TICKS (IXODIDAE) AND OTHER ECTOPARASITES IN ULU MUDA FOREST RESERVE, KEDAH, MALAYSIA

A Mariana[1], Z Zuraidawati[1], TM Ho[1], B Mohd Kulaimi[1], I Saleh[2], MN Shukor[3] and MS Shahrul-Anuar[4]

[1]Infectious Diseases Research Center, Institute for Medical Research, Kuala Lumpur; [2]College of Medical Laboratory Technologist, Institute for Medical Research, Kuala Lumpur; [3]School of Environmental and Natural Resources Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor; [4]School of Biological Sciences, Universiti Sains Malaysia, Minden, Pulau Pinang, Malaysia

Abstract. A survey of ticks and other ectoparasites was carried out during a national biodiversity scientific expedition at Ulu Muda Forest Reserve, Kedah, Malaysia from 23-29 March 2003. A total of 161 animals comprising 20 species of birds, 16 species of bats, six species of non-volant small mammals and 12 species of reptiles were examined for ticks and other ectoparasites. From these animals, nine species in five genera of ticks, 10 species in two families of Mesostigmatid mites and five species of chiggers were collected. Three of the ectoparasitic species found, *Dermacentor auratus, Ixodes granulatus* and *Leptotrombidium deliense* are of known public health importance. This survey produced the first list of ticks and other ectoparasites in the forest reserve and the third study of ectoparasites in Kedah. Fourteen species of these ectoparasites are new locality records.

INTRODUCTION

Ulu Muda Forest Reserve (UMFR) is a protected forest covering the eastern part of Malaysia. It is located astride three districts of Kedah, namely Sik, Padang Terap and Baling. UMFR, which has been listed as one of the ten destinations for eco-tourism under the National Eco-tourism Plan, is a permanent forest reserve and a reservoir for Muda Lake and Pedu Lake. The expedition area is a hill forest located on the Malaysian-Thai border and a watershed area for the state of Kedah (Fig 1).

There are few studies on the distribution and host relationships of ticks in Malaysia. Before the 1970s, studies had been carried out by various foreign researchers (Kohls, 1957; Audy *et al*, 1960; Domrow and Nadchatram, 1963; Hoogstraal *et al*, 1972). Since then, there have only been irregular focalized collections (Ho *et al*, 1985; Shabrina, 1990; 1991; Mariana *et al*, 1996). In Kedah, only two studies on the distribution of ectoparasites were made (Lancaster, 1939; Domrow and Nadchatram, 1963).

With changes in ecology and the environment due to land development and natural as well as man-made calamities, much information from the past may no longer be relevant. There is a need to update this information for public health interests and research purposes. In recent years, the problems of re-emerging and emerging diseases have gained increased attention. One group of such diseases is that transmitted by tick vectors. The objectives of this study are to obtain data on the distribution and host interactions of ticks and other ectoparasites from avifauna, small mammals and reptiles in UMFR, Kedah, Malaysia.

Correspondence: A Mariana, Infectious Diseases Research Center, Institute for Medical Research, 50588 Kuala Lumpur, Malaysia.
E-mail: mariana@imr.gov.my

Fig 1–Map of the expedition site in the state of Kedah, Malaysia.

MATERIALS AND METHODS

Trapping of non-volant small mammals and avifauna was conducted at four sites within the expedition area, *ie*, undisturbed lowland forest within compartment 44 (6º01.483′N, 100º57.536′E at altitude 200 m above sea level), disturbed lowland forest within compartment 45 (6º01.483′N, 100º57.536′E at altitude 200 m above sea level), forest surrounding the base-camp within compartment 74 (6º00.566′N, 100º57.347′E at altitude 185 m above sea level) and disturbed forest at Bukit Genting Kundor (6º100.161′N, 100º55.142′E at altitude 520 m above sea level). All of these sites had a history of selective logging of at least once, and varied in altitudes.

Trapping of non-volant small mammals with wire traps was conducted simultaneously at four sites over three consecutive nights using 35 traps (20x20x30 cm) per site. At each site, trapping was conducted along a transect line where the traps were laid at approximately 10-m intervals. Wire traps were laid along each transect line and baited randomly with either banana, sweet potatoes, oil palm fruits or roasted coconut flesh. Mist-net and Harp Trap® were used to capture bats and birds, respectively. The trapping efforts were similar at all sites with one Harp Trap® and 10 mist-nets per site for three consecutive nights. Checking of traps for non-volant small mammals and avifauna was done once and twice daily, respectively. For avifauna, it was done at a 12-hour interval, *ie* at early dawn and dusk. The animals caught were transported in cloth bags back to the laboratory at base-camp. Those bags were turned inside-out and their contents shaken onto a white enamel tray and examined for ectoparasites.

Non-volant animals were identified individually. Animals that were not protected species were killed using chloroform in a killing jar. For protected species, steps were taken to anesthesize the animal with Zoletil® (active chemical compounds are Tiletamine and Zolazepam, both as hydrochloride; Tiletamine as a major tranquilizer and Zolezepam as muscle relaxant) which ensures a general anesthesia with a short induction time, very few side effects and maximum safety. The dead or anesthesized animal was then removed from the bag, placed on an enamel tray and combed thoroughly with a fine tooth comb so that dislodged materials were dropped onto the tray. The dislodged materials were examined under a dissecting microscope and ectoparasites seen were picked up with a sharpened applicator stick. Each animal was then examined in detail under a dissecting microscope and any ectoparasites found around the eyes, ears, nose, nasal cavity, snout and any other parts of the body were picked up with a pair of fine forceps. Nasal passages of rodents were dissected to look for chiggers.

