

RESEARCH ARTICLE

New Records of Small Mammal Hosts for Five Ectoparasite Species from Sri Lanka

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Abstract: Ticks and fleas act as vectors for a number of zoonotic diseases, hence are medically important. Handful of studies carried out in Sri Lanka to date have reported 6 tick species and 11 flea species from murine rodents and shrews. Here, we report ticks and fleas infesting murine rodents and shrews collected from 18 selected sites in two districts in Sri Lanka, Kurunegala and Kandy. Two species of ticks (*Rhipicephalus haemaphysaloides* and *Haemaphysalis spinigera*), an unidentified *Haemaphysalis* larva and a flea *Xenopsylla cheopis* were found from Kurunegala. From Kandy, four species of ticks (*R. haemaphysaloides*, *H. spinigera*, *Ixodis ceylonensis* and *Dermacentor auratus*) and three species of fleas (*X. cheopis*, *Stivalius phoberus* and *Stivalius aporus*) were collected. *Rhipicephalus haemaphysaloides* was recorded from *Rattus rattus*, *Bandicota indica*, *Mus fernandoni*, *Golunda ellioti* and *Suncus murinus*; *H. spinigera* from *R. rattus*, *B. indica* and *S. murinus*; *I. ceylonensis* from *M. cervicolor* and *R. rattus*; *D. auratus* from *R. rattus*; both *X. cheopis* and *S. phoberus* were collected only from *R. rattus*; *S. aporus* from *R. rattus* and *M. fernandoni*. Though, all species of parasites reported here have been previously recorded from Sri Lanka, *D. auratus* and *H. spinigera* are reported for the first time from murine rodents and shrews. We also report here several new host records for the country: *R. haemaphysaloides* from *B. indica*, *G. ellioti* and *S. murinus*; *H. spinigera* from *B. indica* and *S. murinus*; *D. auratus* and *S. aporus* from *R. rattus*; larvae of *I. ceylonensis* from *M. cervicolor*.

Keywords: Kurunegala, Kandy, ectoparasites, murine rodents, shrews.

INTRODUCTION

Ticks and fleas are medically important ectoparasitic arthropods infesting humans and other animals such as mammals, birds, reptiles and amphibians (Guglielmone *et al.*, 2010). Fourteen genera and 702 species of ticks are recognized globally. They transmit a great

variety of infections than any other blood sucking arthropod, and are only second to mosquitoes in terms of public health and veterinary importance (Mullen and Durden, 2002). Other than disease transmission, their attachment causes local inflammation and even anaphylactic reactions, toxicoses and paralysis in both humans and animals (Mullen and Durden, 2002; Radostits *et al.*, 2006). Intra aural migration of ticks termed as otoacariasis in humans is a serious problem in rural areas, which has been reported from south Africa, south America and Asia including Sri Lanka (Dilrukshi *et al.*, 2004; Somayaji and Rajeshwari, 2007). Otoacariasis in animals may lead to severe bacterial infections. Debilitation and death caused by hemoparasitism, toxicoses and paralysis are major causes contributing to the economic losses in livestock industry (Mullen and Durden, 2002).

From Sri Lanka, 35 species of ticks (Seneviratna, 1965; Walker *et al.*, 2000; Dilrukshi, 2006; Kolonin, 2009) have been recorded. Most comprehensive study on ticks to date is a survey of hard ticks on both wild and domestic species of mammals, birds and reptiles around the country by Seneviratna (1965). Later studies have concentrated more on a single host species or a group. Among them are ticks of goats in the dry zone (Halim *et al.*, 1983), cattle ticks of Sri Lanka (Dilrukshi, 2006) and ticks of murine rodents and shrews (Yathramullage *et al.*, 2014). One recent large scale study reported ticks infesting domestic and wild mammals and humans around the country (Liyanarachchi *et al.*, 2013 and 2014).

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Fleas mainly infest mammals and birds. There are 246 genera and about 2,575 species and sub species of fleas recorded worldwide. They are vectors for many bacterial diseases such as plague, Murine typhus, Q fever and tularemia around the world (Stenseth *et al.*, 2008). They also serve as intermediate hosts of tape worm species that occasionally infect humans such as *Diphilidium caninum* of dogs and cats and *Hymenolepis diminuta* of rodents. They also cause flea bite allergies, dermatitis in humans and animals, and anemia in animals when present in large numbers (Mullen and Durden, 2002).

