



Occurrence of *Amblyomma sculptum* and *Amblyomma ovale* ticks (Acari: Ixodidae) in the state of Paraná - Brazil

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ABSTRACT. *Amblyomma sculptum* and *Amblyomma ovale* are ticks (Acari: Ixodidae) that commonly bite humans and are associated with Spotted Fever (SF). The objective of this study was to conduct a literature review of articles indexed in the Web of Science platform, published between 1992 and 2024, that report the presence of *A. sculptum* and *A. ovale* in the state of Paraná, Brazil. A total of 30 articles were reviewed, of which most (n = 14) were published by Brazilian publishers, although articles in international journals received more citations. The main topics addressed by the articles were: (i) the use of serological and molecular techniques to detect antibodies and bacteria associated with the causative agents of SF; (ii) application of questionnaires to study participants; (iii) geospatial analyses to determine risk areas; and (iv) collection of free-living ticks and those found on parasitized hosts. Of these articles, 25 reported the presence of *A. ovale* and *A. sculptum*, with the first species recorded parasitizing 26 taxonomic groups of vertebrates, while *A. sculptum* was recorded parasitizing 12 groups. *Amblyomma ovale* accounted for the highest number of parasitic ticks (n = 632), mainly adults found on carnivores. In contrast, 365 *A. sculptum* parasitic ticks were collected, primarily from domestic animals (e.g., dogs and horses). Notable research gaps remain, particularly in areas related to basic biology and environmental perception/education.

Keywords: Bioindicators; basic biology; spotted fever; Ixodidae; parasitism.

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Introduction

Ticks (Acari: Ixodidae) can harbor bacteria from the genus *Rickettsia* (Rickettsiaceae), including *Rickettsia rickettsii*, the causative agent of Brazilian Spotted Fever (BSF) (Szabó et al., 2013). Brazilian Spotted Fever is endemic to Brazil, with the primary vectors being the ticks *Amblyomma sculptum* and *Amblyomma aureolatum*, which feed on capybaras (*Hydrochoerus hydrochaeris*) and dogs (*Canis lupus familiaris*), respectively (Szabó et al., 2013). This disease has a higher incidence in the Southeast region of the country, with human fatality rates ranging between 30% and 60% (Angerami et al., 2012). In 2010, a new species of BSF-related *Rickettsia* (the *Rickettsia parkeri* strain from the Atlantic Forest) was reported in the state of Santa Catarina, presenting milder clinical signs (Oliveira et al., 2016; Spolidorio et al., 2010). In Brazil, *A. sculptum* and *A. ovale*, the primary vectors of Spotted Fever (SF), are widely distributed and are among the most frequent human-biting tick species in the Neotropical region (Guglielmone et al., 2006). Due to the difficulty of early diagnosis and rapid clinical progression of symptoms, SF poses a significant public health problem. Although the disease has been subject to compulsory notification by the Brazilian Ministry of Health since 2001, it remains largely neglected in several areas, particularly in regions where cases are less frequent.

The tick *Amblyomma sculptum*, a species within the *Amblyomma cajennense* complex, primarily hosts tapirs in natural environments (Martins et al., 2016). In human-altered (anthropized) environments, horses and capybaras serve as its main hosts (Martins et al., 2016). *Amblyomma sculptum* is associated with higher mortality rates due to the bacterium *R. rickettsii*, with its transmission dynamics influenced by environmental changes. In contrast, *Amblyomma ovale*, the vector of the Atlantic Forest strain of *R. parkeri* (Spolidorio et al., 2010), typically infests carnivores in natural environments, while its immature stages are associated with birds and mainly small rodents (Labruna et al., 2005; Szabó et al., 2013). However, it frequently parasitizes humans and domestic dogs that enter forested areas (Szabó et al., 2006; 2013).

Although most ticks show host preference, their selectivity may vary depending on factors such as species, developmental stage, and the environment in which they are found (Barros-Battesti et al., 2006; Guglielmone et al., 2003). Understanding the current state of knowledge on these vector species can support ongoing research and strengthen epidemiological surveillance efforts aimed at disease prevention. The objective of this study was to conduct a literature review of studies reporting the occurrence of *A. sculptum* and *A. ovale* in the state of Paraná, Brazil. Specifically, we aimed to (i) highlight certain characteristics of the publications (e.g., origin and journal areas, number of citations, temporal trends); (ii) examine the tick-host associations described in these studies; (iii) map the occurrence of both tick species and their developmental stages; and (iv) identify the municipalities in Paraná with records of autochthonous SF cases.

