Experimental and Applied Acarology (2018) 76:551–557
https://doi.org/10.1007/s10493-018-0310-7

The first authenticated record of the pangolin tick *Amblyomma javanense* (Acari: Ixodidae) in Singapore, with notes on its biology and conservation

Mackenzie L. Kwak[1] **· Chia-Da Hsu**[2] **· Guillaume Douay**[2] **· Ali Anwar Ahmad**[2]

Received: 25 June 2018 / Accepted: 2 October 2018 / Published online: 8 October 2018

Abstract
The first authenticated record of the co-endangered pangolin tick (*Amblyomma javanense*) is reported from the Republic of Singapore, based on specimens of males and females collected from the Sunda pangolin (*Manis javanica*). The biology of the species is reviewed and steps for its conservation are outlined to ensure its continued survival across its range.

Keywords Pangolin tick · Co-endangered · *Manis javanica* · Parasite conservation · Holistic conservation

Introduction

The tick fauna of south east Asia has attracted limited study, and is therefore poorly known (Petney et al. 2007). This lack of knowledge is compounded by the rapid decline of many animals in the region which has made it difficult to collect and study once potentially common species (Sodhi et al. 2004). While most of the species for which declines has been recorded are vertebrates, it has been suggested that the greatest number of species at risk of extinction are parasites, including ticks (Dunn et al. 2009). In an assessment of the conservation status of the global hard tick (Ixodidae) fauna, Mihalca et al. (2011) noted many threatened south east Asian tick species, among which the pangolin tick (*Amblyomma javanense*) was reported to be co-endangered. To conserve poorly known but highly threatened tick species, a greater understanding of their distribution, ecology, and biology is required.

✉ Mackenzie L. Kwak
mackenziekwak@gmail.com

[1] Department of Biological Science, National University of Singapore, 16 Science Drive 4, Singapore 117558, Republic of Singapore

[2] Department of Conservation, Research and Veterinary Services, Wildlife Reserves Singapore, 80 Mandai Lake Road, Singapore 729826, Republic of Singapore

The first authenticated record of *A. javanense* from the Republic of Singapore is reported based on ticks taken from a wild Sunda pangolin (*Manis javanica*). The biology of *A. javanense* is reviewed and conservation methods for this species are outlined to allow conservationists to safeguard this enigmatic species against extinction.

Materials and methods

In January 2018 a wild Sunda pangolin (*Manis javanica*) wandering in an urban area in the Republic of Singapore was collected by wildlife management authorities. The animal was brought to the veterinary department of the Singapore Zoo for a health check before being relocated to an undisclosed national park within Singapore. During the course of the veterinary examination ticks were located and given to one of the authors (MLK) for identification. The ticks were examined using a LEICA M80 light microscope and were identified based on morphological characters using keys and descriptions provided by Voltzit and Keirans (2002).

Results

The presence of a scutum distinguished these specimens as belonging to family Ixodidae. The presence of long slender palps and festoons on the idiosoma distinguished the specimens as members of the genus *Amblyomma* and separated them from the other genera of the Ixodidae occurring on the Malaysian peninsula, namely *Haemaphysalis*, *Rhipicephalus*, *Dermacentor*, and *Ixodes*. The female specimens were distinguished from other *Amblyomma* ticks occurring in south east Asia by a combination of the presence of eyes, an inornate scutum, 4/4 dentition along the hypostome, and coxae II and III each with an extremely wide, blunt, rounded spur, and extremely small porose areas. The male specimens were distinguished from other *Amblyomma* ticks occurring on Malaysian peninsula by a combination of the presence of eyes, an inornate scutum, 3/3 dentition along the hypostome, coxa I with two extremely wide, blunt, well separated spurs of approximately equal length, as well as small cornua on the posterior edge of the dorsal basis capituli. Specimens of the female and male are presented in Fig. 1a, b.

