013 to 2019, was carried out. The systematic review of triatomine species was carried out based on original research published on the basis of public access data. The review carried out reported 439 confirmed cases of Chagas with a high incidence in the last two years. The prevalence has been slightly observed in women with a prevalent age group of 20 to 49 years. In Ecuador 17 species of triatomines are registered. The species Triatoma dimidiata and Rhodnius ecuadoriensis are the main vectors of the disease, with a high density in the provinces of Loja and Manabí due to their high capacity for adaptation and the colonization of new habitats. Chagas surveillance and control strategies should be carried out by linking epidemiological and vector aspects to stratify and strengthen control programs.

Keywords: Chagas Disease, Triatominae, Epidemiology, Trypanosoma cruzi.

Resumen

Introducción: La Enfermedad de Chagas es una parasitosis crónica y sistémica causada por el protozoario hemoflagelado Trypanosoma cruzi y transmitida, fundamentalmente, por insectos de la subfamilia Triatominae. Actualmente, se reconocen al menos 151 especies de Triatominae, con especies de los géneros, Triatoma, Rhodnius y Panstrongylus, con un importante papel epidemiológico en la transmisión de la enfermedad. En Ecuador es difícil conocer la verdadera situación epidemiológica de esta enfermedad, sus implicaciones y la situación sobre su gestión de prevención y control. Se realizó una revisión de los datos epidemiológicos de la enfermedad de Chagas, publicadas en el Subsistema de Vigilancia Epidemiológica del Ministerio de Salud Pública desde el 2013 al 2019.

La revisión sistemática de las especies de triatominos fue realizada a partir de investigaciones originales publicadas en base de datos de acceso público. La revisión realizada reportó 439 casos confirmados de Chagas con una alta incidencia en los últimos dos años. La prevalencia se ha observado ligeramente en mujeres con un grupo etario prevalente de 20 a 49 años. En el Ecuador se registra 17 especies de triatominos. Las especies Triatoma dimidiata y Rhodnius ecuadoriensis son los principales vectores de la enfermedad, con una alta densidad en las provincias de Loja y Manabí debido a su alta capacidad de adaptación y la colonización de nuevos hábitats. Las estrategias de vigilancia y control de Chagas deben realizarse con la vinculación de aspectos epidemiológicos y vectoriales para estratificar y fortalecer los programas de control.

Palabras Clave: Enfermedad de Chagas, Triatominae, Epidemiología, Trypanosoma cruzi.

Introduction

Chagas disease is a life-threatening vector-borne disease caused by the parasite Trypanosoma cruzi (T. cruzi). According to Pan American Health Organization (PAHO), it is estimated that there are currently 8 million people worldwide infected with the disease, 100 million at risk of acquiring the infection, 56,000 new cases a year and 12,000 people who die due to the disease [1]. Its natural distribution is limited to the Americas and is one of the public health problems in Latin America, as it is associated with social, cultural, historical, political and economic factors, mainly in rural areas. [2].

In 2003 it was established that the general prevalence of T. cruzi infection in Ecuador reached 1.38%, corresponding to approximately 170,000 seropositive patients in the country. In the coastal region the seroprevalence is estimated to be 1.99%, the Amazon region 1.75% and the southern highlands 0.65% [1]. In the absence of preventive measures, it is projected that around 4,400 people nationwide acquire the infection each year (incidence 36 per 100,000 inhabitants per year). The mortality profiles (7.7 deaths per 1,000 HIV-positive people per year) indicate that about 1,300 people die each year from causes directly related to the disease. Some 33,500 patients could suffer from chronic symptomatic forms; of these, more than 31,700 suffer from heart disease (25,500 mild forms and > 6,200 severe forms) and more than 1,670 digestive disease (1,580 mild and 90 severe) [3].

Unlike other insect-borne diseases, hematophagous infection with T. cruzi does not occur by inoculation. When practicing hematophagy, the triatomine defecates, eliminating the infectious forms of the parasite, which penetrate the site where the bite occurred. Although vector transmission is the most common form, infection can occur through blood transfusion, transplacental route, organ transplants, food contaminated by vector feces, laboratory accidents, or handling the carcasses of infected animals without protection. [4].