Materials and methods

This study was based on a literature review of scientific articles available in the Web of Science database from 1992 to May 2024. The following search terms were used in the advanced search: “*Amblyomma sculptum*”, “*Amblyomma cajennense*”, “*Amblyomma ovale*”, “Febre Maculosa Brasileira,” “Spotted Fever”, “*Rickettsia rickettsii*”, and “ticks”, combined with the term “Paraná” using the Boolean operator AND. Articles referencing the focal species of this study (i.e., *Amblyomma sculptum* [*A. cajennense*] and/or *A. ovale*) were selected. Additionally, the nationality of the journals, number of citations, and year of publication were recorded.

To assess whether the number of citations per article varied according to the nationality of the journals, two averages were calculated: (i) the number of citations for each article was divided by its age in years (from 1992 to May 2024), then (ii) these values were summed according to each nationality and divided by the total number of articles published, resulting in an average number of citations per year by nationality. Some studies did not specify the tick’s developmental stage, and, in these cases, they were categorized as “Undefined.” Similarly, not all studies reported the number of sampled or parasitized hosts, so this quantitative information was not included in this study. The chi-square test was used to verify differences between the number of articles according to the nationality of the journals and between the average number of citations according to each nationality. The chi-square test was performed using the “multinomial.multcomp” function of the “RVAideMemoire” package (Hervé, 2020) in the R programming language (version 4.0.1, R Core Team, 2018).

The spatial analysis of data regarding the occurrence/abundance of tick species and their developmental stages, as well as the municipalities with autochthonous SF cases, was conducted using QGIS 3.22.511 software (QGIS Development Team, 2022). Tick records (i.e., municipalities of occurrence) were extracted from the reviewed articles (1992–2024), while SF case data were obtained from DataSus/Sinan (2007–2023) (Departamento de Informação e Informática do SUS, 2024). The data were spatialized in a Geographic Information System (GIS) environment, and choropleth maps were generated using the natural breaks (Jenks) method.

Results and discussion

A total of 30 scientific articles were identified from 1992 to May 2024. Of these, eight focused primarily on parasitism, one addressed the ecology and behavior of free-living tick communities, another covered aspects of *Ehrlichia canis*, and the remaining articles examined SF or its occurrence in the state of Paraná. Twenty-eight articles were published in English, with the majority coming from Brazilian publishers (47%; $n = 14$), followed by American and German (20%; $n = 6$ each), British (10%; $n = 3$), and Swedish publishers (3%; $n = 1$) ($\chi^2 = 55.900$; $df = 4$; $p < 0.001$). Collectively, the articles had accumulated 479 citations by May 2024, with an average of 15.96 citations per article. When the average number of citations per year was separated according to the publisher’s country, articles published by U.S. and German publishers showed the highest citation rates (an average of 2.85 and 2.35 citations per article per year, respectively). Articles published by Brazilian publishers averaged one citation per year; however, no significant difference was found ($\chi^2 = 1.543$; $df = 4$; $p < 0.819$). Until 2005, studies primarily focused on records of *A. ovale* and *A. sculptum* in free-living stages and on parasitism. After 2010, the number of publications increased significantly, including aspects related to pathogenic agents, particularly those associated with SF. This increase in the number of published articles and the expansion of research focus are likely linked to the first confirmed BSF case in the state of Paraná in 2005 (Freitas et al., 2010). Additionally, from 2011 onwards, articles began to be published in international journals, highlighting the global relevance of this topic. Figure 1 shows the number of publications and the average number of citations per article by year of publication.

