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Ticks infesting humans in Central America: A review of their relevance in public health

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ABSTRACT

Ticks are blood-sucking arthropods that parasitize most groups of terrestrial or semiaquatic vertebrates. Humans are accidental hosts to the ticks; however, in humans the ticks can cause damages varying from simple irritation to severe allergies, toxicosis, paralysis, and the transmission of pathogens, some of which can be fatal. Central America represents a narrow isthmus between North and South America and is considered a biodiversity hotspot. The importance of tick-borne diseases in this region is manifested by fatal outbreaks caused by *Rickettsia rickettsii*, severe and mild cases of other rickettsioses, ehrlichiosis, and tick-borne relapsing fevers, in addition to cases paralysis and strong allergic reactions. Even so, this information is scarce in most countries of this region, and there are no epidemiological data. In this article we present a review of the ticks that parasitize humans in Central America, covering data from the 19th Century to the present day. Of nearly 80 tick species reported in Central America, 28 species are reported on humans. This list includes species that thrive within homes, grazing areas and, to a lesser extent, in wild environments, both in lowland and high mountain forests. The most important genus in this region is *Amblyomma*, followed by *Rhipicephalus* and *Ornithodoros*, and to a lesser extent *Haemaphysalis*, *Ixodes* and *Dermacentor*. These data provide information on the tick species most commonly associated with humans in Central America, and highlight the potential for tick-borne diseases in wild, rural and urban regions.

1. Introduction

Ticks are considered one of the most relevant arthropod groups in public health because of the damage inflicted on their hosts, including the transmission of parasites, bacteria and viruses. In addition to tick-borne diseases, tick bites can cause damage through the effects of their saliva on the hosts producing reactions as severe as anaphylactic shock or paralysis (Sonenshine, 1993; Jongejan & Uilenberg, 2004; Muñoz-Leal et al., 2020). Although humans are not preferential hosts for ticks, some species are anthropophilic whereas other species are found on humans only sporadically (Estrada-Peña & Jongejan, 1999; Guglielmone & Robbins, 2018). Indeed, of the *c.*960 tick species reported throughout the world (*c.*742 species of the Ixodidae, *c.*220 species of the Argasidae, one species of the Nuttalliellidae), nearly 280 species of the Ixodidae and 35 species of the Argasidae have been reported as parasites of humans (Llanos-Soto et al., 2020; Muñoz-Leal et al., 2020).

With an area of approximately 522,000 km^2, Central America has a rich fauna of ticks, with nearly 80 species reported to date (Muñoz-Leal et al., 2020; Charles et al., 2021; Guglielmone et al., 2021). Of this diversity of ticks, *Amblyomma mixtum*, *Amblyomma ovale*, *Rhipicephalus sanguineus* (*sensu lato*), *Ornithodoros puertoricensis*, and *Ornithodoros talaje* have been reported as relevant to human health for their role as vectors of the pathogens that cause rickettsiosis, ehrlichiosis, relapsing fever, and also for causing paralysis and severe allergies (Baeza, 1979; Lopez et al., 2016; Bermúdez & Troyo, 2018; Daza et al., 2018; Martínez-Caballero et al., 2018; Guglielmone et al., 2021). It is likely that the first records of

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ticks affecting humans in this region were reported in the 19th Century in Guatemala by Guérin-Méneville (1849) and Stoll (1894). Later, in the early 20th Century, researchers continued these observations in the region, and described additional reports on ticks that bite humans in Panama, Costa Rica and Belize (Fairchild et al., 1966; Vargas, 1984), and the pathogens transmitted by them and other problems such as allergies and paralysis (Bates et al., 1921; Dunn, 1933; Rodaniche, 1953; Baeza, 1979).

