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Ticks in the Lion City: a preliminary review of the tick fauna of Singapore

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Abstract
To this day, the tick fauna of Singapore remains poorly known. Although several studies of select species have been undertaken within Singapore, much of the information regarding Singaporean ticks is fragmentary. To facilitate future study of this group, the scattered information on Singaporean ticks is synthesised in the present work and includes a preliminary checklist of species reported to occur in Singapore, which comprised 14 species in 5 genera, with confirmed records of *Argas pusillus*, *Amblyomma nitidum*, *Amblyomma varanense*, *Haemaphysalis doenitzi*, *Haemaphysalis nadchatrami*, *Haemaphysalis semermis*, *Ixodes granulatus*, *Rhipicephalus microplus*, and *Rhipicephalus sanguineus*, and unconfirmed reports of *Amblyomma cordiferum*, *Amblyomma geoemydae*, *Amblyomma helvolum*, *Amblyomma javanense* and *Amblyomma testudinarium*.

Keywords Vector · Zoonotic · Biodiversity · Tick-borne disease · Ixodidae · Argasidae

Introduction

Tick are responsible for a huge array of diseases in humans and animals and remain one of the most significant threats to global public health (Dantas-Torres et al. 2012). Over a century ago when research into the ticks of Southeast Asia began, most of the work was undertaken haphazardly as new specimens were acquired, predominately by colonial naturalists (Petney et al. 2007). Although Singapore was part of the British empire in these early days of medical acarology, little research was undertaken on the group. Following the second world war, the United States Armed Forces undertook large scale systematic studies of the ticks and tick-borne diseases of Southeast Asia under the leadership of the eminent Dr Harry Hoogstraal, although little of this was undertaken in Singapore (Petney et al. 2007). Following the death of Hoogstraal in 1986, the field stagnated in the region and it is for this reason that the tick fauna of Singapore remains poorly known (Petney et al. 2007).

However, in recent years, there has been increased interest in the ticks and tick-borne diseases of Southeast Asia due to their public health importance (Petney 1993). This has

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been reinforced by the now widescale use of molecular technologies which have simplified the process of detecting, identifying, and characterising ticks and tick-borne pathogens. However, the foundation of any tick-borne disease study always rests with a firm understanding of the vector. Therefore, for the first time, knowledge of the tick fauna of Singapore is reviewed and synthesised in the present work to facilitate future research on these remarkable arthropods as well as the serious diseases they are associated with.

Materials and methods

A checklist of species reported previously from Singapore is presented based on a survey of the literature. Although several species listed were originally reported under different synonyms, these have been amended to reflect the present nomenclatural consensus on these binomials.

As in Kwak (2018a), the author feels that insufficient data is available to confidently use the system of nomenclature proposed for the family Argasidae by Klompen and Oliver (1993), instead the system presented by Guglielmone et al. (2010) is used. It should be noted that in coming years, as more molecular and morphological data become available to adequately test the system proposed by Klompen and Oliver (1993), the nomenclature may shift in favour of this classification.

Results

Based on a survey of past literature, 14 tick species have thus far been reported to occur in Singapore. These represent five genera and two families (Table 1).

Table 1 Tick species recorded in Singapore

Family	Genus	Species	Reference
Argasidae	*Argas*	*Argas pusillus*	Leong et al. (2010)
Ixodidae	*Amblyomma*	*Amblyomma cordiferum*	Voltzit and Keirans (2002)[a]
		Amblyomma geoemydae	Voltzit and Keirans (2002)[a]
		Amblyomma helvolum	Voltzit and Keirans (2002)[a]
		Amblyomma javanense	Voltzit and Keirans (2002)[a]
		Amblyomma nitidum	Voltzit and Keirans (2002)
		Amblyomma testudinarium	Voltzit and Keirans (2002)[a]
		Amblyomma varanense	Burridge (2001)
	Haemaphysalis	*Haemaphysalis doenitzi*	Hoogstraal and Wassef (1973)
		Haemaphysalis nadchatrami	Hoogstraal et al. (1965)
		Haemaphysalis semermis	Hoogstraal et al. (1965)
	Ixodes	*Ixodes granulatus*	Paperna (2006)
	Rhipicephalus	*Rhipicephalus microplus*	Petney (1993)
		Rhipicephalus sanguineus	Theis and Franti (1971)