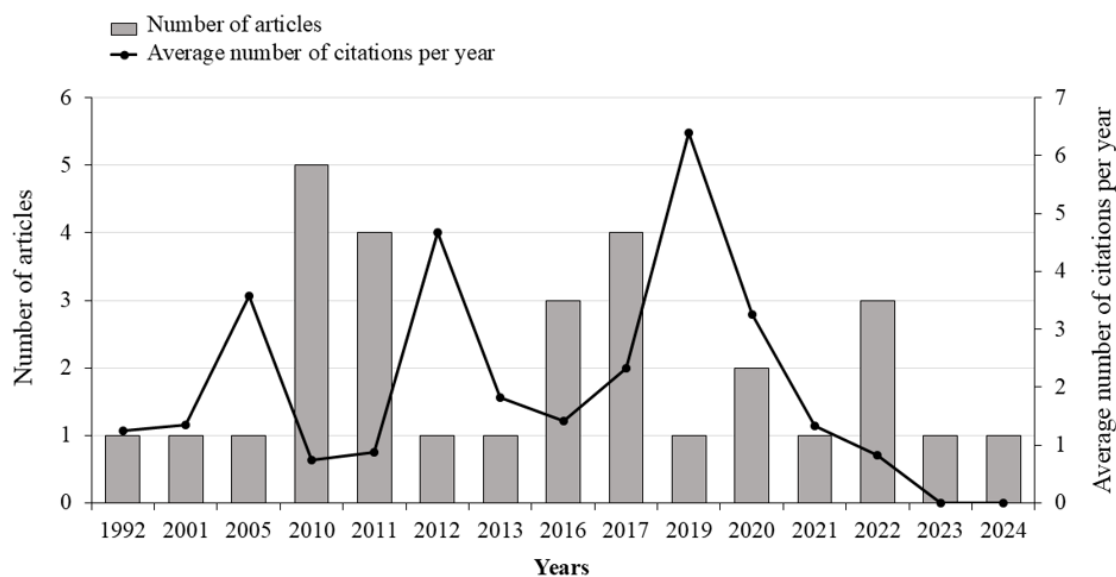


Figure 1. Number of publications and the average number of citations by year of publication of the scientific articles.

The 30 articles addressed the following topics: (i) the use of serological and molecular techniques for the detection of antibodies and bacteria associated with the causative agents of SF; (ii) the application of questionnaires to study participants; (iii) geospatial analyses to determine risk areas; and (iv) the collection of the two tick species from free-living, domestic, and wild animals, and humans.

Eighteen articles addressed serological and molecular techniques used for detecting antibodies and bacteria associated with the causative agents of SF. Thirteen of these studies employed indirect immunofluorescence techniques to detect antibodies in serum samples from humans, dogs, horses, donkeys, wild boars, and capybaras, primarily in the metropolitan and North Central mesoregions of Curitiba. In the metropolitan/coastal region of Curitiba and on oceanic islands, serological evidence of *R. rickettsii*, *R. parkeri*, *R. rhipicephali*, *R. felis*, *R. belli*, and *R. amblyommatis* - all belonging to the BSF group - was found in dogs, horses, wild boars, and humans (Batista et al., 2010; Fortes et al., 2010; Freitas et al., 2010; Kmetiuk et al., 2019; 2022). The first confirmed human case of BSF reported by the Ministry of Health was in the metropolitan region of Curitiba in 2005 (Freitas et al., 2010). Overall, the studies indicate the presence of antibodies, but with low activity in this region of the state.

It is important to note that in the Northern Pioneer mesoregion, where fatal cases of BSF have been recorded, only one study employed a serological approach (Otomura et al., 2016). Based on a large number of samples ($n = 822$ animals, including dogs [$n = 592$], horses [$n = 185$], and donkeys [$n = 45$]), the study found that two dogs tested positive for homologous antigens for *R. parkeri* (maximum titer of 512) and five horses for *R. rickettsii* (maximum titer of 2048). The authors emphasized that, although the seroreactivity rate was low, the studied region constitutes a risk area for BSF, and the ecoepidemiological context requires continuous surveillance actions. Fortes et al. (2011) found that capybaras in Foz do Iguaçu (Western Mesoregion) generally showed low titers (< 512); however, two individuals had homologous antigens for *R. rickettsii*, and one for *R. parkeri*, suggesting a potential risk of human contact with these two species of rickettsiae, and reinforcing the need for monitoring these capybara populations. Kmetiuk et al. (2022) reported that dogs sampled on Superagui Island, Peças Island, and in Guaraqueçaba had maximum titers for *R. parkeri* of 256, 1024, and 2048, respectively, indicating that these locations are likely areas for rickettsial transmission.

Molecular techniques were employed to detect several bacteria of the genus *Rickettsia* spp. in ticks ($n = 8$) (Batista et al., 2010; Durães et al., 2021; Kmetiuk et al., 2019; Toledo et al., 2011a; Toledo et al., 2011b). Notably, Durães et al. (2021) identified rickettsiae from the BSF group in free-living adult *A. sculptum* during an extensive sampling in Porto Rico. *Amblyomma ovale* collected from dogs and the rodent *Euryoryzomys russatus* were found to be infected with *R. bellii*, *R. parkeri* and an unidentified *Rickettsia* species from the Atlantic Forest (Blanco et al., 2017; Durães et al. 2021; Tamekuni et al., 2011). Additionally, Pacheco et al. (2012) recorded three species of rickettsiae (*Rickettsia amblyommii* strain AL - currently referred to as *R. amblyommatis*, *R. parkeri* strain NOD, and *R. parkeri* strain ApPR) in *Amblyomma longirostre* and *Amblyomma parkeri* ticks collected from birds. Factors such as the high pathogenicity of the bacterium *R. rickettsii* and its

