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Protocol for a Scoping Review: State of knowledge about *Rhipicephalus sanguineus* lineages distribution, Ehrlichia and Rickettsia carriage, and vector competence in the Americas: A scoping review of the literature.

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³ University Library, University of California, Davis

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Author Contributions:

Cusi Ferradas: Conceptualization, methodology, investigation, writing – original draft, project administration.

Laura Backus: Conceptualization, methodology, investigation, writing – review & editing.

Winnie Contreras: Conceptualization, methodology, investigation, writing – review & editing.

Erik Davis: Methodology.

Maureen Laroche: Conceptualization, methodology, supervision, writing – review & editing.

Janet Foley: Supervision, writing – review & editing.

Abstract:

Background: *Rhipicephalus sanguineus*, also known as the brown dog tick, was initially considered a single species, but studies have shown that it is a complex encompassing different taxonomic units. Two genetic lineages have been reported in the Americas, the temperate (*Rh. sanguineus* sensu stricto) and the tropical (*R. linnaei*). Previous studies have shown contradictory or inconclusive evidence about the specific vector competence of these two lineages for *Ehrlichia* spp. and *Rickettsia* spp.; however, no previous studies have systematically compiled and discussed field and laboratory data regarding pathogen carriage and vector competence of this taxonomic group in the Americas.

Objectives: The target population of this scoping review includes ticks of the *Rhipicephalus sanguineus* complex collected in the Americas. This review has two main objectives: (1) Describe the geographical distribution of *Rhipicephalus sanguineus* lineages and their spatial association with two bacterial genera: *Ehrlichia* and *Rickettsia*, in the Americas. (2) Describe the laboratory evidence about vector competence for *Ehrlichia* spp. and *Rickettsia* spp. by the tropical and temperate lineages of *Rhipicephalus sanguineus* collected from the Americas.

Design: We will conduct a scoping review as set forth by PRISMA (<https://www.prisma-statement.org/>). We will consult articles published in English, Spanish, or Portuguese between 2000 and 2023 collected from Medline, CAB Abstracts, Scopus, Biosis, and Scielo. We will review articles published in peer-reviewed journals, as well as theses and conference proceedings of 500 words or more. All types of study (descriptive, observational, and

experimental as well as studies about species distribution modeling) will be included if they have studied *Rh. sanguineus* collected from American countries and tested them for *Ehrlichia* spp. and/or *Rickettsia* spp and/or lineage.

Registration: This has been submitted to SYREAF on April 1st 2024, and eScholarship, University of California (<https://escholarship.org/>) on April 1st 2024.

Amendments from Original Protocol:

Date of Amendment and rationale.

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Introduction

Rationale

Ticks (suborder Ixodida) are the group of vectors within the Arthropoda phylum that transmit the highest number and diversity of pathogens, and, therefore, have become an increasing focus of attention in the veterinary and public health fields.^{1,2} The pathogens carried by ticks include bacteria, helminths, protozoa and viruses.³

Rhipicephalus sanguineus, the brown dog tick, is a complex of species first collected from canid hosts in France in 1806.⁴ In recent years, studies carried out throughout the world have found morphological differences between *Rh. sanguineus* populations.^{5,6} In addition, different *Rh. sanguineus* populations have shown distinct biological characteristics, including differences in feeding and reproductive parameters, decreasing the probability that they are all of a single species.⁷ Finally, it has been suggested that the capacity of dogs to develop resistance to *Rh. sanguineus* may be different according to the *Rh. sanguineus* populations.⁷ This supported by recent sequencing data of the 16S, 12S, and *cox1* genes of *Rh. sanguineus*, which highlighted two lineages, the tropical (*Rh. sanguineus*, currently also denominated *Rh. linnaei*, although this scientific name is still controversial) and the temperate (*Rh. sanguineus sensu stricto*).^{5,8} Both lineages have been found to be present in the Americas. The first study that evaluated the correlation between the presence of these lineages and climatic conditions suggested that the tropical lineage was found in places where the annual mean temperature was higher than 20°C, while the temperate lineage was found in places with an annual mean temperature between 10 and 20°C.⁹ However, now it is known that these lineages coexist in certain regions. This may be due to 1) the number of samples and geographic diversity of sampling did not allow an accurate description of the distribution of the lineages; or 2) *Rh. sanguineus* lineages have been able to adapt to different environments.^{10,11}