[a]Unsubstantiated reports in which collection/literature records are not cited to support distribution claims

Discussion

History of tick research in Singapore

It is somewhat unclear when the first work on Singaporean ticks was undertaken, but it likely began in 1909 when Dr. A.R. Wellington sent tick specimens, collected on Singapore's St John's Island, to the eminent acarologists C. Warburton and G.H.F Nuttall (Hoogstraal and Wassef 1973). These specimens proved to be the first of a new, widely spread tick species which was named *Haemaphysalis doenitzi*. In 1933 C. Warburton described *Amblyomma laticaudae* from a sea snake preserved in the collection of the Raffles Museum (now known as the Lee Kong Chian Natural History Museum), although this species is now believed to be a synonym of *Amblyomma nitidum* (Voltzit and Keirans 2002). Following the second world war, for almost two decades little work was undertaken on the Singaporean tick fauna, although Kohls (1957) produced a detailed guide to the ticks of neighbouring Malaya. Finally, in the 1960s Harry Hoogstraal and others described *Haemaphysalis nadchatrami* (syn. *Haemaphysalis papuana nadchatrami*) and *Haemaphysalis semermis* from specimens collected in the region, some of which came from Singapore (Hoogstraal et al. 1965). Hoogstraal and Wassef (1973) also redescribed *Haemaphysalis doenitzi*. Following this period, no further taxonomic work has been undertaken on the ticks of Singapore. Studies of tick ecology and population biology in Singapore began in 1971 with the first study of populations of the brown dog tick (*Rhipicephalus sanguineus*), but no further detailed studies have since been undertaken on tick ecology in Singapore (Theis and Franti 1971). Paperna (2006), Leong et al. (2010), and Law (2014) recently provided cursory reports on *Ixodes granulatus*, *Argas pusillus*, and what the author suspects to be *Amblyomma cordiferum*, respectively. However, much still remains to be learned about the ticks of Singapore. Recently, the author has begun detailed studies of the taxonomy and ecology of the tick fauna of Singapore which will progressively be published in the future.

Tick-borne disease in Singapore

Tick-borne diseases remain largely unstudied in Singapore, despite their significant public health importance. Although Neves et al. (2018) recently studied the blood of small mammals in Singapore and detected the pathogenic bacterial genus *Bartonella*, ticks were not screened despite their known capacity to spread Bartonellosis. Several tick species stand out as potential threats to public health due to their propensity to infest humans and their known capacity to harbor zoonotic pathogens. Perhaps the most important of these is the Brown dog tick (*R. sanguineus*) which was common on Singaporean dogs in the past and remains so to this day (Theis and Franti 1971; M.L. Kwak, personal observation). It is also a largely urban and peri-urban ticks which lives and breeds in close proximity to dwellings and is known to infest humans (Dantas-Torres 2008). Many significant zoonotic pathogens are known from the brown dog tick including *Coxiella burnetii*, *Ehrlichia canis*, *Rickettsia conorii*, and *R. rickettsia* (Dantas-Torres 2008). On top of this, *R. sanguineus* can carry a wide array of animal pathogens of significant veterinary importance (Dantas-Torres 2010). *Ixodes granulatus* is another candidate for intensive disease ecology studies in Singapore. *Ixodes granulatus* is known to infest not only a wide range of mammals, including urban rodents, but also humans (Durden et al. 2008). Perhaps the most significant aspect of the disease ecology of *I. granulatus* is the wide range of zoonotic pathogens which have been

detected within it. These include *Rickettsia honei*, *R. typhi*, *R. conorii*, *R. rickettsia*, *R. felis*, and *R. australis* (Scheld et al. 2014; Kuo et al. 2015). Presently, the author is involved in screening ticks collected in Singapore to identify tick-borne pathogens present on the island. The result of this work will be progressively published in the future.