low capacity for transstadial and transovarial transmission may contribute to the low infection rates observed in *A. sculptum* (Labruna, 2009; Soares et al., 2012). Nieri-Bastos et al. (2016) performed hemolymph tests followed by isolation in Vero cells and identified *Rickettsia* sp. strain from Mata Atlântica (currently referred to as *R. parkeri* strain from the Atlantic Forest) in *A. ovale* collected from a dog in Adrianópolis, a city in the metropolitan region of Curitiba. Considering that *A. ovale* is an aggressive species toward humans in Latin America and Brazil (Guglielmone et al., 2006; Nogueira et al., 2022; Szabó et al., 2006), it is reasonable to think that humans may be exposed to this rickettsiosis in several Brazilian states (Szabó et al., 2013).

Another methodology used in the articles ($n = 6$) was the application of epidemiological questionnaires to park visitors or pet owners (Batista et al., 2010; Kmetiuk et al., 2022; Labruna et al., 2001; Sohn-Hausner et al., 2024; Toledo et al., 2011a; 2011b). This type of methodological approach aids in the initial understanding of shared-use areas among vectors, hosts, and humans, revealing a degree of exposure within this triad. Batista et al. (2010) also included questions about SF in their questionnaires targeting residents in the metropolitan region of Curitiba. The authors found that nearly 43% of dog and horse owners had no knowledge about the disease, its clinical signs, or how the pathogens were transmitted. Therefore, it becomes essential to adopt strategies related to environmental education/perception as a mitigating measure to reduce contact with and control these ectoparasites in both animals and their environments.

The geospatial analyses addressed in the articles ($n = 4$) contributed to identifying risk areas, including the distribution of vectors, fatal and non-fatal cases, and seropositivity for SF (Durães et al., 2021; Otomura et al., 2016; Valente et al., 2021; 2022). More specifically, Durães et al. (2021) found that the number of confirmed cases occurred across a wide area of the state, but fatalities were concentrated in the Northern Pioneer Mesoregion. According to these authors, mild cases were more frequent in areas with agriculture, pasture, and forest cover, while fatalities occurred predominantly in agricultural zones and the Paranapanema River basin. Thus, mapping SF cases and their vectors is an important tool for assessing spatial distribution and guiding surveillance and control efforts (Nasser et al., 2015; Ribeiro et al., 2020).

Regarding ticks, 25 articles reported their presence in free-living conditions or parasitism, with only five research groups collecting these species in the wild, highlighting a lack of systematic studies on free-living ticks (Arzua et al., 2005; Durães et al., 2021; Sohn-Hausner et al., 2024; Suzin et al., 2020; Toledo et al., 2011a). Suzin et al. (2020) collected 78 *A. ovale* ticks in free-living conditions over two and a half years in Iguaçu National Park (11 nymphs and 67 adults), with a notable peak in adult abundance during the spring. Furthermore, this tick species exhibited ambush behavior in vegetation at lower heights compared to other species and was more frequently collected using drag flagging.

Suzin et al. (2020) did not find *A. sculptum* in Iguaçu National Park, an area of preserved forest. However, Durães et al. (2021) conducted extensive health surveillance work in the state of Paraná, collecting 414 nymphs and 105 adults of *A. sculptum* during investigations of SF cases across 67 municipalities in the state between 2013 and 2018. Additionally, Sohn-Hausner et al. (2024) collected 41 nymphs of *A. sculptum* in free-living conditions in Pinhais, where this tick species had not been detected between 2007 and 2020. Understanding the behavior and life cycle of ticks allows for inferences about periods when humans may be more susceptible to bites. It is worth noting that the taxonomic identification key for nymphs of the genus *Amblyomma* was published only in 2010 (Martins et al., 2010), and there is no species-level identification key for the larvae of this genus, which may have contributed to the lower refinement of data published in scientific articles, especially the older ones.

Amblyomma ovale has been recorded parasitizing a greater number of vertebrate taxonomic groups ($n = 26$) compared to *A. sculptum* ($n = 12$) (Table 1), which may be associated with the fact that *A. ovale* primarily occurs in Atlantic Forest areas, the predominant biome in the state of Paraná (Szabó et al., 2013; Valente et al., 2021).

Table 1. Total number of *Amblyomma ovale* and *Amblyomma sculptum* ticks recorded in the 25 scientific articles. L = Larva; N = Nymph; A = Adult; ND = Stage not defined by the authors.