In the past two decades, new cases of tick infestations in humans have complemented the information previously reported for the region (Álvarez et al., 2005; Rangel & Bermúdez, 2013; Bermúdez et al., 2012, 2017; Romero et al., 2021). Moreover, new cases of tick-borne diseases have been described in all countries of Central America (Lopez et al., 2016; Bermúdez & Troyo, 2018; Daza et al., 2018), including severe or fatal cases caused by *Rickettia rickettsii*, the etiological agent of spotted fever in Costa Rica and Panama (Martínez-Caballero et al., 2018; Bolaños & Chacón, 2019; Zaldívar et al., 2021). Despite the above, no country in this region maintains surveillance programmes for the main species of ticks, or the pathogens they transmit, so the information available is still deficient, scattered and scarce.

The aim of this paper is to present a review of the available literature about tick-bite reports in humans in Central America, and to evidence the most common infectious agents transmitted to humans in this region, as well as the environments where these tick bites are most frequently occurring.

2. Information resources

To identify the species of ticks biting humans in Central America and their frequency, a review of the existing literature was performed using Web of Science, PubMed, Scopus, Google Scholar, MDPI, Springer Nature, BioOne, ScienceDirect, Elsevier, or searching in public libraries. Although the species names are treated here as *bona fide*, verified taxonomic updates are included after Guglielmone et al. (2021). The information was supplemented with unpublished reports for ticks extracted from humans and deposited at the Medical Entomology Collection of the University of Costa Rica (UCR-CR), the Parasitology Laboratory of the Universidad Nacional of Costa Rica (LP-UNA), and the Ectoparasites Collection in "Dr. Eustorgio Méndez" Zoological Collection of the Gorgas Memorial Institute for Health Research (EC/CoZEM-ICGES).

To assess a possible affinity of tick species to humans in Central America, we followed the guidelines suggested by Guglielmone & Robbins (2018), according to the literature or the records in reference collections from Costa Rica and Panama. Thus, "without recent information" refers to the lack of confirmed records in the last 30 years; "without information" means a lack of confirmed data for a specific stage; "insufficient information" indicates information that is not clear or requires additional validation; "very rare" corresponds to unique reports; "rare" corresponds to 2–5 reports in the last 10 years; "sporadic" corresponds to 6–10 records in the last 10 years; "frequent" corresponds to 10–20 records; and "very frequent" corresponds to 21 records or more. In addition, this information is discussed in relation to tick-borne diseases reported in Central America.

3. Tick species and biting frequency: data summary

In conjunction with data from the literature and records from EC/CoZEM-ICGES, UCR-CR, LP-UNA, we collected information for 28 species of ticks reported in humans in Central America. These tick species belong to the genera *Ornithodoros* (6 species) (Argasidae), *Amblyomma* (12 species), *Dermacentor* (3 species), *Rhipicephalus* (2 species), *Ixodes* (2 species and 2 unidentified immature forms), and *Haemaphysalis* (1 species) (all Ixodidae). The ticks reported from humans in Central America are shown in Table 1. With 23 species, Panama is the country with the highest number of species reported parasitizing humans, followed by Costa Rica with 12 species. In this checklist we tentatively maintain the records of *O. talaje* in Panama, and the report of *Ixodes affinis* in Costa Rica. We followed the suggestion of Bermúdez et al. (2021a) to denominate *Ixodes* cf. *boliviensis* from Panama (and provisionally for Central America) as a tentatively different species from *Ixodes boliviensis* from South America.

Moreover, three non-native ticks are reported in humans, i.e. *Rhipicephalus microplus*, *R. sanguineus* (*s.l.*) and *Dermacentor variabilis*; of these, the first two are established in Central America, while *D. variabilis* was only associated with people traveling from the USA.

Table 2 shows the frequency of the reports of ticks biting humans in Central America. *A. mixtum* is the only tick species reported parasitizing humans in the seven Central American countries. Considering the number of records, five species were frequent and very frequent, while 11 species were very rare, rare and sporadic. There are insufficient data for three species and current data are not available for eight species. There is a lack of information for the immature stages of most species, in particular for larvae.

