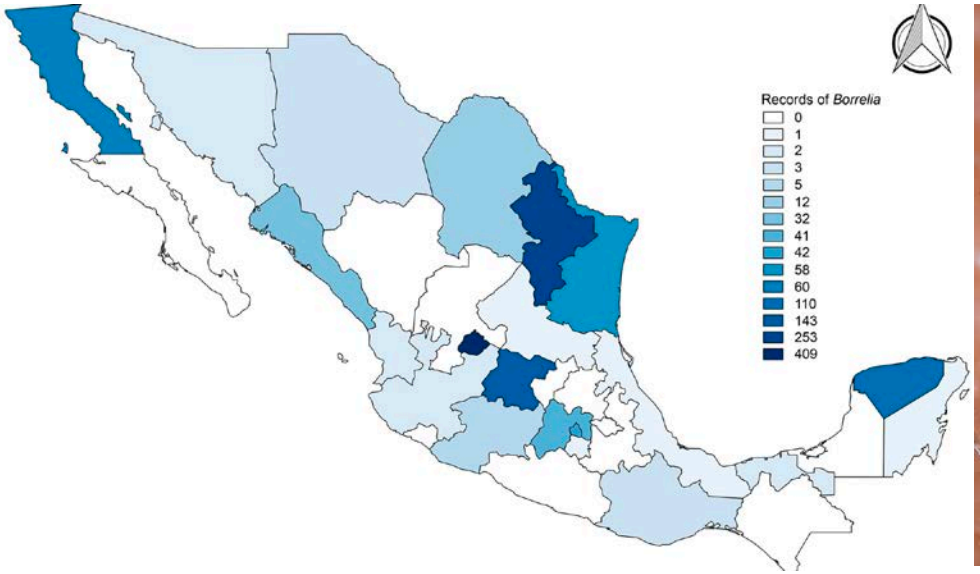

Lyme disease and relapsing fever in Mexico: An overview of human and wildlife infections

Colunga-Salas Pablo and *et al*., 2020. PLOS ONE (IF 3.3, H-Index 367, Q1)
Presented on May 12, 2025

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Introduction

Tick-borne pathogens (TBPs) have emerged as significant public health concerns due to the continuous rise in the incidence of human and animal diseases they cause.

Among these, several bacterial species belonging to the genus *Borrelia* can infect both humans and animals.

This bacterial genus comprises various Gram-negative spirochetes, which are phylogenetically classified into four distinct groups:

- Reptile-associated *Borrelia* (REP).
- Monotreme-associated *Borrelia* (MAB).
- Relapsing Fever group (RF).
- Lyme Borreliosis group (LB).

Introduction

Borrelia species causing relapsing fever are primarily transmitted by soft ticks of the genus *Ornithodoros* and, in some cases, by the human body louse (*Pediculus humanus*).

However, hard ticks from genera such as *Ixodes*, *Amblyomma*, and *Rhipicephalus* have also been proposed as potential vectors.

In Mexico, data regarding *Borrelia* species diversity, wildlife infections, and human cases remain fragmented and often controversial.

Information on this genus is poorly disseminated and frequently published in local bulletins with limited accessibility. Moreover, no confirmatory evidence of endemic human Lyme disease cases has been reported in Mexico.

Case report

In August 2017, a 67-year-old unemployed male sought medical attention. He was originally from Veracruz, Mexico, where his family owns a cattle farm.

After visiting the family property in northern Veracruz in August 2016, he developed a persistent erythematous skin lesion that lasted several weeks but did not seek medical assistance.

In September 2016, he began experiencing diplopia and fatigue.

DNA was extracted from whole blood samples, and serological analysis was performed using Western blotting with anti-*Borrelia burgdorferi* IgM and IgG kits.

A ~280 bp fragment of the *fla* gene encoding flagellin was amplified via conventional PCR and visualized on 2% agarose gels.

Case report

Results

- Western blotting was positive for IgG and indeterminate for IgM.
- The PCR product yielded a ~280 bp band, confirming the presence of *Borrelia burgdorferi sensu stricto.*
- This case represents the first confirmed autochthonous human Lyme disease case in Mexico and includes the first *Borrelia*sequence reported from the country.

