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Title	Nation-wide surveillance of ticks (Acari: Ixodidae) on dogs and cats in Singapore
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Citation	Acta tropica, 263 https://doi.org/10.1016/j.actatropica.2025.107536
Issue Date	2025-02-07
Doc URL	https://hdl.handle.net/2115/97483
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Rights(URL)	https://creativecommons.org/licenses/by-nc-nd/4.0/
Type	journal article
File Information	MS (2.0)black.pdf

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Nation-wide surveillance of ticks (Acari: Ixodidae) on dogs and cats in Singapore

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Abstract

Companion animals are major reservoirs of zoonotic parasites and pathogens. Among these, ticks and tick-borne pathogens are of particular concern. Efforts to study the zoonotic risks associated with companion animals in Singapore have been hampered by a poor understanding of the ticks of local dogs and cats. To address this knowledge gap, ticks from companion animals were collected as part of Singapore's first nation-wide tick surveillance program beginning in 2018. Under the program, a total of 362 ticks were collected from dogs and one cat. These represented three tick genera and five species: *Haemaphysalis bispinosa*, *Haemaphysalis hystricis, Haemaphysalis papuana, Rhipicephalus linnaei,* and *Dermacentor auratus*. The most dominant species within companion animal-tick communities in Singapore were *H. bispinosa* and *R. linnaei*. The species diversity and health risks associated with companion animal ticks in Singapore are discussed

Keywords: *Rhipicephalus linnaei*; *Haemaphysalis bispinosa*; *Dermacentor auratus*; passive surveillance; Babesiosis

Introduction

Ticks and tick-borne pathogens threaten the health of humans and companion animals. Pathogenic viruses, bacteria, protozoa, and nematodes can be transmitted by ticks (Rochlin and Toledo 2020; Tahir et al. 2019). Additionally, ticks can directly cause diseases including rashes, alpha-gal syndrome, tick-bite anaphylaxis, and paralysis (van Nunen 2015). Although decades of progress have been made in studying the ticks in Europe and North America, in Southeast Asia, ticks remain heavily neglected and poorly understood (Hotez et al. 2015). Even in advanced economies like Singapore, only recently (2018 onwards) have major efforts been focused on the study of ticks and tick-borne diseases. Before this period, only scattered reports of ticks in Singapore existed (e.g., Theis and Franti 1971; Hoogstraal and Wassef 1973; Paperna 2006). However, a clearer picture of Singapore's tick fauna has developed over the past six years starting with a preliminary checklist of local species (Kwak 2018), followed by a number of studies confirming the presence or absence of a range of tick species (Kwak et al. 2018; 2019, 2023b), and the detection of a number of previously unreported ticks including members of the genera *Dermacentor*, *Haemaphysalis*, and *Ornithodoros* (Kwak et al. 2021a; 2024a; Kwak and Ng 2022). In addition, host association of local ticks have been more deeply studied including those of small mammals (Kwak et al. 2021b; 2023a), birds (Kwak et al. 2024a), bats (Kwak et al. 2024b), and most recently humans (Kwak et al. 2025). In tandem, numerous researchers have sought to build knowledge on tick-borne pathogens in Singapore. This has included the first detection of an imported *Babesia* infection (Lim et al. 2020) and the discovery of native *Babesia* in local wildlife (Chong et al. 2023). Efforts have also been made to screen for viruses in ticks including the African swine fever virus (Koh et al. 2023) and perhaps most interestingly, the discovery of the

Cencurut virus, a novel *Orthonairovirus* closely related to the tick-borne Crimean-Congo haemorrhagic fever virus which was detected locally in the tick *Amblyomma helvolum* (Low et al. 2023). Efforts are now underway by research teams in both the government and academic sectors to understand the tick-borne pathogens of dogs and cats in Singapore. However, this work has been obstructed by a lack of knowledge regarding the identity of ticks on dogs and cats in Singapore, which act as the key vectors of these pathogens. Therefore, to facilitate more focused, large-scale efforts to understand the diversity and prevalence of tick-borne pathogens of local dogs and cats, this study was undertaken to provide a baseline on the community structure and diversity of ticks on companion animals in Singapore.