Currently, at least 151 species of Triatominae are recognized [5.6], with species in three genera, Triatoma, Rhodnius and Panstrongylus, with an important epidemiological role in the transmission of the disease[7.8]. In Ecuador, in 18 of the 24 provinces, 17 species of triatomines have been reported, considering Rhodnius ecuadoriensis and Triatoma dimidiata as the main vectors involved in the transmission of the disease. R ecuadorensis corresponds to the autochthonous vector distributed in the central coast and in the southern Andean regions of Ecuador, with invasive capacity in peri-domestic habitats and a high rate of infection by T. cruzi [9-11]. Instead, Triatoma dimidiata is the introduced vector and is found exclusively in domestic and peri-domestic habitats, predominant in all the provinces of the Ecuadorian coast [12]. Other species such as Panstrongylus chinai, Panstrongylus howardi and Panstrongylus rufotuberculatus are considered secondary vectors as they are

infected by T. cruzi in peri-domiciliary areas. [9,10,13].

Timely detection and proper management of Chagas disease require a wide dissemination of epidemiological and vector concepts.

The objective of this work is to carry out a rapid review of the epidemiological aspects of Chagas disease, emphasizing the incidence of the disease in recent years; in addition to conducting a bibliographic review of the triatomine species present in the national territory.

Materials and methods

A descriptive review of the epidemiological data was carried out based on the information from the Epidemiological Surveillance Subsystem SIVE - ALERTA of the Ministry of Public Health (MSP) of Ecuador and reports from the epidemiological gazettes published by the MSP (https://www.salud.gob.ec/gaceta-epidemiologica-ecuador-sive-alerta/). The search for information was limited to the period from January 2013 to December 2019, to obtain information on the status of the disease in the last seven years. All the records found for chronic and acute Chagas were examined, analyzing the proportion of registered cases, age group analysis and the incidence of cases by province.

The systematic review of Chagas disease vectors was carried out in Google Scholar and PubMed electronic databases using search terms 'Chagas disease in Ecuador', 'Chagas vectors Ecuador', 'triatominae Ecuador'. The search was carried out including publications made on any date, considering publications in Spanish, English and Portuguese. The inclusion criteria were all studies directly related to the ecology of the vector, distribution studies, new species reports, vector control studies and prevention of Chagas disease. Articles without titles or abstracts that did not match the search query were excluded. Editorials, duplicate studies, and internal reports were excluded.

An independent review of each of the selected investigations was carried out, using a previously tested spreadsheet to compile the information; I include the following information: country, publication date, publication title, species, geographic distribution, and habitat. The review found 12 publications after eliminating duplicates, which met the inclusion criteria, in which the results and conclusions were analyzed.

Results

Epidemiological aspects

From 2013 to 2019, 439 confirmed cases of Chagas disease have been registered in the Epidemiological Surveillance System (SIVE) of the Ministry of Public Health of Ecuador. In these years, the proportion of registered cases is higher for chronic Chagas (n = 331, 75.40%), compared to acute Chagas (n = 108, 24.60%), Table 1.

Table 1. Confirmed cases of Chagas disease by case definition in Ecuador, 2013 - 2019

Year	Acute Chagas		Chronic Chagas		Total
	N	%	N	%	N
2013	7	35,00	13	5,002	0
2014	4	17,39	19 8	2,612	3
2015	17 3	7,782	8	62,22	45
2016	17 3	8,642	7	61,36	44
2017	24 3	9,343	7	60,66	61
2018	20 2	5,325	9	74,68	79
2019	19 1	1,381	48 8	8,621	67
Total	108	24,60	331	75,40	439

Source: *Vector epidemiological gazettes, Ministry of Public Health of Ecuador*

The presence of the disease is slightly higher in women (n = 231, 51.79%) than in men (n = 215, 48.21%), although this behavior was the reverse, in the initial period of the series under study; It is more prevalent for the age group 20 to 49 years (n = 182, 40.81%), followed by those over 65 years (n = 110, 24.66%) and 50 to 64 years (n = 89, 19.96%), which could be related to the fact that notifications are higher for chronic cases of the disease, Table 2