	<i>Amblyomma ovale</i>				<i>Amblyomma sculptum</i>			
	L	N	A	ND	L	N	A	ND
Free living	0	9	69		0	455	608	
Parasitism	17	47	507	61	55	40	199	71
Not specified	0	0	0		0	135	40	
Total specified	17	56	576		55	630	847	
TOTAL		710				1603		

A total of 2,313 ticks were recorded, with the majority being *A. sculptum* (n = 1,603) (Table 1). Furthermore, some articles did not specify the behavior (parasitism or free-living) or the developmental stage of the collected ticks (61 records for *A. ovale* and 71 for *A. sculptum*). The detailed presentation of data is an important tool for review studies and is essential for understanding the ecoepidemiological aspects of SF.

Amblyomma ovale parasitized hosts from six orders: Artiodactyla, Carnivora, Passeriformes, Primates, Rodentia, and Didelphimorphia. Notably, immature stages of this tick species predominated in Passeriformes and rodents (81.25% of the total immature records). In contrast, adult ticks were primarily recorded in Carnivora (94.87% of adult records), with significant numbers in both wild and domestic animals (Table 2). Only adult *A. ovale* specimens were recorded in humans (Table 2). It is noteworthy that a study exclusively addressed parasitism in humans, including aspects such as species, stages, seasonality, and bite sites (Suzin et al., 2022). These findings reinforce the pattern that immature and adult stages of this species are associated, respectively, with rodents and carnivores (Nava et al., 2017). Furthermore, the importance of dogs as hosts is evident, as they carry this tick species to humans, potentially enhancing parasitism and consequently the possible transmission of pathogenic agents (Szabó et al., 2013). It is important to note that *A. ovale* is involved in the transmission of the bacterium *R. parkeri* Atlantic Forest strain, which causes a milder rickettsiosis, characterized by symptoms such as lymphadenopathy, fever, and rash (Barbieri et al., 2014; Krawczak et al., 2016).

Amblyomma sculptum was also recorded parasitizing hosts from six orders: Artiodactyla, Carnivora, Passeriformes, Perissodactyla, Primates, and Rodentia (Table 2). There is a notable predominance of immature stages of this tick species in Carnivora (exclusively in domestic dogs), Passeriformes, and Primates (13.7%, 56.8%, and 25.3%, respectively, of the total immature records). In contrast, adult ticks were predominantly recorded in Perissodactyla (83.42%), Primates (7.03%), and Artiodactyla (6.53%), with nearly 74% of records involving horses (*Equus caballus*) (Table 2). Horses are considered sentinels for BSF due to their ability to seroconvert without presenting clinical manifestations of the disease (Souza et al., 2016). Moreover, their considerable mobility enables them to harbor and transport a large number of ticks. Additionally, 24 nymphs and 14 adults of *A. sculptum* were recorded on humans (Table 2), highlighting the aggressiveness of this species. It is important to emphasize that *A. sculptum* has significant epidemiological relevance in Brazil, as it is involved in the transmission of the bacterium *R. rickettsii*.

Table 2. *Amblyomma ovale* and *Amblyomma sculptum* ticks recorded in different taxa of vertebrate animals. L = Larva; N = Nymph; A = Adult; ND = Stage not defined by the authors.

Order and Species	<i>Amblyomma ovale</i>				<i>Amblyomma sculptum</i>			
	L	N	A	ND	L	N	A	ND
Artiodactyla								
<i>Tayassu pecari</i>	0	0	0	0	1	3	8	0
<i>Sus scrofa</i>	0	0	1	0	0	0	5	0
Total Artiodactyla	0	0	1	0	1	3	13	0
Carnivora								
<i>Cerdocyon thous</i>	0	2	15	0	0	0	0	0
<i>Eira barbara</i>	0	0	61	0	0	0	0	0
<i>Herpailurus yagouaroundi</i>	0	0	1	0	0	0	0	0
<i>Galictis cuja</i>	0	0	2	0	0	0	0	0
<i>Lutra longicaudis</i>	0	0	102	0	0	0	0	0
<i>Nasua nasua</i>	0	0	122	0	0	0	0	0
<i>Procyon cancrivorus</i>	0	0	24	0	0	0	0	0
<i>Puma concolor</i>	0	1	21	0	0	0	0	0
<i>Panthera onca</i>	0	6	21	0	0	0	0	0
<i>Leopardus guttulus</i>	0	0	2	0	0	0	0	0
<i>Leopardus pardalis</i>	0	0	2	0	0	0	0	0
<i>Canis lupus familiaris</i>	0	3	108	61	0	13	3	2
Total Carnivora	0	12	481	61	0	13	3	2
Passeriformes								
<i>Cichlocolaptes leucophrys</i>	0	0	0	0	42	0	0	0
<i>Conopophaga lineata</i>	0	0	0	0	5	0	0	0
<i>Drymophila rubricollis</i>	0	2	0	0	0	0	0	0
<i>Passerina brissonii</i>	16	2	0	0	0	0	0	0
<i>Pyrrhocomma ruficeps</i>	0	0	0	0	3	0	0	0
<i>Tachyphonus coronatus</i>	0	0	0	0	4	0	0	0
<i>Turdus albicollis</i>	0	2	0	0	0	0	0	0
Total Passeriformes	16	6	0	0	54	0	0	0