In Sri Lanka, 20 species of fleas have been recorded (Iyengar, 1973). Much of the contribution to the knowledge on indigenous flea fauna in Sri Lanka was from W. W. A. Phillips (1980), a prominent Zoologist who worked on mammals and birds of Sri Lanka in the 1930s. He recorded 11 species of fleas from 16 species and subspecies of rodents and shrews, during the course of his mammal surveys (Phillips, 1980). New flea species, *Nosopsyllus ceylonensis* and some other already known species collected during Phillips's surveys have been described or reported by Smith (1953). Many publications are also available on rat fleas as a result of extensive plague investigations carried out throughout the country during the early part of 20th century (Hirst, 1933). A smaller study on ectoparasites of rats recorded four species of fleas from *R. rattus kandianus* (Thompson, 1938). A recent study reported two species of fleas from three species of endemic small mammals; *Stivalius aporus* from *Suncus montanus* and *Mus fernandoni*; *Nosopsyllus tamilanus* from *Solisorex pearsoni* (Yathramullage *et al.*, 2014).

Here, we report species of ticks and fleas collected from murine rodents and shrews from two districts in Sri Lanka.

MATERIALS AND METHODS

Study sites

Parasites were collected during the period between 2013 to 2014. Small mammals were captured using 40 mesh traps placed in each site for four consecutive days. Eight localities were sampled in Kurunegala: Bogollagama (07°47'N, 80°10'E, elevation 80m), Herathgama (07°52'N,

80°25'E, elevation 155 m), Ipalawa (07°34'N, 80°27'E, elevation 145 m), Kiwlegedara (07°23'N, 80°12'E, elevation 75 m), Malliyagoda (07°24'N, 80°28'E, elevation 170 m), Minnettiya (07°35'N, 80°18'E, elevation 100 m), Polgahawela (07°19'N, 80°17'E, elevation 75 m), Udawela (07°33'N, 80°02'E, elevation 40 m) and 10 localities in Kandy: 4 in Peradeniya (07°15'N, 80°35' E, elevation 485 m; 07°15'N, 80°36' E, elevation 530 m; 07°15'N, 80°36'E, elevation 565 m; 07°16'N, 80°36' E, elevation 500 m), Mahakanda (07°13'N, 80°36'E, elevation 650 m), Doluwa (07°11'N, 80°36'E, elevation 575 m), Delthota (07°10'N, 80°42'E, elevation 1000 m), Rathmalkaduwa (07°10'N, 80°33'E, elevation 500 m), Nawalapitiya (07°02'N, 80°32'E elevation 620 m) and Kadugannawa (07° 16'N, 80° 29'E, elevation 570 m). All Kurunegala sites are human dwellings with paddy fields, home gardens or vegetable gardens (Figure. 1). In Kandy, four Peradeniya sites are situated within the Peradeniya University premises. These four sites and Mahakanda site are dominated by grass species *Panicum maximum* with intermittent bushes and trees. Of the other sites, Rajawaththa and Doluwa, samples were taken near houses and Delthota, Rathmalkaduwa, Nawalapitiya and Kadugannawa are tea estates (Figure 1).

Collection of parasites and identification

Parasites were collected by combing hair and manually picking using a pair of forceps and stored in 70% alcohol. They were observed under stereo (×45) and light microscopes (×400). Some specimens were mounted on glass slides with or without potassium hydroxide clearing for identification and also to keep as reference material. All ticks and fleas and their species-specific characteristics and other important structures were photographed using a digital camera connected to stereomicroscope and Zeiss light microscope and imaging system. Measurements were taken using photomicrographs in image J software. Ticks were identified with the help of taxonomic keys and species descriptions in Kirwan (1935); Kohls (1950); Trapido *et al.* (1964); Seneviratna (1965); Rajagopalan and Boshell (1966); Walker *et al.* (2000) and fleas with Hopkins and Rothschild (1953) and Mardon (1981).