4. Ecological context and public health relevance

The 28 species of ticks reported from humans in Central America correspond to *c*.35% of the species reported in the region. These ticks have different adaptations and preferences to anthropogenic habitats (rural and urban) and natural landscapes; therefore, their contact with humans depends mainly to the specific characteristics of the environment that each tick species requires. It is important to note that most of the records correspond to adults, since the immature stages were not identified for many species. Numerically, *Amblyomma* is the most important genus with species parasitizing humans in Central America, in addition to their relevance in the transmission of tick-borne rickettsial pathogens, while species of the genera *Dermacentor*, *Haemaphysalis* and *Ixodes* are scarcely reported in humans (Fairchild et al., 1966; Guglielmone & Robbins, 2018). Regarding the Argasidae, the only data available for species parasitizing humans correspond to the genus *Ornithodoros*.

Amblyomma mixtum attracts attention in Central America because all life stages are aggressive human-biters, as well as for its wide distribution (Woke, 1947; Fairchild et al., 1966; Varma, 1973; Bermúdez et al., 2012). This is a Nearctic and Neotropical species reported from the USA to Ecuador, and the Caribbean islands such as Jamaica and Trinidad and Tobago (Guglielmone & Robbins, 2018). *Amblyomma mixtum* belongs to the *Amblyomma cajennense* species complex and, before Nava et al. (2014), all records of *A. mixtum* for this region were reported as *A. cajennense*. This species inhabits shrubs, pastures and riparian forests, and is an eclectic parasite that can be found in domestic and wild vertebrates (Fairchild et al., 1966; Beck & Orozco, 2015; Bermúdez et al., 2016; Düttmann et al., 2016; Guglielmone et al., 2021; Montenegro et al., 2021). In humans, the bites of *A. mixtum* can cause severe and mild dermal lesions (Novakova et al., 2015). In this sense, Varma (1973) described the development of granulomatous lesions at the bite sites of *A. mixtum* (cited as *A. cajennense* in his figure 2), which took more than two years to heal. Even so, the role of *A. mixtum* as a vector of *R. rickettsii*, constitutes its main relevance to human health in Central America (Rodaniche, 1953; Bermúdez et al., 2016; Bolaños & Chacón, 2019). Rickettsioisis caused by *R. rickettsii* is the principal tick-borne disease reported in humans in this region due to the severity of the disease presentation, which can result in a high mortality rate in untreated patients (Álvarez-Hernández et al., 2015). In fact, Rodaniche (1953) described *A. mixtum* as the "perfect vector" of *R. rickettsii* in Panama, since this is one of the most abundant tick species with a wide host range and being highly anthropophilic.

Domestic environments offer an adequate habitat for *R. sanguineus* (*s.l.*) (Fairchild et al., 1966). In the Americas, *R. sanguineus* (*sensu stricto*) and *R. sanguineus* (*s.l.*) have been confirmed in subtropical and tropical countries, respectively (Nava et al., 2018; Guglielmone et al., 2021). These ticks are parasites of dogs, and despite their wide distribution, are not native to America. Their origin, ecology, and taxonomy have been

Table 1
Checklist of tick species that parasitize humans in Central America, with indication of confirmed tick-borne diseases (TBD) and skin damage cases (1849–2021)