This disease is reported in 20 of the 24 provinces of the country, the provinces of El Oro (n = 104, 23.69%), Guayas (n = 64, 14.58%), Loja (n = 60, 13.67%), Sucumbíos (n = 39, 8.88%), Pichincha (n = 36, 8.20%) and Manabí (n = 34, 7.74%),

Table 3. The decomposition of time series of cases of Chagas disease in Ecuador it shows a seasonal pattern, with an increase in the months of November to February and April to June; with an increasing trend from January 2013 to December 2019 (Figure 1). The increasing trend in case reporting has been observed since September 2016 and the expected peaks of higher case registration are in the months of January and June, with the highest report in this series of analyzes in June 2019 (Figure 1 and 2).

Table 2. Demographic profile of Chagas disease in Ecuador, 2013 - 2019

Variable	2013		2014		2015.		2016		2017		2018		2019		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Sex																
Man	11	55.00	13	56.52	26	57.78	23	52.27	30	48.53	37	46.84	73	43.71	213	48.52
Woman	9	45.00	10	43.48	19	42.22	21	47.73	31	51.47	42	53.16	94	56.29	226	51.48
Age group																
from 0 to 11 months	0	0.00	0	0.00	1	2.22	1	2.27	0	0	0	0.00	0	0.00	2	0.46
from 1 to 4 years	3	15.00	0	0.00	1	2.22	1	2.27	2	2.94	3	3.80	0	0.00	10	2.28
from 5 to 9 years	1	5.00	1	4.35	3	6.67	0	0.00	0	0	3	3.80	3	1.80	11	2.51
from 10 to 14 years	0	0.00	1	4.35	5	11.11	3	6.82	2	2.94	3	3.80	6	3.59	20	4.56
from 15 to 19 years	1	5.00	2	8.70	2	4.44	7	15.91	3	4.41	3	3.80	3	1.80	21	4.78
from 20 to 49 years old	8	40.00	11	47.83	19	42.22	21.	47.73	25	41.18	41	51.90	54	32.34	179	40.77
from 50 to 64 years	6	30.00	3	13.04	11	24.44	5	11.36	16	26.47	12	15.19	3. 4	20.36	87	19.82
over 65	1	5.00	5	21.74	3	6.67	6	13.64	13	22.06	14	17.72	66	39.52	108	24.60

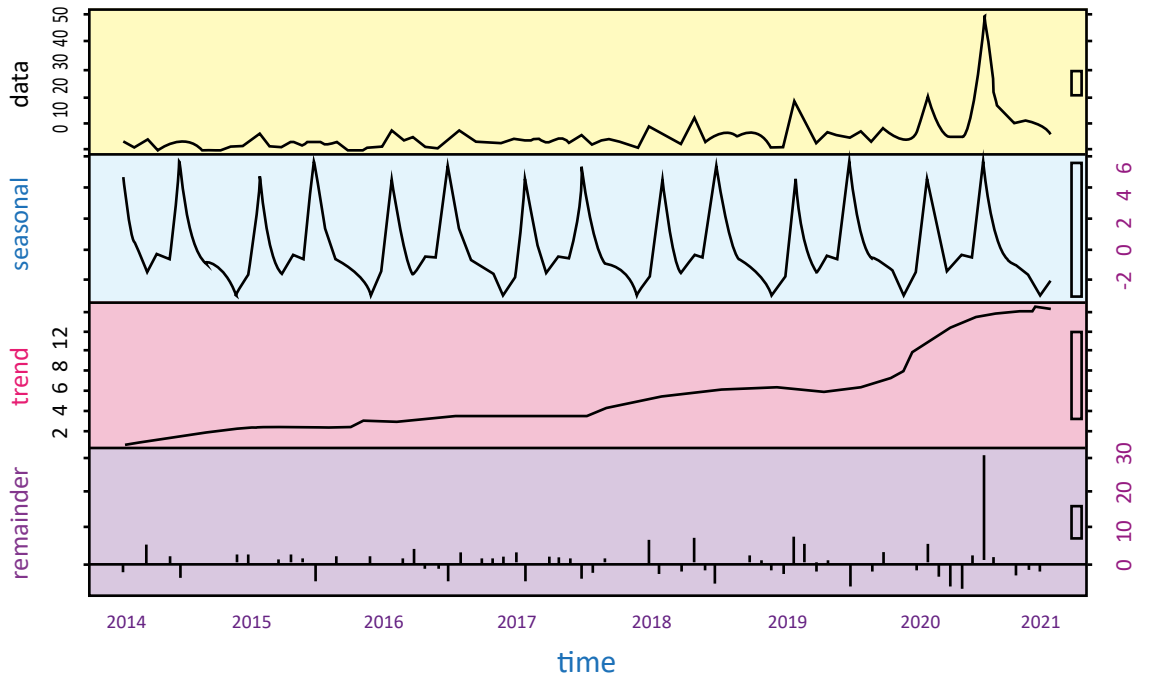
Source: *Vector epidemiological gazettes, Ministry of Public Health of Ecuador*