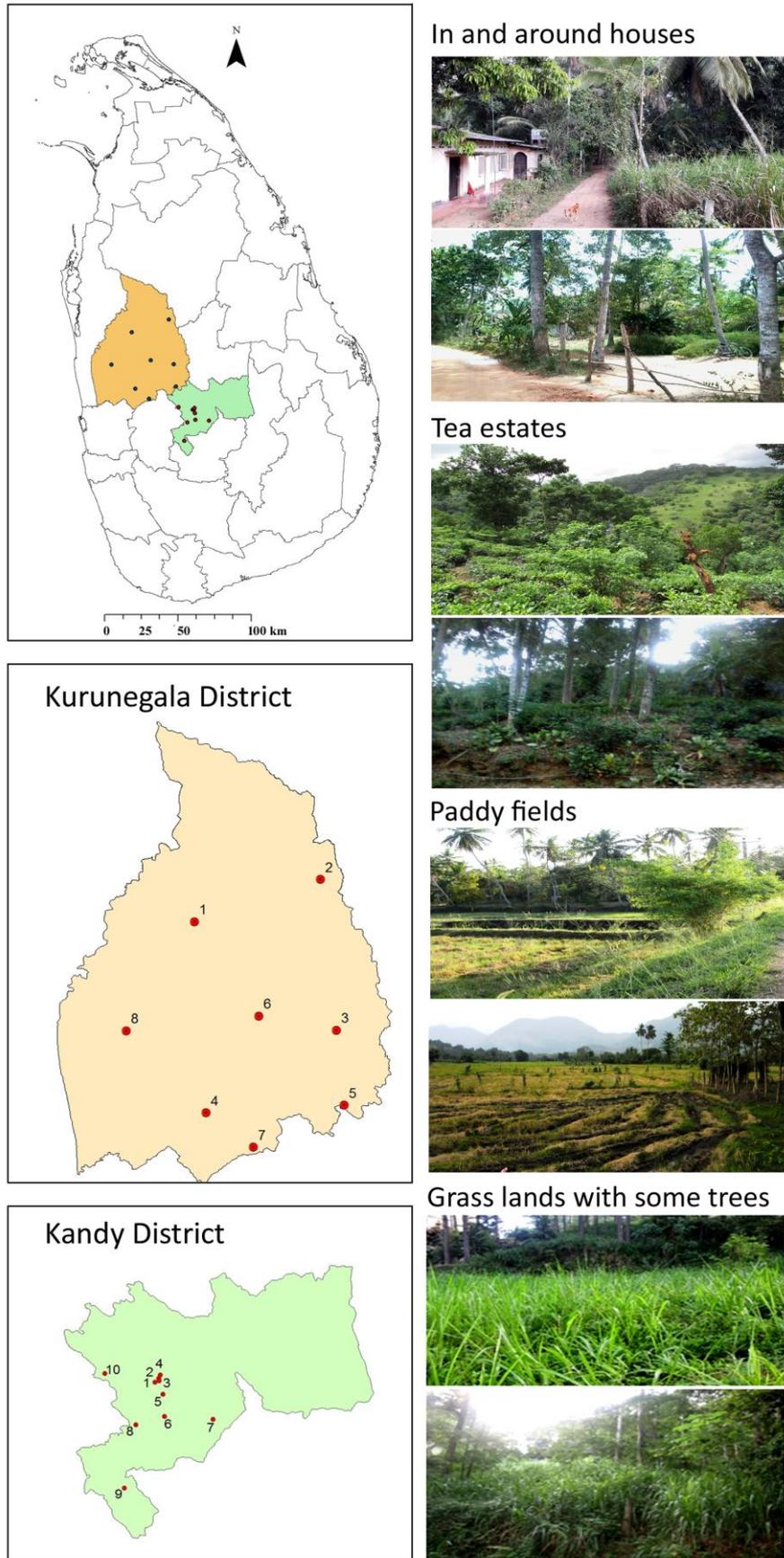


Figure 1: Maps identifying sampling localities of the two districts and photographs of representative study sites.

RESULTS

Eight small mammal species were found from both districts, of which six species (*R. rattus*, *B. indica*, *M. fernandoni*, *M. cervicolor*, *G. ellioti* and *S. murinus*) were infested with four species of ticks (*R. haemaphysaloides*, *H. spinigera*, *I. ceylonensis*, *D. auratus*) and three species of fleas (*X. cheopis*, *S. phoberus*, *S. aporus*). *Bandicota bengalensis* (13 individuals) and *Mus musculus* (5 individuals) did not have parasites. *Rattus rattus* was infested with all species of ticks and fleas recorded in the study. *Mus fernandoni* had *R. haemaphysaloides* and *S. aporus*. *Mus cervicolor* had *I. ceylonensis* only. *Golunda ellioti* had *R. haemaphysaloides*. Both *B. indica* and *S. murinus* had *R. haemaphysaloides* and *H. spinigera*. *Rattus rattus* was the most abundant species of small mammal found from both districts. *Rhipicephalus haemaphysaloides* and *X. cheopis* were the most abundant species of tick and flea species found. *Dermacentor auratus* and *H. spinigera* are reported for the first time from murine rodents and shrews in Sri Lanka. We also recorded several new hosts for four tick species and one flea species for the country: *R. haemaphysaloides* from *B. indica*, *G. ellioti* and *S. murinus*; *H. spinigera* from *B. indica* and *S. murinus*; *D. auratus* and *S. aporus* from *R. rattus*; larvae of *I. ceylonensis* from *M. cervicolor*.