Compilation of Borrelia studies in Mexico from published records

Methodology for databases compilation

An extensive literature review was conducted to create a comprehensive database of published studies on *Borrelia* in humans, mammals, and ticks in Mexico between 1939 and 2020.

Human data parameters.

- *Borrelia* species
- Number of human cases
- Sex
- Age group (newborn [0–2], childhood [3–12], adolescence [13–18], adult [19–60], elderly [+60])
- Population type (urban/rural)
- Vector species
- Year of publication
- Detection method
- Locality

Compilation of Borrelia studies in Mexico from published records

Animal database.

For animal and tick-related studies, the recorded data included:

- *Borrelia* species
- Number of positive animals by taxonomic classification (order, family, genus, species)
- Tick classification (family, genus, species)
- Year of collection
- Detection method
- Locality

Mammalian taxonomy was updated following the most recent taxonomic references for Mexico.

Results of databases for Borrelia studies in Mexico

A total of 1,347 records were identified from 39 studies.

Of these, 29.5% (398/1,347) were human cases, while 70.5% (949/1,347) pertained to animals. Only one study included both host types.

The most common diagnostic tools were serological assays (ELISA, Western blotting, and IFA), followed by molecular detection methods (PCR).

Results of databases for Borrelia studies in Mexico

Table 1. Pathogenic *Borrelia* species.

Borrelia group	Species	Region/Country	Disease
RF	*Borrelia baltazardii*	Iran	TBRF (Tick-borne relapsing fever)
	Borrelia braziliensis	Brazil	TBRF
	Borrelia caucasica	Caucasus area	TBRF
	Borrelia coriaceae	Western North America	Bacteremia of deer
	Borrelia crocidurae	Western and northern Africa	TBRF, mild symptoms
	Borrelia dugesii	Mexico	TBRF
	Borrelia duttonii	Central, eastern and southern Africa	TBRF, Neurological signs, neonatal infections
	Borrelia graingeri	Kenya	Flu-like syndrome
	Borrelia harveyi	Kenya	Bacteremia of monkeys
	Borrelia hermsii	Western North USA, Brirish Columbia (Canada)	TBRF
	Borrelia hispanica	Iberian Peninsula and northern Africa	TBRF
	Borrelia latyschewii	Central Asia and Middle East	TBRF, Flu-like syndrome
	Borrelia lonestari	Southern and eastern United States	Bacteremia of deer
	Borrelia mazzottii	Mexico, Central America and Western USA	TBRF
	Borrelia microti	Iran	TBRF
	Borrelia miyamotoi	Europe, Asia and North America	TBRF, Flu-like syndrome
	Borrelia parkeri	Western USA	TBRF
	Borrelia persica	Central Asia, Middle East, Egypt and India	TBRF
	Borrelia queenslandica	Australia	Bacteremia with relapse in mice
	Borrelia recurrentis	Africa (Global)*	Louse-borne relapsing fever
	Borrelia theileri	Africa (Global)**	Bovine borreliosis
	Borrelia turicatae	British Columbia (Canada), Southwestern and south-central United States and Mexico	TBRF
	Borrelia venezuelensis	Central America and northern South America	TBRF
	Candidatus Borrelia kalaharica	Africa	TBRF

Results of databases for Borrelia studies in Mexico

Table 1. Pathogenic *Borrelia* species.

Borrelia group	Species	Region/Country	Disease
LB	*Borrelia afzelii*	Europe and Asia	Lyme Disease (LD)
	Borrelia americana	North America	LD
	Borrelia andersonii	US	LD
	Borrelia bavariensis	Europe	Lyme borreliosis
	Borrelia bissettii	North America and Europe	LD
	Borrelia burgdorferi s.s.	East and West United States and Eastern Europe	LD
	Borrelia garinii	Europe and Asia	LD
	Borrelia lusitaniae	Mediterranean basin	LD
	Borrelia mayonii	Upper midwestern US	Lyme borreliosis
	Borrelia spielmanii	Europe	LD
	Borrelia valaisiana	Europe and Japan	LD

Results of databases for Borrelia studies in Mexico

Human cases.

- Between 1939 and 2020, 398 human cases of *Borrelia* infection were recorded in Mexico. Lyme borreliosis accounted for 98.7% (393/398) of cases, while relapsing fever was reported in only 1.3% (5/398).