Materials and methods

Beginning in 2018 a nation-wide passive tick surveillance program was commenced in Singapore. As part of this program, veterinarians, animal carers, and volunteers from companion animal charities submitted ticks from dogs (*Canis lupus familiaris*) and cats (*Felis catus*). Ticks were collected using fine tip forceps and were fixed in ethanol (70-100%) for later identification. By the end of 2023, the national tick surveillance program had amassed a total of 3,353 ticks collected across Singapore from numerous locations and hosts, of which 330 were taken from dogs and one cat (Figure 1). Additionally, two collections of ticks (numbering 32 specimens) were taken from two dogs in 2000 and 2017, respectively, deposited in the Lee Kong Chian Natural History Museum (LKCNHM), and included in this study.

Slide mounted larvae were examined using an Olympus BX50 compound microscope (Olympus, Tokyo, Japan) while alcohol fixed adults and nymphs were examined using an M205C stereo microscope (Leica Microsystems, Wetzlar, Germany). Specimens were identified based on descriptions, figures, checklists, and/or keys by Trapido et al. (1964), Wassef and Hoogstraal (1984), Kwak et al. (2021a), Kwak and Ng (2022), Slapeta et al. (2022), and Kwak et al. (2024a). Once identified to species level, they were accessioned with associated metadata (GPS coordinates, host species, date, and location) into the Singapore National Tick Reference Collection (SNTRC) curated by one of the authors (MLK).

Results

A total of 362 ticks were recorded infesting 38 dogs (2 pet dogs, 36 strays) and one cat within Singapore, in this study. These represented three tick genera and five species from dogs in Singapore: *Haemaphysalis bispinosa*, *Haemaphysalis hystricis, Haemaphysalis papuana, Rhipicephalus linnaei,* and *Dermacentor auratus* (Figure 2). The single tick infestation recorded from a cat involved one *Dermacentor auratus* nymph collected from a stray.

The two dominant tick species on dogs in Singapore were *H. bispinosa* and *R. linnaei* which comprised 54% and 42% of the total community, respectively (Figure 3). *Haemaphysalis hystricis, H. papuana,* and *D. auratus* were relatively uncommon on dogs and collectively comprised 5% of the total community. Single-species infestations were common (72% of infestations), while mixed infections were uncommon (18% of infestations) and never comprised more than two tick species. Due to the opportunistic nature of the sampling, prevalence of tick infestations within Singapore's companion animal populations could not be calculated. However, prevalence and mean load on infested dogs could be (Table 1). *Rhipicephalus linnaei* had the highest prevalence (63%) on infested dogs in Singapore with the next most prevalent tick being *H. bispinosa* (39%). Interestingly, although *R. linnaei* was more prevalent, its mean load was less than half that of *H. bispinosa* (Table 1).

Discussion

Companion animal-tick communities in Singapore

Companion animal ticks in Singapore have attracted only limited attention in the past. Hoogstraal et al. (1965) reported *Haemaphysalis semermis* infesting a dog in Singapore. Theis and Franti (1971) studied the impacts of a stray dog control program on the abundance of *Rhipicephalus sanguineus* in Singapore. Kwak et al. (2024a) later showed that the ticks which Theis and Franti (1971) referred to as *R. sanguineus* were actually *R. linnaei*, the only *Rhipicephalus* species occurring in Singapore. Kwak and Ng (2022) reported *H. bispinosa* and *H. hystricis* on dogs in Singapore, but provided little insight into community structure or prevalence. In total, 6 tick species have been recorded infesting companion animals in Singapore, five of which were detected in this study (Table 2). This tick community can be roughly split into two main groups, endemic ticks and opportunistic ticks. The endemic species are *H. bispinosa* and *R. linnaei* (endemic in the epidemiological sense), and populations of these two species utilise dogs as their primary reservoir host within Singapore. This is further evidenced by their comparatively high prevalence and loads on local infested dogs. Yan et al. (2024) detected the same two species on dogs in neighbouring Peninsula Malaysia. Hoogstraal et al. (1969) noted that *H. bispinosa* is non-native to Peninsula Malaysia (and by extension Singapore) and Kwak (2018) noted that Singapore's *R. sanguineus* population (now regarded as *R. linnaei*) is also introduced. Given their introduced status in Singapore and the role of dogs as their primary reservoir host, nation-wide eradication is potentially feasible, though long-term monitoring would be required to avoid potential reintroductions on migratory birds, as noted by Kwak et al. (2024a). The opportunistic tick species (*H. hystricis, H. papuana, H. semermis,* and *D. auratus*), utilise wildlife species (mainly wild pigs and deer) as their main reservoir hosts and only infest companion animals occasionally (Kwak et al. 2021a). These opportunistic species are specialists of large mammal (particularly wild pigs) as nymphs and adults and likely cause infestations when dogs enter forested areas where the abundance of these species is high (Guglielmone and Robbins 2018). These aforementioned opportunistic ticks likely do not serve as important vectors of endemic tick-borne pathogens of cats or dogs in Singapore. Interestingly, only two of the canine tick infestations submitted were from pet dogs (the majority being from stray dogs), despite active tick searchers on pet dogs by numerous veterinarians supporting the tick surveillance program. This suggests that stray dogs, with increased exposure to ticks, are likely the major source of *H. bispinosa* and *R. linnaei* and associated pathogens in Singapore. Similar to the cases of opportunistic ticks on dogs in Singapore, the single case of infestation by a *Dermacentor auratus* nymph on a stray cat is likely a result of the cat roaming within forested areas where the abundance of *Dermacentor* nymphs is high.