Parasites collected from Kurunegala district

A total of 131 individuals belonging to six species of small mammals were collected from Kurunegala: *Rattus rattus* (98), *Bandicota indica* (9), *Bandicota bengalensis* (7), *Mus cervicolor* (4), *M. musculus* (2) and *Suncus murinus* (11). Of these 26% (34/131) were infested with ticks (20.6%) or fleas (5.3%). None had mix infections. Only larval (L) and nymphal (N) stages of ticks and adult (A) fleas were recorded. Two species of ticks (*Rhipicephalus haemaphysaloides* and *Haemaphysalis*

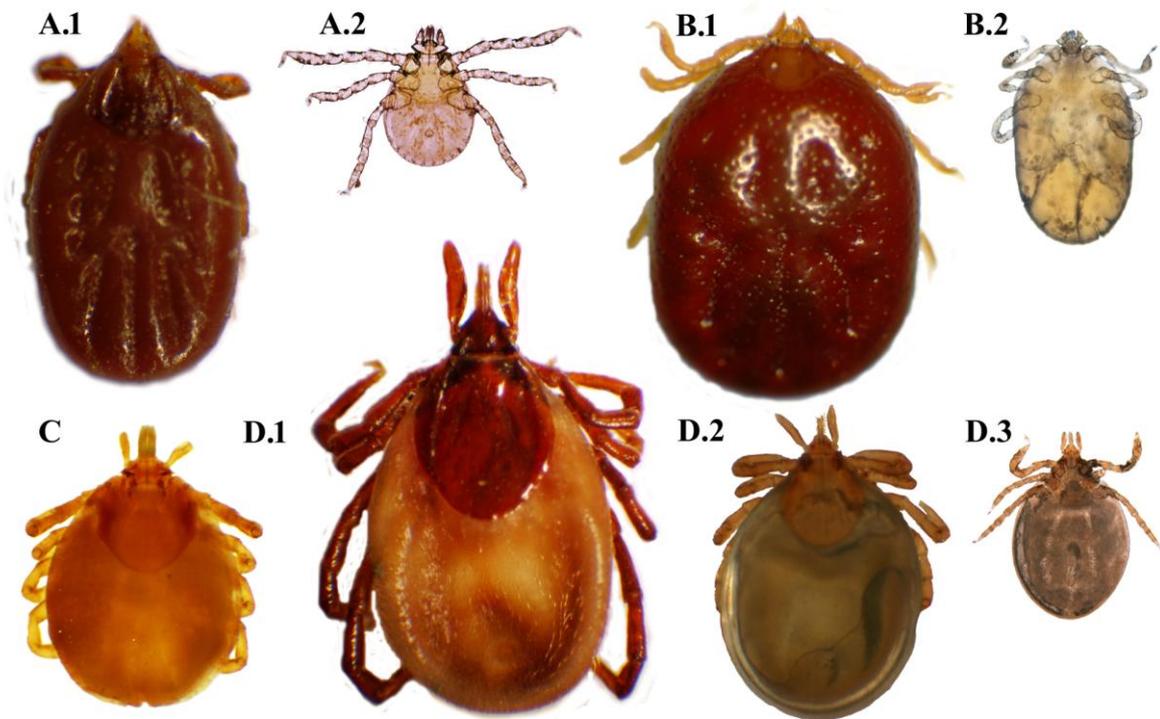
spinigera), an unidentified *Haemaphysalis* larva and a flea *Xenopsylla cheopis* were recorded from *R. rattus*, *B. indica* and *S. murinus* (Table 1; Figures 2 and 3). *Rhipicephalus haemaphysaloides* was the commonest species infesting 25 out of 34 small mammals collected, others were rare; *H. spinigera* (1/34), *Haemaphysalis* larva (1/34) and *X. cheopis* (7/34). Nymphs and larvae of *R. haemaphysaloides* were found from *R. rattus*, *B. indica* and *S. murinus*; nymphs of *H. spinigera* and *Haemaphysalis* larva were found from *S. murinus* and adult male (AM) and female (F) *X. cheopis* were recorded from *R. rattus*. All localities except one (Malliyagoda) had ectoparasite infested small mammals (Appendix 1). Ticks were found in all the sites with infested small mammals but fleas were recorded only from 3 sites.

Parasites collected from Kandy district

From Kandy district, a total of 155 small mammals were trapped, which included 7 murine rodent species: *R. rattus* (99), *Mus cervicolor* (17), *M. fernandoni* (14), *M. musculus* (3), *B. indica* (7), *B. bengalensis* (6), *Golunda ellioti* (3) and *S. murinus* (6). Of these small mammals, 33.5% (52/155) were infested, 14.2% with ticks 18% with fleas and 1.3% with both. Except three *I. ceylonensis* adult ticks found from *R. rattus* in Peradeniya University premises, all the other ticks were immature stages. All the fleas found were adults. Four species of ticks (*R. haemaphysaloides*, *H. spinigera*, *I. ceylonensis* and *Dermacentor auratus*) and three species of fleas (*X. cheopis*, *Stivalius phoberus* and *S. aporus*) were collected from *R. rattus*, *M. cervicolor*, *M. fernandoni*, *B. indica* and *G. ellioti* (Table 1). *Rhipicephalus haemaphysaloides* (15/52), *X. cheopis* (13/52), *S. phoberus* (9/52) and *S. aporus* (11/52) were relatively abundant than the other 3 species; *H. spinigera* (4/52), *I. ceylonensis* (4/52) and *D. auratus* (1/52).