Country	Species[a]	Type of environment[b]	TBD reported	Skin damage	Reference[c]
Belize	*Amblyomma coelebs*	Not described	No	No	Garnham & Lewis (1959)
	Amblyomma maculatum	Not described	No	No	Garnham & Lewis (1959)
	Amblyomma mixtum[e]	Not described	No	Yes	Varma (1973)[d]
	Ixodes boliviensis[f]	Close to a cave	No	No	Redell & Veni (1996)
Costa Rica	*Ornithodoros* sp. (CR)	Intradomiciliary (*c.*1150 m)	No	Yes	This study[g]
	Ornithodoros kelleyi	Intradomiciliary (*c.*1400–1500 m)	No	Yes	Vargas (1984)[d]
	Amblyomma coelebs	Primary wet forest	No	Yes	Ito et al. (2017)[d]
	Amblyomma sp.	Not described	No	No	This study[h]
	Amblyomma mixtum	Pastures	?	No	Álvarez et al. (2005)
	Amblyomma ovale	Not described	No	No	Álvarez et al. (2005)
	Amblyomma pecarium	Not described	No	No	Álvarez et al. (2005)
	Amblyomma varium	Not described	No	No	Troyo et al. (2016)
	Ixodes affinis[i]	Not described	No	No	Carreno et al. (2001)
	Ixodes cf. *boliviensis*	Peridomiciliary (*c.*1400 m)	No	Yes	This study[j]
	Rhipicephalus microplus	Pastures	No	No	Álvarez et al. (2005)
	***Rhipicephalus sanguineus* (*s.l.*)**	Intradomiciliary (900 and 1100 m)	?	No	This study[h]
El Salvador	***Amblyomma mixtum***	Not described	No	No	Romero et al. (2021)
	***Rhipicephalus sanguineus* (*s.l.*)**	Intradomiciliary, rural and urban	No	No	Romero et al. (2021)
	Rhipicephalus microplus	Pastures	No	No	Romero et al. (2021)
Guatemala	***Amblyomma mixtum***	Not described	No	No	Stoll (1894)
	Amblyomma parvum[k]	Not described	No	No	Guglielmone et al. (1990)
	Ornithodoros talaje	Rural town	No	Yes	Guérin-Méneville (1849)[d]
Honduras	*Amblyomma coelebs*	Wet forest	No	No	Gorham (1996)
	Amblyomma mixtum	Caribbean lowland coast	No	No	Novakova et al. (2015)
Nicaragua	***Amblyomma mixtum***[e]	Deciduous, dry area	No	No	Woke (1947)
	Amblyomma coelebs	Wet forest	No	No	Arana et al. (2021)
Panama	*Ornithodoros* sp. (Pan)	Intradomiciliary, rural	No	No	Rangel & Bermúdez (2013)
	Ornithodoros puertoricensis	Intradomiciliary, urban and rural	No	Yes	Bermúdez et al. (2016)[d]
	Ornithodoros rudis	Intradomiciliary, rural	Yes	No	Dunn (1933)[l,d]
	Ornithodoros talaje	Intradomiciliary, rural	Yes	No	Bates et al. (1921)[d]
	Amblyomma dissimile	Deciduous, dry and wet forests	No	No	Bermúdez et al. (2012)
	Amblyomma mixtum[e]	Pastures and riparian forest	?	No	Rodaniche (1953)
	Amblyomma naponense	Wet forest	No	No	Fairchild et al. (1966)
	Amblyomma cf. *oblongoguttatum*	Rural areas, deciduous and wet forests	No	No	Fairchild et al. (1966)
	Amblyomma ovale	Rural towns, wet forests	No	No	Fairchild et al. (1966)
	Amblyomma cf. *parvum*	Rural areas, dry forests	No	No	Fairchild et al. (1966)
	Amblyomma pecarium	Not described	No	No	Esser et al. (2016)
	Amblyomma sabanerae	Wet forest	No	No	Fairchild et al. (1966)
	Amblyomma tapirellum	Wet forest	No	No	Fairchild et al. (1966)
	Amblyomma varium	Not described	No	No	Esser et al. (2016)
	Dermacentor imitans	Wet forest (*c.*1500 m)	No	No	Fairchild et al. (1966)
	Dermacentor latus	Wet forest (*c.*1500 m)	No	No	Fairchild et al. (1966)
	Dermacentor variabilis	Exotic tick from Nearctic	No	No	Bermúdez et al. (2010)
	Haemaphysalis juxtakochi	Deciduous and wet forests	No	No	Bermúdez et al. (2012)
	Ixodes sp. 1	Cloud forest (1900–2500 m)	No	No	Fairchild et al. (1966)
	Ixodes sp. 2	Cloud forest (*c.*1400 m)	No	No	This study[g]
	Ixodes cf. *boliviensis*	Rural and cloud forest (1800–2800 m)	No	No	Fairchild et al. (1966)
	Rhipicephalus microplus	Pastures	?	No	Bermúdez et al. (2021)[c,d]
	***Rhipicephalus sanguineus* (*s.l.*)**	Intradomiciliary, rural and urban	?	No	Fairchild et al. (1966)