Perissodactyla								
<i>Equus caballus</i>	0	0	0	0	0	0	147	69
<i>Tapirus terrestris</i>	0	0	0	0	0	0	19	0
Total Perissodactyla	0	0	0	0	0	0	166	69
Primates								
<i>Cebus apella</i>	0	0	1	0	0	0	0	0
<i>Homo sapiens</i>	0	0	11	0	0	24	14	0
Total Primates	0	0	12	0	0	24	14	0
Rodentia								
<i>Akodon montensis</i>	0	4	0	0	0	0	0	0
<i>Euryoryzomys russatus</i>	0	22	0	0	0	0	0	0
<i>Hydrochoerus hydrochaeris</i>	0	0	0	0	0	0	2	0
<i>Nectomys squamipes</i>	0	0	2	0	0	0	0	0
<i>Oligoryzomys nigripes</i>	1	1	0	0	0	0	0	0
<i>Oligoryzomys sp.</i>	0	1	0	0	0	0	0	0
<i>Sphiggurus villosus</i>	0	0	1	0	0	0	1	0
<i>Thaptomys nigrita</i>	0	1	0	0	0	0	0	0
Total Rodentia	1	29	3	0	0	0	3	0
Didelphimorphia								
<i>Didelphis albiventris</i>	0	0	10	0	0	0	0	0
Total Didelphimorphia	0	0	10	0	0	0	0	0
TOTAL	17	47	507	61	55	40	199	71
			632				365	

Spatially, the presence of *A. ovale* and *A. sculptum* ticks was recorded in 47 municipalities across the state of Paraná. *Amblyomma ovale* was detected in 21 municipalities (representing 7 mesoregions), while *A. sculptum* was found in 35 municipalities (9 mesoregions) (Figure 2).

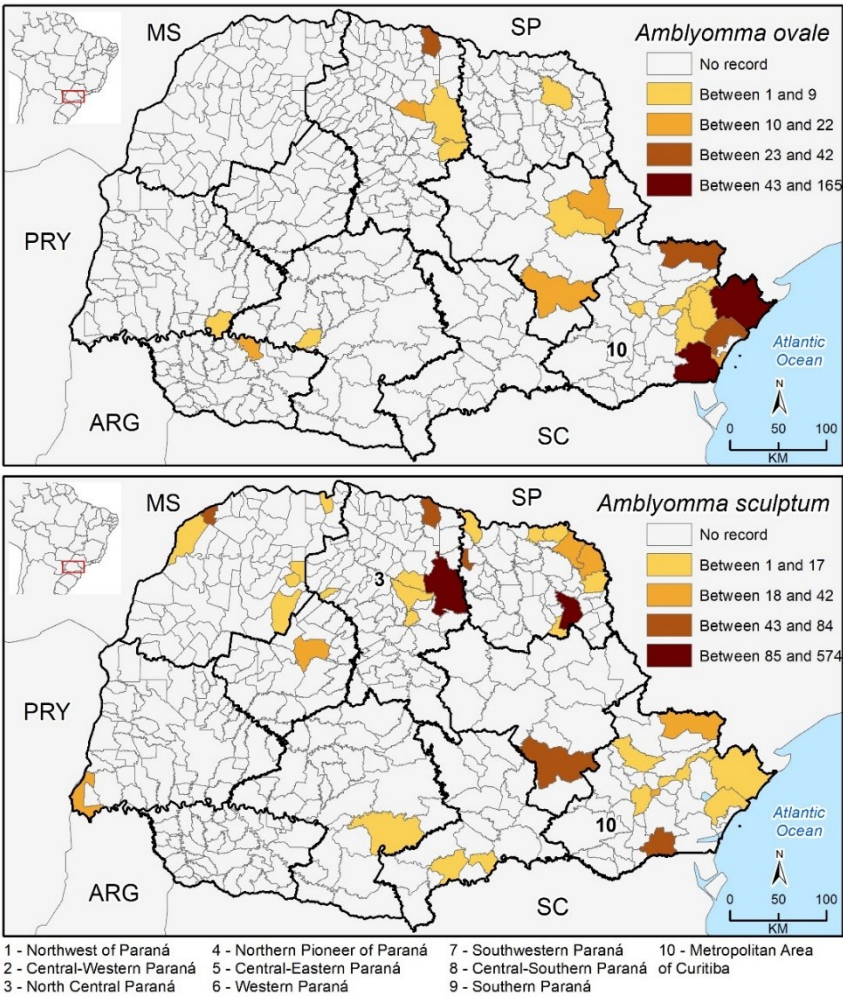


Figure 2. Geographic distribution of *Amblyomma ovale* and *Amblyomma sculptum* ticks in the state of Paraná, Brazil, from 1992 to 2024.