Table 1 : Species of ticks and fleas (No of hosts infected with N:nymphs, L:larvae, M:males, F: females, AF: adult female) collected from murine rodents and shrews in Kurunegala and Kandy districts.

	Species of small mammal	Species of ticks	Species of fleas
Kurunegala	<i>Rattus rattus</i>	<i>Rhipicephalus haemaphysaloides</i> (N:13), (N/L:4), (L:1)	<i>Xenopsylla cheopis</i> (M/F:5) (M:1) (F:1)
	<i>Bandicota indica</i>	<i>R. haemaphysaloides</i> (N:2)(N/L:1)	
	<i>Suncus murinus</i>	<i>R. haemaphysaloides</i> (N:1) (L:2) (N/L:1) <i>Haemaphysalis spinigera</i> (N:1) <i>Haemaphysalis</i> sp. (L:1)	
Kandy	<i>Rattus rattus</i>	<i>Rhipicephalus haemaphysaloides</i> (N/ L: 1), (N:8), (L:1) <i>Haemaphysalis spinigera</i> (N/L: 2), (N:2) <i>Ixodis ceylonensis</i> (AF:2), (N:1) <i>Dermacentor auratus</i> (N:1)	<i>Xenopsylla cheopis</i> (M/F: 5), (M:2), (F:6) <i>Stivalius phoberus</i> (M/F: 3), (M6) <i>Stivalius aporus</i> (M/F:1), (F:1)
	<i>Bandicota indica</i>	<i>R. haemaphysaloides</i> (N:1) <i>H. spinigera</i> (N:4) <i>Haemaphysalis</i> sp. (L:1)	
	<i>Mus cervicolor</i>	<i>I. ceylonensis</i> (L:1)	
	<i>Mus fernandoni</i>	<i>R. haemaphysaloides</i> (N:2)	<i>S. aporus</i> (M:4); (F:2); (M/F: 3)
	<i>Golunda ellioti</i>	<i>R. haemaphysaloides</i> (N:1)	

**Figure 2:** Ticks collected from Kurunegala and Kandy. *Rhipicephalus haemaphysaloides*: (A.1) nymph, (A.2) larva; *Haemaphysalis spinigera*: (B.1) nymph, (B.2) larva; *Dermacentor auratus* nymph (C); *Ixodis ceylonensis*: adult (D.1) nymph, (D.2) larva; (D.3).