Note: Reports with suspected TBD in humans are indicated by a question mark.
[a] Species reported as vectors are indicated in bold.
[b] Type of environment where bites have been reported in humans, although not representing the entire range of distribution.
[c] Reference represents the first report in humans for each country.
[d] Publications with case descriptions.
[e] Reported as *Amblyomma cajennense*.
[f] Since *Ixodes boliviensis* is usually reported from highlands, the identity of this female requires confirmation.
[g] CoZEM-ICGES.
[h] UCR-CR.
[i] The species is tentatively kept in this list.
[j] LP-UN.
[k] The identity of Central American *A. parvum* requires confirmation (Lado et al., 2016).
[l] Reported as *Ornithodoros venezuelensis*.

discussed previously by Moraes-Filho et al. (2011), Nava et al. (2015, 2018), Páez-Triana et al. (2021) and Sánchez-Montes et al. (2021). Although the records of *R. sanguineus* (*s.l.*) parasitizing humans are scarce in Central America, this species has been implicated in febrile cases of rickettsiosis and ehrlichiosis (Daza et al., 2018; Martínez-Caballero et al., 2018). In addition, despite *R. sanguineus* (*s.l.*) has not been associated with severe allergy reactions in Central America, Valls et al. (2007) reported an anaphylactic shock caused by *R. sanguineus* bites in Spain. This report demonstrates that some cases can lead to serious complications for the patient and there is a need for a differential diagnosis for guiding treatment. In this case, the authors pointed out that the patient had a history of severe and recurring reactions after tick bites.

Other tick species can also benefit from the environment provided in human dwellings. So far, Central American reports of *Ornithodoros* spp. parasitizing humans are related to the presence of synanthropic fauna in homes, such as opossums, rodents or bats (Fairchild et al., 1966; Vargas,

Table 2
Frequency of the reports of ticks parasitizing humans in Central America, according to reports from the last 20 years

Tick species	Frequency		
	Larva	Nymph	Adult
Ornithodoros sp. (CR)	?	?	?
Ornithodoros sp. (Pan)	?	?	?
Ornithodoros kelleyi	–	–	nr
Ornithodoros puertoricensis	–	VF	VF
Ornithodoros rudis	nr	nr	nr
Ornithodoros talaje	nr	nr	nr
Amblyomma cf. *oblongoguttatum*	–	F	F
Amblyomma cf. *parvum*	–	–	R
Amblyomma coelebs	–	R	R
Amblyomma dissimile	–	–	R
Amblyomma maculatum	–	–	–
Amblyomma mixtum	VF	VF	VF
Amblyomma naponense	–	R	R
Amblyomma ovale	–	R	F
Amblyomma pecarium	–	VR	–
Amblyomma sabanerae	–	–	VR
Amblyomma tapirellum	–	R	F
Amblyomma varium	–	VR	–
Dermacentor imitans	–	–	VR
Dermacentor latus	–	–	VR
Dermacentor variabilis	–	–	VF
Haemaphysalis juxtakochi	–	S	S
Ixodes affinis	–	–	?
Ixodes cf. *boliviensis*	–	–	R
Ixodes sp. 1	–	VR	–
Ixodes sp. 2	–	VR	–
Rhipicephalus microplus	–	S	S
Rhipicephalus sanguineus (*s.l.*)	–	–	S

Abbreviations: VR, very rare; R, rare; S, sporadic; F, frequent; VF, very frequent; nr, without recent information; –, without information; ?, insufficient information.