Animal reports

- A total of 949 records involved 17 mammalian species across six taxonomic orders. Of these, 58% (551/949) were caused by the RF group, and 41.9% (398/949) were attributed to the *B. burgdorferi sensu lato* complex.

Results of databases for Borrelia studies in Mexico

Table 2. *Borrelia* species reported in Mexico.

Borrelia group	*Borrelia* species	No. of records	Type of host
RF	***B. duguesii***	1	Animal
	B. mazzottii	1	Animal
	B. turicatae	549	Animal
LB	***B. afzelii***	2	Human
	B. burgdorferi s.s.	128	Human
		36	Animal
	B. garinii	10	Human

Results of databases for Borrelia studies in Mexico

Studies on arthropods and potential *Borrelia* vectors revealed 14 species

Table 4. Tick species recorded to be associated with *Borrelia* species in Mexico.

Tick species		Mammalian species	*Borrelia* species
Family	**Species**		
Argasidae	*Ornithodoros turicata*	ND	*B. turicatae*
	Ornithodoros duguesi	*Neotoma micropus*	*B. duguesii*
	Ornithodoros talaje	ND	*B. mazzottii*
Ixodidae	*Amblyomma americanum*	*Homo sapiens sapiens*	*B. burgdorferi* s.s.
	Amblyomma cajennense	*Bos Taurus*	*B. burgdorferi* s.s.
		Canis lupus familiaris	*B. burgdorferi* s.s.
		ND	*B. burgdorferi* s.s.
	Amblyomma mixtum	*Canis lupus familiaris*	*B. burgdorferi* s.l.
	Dermacentor andersoni	ND	*B. burgdorferi* s.s.
	Dermacentor variabilis	ND	*B. burgdorferi* s.l.
	Ixodes affinis	*Canis lupus familiaris*	*B. burgdorferi* s.l.
	Ixodes kingi	*Vulpes macrotis*	*B. burgdorferi* s.s.
	Ixodes scapularis	*Heteromys pictus*	*B. burgdorferi* s.l.
		Panthera onca	*B. burgdorferi* s.l.
		Sylvilagus floridianus	*B. burgdorferi* s.s.
		Sylvilagus floridianus	*B. burgdorferi* s.l.
		ND	*B. burgdorferi* s.l.
	Ixodes spinipalpis	ND	*B. burgdorferi* s.l.
	Ixodes texanus	*Basariscus astutus*	*B. burgdorferi* s.s.
	Ixodes tovari	ND	*B. burgdorferi* s.l.
	Rhipicephalus sanguineus s.l.	*Canis lupus familiaris*	*B. burgdorferi* s.l.

Results of databases for Borrelia studies in Mexico

Among 569 tick records, 96.7% (550/569) contained RF-causing *Borrelia*, and only 3.3% (19/569) were linked to the LB group.

Geographic analysis

Of 1,364 total cases (including 17 from national surveillance systems), 85.4% (1,166) were geo-referenced at least to the state level, spanning 18 of Mexico's 32 states.
States with the highest case numbers were Aguascalientes (30%), Nuevo León (18.5%), and Guanajuato (10.4%).