One Health importance of companion animal ticks in Singapore

Companion animals represent important reservoirs of zoonotic pathogens and human-biting ticks. Both *H. bispinosa* and *R. linnaei* are known to infest humans (Guglielmone and Robbins 2018). Given the zoonotic potential of ticks, public health campaigns emphasising tick prevention for pet owners and stray animal management could mitigate risks. Chinuki et al. (2016) identified an important association between *Haemaphysalis* tick bites and the development of alpha-gal syndrome. However, the prevalence and epidemiology of alpha-gal syndrome in Singapore remains largely unexplored, though is probably present but underdiagnosed.

Zoonotic pathogens, such as *Ehrlichia canis* and *Anaplasma phagocytophilum*, can also be transmitted from companion animals to humans by ticks and threaten public health (Woldehiwet 2010; Sgroi et al. 2024). Tick-borne pathogens are also of major veterinary importance, most notably the genera *Babesia, Ehrlichia, Anaplasma, Hepatozoon*, and *Rickettsia* (Sharifah et al. 2020). Although multiple research groups in Singapore are actively studying tick-borne pathogens in local companion animals, they have yet to publish their findings. Though local veterinarians commonly diagnose babesiosis and ehrlichiosis in dogs in Singapore based on PCR tests and/or blood smears (Abigail Ng; personal observation). So, while tick-borne diseases of companion animals are known in Singapore (e.g., babesiosis, ehrlichiosis), the microbial species involved remain unknown for now, though will likely be increasingly revealed in studies in the very near future.

Conclusion

Companion animals in Singapore host numerous tick species with the taxa of greatest importance being *H. bispinosa* and *R. linnaei* due to their role as vectors of a range of pathogens in companion animals and their propensity to also infest humans. This foundational information on the diversity and community structure of companion animal ticks in Singapore provides the framework for further studies of the tick-borne pathogens of companion animals in Singapore. Most importantly this study highlights key vector species which control programs can focus on to alleviate the impacts of tick-borne diseases locally. Future studies should prioritise molecular identification of tick-borne pathogens, while authorities should consider integrating these findings into national tick control and zoonotic disease prevention programs.

Acknowledgements

We kindly thank the staff and volunteers of the Save Our Street Dogs (Singapore), Society for the Prevention of Cruelty to Animals (Singapore), and Mount Pleasant Animal Hospital for collecting samples used in this study. We also thank all pet owners who donated samples.

Funding

The work was supported in part by the Japan Society for the Promotion of Science (JSPS) KAKENHI, Japan (JP23K23770, and JP24KK0133); the Japan Agency for Medical Research and Development (AMED), Japan (JP23wm0225034).

Ethical statement: No experiments were performed on animals or human subjects and all ethical guidelines for research in Japan and Singapore were adhered to.

Declaration of Competing Interest: We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability: Data will be made available on request.

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Figure 1: Locations across Singapore from which tick samples were collected from 2018-onwards under the national tick surveillance program.

Figure 2: Tick species collected on dogs in Singapore; A) *Dermacentor auratus*; B) *Rhipicephalus linnaei*; C) *Haemaphysalis bispinosa*, D) *Haemaphysalis papuana*; E) *Haemaphysalis hystricis* (Copyright M.L.Kwak, all rights reserved).

Figure 3: Community composition of ticks on companion animals in Singapore.