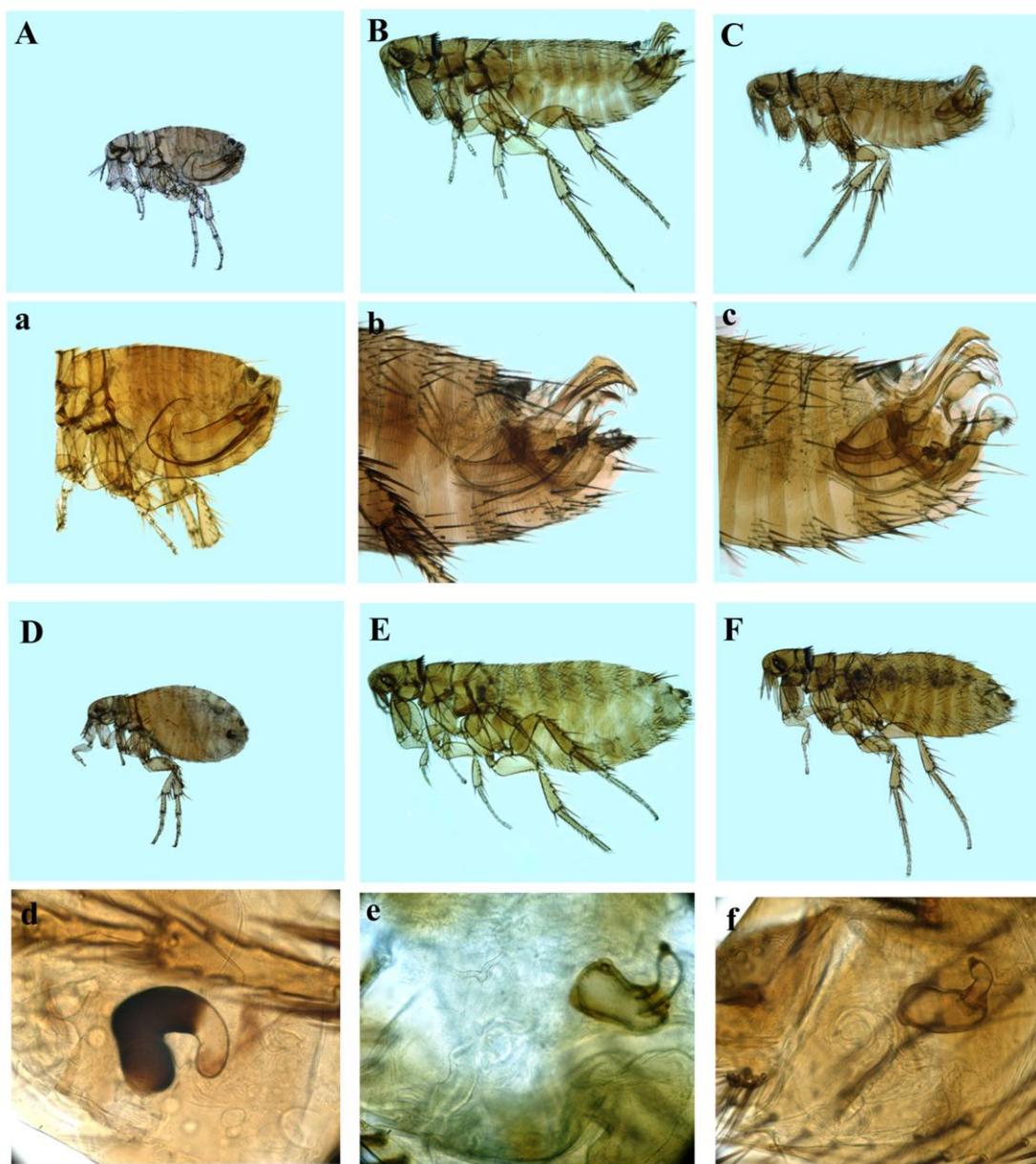


Figure 3: Fleas collected from Kurunegala and Kandy and their reproductive structures used in species identification. *Xenopsylla cheopis*: (A) and (a) male, (B) and (b): female; *Stivalius phoberus*: (C) and (c) male, (D) and (d) female; *Stivalius aporus*: (E) and (e) male, (F) and (f) female.

Of the ticks, nymphs and larvae of *R. haemaphysaloides* were recorded from *R. rattus*, *B. indica*, *M. fernandoni* and *G. ellioti*; nymphs and larvae of *H. spinigera* from *R. rattus*, *B. indica*; nymphs, larvae and adult females of *I. ceylonensis* from *R. rattus*, and *M. cervicolor*; nymphs of *D. auratus* from *R. rattus*; and an unidentified *Haemaphysalis* sp. from *B. indica*. Of the fleas, *X. cheopis*, *S. phoberus* and *S. aporus* were recorded from *R. rattus* and the latter species from *M. fernandoni* (Table 1; Figures 1 and 2). Some small mammals (5.2 %)

had mix infections with more than one tick species, flea species or both ticks and fleas. Four individuals of *R. rattus* had *I. ceylonensis* (AF)/*R. haemaphysaloides* (N); *I. ceylonensis* (AF)/*Haemaphysalis* (L), *S. phoberus*/ *S. aporus* and *R. haemaphysaloides* (N)/ *Haemaphysalis* (L), another two had *X. cheopis*/ *S. phoberus*. A *R. rattus* and a *M. fernandoni* had *S. phoberus* and *S. aporus*, respectively with *R. haemaphysaloides*. All localities had ectoparasite infested small mammals (Appendix 2).

DISCUSSION

All the tick and flea species recorded here have been previously reported from Sri Lanka, but *D. auratus* and *H. spinigera* are reported for the first time from murine rodents and shrews. We also report new host species for *R. haemaphysaloides*, *H. spinigera*, *I. ceylonensis*, *D. auratus* and *S. aporus*. Of the ticks, *R. haemaphysaloides* have previously been reported from many domesticated and farm animals such as dog, cat, cattle, water buffalo, sheep, goat, pig, horse, chicken, and from wild animals such as black-naped hare, wild boar, mouse deer, barking deer, spotted deer, pangolin, wild buffalo, bear and owl. Immature stages of this tick species were recorded from humans (Dilrukshi, 2006, Liyanarachchi, 2014). Through the present study, three new host species are added to the above list; *B. indica*, *G. ellioti* and *S. murinus*. Outside Sri Lanka *R. haemaphysaloides* has been recorded in South and South East Asian countries and China; adults from large and middle sized mammals and immature stages from small mammals including rodents and insectivores (Kolonin, 2009). *Haemaphysalis spinigera* has been previously recorded from domesticated animals like dog, cat, cattle, chicken and in wild animals such as leopard, sloth bear, forest wagtail, porcupine and sambar from Sri Lanka (Senevirathna, 1965; Dilrukshi, 2006; Liyanaarachchi, 2013 and 2014). *Bandicota indica* and *S. murinus* are new hosts reported here for this species. In Nepal, India, China and Vietnam, adults of *H. spinigera* have been reported from large ungulates, carnivores and immature stages from small and middle-sized mammals and birds. *Ixodis ceylonensis* is a species described from Sri Lanka (Kohls, 1950), which was first reported from mongoose, *Herpestes smithii zeylanicus* collected by W. W. A. Philips (1946). It was later recorded from *R. rattus kandianus*, Ceylon rudi mongoose (Senavirathna, 1965), *Crocidura miya*, *S. montanus* and *Solisorex pearsoni* (Yathramullage et al., 2014). From India it was reported from *Rattus* sp., *Bandicota* sp., *Mus booduga*, *G. ellioti*, jungle cat, leopard cat, wild monkey and squirrel. The chief host of *I. ceylonensis* was identified as *S. murinus* in India (Rajagopalan and Boshell, 1966). Here we report a new host for this species, *M. cervicolor*. *Dermacentor auratus* has been previously recorded from dog, chicken, wild boar, Sambar and sloth bear from Sri Lanka. Wild pig *Sus scorfa* is considered as