Ticks from the *Rh. sanguineus* complex have been reported to vector pathogens of veterinary importance, like *Ehrlichia canis* and *Anaplasma platys*, and pathogens of veterinary and public health importance, such as *Rickettsia rickettsii*, *R. conorii*, and *R. massiliae*. Previous studies have suggested differences in vector competence between the tropical and temperate lineages of *Rh. sanguineus*.¹²⁻¹⁴ This has been presumed based on the overlap or lack thereof in spatial distribution between *Rh. sanguineus* tropical or temperate lineages and cases of tick-borne bacterial diseases among dogs, but also observed in some experimental studies where the two lineages have been infected with tick-borne bacteria under laboratory conditions.^{12,15} However, these reports are scattered among the American territories and some of them present contradictory evidence, making it difficult to get a clear picture of what is already known about *Rickettsia* spp. and *Ehrlichia* spp. carriage and the vectorial competence of these lineages and where prevention and control strategies should be mainly implemented.¹⁶⁻¹⁸ For example, a laboratory-based study indicated that *Rh. sanguineus* s.s was not able to maintain or transmit *E.*

canis to dogs, but *E. canis* has been detected in blood samples from dogs in southern regions of Argentina where only this *Rh. sanguineus* lineage has been found.^{13,17} Moreover, *E. canis* has been detected in naturally infected *Rh. sanguineus* s.s from Buenos Aires, Argentina.¹⁸ Three hypothesis are proposed by the authors: 1) *Rh. sanguineus* s.s ticks got infected with *E. canis* after feeding on infected dogs that came from areas where *Rh. sanguineus* s.l. is present, but they may not be able to transmit this pathogen; 2) There are focally distributed populations of *Rh. sanguineus* s.l. in Buenos Aires, Argentina that are only active during certain seasons, but they have not been identified by previous studies (probably due to tick collections when *Rh. sanguineus* s.l. was not active); 3) *Rh. sanguineus* s.s is able to transmit *E. canis*.¹⁸ Moreover, although *Rh. sanguineus* is the main vector of *R. rickettsii* in Mexico and the US-Mexico border, it is not clear if the Brazilian populations are competent vectors of this pathogen, probably due to different linages present in these two countries.^{19,20} Additionally, it is not known whether the two lineages of *Rh. sanguineus* are equivalent in their ability to transmit different clades of *R. rickettsii*.²¹

The present scoping review has two main aims. The first one is to critically summarize the descriptive and observational studies describing the spatial distribution of *Rh. sanguineus* lineages and their associated pathogens (from the *Ehrlichia* and *Rickettsia* genera). Previous studies have summarized the distribution of *Rh. sanguineus* lineages in the Americas;^{22,23} however, to our knowledge, no previous study has described where *Rh. sanguineus* have been tested for *Ehrlichia* spp. and/or *Rickettsia* spp. The second aim is to systematically map the literature about confirmed *Rh. sanguineus* lineages vector competence for *Rickettsia* spp. and *Ehrlichia* spp. pathogens under laboratory conditions (experimental studies). This scoping review will result in: 1) a synthesis of the knowledge about *Rh. sanguineus* lineages and tick-borne pathogens (from the *Ehrlichia* and *Rickettsia* genera) spatial distribution in *Rh. sanguineus* ticks in the Americas; 2) a summary of the evidence of the different vector competence of the two *Rhipicephalus sanguineus* lineages present in the Americas; and 3) a list of the knowledge gaps about the distribution of *Rickettsia* spp. and *Ehrlichia* spp. pathogens transmitted by different lineages of *R. sanguineus*, information that could be used to guide future studies.

Objectives

Primary objectives:

1. Describe the spatial distribution of *Rhipicephalus sanguineus* lineages in the Americas.
2. Describe the overlap between the distribution of *Rh. sanguineus* lineages and pathogen detection in the *Rh. sanguineus* complex of two bacterial genera: *Ehrlichia* and *Rickettsia*, in the Americas.
3. Describe the laboratory evidence about vector competence for *Ehrlichia* spp. and *Rickettsia* spp. by the tropical and temperate lineages of *Rhipicephalus sanguineus* collected in the Americas.