Table 3. Confirmed cases of Chagas disease in Ecuador, by province, 2013 - 2019

	Acute Chagas	Chronic Chagas	Total Cases	%
El Oro	28	76	104	23.69
Guayas	11	53	64	14.58
Loja	6	54	60	13.67
Sucumbíos	15	24	39	8.88
Pichincha	7	29	36	8.20
Manabí	13	21	3. 4	7.74
Orellana	11	9	20	4.56
Los Ríos	2	12	14	3.19
Esmeraldas	3	8	11	2.51
Morona Santiago	3	7	10	2.28
Zamora Chinchipe	1	9	10	2.28
Azuay	2	5	7	1.59
Napo	1	6	7	1.59
Santa Elena	1	6	7	1.59
Santo Domingo De Los Tsáchilas	2	4	6	1.37
Cotopaxi	1	2	3	0.68
Pastaza	1	2	3	0.68
Carchi	0	2	2	0.46
Imbabura	0	1	1	0.23
Tungurahua	0	1	1	0.23

Source: *Vector epidemiological gazettes, Ministry of Public Health of Ecuador*

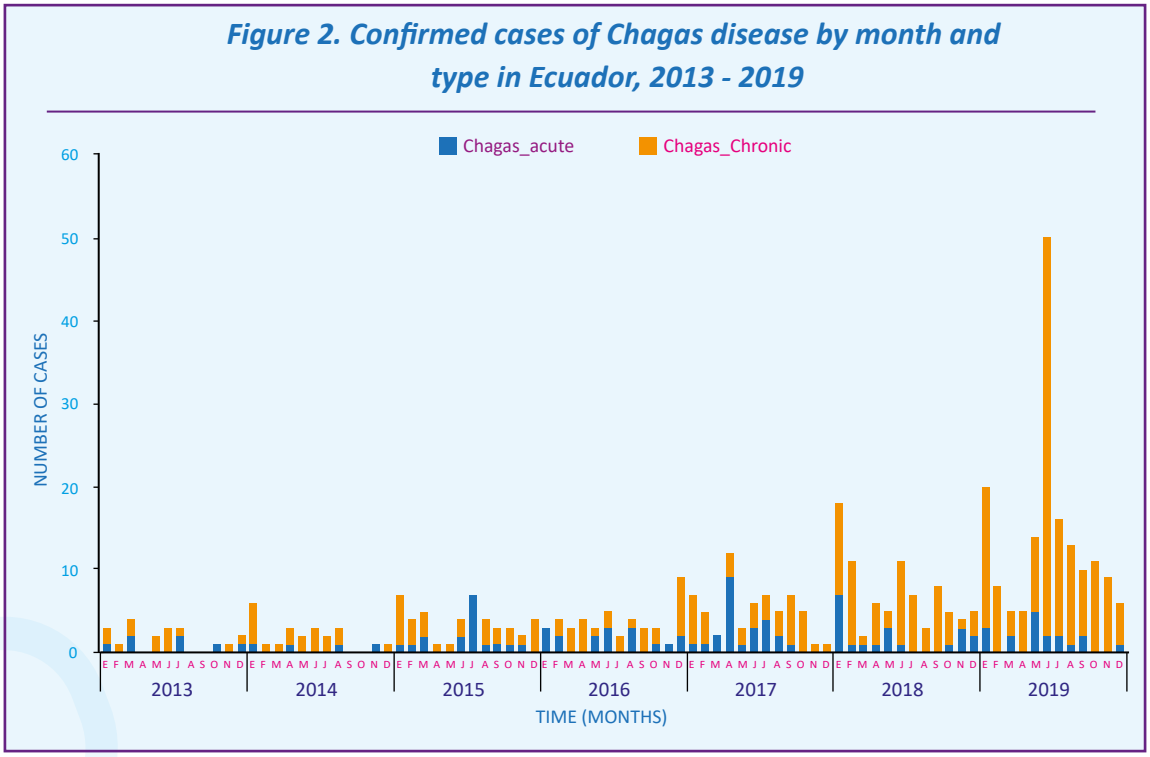
Figure 1. Time series breakdown of total confirmed cases of Chagas disease in Ecuador, 2013 - 2019