the main host of adult *D. auratus*. In the present study we found *D. auratus* nymph from *R. rattus* in Hantana area, where wild pigs are abundant, which may be hosting adult ticks. Outside Sri Lanka *D. auratus* has been recorded from south and south east Asian countries and China. Other than in wild pigs it is also found in domestic pig, bear, rhinoceros and deer (Kolonin, 2009). Immature stages are known to be parasitic chiefly on *Rattus* spp., carnivores, badgers, civets, mongooses, cats, leopards and tigers.

Some of the above reported species are known to act as vectors for many human diseases and hence, this report is of medical importance too. Both *R. haemaphysaloides* and *H. Spinigera* have been identified as principal vectors for Kyasanur Forest Disease (Kolonin, 2009), a viral disease endemic in India. Immature stages of *D. auratus* frequently parasitize humans and cause paralysis and facial palsy and it is a major species causing intra aural tick infestation. It is also identified as a carrier of Kyasanur forest disease virus, *Rickettsia* and *Anaplasma* strains (Hoogstral and Wassef, 1985; Ajithkumar et al., 2012).

All flea species found in the present study have been reported previously from rodents and shrews studied here. *Stivalius aporus*, a flea which was originally described from India from a field rat, was later found from several other murine rodents (*Millardia meltada*, *R. rattus*, *Rattus nitidus*), shrews (*Suncus* sp.), domestic cat, tree shrews and squirrel, *Callosciurus flavimanus* (Mardon, 1981). In Sri Lanka it has been recorded from four murine rodents, *Rattus ohiensis*, *M. booduga*, *M. cervicolor*, *M. fernandoni* and a shrew, *S. montanus* (Hirst, 1933; Phillips, 1980; Mardon, 1981; Yathramullage et al., 2014). *Stivalius phoberus* is an endemic flea. It has been recorded from murine rodents (*R. rattus*, *R. ohiensis*, *R. montanus*, *M. mayori*, *M. musculus* and *B. indica*), *S. montanus*, squirrel *Funambulus palmarum* and jungle cock (Hirst, 1933; Smit, 1953; Mardon, 1981, Yathramullage et al., 2014). *Xenopsylla cheopis*, the oriental rat flea had originated from Egypt and distributed worldwide through ships carrying rats. *Rattus rattus* and *R. norvegicus* are the main hosts of *X. cheopis*, however it also feeds on primates including humans. It is a vector for *Yersinia pestis*, causative agent for plague, which has caused huge historic pandemics and epidemics,

still present in western United States of America and in parts of Asia and Africa. It is the main vector for *Rickettsia typhi*, the causative agent for Murine typhus and carries tapeworm of rats and mice, *H. diminuta* (rat tapeworm) and *Hymenolepis nana* (mouse tapeworm).

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Appendix 1. Site wise distribution of small mammals and their ectoparasites of Kurunegala district.