Secondary objectives:

1. Describe which bacterial tick-borne pathogens (from the *Ehrlichia* and *Rickettsia* genera) have been detected in *Rh. sanguineus* ticks.
2. Describe the proportion of studies investigating pathogens (from the *Ehrlichia* and *Rickettsia* genera) in *Rh. sanguineus* complex that identified the lineages of *R. sanguineus*.
3. Determine which bacterial tick-borne pathogens (from the *Ehrlichia* and *Rickettsia* genera) have been isolated in each country of the Americas from each lineage of *Rhipicephalus sanguineus*.
4. Determine how often is *Rh. sanguineus* complex testing associated with humans, domestic animals, and/or rodent testing and determine if pathogens were also found in these hosts.

Population: Ticks of the *Rhipicephalus sanguineus* complex collected in the Americas. For this review, the Americas includes all the countries in South, Central, and North America.²⁴ Countries from the Caribbean are not included.

Exposure: Spatial distribution of the temperate and tropical lineages of *Rh. sanguineus* in the Americas.

Outcome: Spatial distribution of tick-borne pathogens of two bacterial genera (*Ehrlichia*, and *Rickettsia*) in lineages of *Rhipicephalus sanguineus* ticks in the Americas.

Methods

Eligibility Criteria:

The following studies will be included:

- Articles published in English, Spanish, or Portuguese between 2000 and 2023.
- Publication status: peer-reviewed journals, theses, and conference proceedings (500 words or more).
- Original scientific reports.
- All study designs (descriptive, observational, and experimental) and studies that model the distribution of *Rh. sanguineus* lineages in the Americas.
- Articles that study *Rhipicephalus sanguineus* lineages and/or articles that study bacterial tick-borne pathogens of the genera *Ehrlichia* and *Rickettsia* in *Rh. sanguineus* complex.
- Laboratory transmission/competence studies conducted using the tropical and temperate lineages from the Americas (determined by place of collection and /or genotyping) will also be included.
- The study population will be restricted to *Rh. sanguineus* collected from the Americas.

Databases Used and Search Strategy:

PRISMA-S Template (based on v1.0 retrieved from <https://osf.io/2ybwn/>)

Research Questions being addressed:

1. What studies exist that describe the presence of the *Rhipicephalus sanguineus* complex and the bacterial pathogens they carry in the Americas?
2. What is the spatial overlap between specific *Rh. sanguineus* lineages in the complex and bacterial pathogens of the genus *Rickettsia* and *Ehrlichia*?
3. Is the literature adequate to answer research question 2, and what gaps are present.

Databases and Interfaces Searched:

Database	Interface	Date Coverage	Date Searched
CAB Abstracts <small>(included products: CAB ABSTRACTS, VetMed Resource, CABI Full Text, Global Health, Animal Health and Production Compendium (AHPC))</small>	CABDirect	1973 to Present	14 December 2023
Medline <small>(Included products: Medline, in process citations, "ahead of print" citations, out-of-scope citations, journals indexing prior to medline inclusion, pre-1966 citations, PubMed Central, author manuscripts NIH funding, NCBI Bookshelf)</small>	PubMed	1902 to Present	14 December 2023
Scopus	Elsevier	1996 to Present	14 December 2023
Scielo	Web of Science	2002 to Present	14 December 2023
Biosis	Web of Science	1926 to Present	14 December 2023

Simultaneous Searches: Not Applicable

Item 2: Other Online Resources (As Needed):

Not Applicable

Manual Searching (searching relevant journals Table of Contents): Not Performed

Citation Searching And Text Analysis:

Article Citation:
Sánchez-Montes, S.; Salceda-Sánchez, B.; Bermúdez, S.E.; Aguilar-Tipacamú, G.; Ballados-González, G.G.; Huerta, H.; Aguilar-Domínguez, M.; Mora, J.D.-d.I.; Licon-Enríquez, J.D.; Mora, D.D.-d.I.; et al. <i>Rhipicephalus sanguineus</i> Complex in the Americas: Systematic, Genetic Diversity, and Geographic Insights. <i>Pathogens</i> 2021, 10, 1118. https://doi.org/10.3390/pathogens10091118

Di Cataldo S, Cevidanes A, Ulloa-Contreras C, Hidalgo-Hermoso E, Gargano V, Sacristán I, Sallaberry-Pincheira N, Peñaloza-Madrid D, González-Acuña D, Napolitano C, Vianna J, Acosta-Jamett G, Vicari D, Millán J, Mapping the distribution and risk factors of Anaplasmataceae in wild and domestic canines in Chile and their association with Rhipicephalus sanguineus species complex lineages, *Ticks and Tick-borne Diseases*, Volume 12, Issue 5, 2021