Introduced ticks in Singapore

Of the tick species reported from Singapore, the author believes that only two represent recent introductions. These are the cattle tick (*Rhipicephalus microplus*) and the Brown dog tick (*R. sanguineus*). Kwak (2018b) noted the difficulty in inferring the introduction histories of invasive ticks, and in regards to the two aforementioned species, this is the case. The cattle tick (*R. microplus*) is clearly an introduction owing to the fact that no members of the family Bovidae, the natural hosts, are native to Singapore (Harrison 1974). Therefore, *R. microplus* must have been introduced with cattle sometime during the colonial era. The continued presence of *R. microplus* within Singapore is unknown, but it may now be locally extinct due to the huge reduction in cattle numbers on the island in recent years. It remains unclear where *R. sanguineus* originated, but it invariably must have been somewhere canids occur (Dantas-Torres 2008). However, as no canids are native to Singapore, *R. sanguineus* is clearly an introduced species (Harrison 1974). *Rhipicephalus sanguineus* was probably introduced sometimes during the colonial era with dogs.

Threatened ticks in Singapore

Mihalca et al. (2011) was the first to attempt to systematically assess the conservation status of various tick species. Following this, Kwak et al. (2017) and Kwak (2018c) outlined methods for the conservation of threatened tick species. Of the tick species assessed to be co-endangered by Mihalca et al. (2011), only one, *Amblyomma javanense*, is present in Singapore. Despite it's conservation status, no deliberate action has been taken within Singapore to recognise or conserve this species. Although, conservation efforts are ongoing to protect its host, the Sunda pangolin (*Manis javanica*), in Singapore (Vijayan et al. 2008). As Kwak et al. (2017) and Kwak (2018c) have suggested for other co-endangered tick species, *A. javanense* could be incorporated into conservation programs including captive breeding, conservation translocations, and in situ protection. Within Singapore, no conservation assessment has been undertaken for the other tick species, although it is possible that other species may be co-threatened at the national level. For example, the sea snake tick (*A. nitidum*) may be threatened within Singapore due to highly fragmented and degraded coastline where it's host emerges to lay eggs and where the tick emerges to breeds. To facilitate future conservation efforts, a full assessment of the national conservation status of the ticks of Singapore must be undertaken and conservation plans outlines to preserve any native species threatened with declines.

References

Burridge MJ (2001) Ticks (Acari: Ixodidae) spread by the international trade in reptiles and their potential roles in dissemination of diseases. Bull Entomol Res 91:3–23

Dantas-Torres F (2008) The brown dog tick, *Rhipicephalus sanguineus* (Latreille, 1806) (Acari: Ixodidae): from taxonomy to control. Vet Parasitol 152(3–4):173–185

Dantas-Torres F (2010) Biology and ecology of the brown dog tick, *Rhipicephalus sanguineus*. Parasite Vector 3(1):26

Dantas-Torres F, Chomel BB, Otranto D (2012) Ticks and tick-borne diseases: a One Health perspective. Trends Parasitol 28(10):437–446

Durden LA, Merker S, Beati L (2008) The tick fauna of Sulawesi, Indonesia (Acari: Ixodoidea: Argasidae and Ixodidae). Exp Appl Acarol 45:85–110

Guglielmone AA, Robbins RG, Apanaskevich DA, Petney TN, Estrada-Peña A, Horak IG, Shao R, Barker SC (2010) The Argasidae, Ixodidae and Nuttalliellidae (Acari: Ixodida) of the world: a list of valid species names. Zootaxa 2528:1–28

Harrison J (1974) An introduction to mammals of Singapore and Malaya, 2nd edn. Malayan Nature Society, Singapore

Hoogstraal H, Wassef HY (1973) The Haemaphysalis ticks (Ixodoidea: Ixodidae) of birds. 3. H. (Ornithophysalis) subgen. n.: definition, species, hosts, and distribution in the Oriental, Palearctic, Malagasy, and Ethiopian faunal regions. J Parasitol 59:1099–1117