When we spatialize these two species according to their developmental stages, we can observe that larvae and adults were the least and most abundant stages, respectively, for both species (Figure 3).

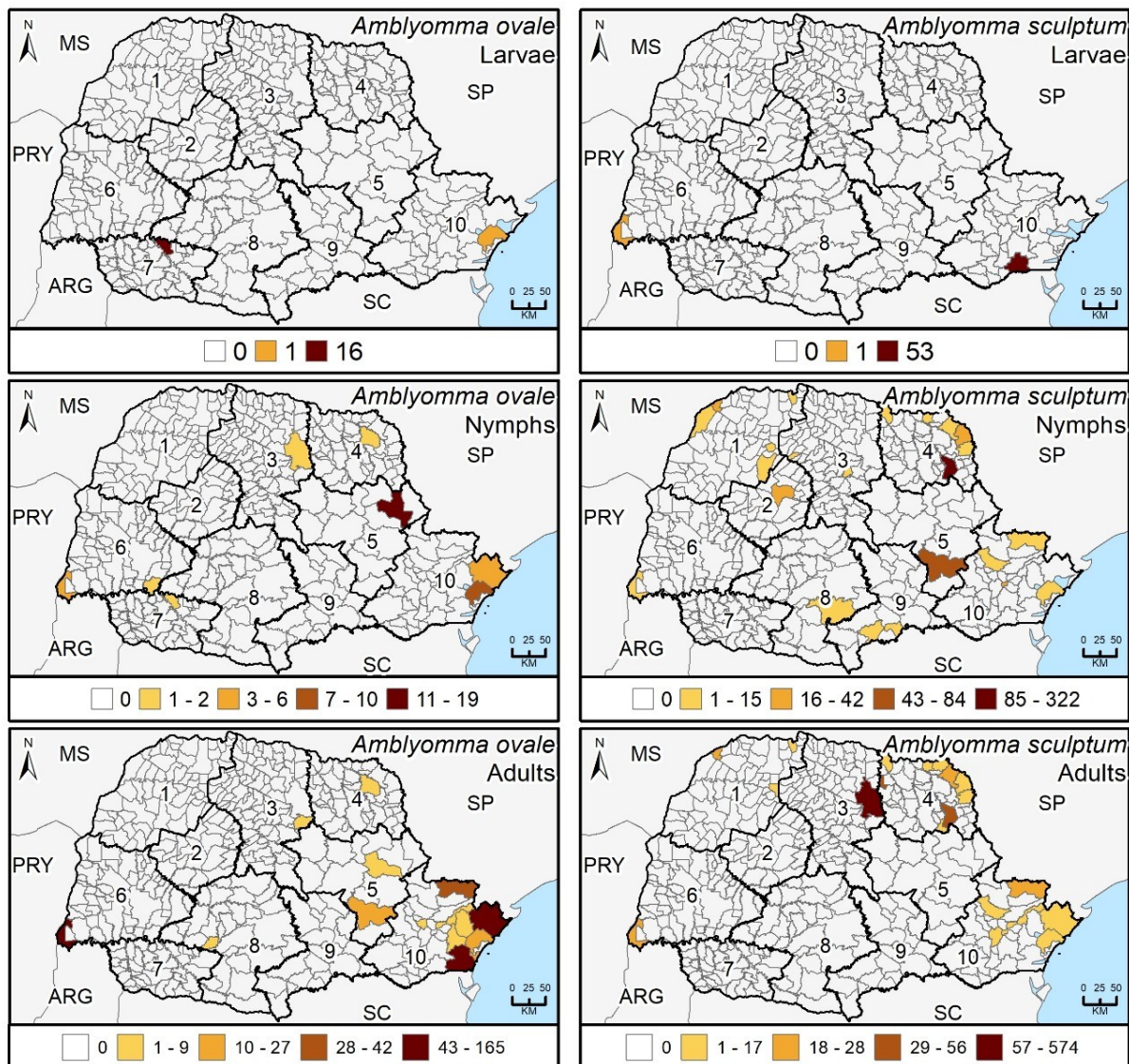


Figure 3. Geographic distribution of *Amblyomma ovale* and *Amblyomma sculptum* ticks in the larval, nymph, and adult stages in the state of Paraná, Brazil, from 1992 to 2024.