Discussion

Ecology

As with many tick species present in Southeast Asia, the ecology of *A. javanense* is far from well-studied. Although Mihalca et al. (2011) recorded the Sunda pangolin (*M. javanica*) as the main host of *A. javanense*, it has been reported to infest 12 species of mammal and four species of reptile, tabulated in Tables 1 and 2, respectively. While *A. javanense* has been recorded from this wide list of hosts, records from hosts other than pangolins are rare, suggesting that this species is highly host specific. The Sunda pangolin, apparently one of the main host of *A. javanense*, has been shown to use a network of dens in which to shelter during the day (Lim and Ng 2008). Many tick species have adapted to become

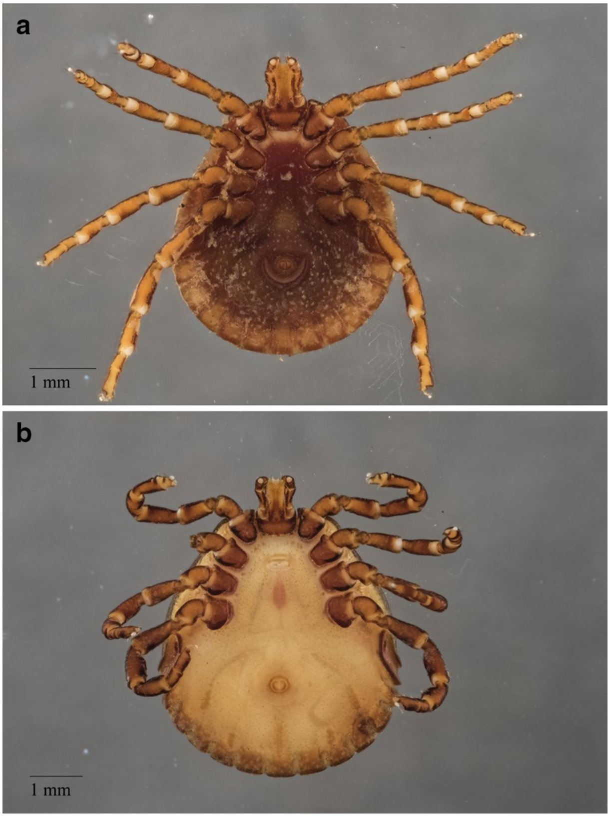

Fig. 1 Female and male Pangolin tick (*Amblyomma javanense*) collected from the Sunda pangolin (*Manis javanica*) in Singapore

Table 1 Mammals from which the pangolin tick *Amblyomma javanense* has been reported

Common name	Scientific name	References
Sunda pangolin	*Manis javanica*	Kohls (1957)
Chinese pangolin	*Manis pentadactyla*	Kollars and Sithiprasasna (2000)
Indian pangolin	*Manis crassicaudata*	Sanyal et al. (1987)
Palawan pangolin	*Manis culionensis*	Voltzit and Keirans (2002)
Wild boar	*Sus scrofa*	Kohls (1957)
Bat	'*Vesperugo abramus*'	Kohls (1957)
Hyena	*Hyaena hyaena*	Kohls (1957)
'Bear'	–	Kohls (1957)
Sambar deer	*Cervus unicolor*	Kohls (1957)
Indian crested porcupine	*Hystrix indica*	Liyanaarachchi et al. (2016)
Mouse deer	*Moschiola meminna*	Liyanaarachchi et al. (2016)
Human	*Homo sapiens*	Gould et al. (1970)

specialists of hosts with predictable nidicolous habits such as the pangolin (Randolph 2014). It is likely that *A. javanense* is a nidicolous species adapted to the highly predictable den using habit of its host. It is also highly likely that *A. javanense* is a three-host tick,

Table 2 Reptiles from which the pangolin tick *Amblyomma javanense* has been reported