Nieto-Cabrales JF, Salceda-Sánchez B, Zazueta-Islas HM, et al. New records of Rhipicephalus linnaei infected by Rickettsia massiliae from Central Mexico. *Zoonoses Public Health*. Published online December 5, 2023. doi:10.1111/zph.13101

Eremeeva ME, Zambrano ML, Anaya L, et al. Rickettsia rickettsii in Rhipicephalus ticks, Mexicali, Mexico. *J Med Entomol*. 2011;48(2):418-421. doi:10.1603/me10181

Cicuttin GL, Tarragona EL, De Salvo MN, Mangold AJ, Nava S. Infection with Ehrlichia canis and Anaplasma platys (Rickettsiales: Anaplasmataceae) in two lineages of Rhipicephalus sanguineus sensu lato (Acari: Ixodidae) from Argentina. *Ticks Tick Borne Dis*. 2015;6(6):724-729. doi:10.1016/j.ttbdis.2015.06.006

Pascoe EL, Nava S, Labruna MB, et al. Predicting the northward expansion of tropical lineage Rhipicephalus sanguineus sensu lato ticks in the United States and its implications for medical and veterinary health. *PLoS One*. 2022;17(8):e0271683. Published 2022 Aug 24. doi:10.1371/journal.pone.0271683

Sebastian PS, Mera Y Sierra R, Neira G, Hadid J, Flores FS, Nava S. Epidemiological link between canine monocytic ehrlichiosis caused by Ehrlichia canis and the presence of Rhipicephalus sanguineus sensu stricto in Argentina. *Parasitol Res*. 2021;120(2):725-729. doi:10.1007/s00436-020-07005-7

Sanches GS, Villar M, Couto J, et al. Comparative Proteomic Analysis of Rhipicephalus sanguineus sensu lato (Acari: Ixodidae) Tropical and Temperate Lineages: Uncovering Differences During Ehrlichia canis Infection. *Front Cell Infect Microbiol*. 2021;10:611113. Published 2021 Jan 29. doi:10.3389/fcimb.2020.611113

Moraes-Filho J, Krawczak FS, Costa FB, Soares JF, Labruna MB. Comparative Evaluation of the Vector Competence of Four South American Populations of the Rhipicephalus sanguineus Group for the Bacterium Ehrlichia canis, the Agent of Canine Monocytic Ehrlichiosis. *PLoS One*. 2015;10(9):e0139386. Published 2015 Sep 28. doi:10.1371/journal.pone.0139386

Process: Key articles were identified by Principal Investigator and keywords were mined by finding references in PubMed and CAB Direct. Keywords were collected and compared with keywords already utilized and examined in SR-Accelerator WordFreq (Bond University, <https://sr-accelerator.com/#/wordfreq>). SR Accelerator Search Refinery (Bond University, <https://sr-accelerator.com/#/searchrefinery>) and Yale MeSH Analyzer (Yale University, <https://mesh.med.yale.edu/>) was also utilized to compare common Medical Subject Headings across articles.

Contacts (Researchers contacted for additional information): not applicable

Additional Methodologies Not Listed Above:

Process: All studies that were included for data extraction will be put into Scopus for forward and backward citation tracking (“snowballing”) and then those citations will be put into Covidence for screening.

Limits and Restrictions

Date and Time Period: 2000 - 2022

Language: Spanish, English, Portuguese and Spanish

Publication status: peer-reviewed journals, theses and conference proceedings (500 words or more)

Species Included: *Rhipicephalus sanguineus*

Study Design: Any original research synthesis, experimental, observational and descriptive.

Database Subset: Not applicable

Pre-specified cut-off or saturation point for results: Not applicable

Other Restrictions:

Not seeking literature on anaplasmosis and babesiosis. Search limited to geographical regions of the North and South America.

