TRIATOMINES OR HUMANS: WHO ARE THE INVADERS?

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ABSTRACT. Among 140+ kissing bug species (Hemiptera: Heteroptera: Reduviidae: Triatominae), all of which are potential vectors of the etiological agent of Chagas disease (i.e. *Trypanosoma cruzi*), only few of them have been reported visiting and inhabiting human abodes, therefore, considered of major epidemiological importance. Commonly, triatomine species are arranged in grades of increasing association with humans. This ad hoc classification has two extremes: domestic and sylvatic triatomines, with in-between levels that depend on the capability of the species to invade human houses. Although the use of these levels is convenient for epidemiological comprehension of Chagas disease, we cannot deny that there are two controversial criteria in the choice of these categorical terminologies: anthropocentrism and adaptationism. Our viewpoint considers these elements as problems of the current and widespread classification system for kissing bug species regarding their association with humans. Anthropocentrism might derive from how vectors of Chagas disease are seen by medical professionals. Adaptationism, conceives all evolutionary traits in organisms to be driven to an optimum. Current Chagas disease control programs have been designed through these approaches. Our viewpoint aims to hypothesize a paradigm shift in this topic and to induce a controversial debate that lay new foundations for research in ecology of triatomines. This would improve triatomine control programs efficiency.

KEY WORDS. Triatomites, Chagas disease eco-epidemiology, anthropocentrism, adptationism, disease vector, poverty, humans as invaders, anthropic ecosystems.

Triatomines are a type of reduviid bugs that can carry the parasite *Trypanosoma cruzi* that causes Chagas disease. This illness has acquired reputation as the most neglected of neglected diseases [1]. Nifurtimox and benznidazole are the only existing drugs to treat the disease, but neither

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is ideal because they are not specific. There is lack of interest from scientific and health sectors, such as research institutions and big drug companies, towards Chagas disease because: 1) it has a rather modest impact in "developed" countries, 2) it disproportionately and predominantly affects the rural poor populations in Latin-America, and 3) because its symptoms are not obvious, so adequate diagnosis remains a challenge. As treatment is fraught with difficulties in Chagas disease, prevention via vector control is the main focus of most health programs.

Triatomines (Hemiptera: Heteroptera: Reduviidae: Triatominae) are insects associated with vertebrate refuges (*sensu lato*). Most triatomine species feed on vertebrate blood, but some perform better when feeding on invertebrate haemolymph [2]. Among 140+ kissing bug species, all of which are potential vectors of Chagas disease, only a few such as *Triatoma infestans, T. dimidiata, T. sordida, T. brasiliensis, Rhodnius prolixus, R. pallescens* and *Panstrongylus megistus* have been reported visiting and inhabiting human abodes, and thus recognized as responsible for most vector-borne human infections. Epidemiologists commonly arrange triatomines in grades of increasing association with humans. To the best of our knowledge, the first use for this criterion was formally presented by Zeledón [3]. According to this author triatomines can be arranged in five categories. Triatomines in grade 1 are highly adapted to synantropic environments and include the main vectors of Chagas disease. *Triatoma infestans* and *R. prolixus* are clear examples of this association, mainly because of their wide geographical distributions and their capabilities to colonize human habitations. Species in grade 2 are in process of adaptation to establish in human dwellings, as they have ecological demands that limit their dispersion and distribution. According to Zeledón, these species adapt better to the peri-domiciliary habitat (e.g., chicken and pig pens) than to human domiciles. This grade includes several locally important vectors such as *Triatoma dimidiata, T. sordida, T. maculata, T. phyllosoma, T. brasilensis, T. guasayana, T. patagonica, Rhodnius pallescens* and *Panstrongylus megistus,* among others. Species in grade 3 are usually found in sylvan ecotopes, but occasionally colonize houses, e.g., *T. platensis, T. rubrovaria, R. ecuadoriensis, R. neglectus*, and many North American species, e.g., *T. protracta, T. sanguisuga* and *T. rubida*. Species in grade 4 are fairly sylvatic although adults have been found in houses, sometimes attracted by lights. In this regard, colonization has been rarely demonstrated for *T. vitticeps, T. spinolai, T. nitida, P. geniculatus* and *Eratyrus cuspidatus*, among others. Species in grade 5 are exclusively sylvatic, e.g., the genera Cavernicola and Psammolestes. Zeledón's criterion has two extremes: domestic and sylvatic triatomines, with three levels in between that depend on the species capability to invade human residences. Other authors, inspired by this idea, have proposed similar levels reversing the scale [4]. The "five grades" criterion