Source: *Vector epidemiological gazettes, Ministry of Public Health of Ecuador*

Note: *The top plot is broken down into seasonal, trending, and irregular components. The gray bar on the right indicates the relative magnitude of each of the decomposed components (bar length = relative magnitude).*

Figure 2. Confirmed cases of Chagas disease by month and type in Ecuador, 2013 - 2019



Source: *Source: Vector epidemiological gazettes, Ministry of Public Health of Ecuador*

Chagas Vectors in Ecuador

In Ecuador, 17 species of triatomines are reported, eight species distributed in the littoral region, 10 in the sierra region and 10 in the Amazon region. Triatoma dimidiata and Rhodnius ecuadoriensis are considered the main vectors of Chagas disease due to their high capacity for adaptation and colonization of new habitats. Triatoma dimidiata is considered an allochthonous vector characterized by being a large species that ranges from 24 to 32 mm long, with a general black color, with pale yellow to orange yellow connectiveum and corium. This species is found in domestic and peri-domestic areas, associated with armadillo and opossum burrows. In the national territory it is distributed in the provinces of: Esmeraldas, Guayas, Loja, Los Ríos, and Manabí.

Rhodnius ecuadoriensis It is considered as the autochthonous vector and is characterized by being a small species that ranges from 13 to 14 mm in length; It has light brown placement with dark brown markings on the body and the appendages in the form of stripes or small spots of irregular shape. This species is found in palm trees, especially in palms known as tagua or cade in urban dialect (Phytelephas aecuatorialis), these palm trees serve as a refuge for various types of animals, mostly rodents.

Although Triatoma dimidiata and Rhodnius ecuadoriensis are the main vectors of Chagas disease: Panstrongylus Chinai, Panstrongylus geniculatus, Panstrongylus herreri, Panstrongylus howardi, Panstrongylus lignarius, Panstrongylus rufotuberculatus, Rhodnius barretti, Rhodnius pictipes, Rhodnius robustus and Triatoma carrioni are considered potential vectors as they are naturally infected by T. cruzi and their ability to colonize domestic and wild environments. On the other hand, Cavernicola pilosa, Eratyrus cuspidatus, Eratyrus mucronatus, venous triatoma, Triatoma dispar are considered species with wild habits and apparently without a potential risk. Table 4 shows the distribution of triatomines by province.