Search Filters:

Database	Interface	Search Filters Applied
CAB Abstracts	CAB Direct	Language Filters: "English" OR "Spanish" OR "not specified" OR "portuguese" and Publication dates 2000-2022
Medline	PubMed	Language (English, Spanish and Portuguese) and date filters (2000 - 2023)
Scopus	Elsevier	Language (English, Spanish and Portuguese) and date filters (2000 - 2023)
Scielo	Web of Science	Language (English, Spanish and Portuguese) and date filters (2000 - 2023)
Biosis	Web of Science	Language (English, Spanish and Portuguese) and date filters (2000 - 2023)

Full Search Strategy:

Search Database: CABDirect

Search ID	Terms (copy and paste)	Results
#1 tick	<u>title:(“rhipicephalus” OR “Rhipicephalus sanguineus” OR “Rhipicephalus linnaei” OR “brown dog tick” OR “brown tick” OR “brown dog tick” OR “dog tick” OR “kennel tick” OR “pantropical dog tick” OR “Ixodes sanguineus” OR “I. sanguineus” OR “R. sanguineus” OR “R. linnaei”)</u> OR <u>ab:(“rhipicephalus” OR “Rhipicephalus sanguineus” OR “Rhipicephalus linnaei” OR “brown dog tick” OR “brown tick” OR “brown dog tick” OR “dog tick” OR “kennel tick” OR “pantropical dog tick” OR “Ixodes sanguineus” OR “I. sanguineus” OR “R. sanguineus” OR “R. linnaei”)</u> OR <u>id:(“Rhipicephalus linnaei”)</u> OR <u>od:(“Rhipicephalus sanguineus” OR “Rhipicephalus”)</u>	3,466
#2 disease/lineage	<u>ti:(“ehrlich*” OR “ricketts*” OR “spotted fever” OR “vector competence” OR “temperate lineage*” OR “tropical lineage*”)</u> OR <u>ab:(“ehrlich*” OR “ricketts*” OR “rocky mountain spotted fever” OR “vector competence” OR “temperate lineage*” OR “tropical lineage*”)</u> OR <u>de:(“ehrlichioses” OR “vector%20competence”)</u> OR <u>up:(“Rickettsiales”)</u>	30,237
#3	#1 AND #2	443
#4	#3 AND (language:((“English” OR “Spanish” OR “not specified” OR “portuguese”)	443
#5	#4 AND yr:[2000 TO 2023]	443
Copy and paste	(<u>ti:(“ehrlich*” OR “ricketts*” OR “spotted fever” OR “vector competence” OR “temperate lineage*” OR “tropical lineage*”)</u> OR <u>ab:(“ehrlich*” OR “ricketts*” OR “rocky mountain spotted fever” OR “vector competence” OR “temperate lineage*” OR “tropical lineage*”)</u> OR <u>de:(“ehrlichioses” OR “vector competence”)</u> OR <u>up:(“Rickettsiales”)</u>) AND (<u>title:(“rhipicephalus” OR “Rhipicephalus sanguineus” OR “Rhipicephalus linnaei” OR “brown dog tick” OR “brown tick” OR “brown dog tick” OR “dog tick” OR “kennel tick” OR “pantropical dog tick” OR “Ixodes sanguineus” OR “I. sanguineus” OR “R. sanguineus” OR “R. linnaei”)</u> OR <u>ab:(“rhipicephalus” OR “Rhipicephalus sanguineus” OR “Rhipicephalus linnaei” OR “brown dog tick” OR “brown tick” OR “brown dog tick” OR “dog tick” OR “kennel tick” OR “pantropical dog tick” OR “Ixodes sanguineus” OR “I. sanguineus” OR “R.</u>	

	sanguineus" OR "R. linnaei) OR id:("Rhipicephalus linnaei") OR od:("Rhipicephalus sanguineus" OR "Rhipicephalus")) AND yr:[2000 TO 2023] AND (language:(("English" OR "Spanish" OR "not specified" OR "portuguese")	
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Search Database: PubMed