states that the species included in grade 1 have a highest *ecological valence* or *ecological amplitude* given their high degree of adaptation to human habitat, while species of grade 5 have the lowest ecological amplitude given their low degree for such adaptation [3]. For grade 2, 3 and 4, the other species will sit as easily in one category as another, as species in these grades are "in process of adaptation" to human habitat colonization. The criterion used by Zeledón and by Schofield [3, 4] suggests that synantropic species could be regarded as generalists, while sylvatic species could be regarded as specialists (*sensu* Devictor, et al. [5]). By this criterion, *T. infestans* and *R. prolix*us should be the most generalist species among triatomines, given their capability to adapt to human houses. As the three grades in between are rather ambiguous, most authors only use *domestic* or *sylvatic* categories to describe the species they study. The related terms *invasive, domiciliary* and *peri-domiciliary*, which are based on this paradigm, are also very common in the literature.

Although the conceptual dichotomy (and its intermediate scale) between domestic and sylvatic triatomines is convenient for epidemiological comprehension of Chagas disease, we cannot deny that there are two controversial elements in the choice of these categorical terminologies: anthropocentrism and adaptationism. This scale could be regarded as anthropocentrical, as it refers to the ecological amplitude or capability of the reduviids to adapt to different circumstances depending on the degree of association with humans. The basic epistemological principle that supports this classification is a classic and simple one: humans are separate from nature [6, 7]. According to such logic, triatomines are recognized as *invaders* from nature and humans as *victims* living beyond nature (Figure 1). Additionally, this scale is adaptationist (*sensu* Spencer [8]), as grade 1 is regarded as an optimal level of "highly adapted" species [9].

Zeledón [3] and Schofield [4] hierarchy ignores that triatomine bugs as well as humans are all animal species that coexist in the same ecosystems. Each category is associated with threat levels, in which the species that are in the first level are seen as the most menacing ones. Although species such as *T. infestans* and *R. prolixus* are of major importance, we should not underestimate the eco-epidemiological importance of species that are rarely observed in human abodes, as they contribute to maintain the life cycles of *Trypanozoma cruzi* different lineages. Additionally, there are increasing reports describing species previously not considered important vectors of Chagas disease, but currently associated with *Homo sapiens* [10, 11].

Furthermore, this perspective neglects that humans evolved and dispersed along continents already stocked with blood-sucking bugs, and it also seems to ignore that the arrival of triatomines to human dwellings had been facilitated by human activities impacting their habitats [12, 13].

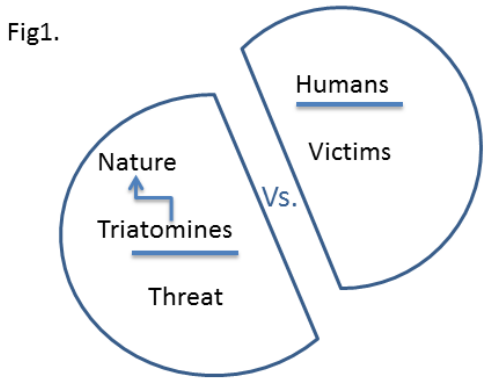

FIGURE 1. Triatomines vs. humans? We do not intend to state that humans are a threat. But, if we accept that they are separated and confronted with nature we will perceive ourselves as victims, neglecting important ecological aspects of triatomine bugs association with humans. Most Chagas disease control programs are designed through this reductionist approach, disregarding how human economic activities drive triatomines to anthropic ecosystems.

Even if the transmission of Chagas disease could occur independently of bug domiciliation [14], most vector-borne cases are associated with such process. Triatomines were present in America millions of years before humans crossed the Bering Strait [15]; thus, triatomines first contact with modern humans may have taken place recently when *H. sapiens* reached America from Siberia, probably ca. 15,000 years ago [15]. Even if no one is certain when the first American settlers lodged triatomines in their dwellings, it is quite clear that the association was well established during Pre-Columbian times, at least 9,000 years ago [16]. Surprisingly, there have been no reports of *T. cruzi* among modern Amazonian nomad tribes or of bug vectors in their traditional houses, despite thousands of years of occupation by these Americans of the Amazon Basin, where triatomine species richness is notably high [17]. Only sedentary tribes appear to be affected by Chagas disease [18]. According to Coimbra, 18 small settlements that rarely exceeded 500 people and high village mobility explain the Amazon natives' "immunity" to this and other vector-borne diseases. Additionally, early domestication of vertebrates by sedentary civilizations facilitated triatomine colonization of the peridomestic habitat [18]. Although some nomad native communities, most commonly their children, keep immature animals found in the forest as pets, these seldom breed in captivity, so the number of animals in houses is low and unstable. It has been reported that present-day Amazonian tribes present low indexes of trypanosomiasis (and leishmaniasis, another zoonosis transmitted by