1984). *Ornithodoros* spp. have an underestimated importance to human health in the region, since their bites can cause severe reactions, in addition to being vectors of tick-borne relapsing fever (Lopez et al., 2016). In Guatemala, the description of *O. talaje* was accompanied by the report of human bites in a rural town in a dry region, where the bites were described as "an excruciating itch" and the species as "monstrous" (Guérin-Méneville, 1849). In terms of severity, Vargas (1984) reported cases of *Ornithodoros* spp. bites in humans from highlands of Costa Rica (1100–1500 m above sea level), of which one required hospitalization for anaphylactic shock. In this report, the bites were caused by *Ornithodoros kelleyi* in homes with bats in the roof structure, and provoked pain and edema in the affected area. It is possible that greater attention to these species will add more information for *Ornithodoros* spp. parasitizing humans in Central America, which could involve natural environments beyond the domicile. This is supported by the fact that different species of *Ornithodoros* have been reported parasitizing humans in caves and seabird nesting areas in South America (Clifford et al., 1980; Muñoz-Leal et al., 2019; Llanos-Soto et al., 2020).

Relapsing fever was initially reported in Panama during early 20th Century and was attributed to infection with *Borrelia venezuelensis* (*Borrelia recurrentis* complex) (Lopez et al., 2016). Currently, except for a recent case of relapsing fever reported for a tourist traveling in Belize and Guatemala (Heerdink et al., 2006), there is no recent information of this disease in Central America, a fact possibly attributed to the lack of epidemiological suspicion among physicians. In the last years, *O. puertoricensis* has been reported parasitizing several groups of ectotherm and endotherm vertebrates in Panama, including humans (Rangel & Bermúdez, 2013; Bermúdez et al., 2017). Additionally, *Borrelia puertoricensis*, a new spirochete species of the *B. recurrentis* group, was isolated and described from *O. puertoricensis* in Panama (Bermúdez et al., 2021b). The information of relapsing fever in Belize or Guatemala, the recent cases of human-bites by *O. puertoricensis*, and a description of a new species of *Borrelia* from Panama (*B. puertoricensis*), not only indicate that the pathogens continue to circulate in Central America, but also highlight the need to establish tick surveillance programmes in recreational areas and to reassess relapsing fever in patients with nonspecific febrile signs (Heerdink et al., 2006; Bermúdez et al., 2017, 2021b).

In addition to *A. mixtum*, *R. microplus* has also been reported on humans as a result of exposure to pasture areas in Central America (Table 1). *Rhipicephalus microplus* is the most important parasite of cattle worldwide, due to the direct damage that it causes on livestock, as well as the transmission of pathogens such as *Anaplasma marginale*, *Anaplasma centrale*, among others (Anonymous, 2015; Düttmann et al., 2016). Similar to *R. sanguineus* (*s.l.*), despite the wide distribution of *R. microplus* and its habitats in close proximity to humans, records of this species on humans are discontinuous and considered sporadic (Guglielmone & Robbins, 2018). Similar to other regions, the reports of *R. microplus* in Central America usually correspond to ranchers or farm laborers. In Central America, this species has been recorded parasitizing humans in Costa Rica, El Salvador and Panama (Table 1); in the latter country, the reports were from hospitalized patients with severe and nonspecific febrile symptoms (Bermúdez et al., 2021c). Of note, *R. microplus* is a one-host tick (development from the larval to the adult stage occurs on the same individual host); even so, the reports of this species on humans corresponded to nymphs and adults (Table 2). In this regard, Guglielmone & Robbins (2018) suggested that larval infestations on humans are probably a consequence of entering infested environments, while contacts with nymphs or adults occur for ticks being transferred directly from infested animals.