Common name	Scientific name	References
Water monitor	*Varanus salvator*	Kohls (1957)
'Python'	–	Hassan et al. (2013)
Long-tailed skink	'*Mabuya* sp.'	Kohls (1957)
Hill turtle	*Geoemyda tricarinata*	Kohls (1957)

as is the case with all other *Amblyomma* ticks for which the complete life cycle is known (Apanaskevich and Oliver 2014). Usurpingly, many of the exceptional hosts recorded in Tables 1 and 2 are species which are likely to enter the dens of pangolins and become accidentally infested while seeking shelter or during foraging. Interestingly, Nelder et al. (2009) recorded *A. javanense* surviving on a water monitor (*Varanus salvator*), which had been in captivity in a South Carolina zoo (USA) for 7 years. This suggests that the species can survive and reproduce on this apparently abnormal host. However, it is unclear whether the apparently nidicolous ecology of *A. javanense* is compatible enough with the ecology of *V. salvator* to enable stable populations to exist which parasitised *V. salvator* exclusively. Although Træholt (1995) recorded the use of burrows by *V. salvator* as sleeping sites, the author has also observed the same species in Singapore sleeping in the branches of mangrove trees at night (Author's Personal Observation 2018). Therefore, it is unclear how extensively *V. salvator* uses burrows throughout its range, and therefore the likelihood of it supporting viable populations of *A. javanense*.

The infestation ecology of *A. javanense* on *M. javanica* remains poorly known. However, a recent study undertaken by Hassan et al. (2013) has begun to elucidate this. Usurpingly, all juveniles examined in the aforementioned study were infested by *A. javanense*, which supports the notion that *A. javanense* is a nidicolous species. Interestingly the male pangolins samples, had significantly higher rates of infestation compared with female pangolins. Hassan et al. (2013) suggested this may be a combination of testosterone inhibiting the immune response coupled with increased den visiting as males move through their ranges seeking females. The author is inclined to suspect the later over the former explanation, although both may play a role.

Ambiguous host records

Despite the numerous infestation records for *A. javanense*, the identities of some of the hosts from which it has been reported are ambiguous. This is due to poor recording by some past authors who used the common names of host species rather than their binomials. It is also due to changes in taxonomic nomenclature which have made it difficult, and sometimes impossible, to link the host species referred to in historical literature with those presently recognised by taxonomists. These problems are exemplified by a number of recorded host-tick associations in Tables 1 and 2.

Kohls (1957) reported *A. javanense* from a 'bear', however, as several members of the family Ursidae (bears) occur throughout the wide range of *A. javanense*, it is impossible to determine which species he was referring to. Kohls (1957) also reported *A. javanense* from a bat species listed as '*Vesperugo abramus*'. However, while the genus *Vesperugo* remains valid, the species formerly known as '*Vesperugo abramus*' has since been placed within the genus *Pipistrellus*, with the species now recognised as *Pipistrellus abramus* (Chan et al. 2009). Notably though, this bat species only occurs in north east Asia, namely eastern Russia, Taiwan, Japan, the Korean peninsula, and China (Wei et al. 2010). This is generally outside the range of *A. javanense* and therefore, it is likely that this host record is erroneous. It remains impossible to determine which bat species this recorded infestation is from. However, it may be *Pipistrellus javanicus*, which has historically been reported as '*Vesperugo abramus*' in Singapore and has significant geographical overlap with *A. javanense* (Chan et al. 2009).

Several reptile records are also difficult to interpret, Kohls (1957) reported *A. javanense* from a lizard of the genus *Mabuya* sp., commonly known as long-tail skinks. However, in the time since the original record by Kohls (1957) was made, the formerly large *Mabuya* genus has been split into smaller genera which more accurately reflect evolutionary diversification (Karin et al. 2016). Within the range of *A. javanense*, three genera formerly regarded as members of *Mabuya* are now recognised, namely *Europsis*, *Dasia*, and *Toenayar* (Karin et al. 2016). This makes it impossible to determine which host Kohls (1957) was referring to. Liyanaarachchi et al. (2016) recently reported a reference to *A. javanense* infesting a 'python' (misspelled as "phyton" in their publication) reported by Kolonin (2009). Unfortunately, only the common name allegedly reported by Kolonin (2009) was used, which makes it impossible to link the infestation record to a recognised binomial. More worrying still, the reference was an online tick database which has since been defunct and can no longer be accessed to check the validity of the record.