Search ID	Terms (copy and paste)	Results
#1 species	"Rhipicephalus sanguineus"[MeSH Terms] OR "Rhipicephalus sanguineus"[Title/Abstract] OR "Rhipicephalus linnaei"[Title/Abstract] OR "brown dog tick"[Title/Abstract] OR "rhipicephalus"[Tiab] OR "brown tick"[Title/Abstract:~0] OR "brown dog tick"[Title/Abstract] OR "dog tick"[Title/Abstract] OR "kennel tick"[Title/Abstract] OR "pantropical dog tick"[Title/Abstract:~0] OR "Ixodes sanguineus"[Title/Abstract:~0] OR "i sanguineus"[Title/Abstract:~0] OR "r sanguineus"[Title/Abstract] OR "r linnaei"[All Fields]	5,056
#2 disease	"ehrlichi*"[Title/Abstract] OR "ricketts*"[Title/Abstract] OR "Ehrlichiosis"[MeSH Terms] OR "Spotted Fever Group Rickettsiosis"[MeSH Terms] OR "Rickettsia Infections"[MeSH Terms] OR "vector competence"[Title/Abstract] OR "rhipicephalus sanguineus/microbiology"[MeSH Terms] OR "temperate lineage*"[Title/Abstract] OR "tropical lineage*"[Title/Abstract]	22,340
#3	#1 AND #2	1,115
#4	#3 AND (english[Filter] OR portuguese[Filter] OR spanish[Filter])	1,079
#5	#4 AND (2000:2023[pdat])	986
Copy and paste	((("ehrlichi*"[Title/Abstract] OR "ricketts*"[Title/Abstract] OR "Ehrlichiosis"[MeSH Terms] OR "Spotted Fever Group Rickettsiosis"[MeSH Terms] OR "Rickettsia Infections"[MeSH Terms] OR "vector competence"[Title/Abstract] OR "rhipicephalus sanguineus/microbiology"[MeSH Terms] OR "temperate lineage*"[Title/Abstract] OR "tropical lineage*"[Title/Abstract]) AND ("Rhipicephalus sanguineus"[MeSH Terms] OR "Rhipicephalus sanguineus"[Title/Abstract] OR "Rhipicephalus linnaei"[Title/Abstract] OR "brown dog tick"[Title/Abstract] OR "rhipicephalus"[Title/Abstract] OR "brown tick"[Title/Abstract:~0] OR "brown dog tick"[Title/Abstract] OR "dog tick"[Title/Abstract] OR "kennel tick"[Title/Abstract] OR "pantropical dog tick"[Title/Abstract:~0] OR "Ixodes sanguineus"[Title/Abstract:~0] OR "i sanguineus"[Title/Abstract:~0] OR "r sanguineus"[Title/Abstract] OR "r linnaei"[All Fields])) AND ((english[Filter] OR portuguese[Filter] OR spanish[Filter]) AND (2000:2024[pdat]))	

Search Database: Scopus

Search ID	Terms (copy and paste)	Results
#1 Species	TITLE-ABS-KEY ("ehrlich*" OR "ricketts*" OR "vector competence" OR "temperate lineage*" OR "tropical lineage*")	28,545
#2 Disease	TITLE-ABS-KEY ("Rhipicephalus sanguineus" OR " <u>Rhipicephalus linnaei</u> " OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei")	2,996
#3	#1 AND #2	1,040
#4	#3 AND AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese"))	998
#6	#4 AND (LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000))	899

#4 copy and paste	(TITLE-ABS-KEY ("ehrlich*" OR "ricketts*" OR "vector competence" OR "temperate lineage*" OR "tropical lineage*")) AND (TITLE-ABS-KEY ("Rhipicephalus sanguineus" OR "Rhipicephalus linnaei" OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei")) AND (LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002) OR LIMIT-TO (PUBYEAR , 2001) OR LIMIT-TO (PUBYEAR , 2000)) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese"))	
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Search Database: Scielo

Search ID	Terms (copy and paste)	Results
#1 brown dog tick	"Rhipicephalus sanguineus" OR "Rhipicephalus linnaei" OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei" (Topic)	153
#2 disease	"ehrlich*" OR "ricketts*" OR "vector competence" OR "temperate lineage*" OR "tropical lineage"	627
#3	#1 AND #2	61
#4	#3 AND Limit to Portuguese, Spanish and English	61
#3	#4 AND limited to years 2000 - 2023	61

Copy and paste	TS=("ehrlich*" OR "ricketts*" OR "vector competence" OR "temperate lineage*" OR "tropical lineage*") AND TS=("Rhipicephalus sanguineus" OR "Rhipicephalus linnaei" OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei") AND (LA=("ENGLISH" OR "SPANISH" OR "PORTUGUESE") AND PY=("2023" OR "2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012" OR "2011" OR "2010" OR "2009" OR "2008" OR "2007" OR "2006" OR "2005" OR "2004" OR "2003" OR "2002"))	
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Search Database: Biosis