Results of databases for Borrelia studies in Mexico

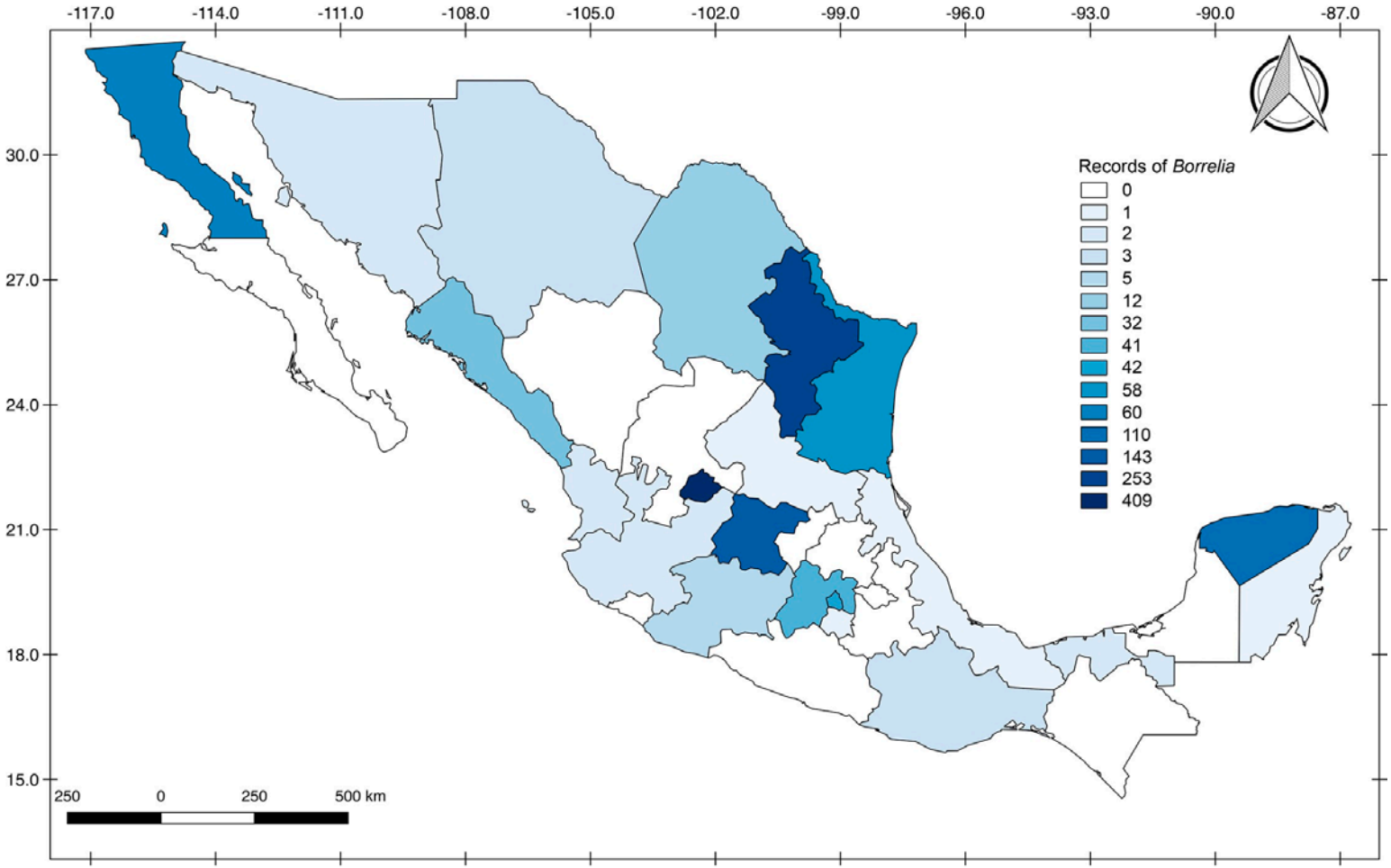

Fig 2. Geographic distribution of the 1,364 geo-referred records of *Borrelia* in Mexico. Records include both human cases and animal infections or expositions to *Borrelia* in Mexico from 1939 to 2020.

Results of databases for Borrelia studies in Mexico

The highest diversity of *Borrelia* species was shown in the central and northeastern regions of the country, being Mexico City, the state with the largest number of species registered (3/6 = 66.7%), followed by Coahuila with two species [2/6 = 33.3%].