Site (Number of small mammals captured)	Species of small mammal (Number captured)	Species of ticks (No of host infested)	Species of fleas (Number of hosts infested)
Bogollagama (20)	<i>R. rattus</i> (19)	<i>R. haemaphysaloides</i> (2)	<i>X. cheopis</i> (5)
	<i>B. bengalensis</i> (1)		
Epalawa (13)	<i>R. rattus</i> (9)		<i>X. cheopis</i> (1)
	<i>S. murinus</i> (3)	<i>R. haemaphysaloides</i> (1)	
	<i>M. cervicolar</i> (1)		
Herathgama (19)	<i>R. rattus</i> (19)	<i>R. haemaphysaloides</i> (3)	
Kiwlegedara (16)	<i>R. rattus</i> (10)	<i>R. haemaphysaloides</i> (1)	
	<i>S. murinus</i> (1)	<i>H. spinigera</i> (1)	
	<i>B. bengalensis</i> (3)		
	<i>M. cervicolor</i> (2)		
Malliyagoda (7)	<i>R. rattus</i> (1)		
	<i>S. murinus</i> (2)		
	<i>B. indica</i> (2)		
	<i>B. bengalensis</i> (2)		
Minhettiya (25)	<i>R. rattus</i> (22)	<i>R. haemaphysaloides</i> (11)	
	<i>S. murinus</i> (3)	<i>R. haemaphysaloides</i> (2)	
Polgahawela (10)	<i>R. rattus</i> (6)		<i>X. cheopis</i> (1)
	<i>S. murinus</i> (1)	<i>Haemaphysalis</i> larva (1)	
	<i>B. indica</i> (2)	<i>R. haemaphysaloides</i> (1)	
	<i>B. bengalensis</i> (1)		
Udawela (21)	<i>R. rattus</i> (12)	<i>R. haemaphysaloides</i> (1)	
	<i>S. murinus</i> (1)	<i>R. haemaphysaloides</i> (1)	
	<i>B. indica</i> (5)	<i>R. haemaphysaloides</i> (2)	
	<i>M. cervicolor</i> (1)		
	<i>M. musculus</i> (2)		

Appendix 2. Site wise distribution of small mammals and their ectoparasites from Kandy district. *Mix infections.

Site (No of small mammals captured)	Species of small mammals (Number captured)	Species of ticks (Number of host infested)	Species of fleas (Number of host infested)	
Peradeniya-site 1 (25)	<i>R. rattus</i> (15)	<i>R. haemaphysaloides</i> (4)		
		<i>H. spinigera</i> (1)		
		<i>R. haemaphysaloides</i> , <i>Haemaphysalis</i> (1)*		
		<i>I. ceylonensis</i> , <i>R. haemaphysaloides</i> (1)*		
		<i>I. ceylonensis</i> , <i>Haemaphysalis</i> (1)*		
		<i>M. cervicolor</i> (5)	<i>I. ceylonensis</i> (1)	
		<i>G. ellioti</i> (3)	<i>R. haemaphysaloides</i> (1)	
		<i>B. indica</i> (1)	<i>H. spinigera</i> (1)	
Peradeniya-site 2 (19)	<i>M. fernandoni</i> (8)	<i>R. haemaphysaloides</i> (1)*	<i>S. aporus</i> (1)*	
		<i>R. haemaphysaloides</i> (1)		
			<i>S. aporus</i> (3)	
		<i>R. rattus</i> (6)	<i>R. haemaphysaloides</i> (1)	
			<i>X. cheopis</i> (1)	
		<i>M. cervicolor</i> (3)		
Peradeniya-site 3 (20)	<i>M. cervicolor</i> (8)			
		<i>R. rattus</i> (7)	<i>D. auratus</i> (1)	
		<i>B. indica</i> (3)	<i>Haemaphysalis</i> (1)	
		<i>M. fernandoni</i> (2)		
			<i>S. aporus</i> (1)	
Peradeniya-site 4 (1)	<i>R. rattus</i> (1)		<i>X. cheopis</i> (1)	
Mahakanda (4)	<i>M. fernandoni</i> (4)		<i>S. aporus</i> (4)	
Doluwa (3)	<i>R. rattus</i> (2)	<i>I. ceylonensis</i> (1)		
		<i>S. murinus</i> (1)		
Delthota (20)	<i>R. rattus</i> (15)	<i>R. haemaphysaloides</i> (2)		
		<i>R. haemaphysaloides</i> (1)*	<i>S. Phoberus</i> (1)*	
			<i>X. cheopis</i> (5)	
			<i>S. Phoberus</i> (1)	
			<i>S. Phoberus</i> , <i>X. cheopis</i> (2)*	
		<i>M. musculus</i> (3)		
		<i>M. cervicolor</i> (1)		
		<i>B. bengalensis</i> (1)		
Rathmalkaduwa (23)	<i>R. rattus</i> (18)		<i>X. cheopis</i> (4)	
		<i>S. murinus</i> (3)		
		<i>B. bengalensis</i> (1)		
		<i>B. indica</i> (1)		
Nawalapitiya (22)	<i>R. rattus</i> (22)	<i>R. haemaphysaloides</i> (1)		
			<i>S. phoberus</i> (4)	
Kadugannawa (18)	<i>R. rattus</i> (13)	<i>H. spinigera</i> (2)		
			<i>S. aporus</i> (1)	
			<i>S. phoberus</i> , <i>S. aporus</i> (1)*	
		<i>S. murinus</i> (2)		
		<i>B. indica</i> (2)	<i>R. haemaphysaloides</i> (1)	
	<i>B. bengalensis</i> (1)			