Search ID	Terms (copy and paste)	Results
#1 Country/region	"Rhipicephalus sanguineus" OR "Rhipicephalus linnaei" OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei" (Topic)	2,897
#2 Species	"vector competence" OR "temperate lineage*" OR "tropical lineage*" OR "ehrlich*" OR "ricketts*" (Topic)	66,988
#3	#1 AND #2	938
#4	#3 AND English, Spanish and Portuguese language filters	907
#5	#4 AND PY=("2023" OR "2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012" OR "2011" OR "2010" OR "2009" OR "2008" OR "2007" OR "2006" OR "2005" OR "2004" OR "2003" OR "2002" OR "2001" OR "2000"))	723

Copy and paste	<p>TS=("ehrlichi*" OR "ricketts*" OR "vector competence" OR "temperate lineage*" OR "tropical lineage*") AND TS=("Rhipicephalus sanguineus" OR "Rhipicephalus linnaei" OR "brown dog tick" OR "brown tick" OR "brown dog tick" OR "dog tick" OR "kennel tick" OR "pantropical dog tick" OR "Ixodes sanguineus" OR "I. sanguineus" OR "R. sanguineus" OR "R. linnaei") AND (LA==("ENGLISH" OR "SPANISH" OR "PORTUGUESE") AND PY==("2023" OR "2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012" OR "2011" OR "2010" OR "2009" OR "2008" OR "2007" OR "2006" OR "2005" OR "2004" OR "2003" OR "2002"))</p>	
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Updates: Not Applicable

Search Designers:

Information Specialists or Librarians involved in process were: Erik Fausak, MSLIS, MA
Additional input from domain chairs in project: Cusi Ferradas Carrillo, DVM, MPH

Peer Review:

Librarians review searches with Systematic Review Service at UC Davis and validated with 24 citations independently identified by content expert as important articles to pick up across CAB Direct and PubMed.

Results:

Total Records	Total Records after deduplication	Deduplication software/methodology
3,112	2,549	SR Accelerator
2,549	1,685	Covidence

Records Screened: 1,685

Study Records:

We will import all the articles after being deduplicated and downloaded as one file from SR-Accelerator Deduplicator into Covidence (Australia) for Title/Abstract and Full Text screening. Data extraction will be done in Excel (Microsoft Excel, USA).

Selection Process:

The search for the articles will be carried out using two levels. Level 1 starts with the evaluation of the title/abstract for its inclusion in the database and level 2 will be at the full text level. Criteria used to pass level 1 will consist of the following questions:

1. Is the abstract in English, Spanish, or Portuguese?
2. Was the study published in 2000 or later?
3. Is the study: (a) an observational study conducted in the Americas that collected *Rh. sanguineus* ticks from the field and tested them for *Ehrlichia* spp. and/or *Rickettsia* spp.; (b) a laboratory-based study about vector competence of *Rh. sanguineus* collected in the Americas; (c) a review about *Rh. sanguineus* in the Americas; or (d) a study that includes information about the spatial distribution of *Rh. sanguineus* lineages in the Americas.

Two reviewers (CF and LB) will be evaluating the references independently. To consider the citations for level 2 review, questions 1 and 2 and at least one of the four questions included in question 3 (a-d) for level one should be answered "yes", otherwise the citation will be removed. For publications where there is disagreement between reviewers or where one of the reviewers chooses "maybe" consensus will be sought with the help of a third reviewer (WC). Studies where no consensus can be reached will be labeled as "unable to decide" and be evaluated at the full text level. Pre-testing of a random sample of 10 studies at level 1 will be completed by all reviewers to validate screening questions and reach consensus on wording and interpretation of criteria.

The criteria selected to pass the level 2, which will cover the full text, will be questions that will be answered with "yes", "no" or "can't decide." The questions chosen to determine which articles will be taken are: (1) Is the full text available in English, Spanish or Portuguese (2) Is the study published in a peer-reviewed journal or is it a thesis or a conference proceeding of more than 500 words? (3) Is the study an original scientific report? (4) Is the study: (a) an observational study conducted in the Americas that collected *Rh. sanguineus* ticks and tested them for *Ehrlichia* spp. and/or *Rickettsia* spp.; (b) a laboratory-based study about vector-competence of *Rh. sanguineus* lineages collected in the Americas; (c) a review about *Rh. sanguineus* in the Americas; or (d) a study that includes information about the spatial distribution of *Rh. sanguineus* lineages in the Americas.