Table 4. Distribution of triatomines reported in Ecuador

	Azuay	Cañar	Cotopaxi	El Oro	Esmeraldas	Guayas	Imbabura	Loja	Los Ríos	Manabí	Morona Santiago	Napo	Orellana	Pastaza	Pichincha	Sto. Dgo de los Tsáchilas	Sucumbíos	Zamora Chinchipe	References
Hairy caveman												X	X	X					
Eratyrus cuspidatus					X			X											(10), (16)
Eratyrus mucronatus												X	X						(16), (10)
Panstrongylus Chinai				X				X											(10.17)
Panstrongylus geniculatus					X		X			X		X	X		X		X		(16), (10)
Panstrongylus herreri												X	X						(16), (10)
Panstrongylus howardi										X									-13
Panstrongylus lignarius																	X		-10
Panstrongylus rufotuberculatus				X		X	X	X	X	X						X			(10.18)
Rhodnius barretti												X							-12
Rhodnius ecuadoriensis				X		X		X	X	X						X			-10
Rhodnius pictipes	X										X	X	X				X		-11
Rhodnius robustus											X	X	X				X		(11.19), (20)
Triatoma carrioni	X	X	X	X				X							X			X	(21), (10)
Triatoma dimidiata					X	X		X	X	X									-10
Disparate triathome			X				X							X	X				(10), (14)
Venous triatoma	X											X	X						(10.19)

Discussion

Chagas disease is one of the vector-borne diseases of which little is known about its epidemiological behavior. This is a neglected tropical disease cited by the Pan American Health Organization / World Health Organization (PAHO / WHO). Ecuador, through Resolution CD49.R19, has indicated its interest in controlling and eliminating vertical transmission and by introduced vectors.

This disease, related to poverty and to the deficit of access to basic services, water and housing, affects populations with geographic problems for access to public or private health services, therefore and based on studies carried out in Ecuador [3], this disease is under-reported, with a greater probability of indeterminate forms that have not been captured by health systems.

From 2013 to 2019, the country has experienced an increase in the reporting of cases of the disease, in greater proportion in the provinces of the coast and the south west of the country, being the province of El Oro, in which the largest report of cases in the period analyzed [22]. In 2017, the reporting of cases has increased due to the notification of reactive serologies for T. cruzi in blood banks; These people are recruited by the nearest health facility, where diagnostic confirmation is carried out, initiating treatment and monitoring of the disease. Despite the fact that the cases reported by blood banks exceed those reported in the Epidemiological Surveillance System, this strategy of notifying reactive serologies has substantially contributed to the active search for cases for this disease.

Strategies focused on the elimination of mother-to-child transmission should also be incorporated, this is a priority activity, so screening with rapid tests and a flow for diagnostic confirmation, multidisciplinary follow-up of the control of the Chagasic pregnant woman and the newborn, is the strategy that was proposed to implement to address this population group [23].

According to this review, the presence of the Chagas disease vector is recorded in 18 of the 24 provinces of the national territory [24]; being Manabí and Loja, the provinces with the highest infestation. Many of the vector species have an endemic distribution such as Panstrongylus howardi, reported only in the province of Manabí [9-25]. In Ecuador, 17 species of triatomines have been registered, of which Triatoma dimidiata is the most important vector of T. cruzi and Rhodnius ecuadorensis, considered the second vector in domestic and wild habitats. [9-14]. The prevention of the disease depends largely on the control of triatomines that infest the home, through spraying with insecticides reducing the incidence of the vector, however persistent re-infestation in the home can cause the reappearance of the disease [1].

To improve interventions and maintain current achievements in surveillance and control of Chagas disease, it is important to conduct research to broaden understanding of triatomine infestation and transmission cycles in different endemic areas. [26].

Triatomines are found distributed in the tropical and subtropical regions of South America, closely related by environmental variables, such as humidity and temperature, which directly influence the physiological and behavioral processes in different species. Thermal preference, host search, feeding, fecundity, hatching rate and pre-adult development time have been related to temperature, so any variation could have effects on vital processes and consequently on the distribution of species [19,27,28].

According to the reviews carried out, Eratyrus cuspidatus, Panstrongylus chinai, Panstrongylus geniculatus, Panstrongylus howardi, Panstrongylus rufotuberculatus, Rhodnius ecuadoriensis, Triatoma carrioni and Triatoma dimidiata, are found in the littoral region, with some species also distributed in the Amazon region.