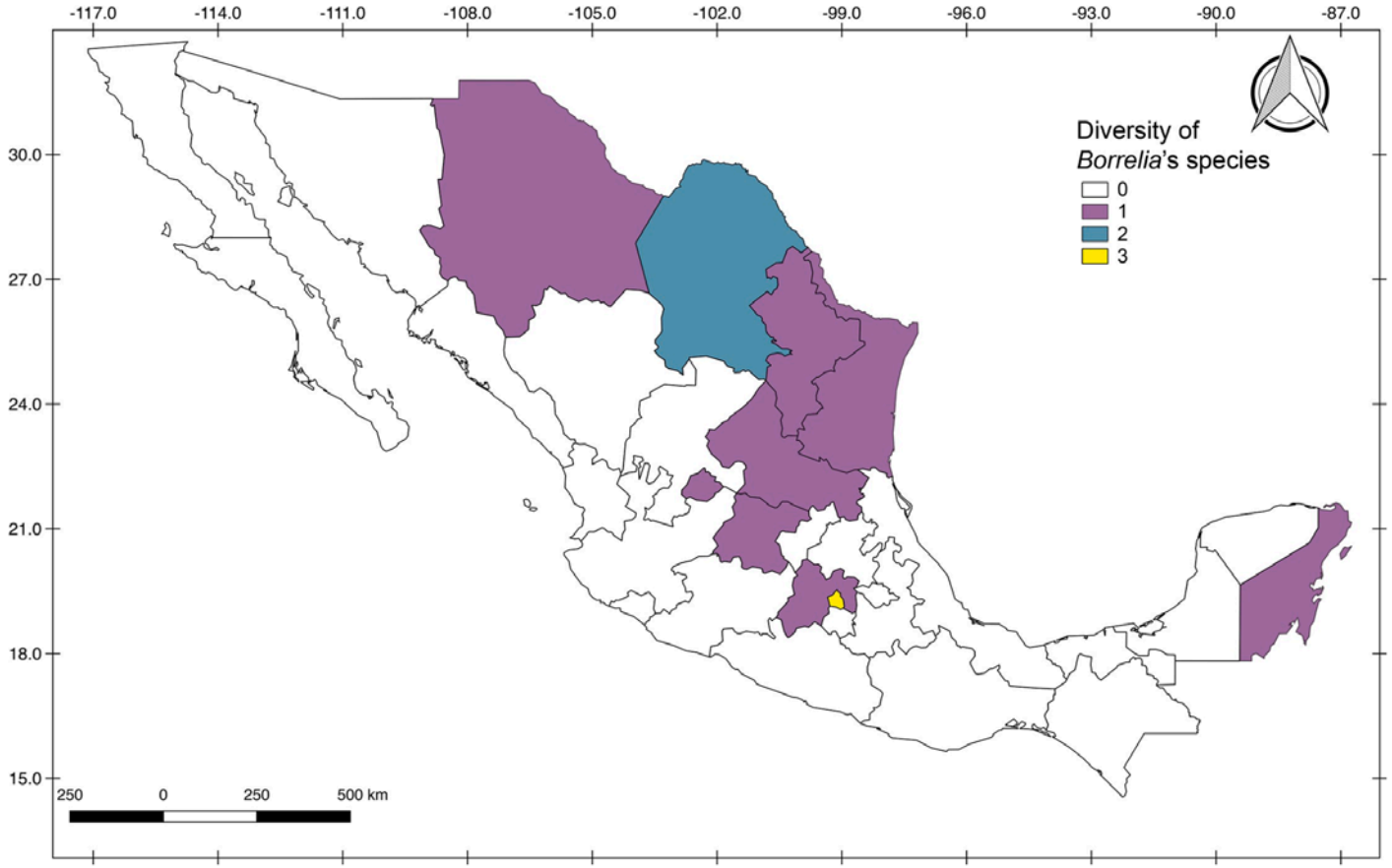

Fig 3. Geographic distribution of the genus *Borrelia* in Mexico according to species richness. Colors indicates the number of species of the bacterial genus per State. Records of bacteria defined as *B. burgdorferi* s.l. were not included, since the species was not specified.

Discussion

The highest diversity of *Borrelia* species was reported in the central and northeastern regions. Mexico City reported the most species (3/6 = 66.7%), followed by Coahuila (2/6 = 33.3%).

The first *Borrelia* record was *B. turicatae* isolated from *Ornithodoros turicata* ticks in Aguascalientes, Guanajuato, and San Luis Potosí.

The first human cases of RF were described in Aguascalientes.

Efforts to confirm and diagnose Lyme borreliosis remain insufficient.

Preliminary findings suggest a higher infection susceptibility in women for both LB and RF.

Rodents (Order: Rodentia) were the most commonly studied host group and are considered key reservoirs.

Take-away, Food for thought

Tick-borne diseases, such as Lyme borreliosis and relapsing fever, are emerging threats to public health.

In Mexico, information on *Borrelia* species, reservoirs, and vectors is incomplete and underreported.

From the total 1,347 analyzed records, 29.5% were human and 70.5% were animal cases. Evidence supports active circulation of *Borrelia* in vectors and animal hosts, while human cases are likely underdiagnosed.

These findings highlight the urgent need for strengthened epidemiological surveillance, public health education, and improved molecular diagnostic techniques.

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