Then to be included in the data extraction step, both reviewers must have answered "yes" to questions 1 and 2 and at least one of the four questions (a-d) included in question 3 for level two. If there are discrepancies between the two reviewers, a third reviewer will seek consensus. We will conduct a pilot testing with 10 randomly selected studies to reach consensus on wording and interpretation criteria.

Data Collection Process:

The publications included after abstract/title and full text screening in Covidence (Australia) will have data extracted into Excel (Microsoft Corporation, USA). The following characteristics of the included studies will be incorporated:

Observational and descriptive studies (all characteristics, besides number 2, will also be recorded from studies that build species distribution models for *R. sanguineus*):

1. Year of publication, year of study completion
2. Type of study: Observational (Cross-sectional, cohort, or case control) or Descriptive (Case reports or series)
3. Geographical distribution by region where the study was carried out (Colombia, Brazil, Perú, Argentina, Chile, Uruguay, Paraguay, Ecuador, Venezuela, Bolivia, Guyana, Panamá, Mexico, Honduras, Costa Rica, Nicaragua, Guatemala, El Salvador, Belize, Suriname, USA, Canada). We will record the country and city where the study was conducted.
4. Does the study identify the lineage of *Rhipicephalus sanguineus*?
5. If answer to question 4 is yes, which lineage(s) of *Rhipicephalus sanguineus* was/were found? If answer is no, it will be marked as NA.
6. Were lineages identified by molecular techniques?
7. City where lineage was found.
8. Can we determine (or assume) the lineage based on geographic location?
9. Does the study investigate *Ehrlichia* spp. and/or *Rickettsia* spp. carried by *Rhipicephalus sanguineus*?
10. Bacterial pathogens detected in *Rhipicephalus sanguineus* of the genus *Ehrlichia* or *Rickettsia*.
11. Does the study include testing on domestic animals, rodents and/or human samples for detection of tick-borne bacterial pathogens of the genera *Ehrlichia* and/or *Rickettsia*?
12. Bacterial pathogens (of the genus *Ehrlichia* or *Rickettsia*) known to be transmitted by *Rhipicephalus sanguineus* or suggested by this article to be transmitted by this tick detected in humans.
13. Bacterial pathogens known to be transmitted by *Rhipicephalus sanguineus* or suggested by this article to be transmitted by this tick detected in domestic animals and/or rodents.

Laboratory-based (experimental) studies about *Rhipicephalus sanguineus* lineages vector competence:

- Year of publication, year of study completion.
- Pathogen studied.
- Lineage able to transmit the pathogen.
- Laboratory method used to evaluate vector competence.

Outcomes and Prioritization:

Observational studies:

- Lineage of *Rhipicephalus sanguineus* identified.
- Prevalence of *Ehrlichia* spp. and *Rickettsia* spp. in *Rhipicephalus sanguineus* ticks.

Laboratory-based studies:

- Vector competence of each lineage for the pathogen(s) evaluated.

Risk of bias in Individual Studies:

Not applicable.

Data Synthesis:

Not applicable

Confidence in Cumulative Evidence:

Not Applicable

Discussion:

Limitations:

Observational studies that indicate spatial overlap between *Rh. sanguineus* lineages and a specific species of pathogens detected in the *Rh. sanguineus* complex are not sufficient evidence to conclude vector competence of each lineage. However, they serve as important preliminary evidence that requires future studies. On the other hand, lack of spatial overlap between a lineage and a pathogen does not necessarily indicate lack of vector competence. It is possible that in some regions the ecological niche of this pathogen is not present and, therefore, despite the presence of the competent vector, other conditions needed for the presence of this pathogen are not met.

Identifying lineages of *Rh. sanguineus* using taxonomic keys poses significant challenges, leading to numerous observational studies omitting lineage identification. Nonetheless, it is pertinent to describe the proportion of studies that do and do not identify these lineages.

Conclusions:

In this scoping review we aim to provide a broad overview about the current state of knowledge of: 1) the spatial distribution of *Rhipicephalus sanguineus* lineages and tick-borne bacterial pathogens of the genera *Ehrlichia* and *Rickettsia* isolated from this tick complex in the Americas; 2) the vector competence of the tropical and temperate lineages of *Rh. sanguineus* collected from the Americas according to laboratory-based studies.

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