Triatoma dimidiata and Rhodnius ecuadoriensis are located on the Pacific slope of the Ecuadorian Andes, in the case of T. dimidiata restricted to urban areas of the coastal region, mainly in the provinces of Guayas and Manabí [29].

Rhodnius ecuadoriensis found in the central coastal region, adapted primarily to peri-domestic and jungle habitats in chicken nests, guinea pig pens, woodpiles, rat nests, and on endemic palms such as Phytelephas aequatorialis [30].

Other species such as Panstrongylus howardi, their distribution has been restricted to the province of Manabí, but their presence has been reported in five ecological zones of the province, including dry mountain shrub forests, deciduous forests, savanna, green forests of low mountain and semi-deciduous forests [13-30].

The great variety of jungle habitats such as savannas,

humid forests, humid rainy forests form a diversity of ecotypes in the Amazon region, which are home to different species of triatomines in palm trees, hollow trees and in refuges of wild mammals. [31].

In the Amazon provinces, Rhodnius pictipes, Rhodnius robustus, Cavernicola pilosa, Eratyrus mucronatus, Panstrongylus geniculatus, Panstrongylus herreri, Rhodnius barretti, Rhodnius robustus, venous triatoma, Panstrongylus lignarius and venous triatoma have been reported.

P. rufotuberculatus It corresponds to a jungle species, however, together with other species such as P. geniculatus and P. chinai, they would be involved in a process of domiciliation, indicating the capacity of the species to colonize human dwellings attracted by light. [17-31]. Other species such as R. robustus, R. pictipes are strictly jungle, but can invade nearby dwellings. Deforestation and loss of habitat have caused species of the genus Rhodnius to colonize new habitats as a result of anthropic contact. [31-32].

In the provinces of the Sierra Azuay, Cañar, Cotopaxi, Imbabura, Loja and Pichincha, triatomines have been distributed mainly in the transition of subtropical valleys influenced by climate and vegetation. In this area we find Rhodnius pictipes, Triatoma carrioni, venous triatoma, Triatoma dispar, Panstrongylus geniculatus, Panstrongylus rufotuberculatus, Eratyrus cuspidatus, Panstrongylus Chinai, Rhodnius ecuadoriensis, Triatoma dimidiata and Cavernicola pilosa.

According to the review carried out, the province of Loja registers six species of triatomines, of which two species are main vectors for the transmission of Chagas disease. This area has been considered endemic for the disease for several years as it is located in a topographic variation that ranges from 150 to 3,800 meters above sea level, ideal for the development of vectors, in addition to registering socio-cultural conditions that contribute to the epidemiological burden [33].

The strategies for the control of Chagas disease should be carried out based on updated information on the distribution and synanthropic behavior of triatomine species, together with epidemiological data to identify the main risk areas for the disease. [1].

The reported records of triatomine species by province constitute initial information to understand the transmission cycle. We believe that adjacent localities, despite not having reported cases or infestations, could be at potential risk. The Amazon region should be considered as a point of interest for vector surveillance, studies confirm that possible epidemiological changes in the Amazon region, which may be associated with increased deforestation. Some indigenous species can behave as secondary vectors, occupying empty niches when domestic triatomines are eliminated through control measures.

Conclusions and recommendations

The environmental and geographical conditions generate a favorable scenario for the presence of triatomines in our country, this added to the socioeconomic and cultural characteristics of the populations, especially due to internal mobility from or to areas of transmission of the disease, and the low perception Of symptoms in the acute phase, Chagas disease in our country tends to continue as a silent disease, but year after year it could be causing sequelae, in many disabling people, due to the low clinical perception and epidemiological risk. Chagas disease continues to be a subject of great concern in endemic and non-endemic countries, so achieving complete eradication of this disease is an ambitious but necessary goal. Faced with the current scenario,

We emphasize the importance of working with top-level institutions, academy, and agencies of the Ministry of Public Health of Ecuador to improve operational capacities, together with the community to reduce and control vector populations in Ecuador.

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