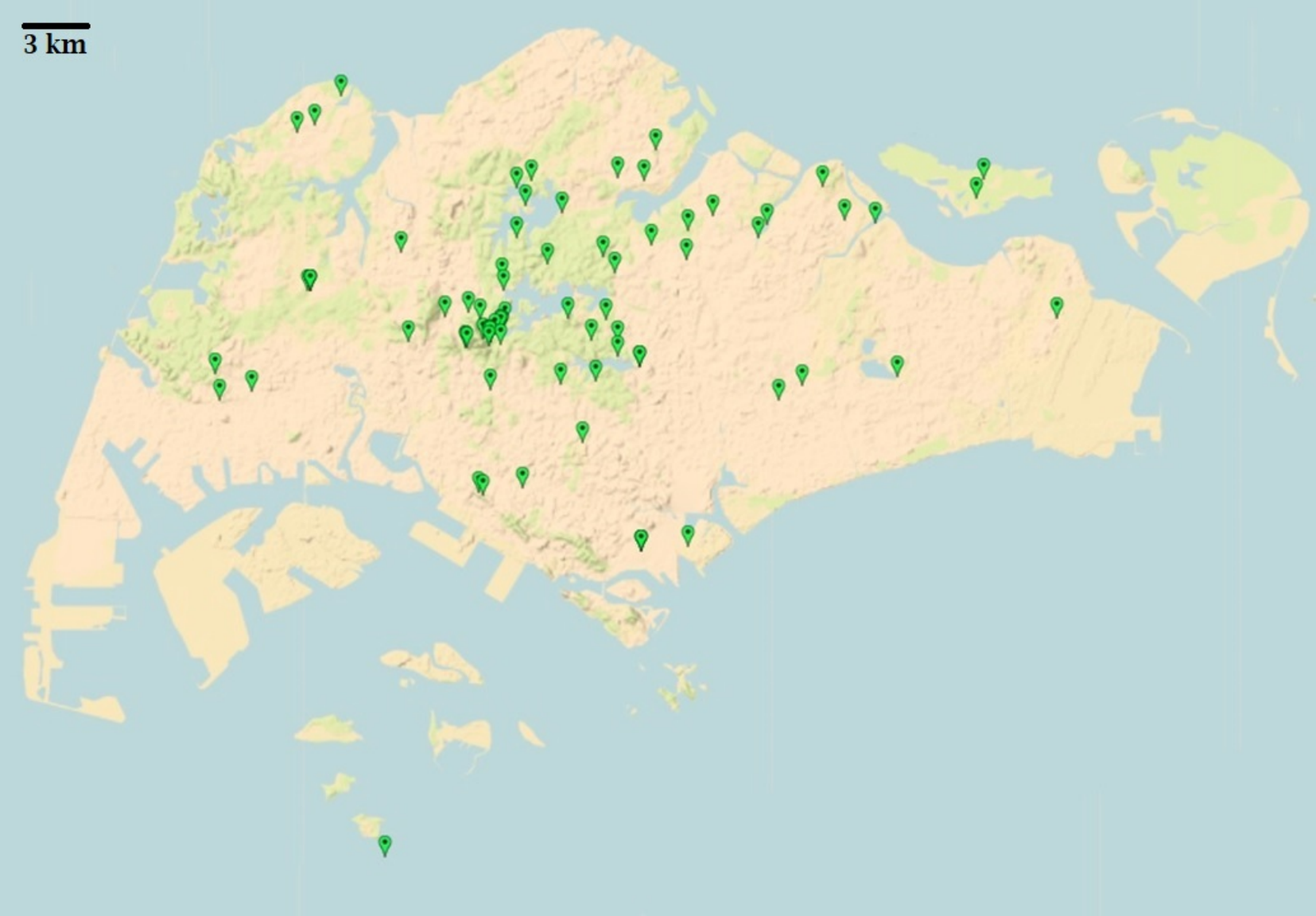
Table 1: prevalence and load of tick species on infested dogs in Singapore

Tick species	Total	Adults	Nymphs	Larvae	Mean load ± 95% CI	Prevalence
Haemaphysalis bispinosa	195	100	74	21	13 ± 8.2	39%
Haemaphysalis hystricis	3	3	0	0	3*	3%
Haemaphysalis papuana	7	7	0	0	2*	8%
Rhipicephalus linnaei	151	113	38	0	6 ± 3.4	63%
Dermacentor auratus	5	0	5	0	3*	8%

(*confidence interval was not calculated if the number of infestations was ≤3)