Hoogstraal H, Trapido H, Kohls GM (1965) Southeast Asian *Haemaphysalis* ticks (Ixodoidea, Ixodidae). *H.* (*Kaiseriana*) *papuana nadchatrami* ssp. n. and redescription of *H.*(*K.*) *semermis* Neumann. J Parasitol 51(3):433–451

Klompen JSH, Oliver JH (1993) Systematic relationships in the soft ticks (Acari: Ixodida: Argasidae). Syst Entomol 18(4):313–331

Kohls G.M (1957) Malaysian parasites-XVIII. Ticks (Ixodoidea) of Borneo and Malaya. Studies from the Institute for Medical Research, Federated Malay States 28: 65–94

Kuo CC, Shu PY, Mu JJ, Lee PL, Wu YW, Chung CK, Wang HC (2015) Widespread *Rickettsia* spp. infections in ticks (Acari: Ixodoidea) in Taiwan. J Med Entomol 52(5):1096–1102

Kwak ML (2018a) A checklist of the ticks (Acari: Argasidae, Ixodidae) of Japan. Exp Appl Acarol 75(2):1–5

Kwak ML (2018b) The introduction and subsequent extinction of the camel tick *Hyalomma* (*Euhyalomma*) *dromedarii* (Acari, Ixodidae) in Australia, with a review of the introduction of foreign ticks to Australia. Exp Appl Acarol 74(3):329–333

Kwak ML (2018c) An expanded description of the threatened tree kangaroo tick *Ixodes* (*Sternalixodes*) *dendrolagi* Wilson, 1967 (Acari: Ixodidae) from Papua New Guinea. Acarologia 58(2):408–413

Kwak ML, Ash A, Elliot A (2017) Redescription of the numbat tick *Ixodes* (*Sternalixodes*) *myrmecobii* Roberts, 1962 (Acari: Ixodidae) with descriptions of the male and nymph, and new host records. Zootaxa 4272(1):40–56

Law IS (2014) A tick-infested reticulated python. Singap Biodivers Rec 2014:253–254

Leong TM, Shunari M, Lim KK (2010) The narrow-winged pipistrelle, *Pipistrellus stenopterus* (Dobson) in Singapore (Mammalia: Chiroptera: Vespertilionidae). Nat Singap 3:159–165

Mihalca AD, Gherman CM, Cozma V (2011) Co-endangered hard-ticks: threatened or threatening? Parasite Vector 4(1):71

Neves ES, Mendenhall IH, Borthwick SA, Su YCF, Smith GJD (2018) Detection and genetic characterization of diverse *Bartonella* genotypes in the small mammals of Singapore. Zoonoses Public Health 65(1):e207–e215

Paperna I (2006) The tick *Ixodes granulatus* infests *Rattus rattus* populating a small island offshore of Singapore. Parasite 13(1):83–84

Petney TN (1993) A preliminary study of the significance of ticks and tick-borne diseases in South-east Asia. Mitt Österr Ges Tropenmed Parasitol 15:33–42

Petney TN, Kolonin GV, Robbins RG (2007) Southeast Asian ticks (Acari: Ixodida): a historical perspective. J Parasitol Res 101(2):201

Scheld MW, Whitley RJ, Marra CM (2014) Infections of the central nervous system. Lippincott Williams & Wilkins, Philadelphia

Theis JH, Franti CE (1971) Changing infestation rates of *Rhipicephalus sanguineus* (Latreille) (Ixodidae) ticks on dogs on Singapore Island, 1965–1966. J Med Entomol 8(1):23–28

Vijayan M, Yeong C, Ling D (2008) Captive management of Malayan pangolins *Manis javanica* in the Night Safari. In: Pantel S, Chin SY (eds) Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia. TRAFFIC Southeast Asia, Singapore Zoo, Singapore, 119–129

Voltzit OV, Keirans JE (2002) A review of Asian *Amblyomma* species (Acari, Ixodida, Ixodidae). Acarina 10:95–136