sandflies), regardless of their house designs, which according to the classic theory provide a comfortable niche for triatomines [18].

The intensive agricultural practices (e.g., potato and maize) that native American civilizations developed more than 4,000 years ago [19] surely produced a strong impact on the triatomine ecosystems and promoted its domiciliation. Currently, there is a great and increasing potential of Chagas disease endemization in the Amazon due to recent human migrations and the environmental degradation inflicted upon the region [18]. Modern non-native American societies have been experiencing the same cultural practices that led to triatomine domiciliation of sedentary native populations thousands of years ago. These practices, accentuated by our socio-economic development, produce ecological disturbance and environmental pressures that facilitate the presence of triatomine species in human dwellings, and the existence of highly endemic areas of Chagas disease in the Neotropics. Regrettably, there is lack of research of how cultural heritage is influencing Chagas disease epidemiology, probably due to political and scientific prejudices.

Although, many authors associate triatomine colonization of human houses and Chagas disease with poverty, very few associate this disease with capitalism. We think that the ultimate cause of Chagas disease is linked to the capitalist system (*sensu* Marx [20]) prevailing in the global society. Capitalism is an economic system in which the means of production are privately owned. This private property gives rise to economic inequality, i.e., poverty. Marx defines poverty as "the passive bond that causes the human being to experience the need of the greatest wealth—the *other* human being [21]." This need means lack of basic capacity to participate effectively in society; not having, among other things, enough food and health, and it often implies living on marginal or fragile environments. Many epidemiological risk factors commonly associated with Chagas disease, such as poor housing, lack of access to healthcare and environmental destruction, are characteristic of poverty, a product of capitalism.

Adaptationism and anthropocentricity limit the understanding of Chagas's disease eco-epidemiology. Triatomine ecology is a complex process where association with human abodes is one of its multiple dimensions. The accepted theory [3, 4] does not explain why there are only some triatomine bug species appearing in human abodes; obviously these have traits that serve to overcome the constraints of human niche, in the context of the *adaptationism* paradigm (*sensu* De Renzi [22]). This major change of hosts is occurring very rapidly as a consequence of the way humans alter their surroundings [12, 13]. It is crucial to understand the widespread epistemology used to describe the ecology of triatomines, because this is influencing how experts are designing strategies for vector control. As triatomines are considered alien enemies from nature, most experts pro-

pose to create barriers (e.g., to adequate houses and applying insecticides) to stop the colonization of human abodes. By these means we are attacking the consequences and not the causes, since less attention is paid to how human economic activities drive these bugs to anthropic systems [12, 13].

Many questions remain to be answered. What could be proposed to understand whether the association between hosts (humans and synanthropic animals) and triatomine bugs has an adaptationist imprint or emerged across a spectrum of possibilities (i.e., exaptations, *sensu* Gould and Vrba [23]) for host and vector encounters? Which concepts and methodological tools in evolution and ecology could be used to better describe the patterns of triatomine bugs association with humans? The answers are beyond the ambition of this essay. Regarding the question that entitles this essay, although triatomines are currently viewed as the invaders, according to what we have mentioned here, we are tempted to state the opposite, that humans are the invaders, inasmuch as ecologically speaking we have trespassed their premises. Nevertheless, it is not our goal to answer this question but to unveil the anthropocentric and adaptationist view prevailing among Chagas disease epidemiologists. This subject goes beyond semantics as both, anthropocentrism and adaptationism viewpoints limit the understanding of Chagas's disease ecology and the conception of any alternative vector control strategies. Chagas disease control programs have been designed under a reductionist approach. The ideas discussed above intend to hypothesize for such a paradigm shift in this topic and to induce a debate aimed to lay new foundations for research in the ecology of triatomines.

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NOTES

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