Table 2: Checklist of companion animal-tick interactions in Singapore

Tick species	Host species	Interaction type	Reference
Haemaphysalis bispinosa	*Canis lupus familiaris*	Endemic	This study, Kwak & Ng (2022)
Haemaphysalis hystricis	*Canis lupus familiaris*	Opportunistic	This study, Kwak & Ng (2022)
Haemaphysalis papuana	*Canis lupus familiaris*	Opportunistic	This study
Haemaphysalis semermis	*Canis lupus familiaris*	Opportunistic	Hoogstraal et al. (1965)
Rhipicephalus linnaei	*Canis lupus familiaris*	Endemic	This study; Theis and Franti (1971) (as *R. sanguineus*)
Dermacentor auratus	*Canis lupus familiaris*	Opportunistic	This study
Dermacentor auratus	*Felis catus*	Opportunistic	This study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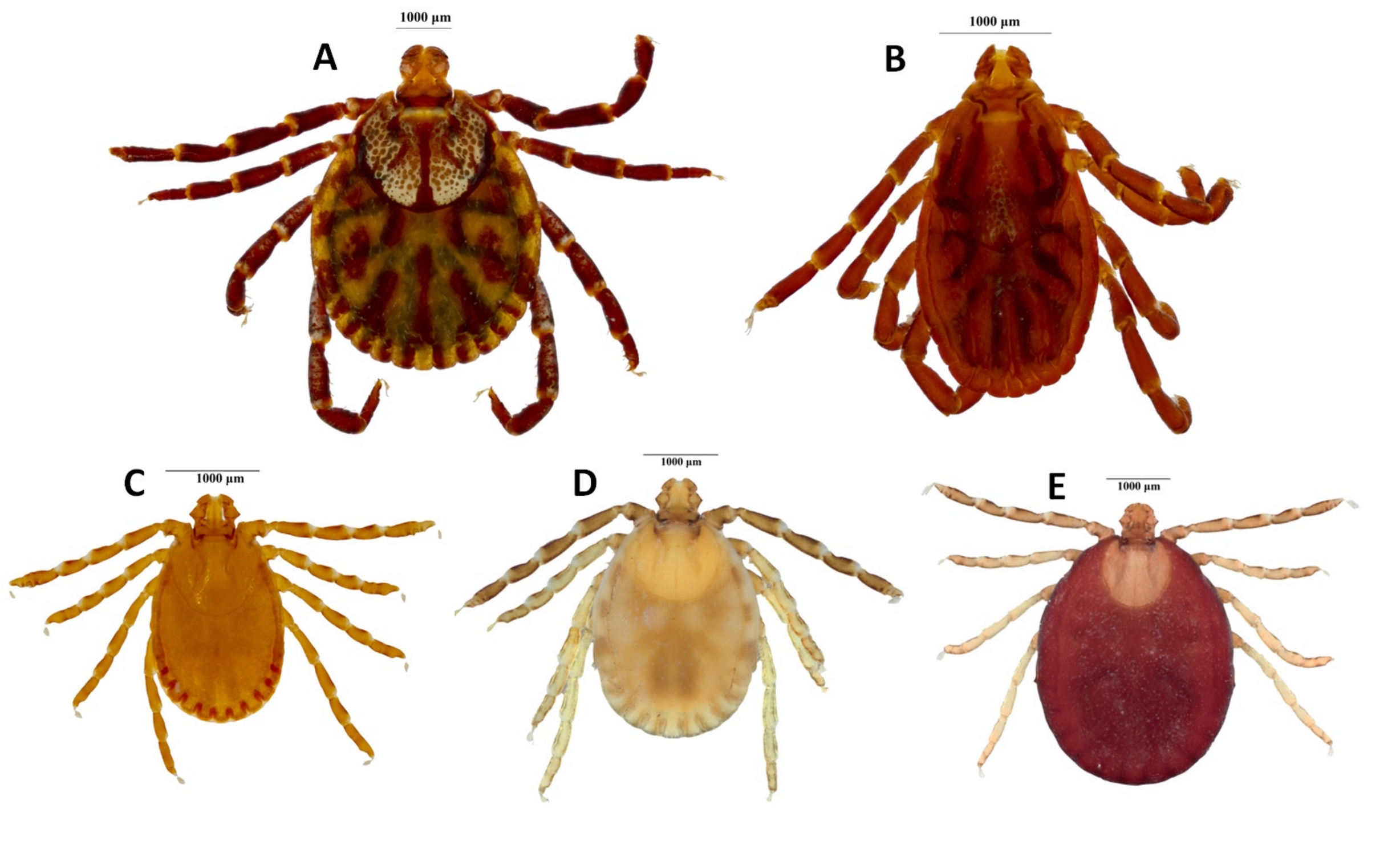
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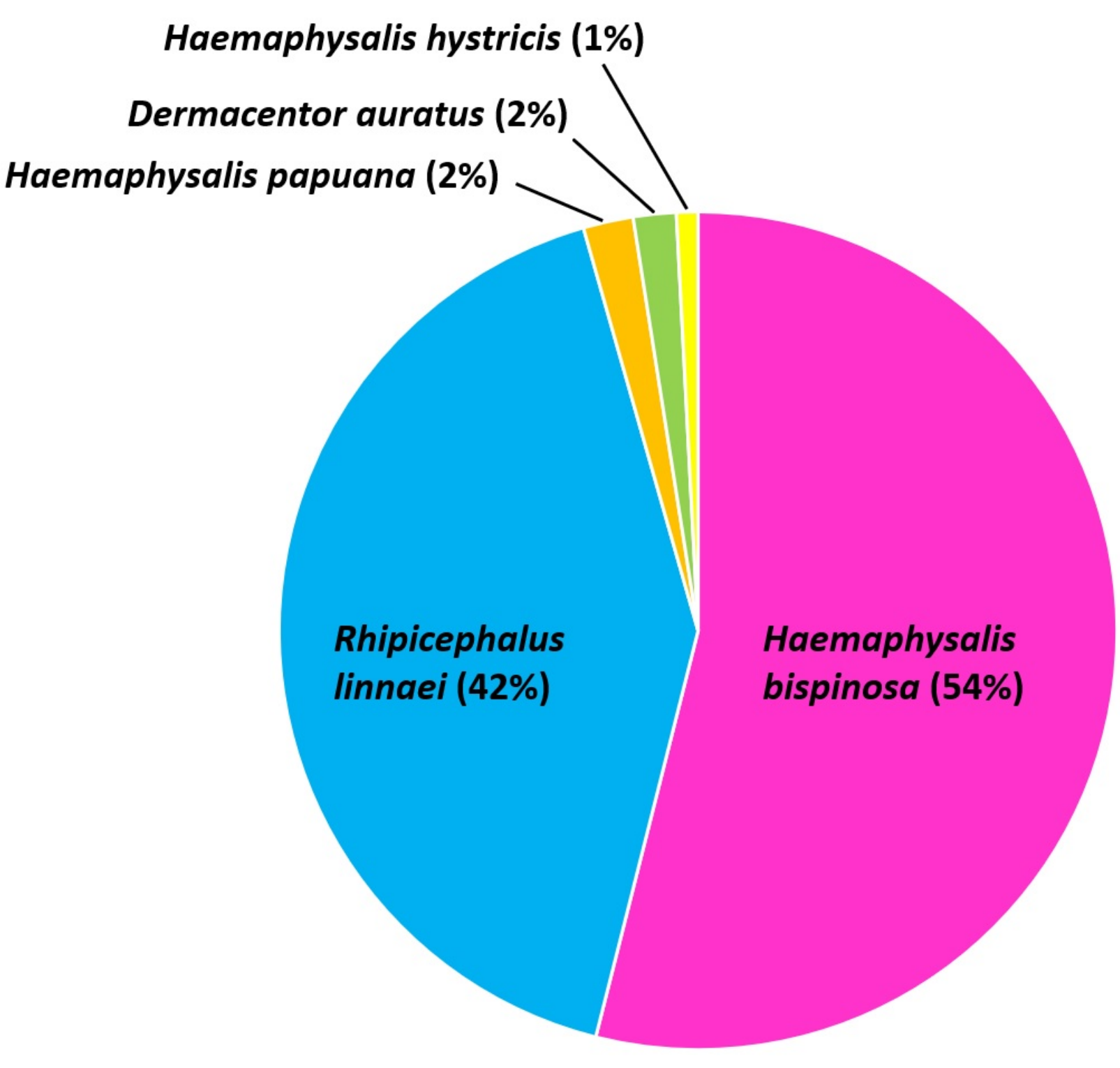
Haemaphysalis hystricis (1%)
Dermacentor auratus (2%)
Haemaphysalis papuana (2%)
Rhipicephalus linnaei (42%)
Haemaphysalis bispinosa (54%)