Distribution

Amblyomma javanense is found in the oriental zoogeographical region, exclusively (Guglielmone et al. 2014). Unsurprisingly though, there are records outside this region on captive animals in zoos, likely due to improper quarantine measures which have allowed the tick to be transported into such collections from its natural range in Asia (Nelder et al. 2009). Voltzit and Keirans (2002), reported *A. javanense* from Pakistan, India, Sri Lanka, Myanmar, Thailand, Vietnam, Malaysia, Singapore, Indonesia, Philippines, and China. However, the only specimens of *A. javanense* referenced in their work come from Malaysia and the Philippines, respectively. Therefore, it is unclear how this distribution list was assembled and until such a time as this is clarified, the author considers the list unauthenticated. Within this report, the author presents the first authenticated record of *A. javanense* in Singapore, thus conforming the report by Voltzit and Keirans (2002). Interestingly, *A. javanense* has not been recorded from Nepal, Bangladesh, Laos or Cambodia. Pangolins are known from these four nations and they are contiguous with nations from which *A. javanense* has been reported (Zhang et al. 2015). Therefore, it is likely that in the future as sampling for ticks increases in these countries, that *A. javanense* will likely be recorded. Interestingly, while a subspecies of the Chinese pangolin (*Manis pentadactyla*) is found on the island nation of Taiwan, *A. javanense* is not known from the country. This is likely due to absence from Taiwan, rather than lack of sampling, as recent surveys of the pangolin in Taiwan found three species, none of which were *A. javanense* (Khatri-Chhetri et al. 2016).

Conservation

Mihalca et al. (2011) was the first to highlight the huge number of tick species facing extinction. In recent years the conservation biology of threatened ticks has been increasingly examined in taxonomic and ecological papers concerning them (Kwak et al. 2017;

Kwak 2018; Kwak and Heath 2018). Unfortunately, all species within the pangolin genus *Manis*, the chief hosts of the *A. javanense*, are threatened with extinction and are classed as either endangered or critically endangered (Zhang et al. 2015). Therefore, by extension, *A. javanense* is also threatened with extinction due to the fact that the loss of its main hosts would likely also result in it's co-extinction. This same assertion has also been made by Mihalca et al. (2011).

A number of methods have been outlines for the conservation of threatened ticks and these can be applied to *A. javanense*. Kwak et al. (2017) first suggested the potential for conservation translocation as a method for protecting threatened ticks from extinction. When employing conservation translocation, threatened tick species are deliberately reintroduced to host populations where they are locally extinct. Through this action new populations are established to safeguard against stochastic extinction events. With reference to *A. javanense*, until such a time as a full taxonomic study to can be undertaken of the species across it's wide range to establish whether it represents a single species, or a complex, translocations should not be undertaken between countries. This will ensure local pangolin tick population are protected. Kwak (2018) also proposed ex situ conservation for threatened ticks, wherein they are included in captive breeding programs with their natural hosts. This allows for threatened tick species to be maintained in captivity from which they can be reintroduced to wild host populations to ensure their survival. Perhaps the most important step towards protecting threatened ticks from extinction is simple recognition of their plight. To this day no major threatened species registry, including the IUCN Redlist, recognise any tick species as threatened. If threatened ticks like *A. javanense* are to be protected from extinction, the first step is international recognising of the risk of extinction faced by parasites, more specifically ticks.

Acknowledgements We kindly thank the veterinary staff at Singapore Zoo for their kind assistance in collecting the specimens examined in this study.

References

Apanaskevich DA, Oliver JH Jr. (2014) Life cycles and natural history of ticks. In: Sonenshine DE, Roe RM (eds) Biology of ticks, vol 1, 2nd edn. OUP, Oxford, pp 59–73

Chan KW, Lim KKP, Leong TM (2009) The Javan pipistrelle, *Pipistrellus javanicus* (Mammalia: Chiroptera: Vespertilionidae) in Singapore. Nat Singap. 2:23–327

Dunn RR, Harris NC, Colwell RK, Koh LP, Sodhi NS (2009) The sixth mass coextinction: are most endangered species parasites and mutualists? Proc R Soc Lond B Biol Sci 276(1670):3037–3045