As observed, autochthonous cases of SF were recorded in 38 municipalities in the state of Paraná, with 71 confirmed cases between 2007 and 2023 (Figure 4). A case cluster was also observed in the Metropolitan Region of Curitiba (Figure 4). Despite this, four of the five confirmed fatal cases of SF (confirmed by laboratory tests) occurred in the Northern Pioneer Region of Paraná (Departamento de Informação e Informática do SUS [DATASUS], 2024). In many municipalities, although no tick records exist, cases of BSF have been reported. This may be associated with the possible presence of other vector species, such as *A. aureolatum* (Faccini et al., 2022; Pinter et al., 2004). Therefore, these findings underscore the need to expand studies on the basic biology of these tick species as a means of preventing the disease.

Conclusion

The increase in international publications on ticks and Spotted Fever may be related to the disease's geographic expansion and the high visibility of these journals. Most studies focus on detecting antibodies and bacteria, emphasizing the importance of this topic for public health. However, there are still gaps regarding tick behavior and parasitism. In our study, two tick species showed associations with specific hosts and areas. Future research should explore ticks as environmental bioindicators. Environmental education and geospatial

analysis may help identify risk areas and support surveillance efforts, improving data quality and guiding preventive public health strategies.

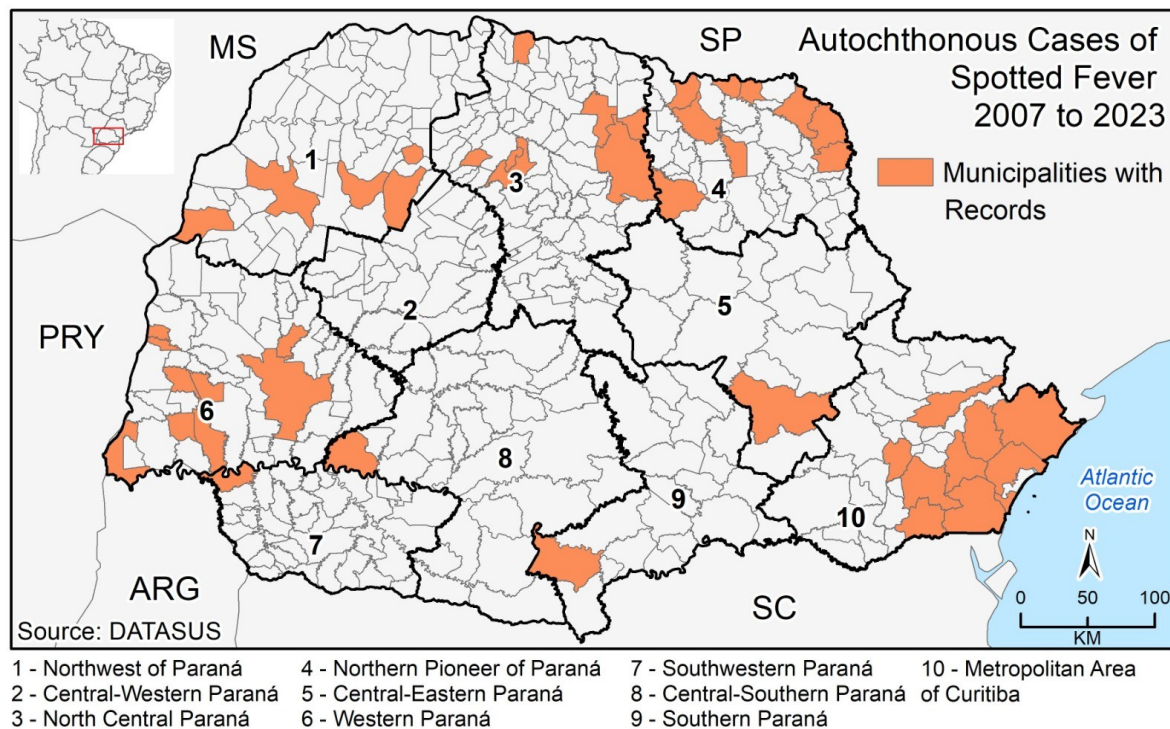


Figure 4. Autochthonous cases of SF recorded in the state of Paraná, Brazil, from 2007 to 2023. Source: DataSus, accessed on August 8, 2024.

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