In Central American forests, *Amblyomma* is the most common genus reported on humans in dry and wet forests lowlands ($\leq$ 1000 m) (Table 2). Therefore, eco-tourists, scientists, park-rangers, or poachers that visit these areas are exposed to both immature and adult stages of various species of ticks (Gorham, 1996; Álvarez et al., 2005; Bermúdez et al., 2012; Troyo et al., 2016; Arana et al., 2021). Compared to *A. mixtum*, sylvatic species seem to maintain a low affinity to humans, in particular species that parasitize ectotherm vertebrates (e.g. *Amblyomma dissimile* and *Amblyomma sabanerae*). Nevertheless, species such as *Amblyomma tapirellum*, *A. ovale*, *A.* cf. *oblongoguttatum*, which were once considered as sporadic on humans (Fairchild et al., 1966; Bermúdez et al., 2012; Guglielmone & Robbins, 2018), seem to be frequently found on people in this region (Table 2). To a lesser extent in Central America, there are sporadic reports of *Haemaphysalis juxtakochi* biting humans, and the mention of *I. affinis* requires confirmation (Guglielmone & Robbins, 2018) (Table 2). Despite there is a considerable information of microorganisms in sylvatic ticks from Central America (Bermúdez & Troyo, 2018; Bermúdez et al., 2021d; Romero et al., 2021), no tick-borne disease records have been associated with sylvatic ticks in this region, but Baeza (1979) reported a case of paralysis caused by *A. ovale* in an USA soldier in Panama.

There are few records of humans being parasitized by ticks in the highlands of Central America (1000–3000 m). Fairchild et al. (1966) provided the only reports of *Dermacentor imitans* and *Dermacentor latus* on humans visiting mature forests in the highlands of Panama. On the other hand, *I.* cf. *boliviensis*, a synanthropic species, is most frequently associated with humans in the highlands of Panama and Costa Rica (Troyo et al., 2014; Bermúdez et al., 2021a). Moreover, the report of an unidentified putative new species of *Ixodes* that has been found parasitizing humans in the mountains of eastern Panama deserves further investigation (Table 1).

Regarding exotic species, *D. variabilis* was reported twice in Panama (Bermúdez et al., 2010, 2019). This exotic species was parasitizing travelers from the USA and is an important vector of Rocky Mountain spotted fever, tularemia, anaplasmosis, as well as an agent of paralysis (Halliday & Sutherst, 1990). Unlike *R. microplus* and *R. sanguineus* (*s.l.*), which were able to thrive and adapt to the ecological characteristics of Central America, the establishment of *D. variabilis* in this region is highly unlikely (Bermúdez et al., 2010). In any case, the findings of exotic tick species like *D. variabilis* may represent a threat due to the transmission of

foreign pathogens, a fact that reinforces the need to increase knowledge about the native species, as well as the pathogens that they can transmit.

5. Conclusions

Despite the diversity of ticks that have been reported in Central America, the region lacks awareness of ticks that parasitize humans and the risks they pose to public health. This is reflected in the scarce information available for most Central American countries, which could be attributed to the fact that tick bites are often underestimated by patients and physicians, preventing more accurate case descriptions. This is important because all ticks should be considered a risk to human health, even if their role as vectors is not known. In Central America, ticks may parasitize humans in habitats as diverse as natural forests, rural landscapes, and cities, in lowlands and highlands, where different zoonoses could become established. Moreover, the broad range of clinical signs and symptoms accompanying tick bites in humans (associated or not with pathogen transmission) warrants the publication of more case descriptions, which would strengthen the diagnostic ability of public health workers in Central America. In this sense, including information detailing life stages and attachment sites is also vital in order to establish prevention strategies, and this should be reported systematically. In addition to the tick species included in this review, there are probably other species that are capable of parasitizing humans in Central America, particularly considering that more than 80 species of ticks have been reported for this region. This review encourages awareness of the importance of ticks in the region by those people who are parasitized, the medical and public health personnel, as well as acarologists, both in Central America and in other countries of the continent.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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