Gould DJ, Clifford CM, Lakshana P, Emerson KC, Hoogstraal H, Marshall JT, Stark HE, Nadchatram M, Davis EW, Inlao I, Maneechai N, Klaimanee N, Punthusiri P (1970) Distribution and ecology of ectoparasites of vertebrates in Southeast Asia. Annual Program Report SEATO Medical Research Laboratory, April 1969–March 1970, United States Army Medical Component, Bangkok, Thailand, pp 97–105

Guglielmone AA, Robbins RG, Apanaskevich DA, Petney TN, Estrada-Peña A, Horak IG (2014) The hard ticks of the world. Springer, Dordrecht

Hassan M, Sulaiman MH, Lian CJ (2013) The prevalence and intensity of *Amblyomma javanense* infestation on Malayan pangolins (*Manis javanica* Desmarest) from Peninsular Malaysia. Acta Trop 126(2):142–145

Karin BR, Metallinou M, Weinell JL, Jackman TR, Bauer AM (2016) Resolving the higher-order phylogenetic relationships of the circumtropical *Mabuya* group (Squamata: Scincidae): an out-of-Asia diversification. Mol Phylogenet Evol 102:220–232

Khatri-Chhetri R, Wang HC, Chen CC, Shih HC, Liao HC, Sun CM, Khatri-Chhetri N, Wu HY, Pei KJC (2016) Surveillance of ticks and associated pathogens in free-ranging Formosan pangolins (*Manis pentadactyla pentadactyla*). Ticks Tick Borne Dis 7(6):1238–1244

Kohls GM (1957) Malaysian Parasites-XVIII. Ticks (Ixodoidea) of Borneo and Malaya. Stud Inst Med Res Fed Malay States 28:65–94

Kollars TM, Sithiprasasna R (2000) New host and distribution record of *Amblyomma javanense* (Acari: Ixodidae) in Thailand. J Med Entomol 37(4):640

Kolonin GV (2009) Fauna of Ixodid ticks of the world. http://www.kolonin.org (now defunct)

Kwak ML (2018) 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, Heath AC (2018) Redescription of the kiwi tick *Ixodes anatis* (Acari: Ixodidae) from New Zealand, with notes on its biology. Exp Appl Acarol 74(2):207–223

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

Lim NT, Ng PK (2008) Home range, activity cycle and natal den usage of a female Sunda pangolin *Manis javanica* (Mammalia: Pholidota) in Singapore. Endanger Species Res 4:233–240

Liyanaarachchi DR, Rajakaruna RS, Rajapakse RPVJ (2016) Spotted fever group *Rickettsia* in ticks infesting humans, wild and domesticated animals of Sri Lanka: one health approach. Ceylon J Sci 44(2):67–74

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

Nelder MP, Reeves WK, Adler PH, Wozniak A, Wills W (2009) Ectoparasites and associated pathogens of free-roaming and captive animals in zoos of South Carolina. Vector Borne Zoonotic Dis 9(5):469–477

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

Randolph SE (2014) Ecology of non-nidicolous ticks. In: Sonenshine DE, Roe RM (eds) Biology of ticks, vol 1, 2nd edn. OUP, Oxford, pp 59–73

Sanyal AK, De SK, Rao AT, Acharjyo LN (1987) Metastigmata (ticks), Fauna of Orissa. Publication Zoological Survey of India. State Fauna Series No. 1, pp 273–287

Sodhi NS, Koh LP, Brook BW, Ng PK (2004) Southeast Asian biodiversity: an impending disaster. Trends Ecol Evol 19(12):654–660

Træholt C (1995) Notes on the burrows of the water monitor lizard, *Varanus salvator*. Malay Nat J 49:103–112

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

Wei L, Flanders JR, Rossiter SJ, Miller-Butterworth CM, Zhang LB, Zhang SY (2010) Phylogeography of the Japanese pipistrelle bat, *Pipistrellus abramus*, in China: the impact of ancient and recent events on population genetic structure. Biol J Linn Soc 99(3):582–594

Zhang H, Miller MP, Yang F, Chan HK, Gaubert P, Ades G, Fischer GA (2015) Molecular tracing of confiscated pangolin scales for conservation and illegal trade monitoring in Southeast Asia. Glob Ecol Conserv 4:414–422