Killing of avifauna was not allowed in this study. Examination was therefore made on live avifauna and only a general screening was

possible. For bats, special attention was given to the wing membranes, eye-lids, ear lobes and nose. The body fur was parted with a forcep for ectoparasites. For birds, a general examination for ticks, Mesostigmatid mites and chiggers was made on the skin, primary and secondary feathers. Skin and feathers under both wings and the anal portion of the bird were given priority.

Reptiles, centipedes and millipedes were hand-caught by researchers from World Wildlife Fund (WWF) Malaysia and Universiti Kebangsaan Malaysia. The areas underneath the scales of reptiles and in between body segments of centipedes and millipedes were screened for ectoparasites. Ticks were also collected by flagging or dragging white towels onto vegetation and the examination of edges and undersides of leaves.

Most of the ectoparasites detached from animals were preserved in 70% alcohol and, where possible, fed immature ticks were reared in the laboratory for confirmation of species. All preserved ectoparasites, excluding ticks were later mounted for identification. Chiggers were directly mounted. Mesostigmatid mites were first cleared in lactophenol and Astigmatid mites were placed in lactic acid; these were then heated on a hot plate at 200ºC for five minutes before mounted in Hoyer's medium. Mounted slides were then incubated at 40ºC for a week and cover-slips were ringed with paint to prevent dissection of medium during storage. Wherever possible, adult ticks and other ectoparasites were identified to the species level. Identification of sex and different life-cycle stages (excluding eggs) were made.

RESULTS

A total of 161 animals comprising of 20 species of birds, 16 species of bats, six species of non-volant small mammals and 12 species of reptiles in Ulu Muda Forest Reserve, Kedah were caught and examined for ectoparasites. The species of avifauna and small mammals caught as well as the infestation rates are shown in Table 1. Comparisons made among the trapping sites indicated that diversity and abundance of avifauna were high in lowland forest with moderate disturbance, but poor in forest at higher altitudes. For non-volant small mammals, *Maxomys whiteheadi* was the most commonly caught. The most common species of bats and birds caught were *Rhinolopus affinis* and *Arachnothera longirostra,* respectively.

Ticks

Ticks were found on all species of non-volant small mammals, two species of birds and a species of bat (Table 2). Two genera of ticks were found on birds *ie* one larval *Haemaphysalis* on Garnet Pitta (*Pitta granatina*) and two larval *Dermacentor* (Table 2) on Asian Paradise Flycatcher (*Terpsiphone paradise)* (Fig 2). The *Haemaphysalis* tick was feeding on the pitta, whereas the two *Dermacentor* ticks were attached to the same rachis of the flycatcher's under-developed tail feather. A single larval *Ornithodoros* tick was found on Dusky Fruit-bat (*Penthetor lucasi*).

Dermacentor, Haemaphysalis and *Ixodes* are the three genera of Ixodid ticks found on non-volant small mammals. Of the total ticks found, the most common genera was *Dermacentor* (59.7%), followed by *Ixodes* (27.4%) and *Haemaphysalis* (9.7%). The only species of ticks that can be identified to the species level was *Ixodes granulatus*, which was found on *Sundamys muelleri*. All stages in the life-cycle of *I. granulatus,* excluding eggs were found on the animal.

Three genera of ticks were recovered from flagging vegetation. They were *Amblyomma, Dermacentor* and *Haemaphysalis*. Of the total ticks, *Dermacentor* being the most commonly found genera (88.2%) was represented by five species: *D. steini* (48.0%), *D. compactus* (16.0%), *D. auratus* (10.0%), *D. astrosignatus* (8.0%) and *D. taiwanensis* (6.0%). The next most common genera found, *Haemaphysalis* (10.0%)

Table 1
Ectoparasitic infestation rates on avifauna and small mammals in Ulu Muda Forest Reserve, Kedah (23-29 March 2003).

Host species	No. caught	No. of host infested			
		Ticks	Mesostigmatids	Chiggers	Others
Birds (Aves)					
Actenoides concretus	3	0	0	0	0
Alcedo euryzona	1	0	0	0	1
Arachnothera longirostra	5	0	0	0	0
Ceyx rufidosa	3	0	0	0	2
Criniger bres	1	0	0	0	0
Criniger phaeocephalus	4	0	0	0	0
Hypsipetes criniger	1	0	0	0	0
Malacocincla malaccense	1	0	0	1	0
Malacopteron magnum	2	0	0	0	0
Muscicapa daurica	2	0	0	0	0
Otus bakkamoena	1	0	0	0	0
Pellorneum capistratum	1	0	0	0	0
Phylloscopus plumbeitarsus	1	0	0	0	0
Pitta granatina	1	1	0	1	0
Prionochilus maculatus	1	0	0	0	0
Pycnonotus cyaniventris	1	0	0	0	0
Pycnonotus erythropthalmus	2	0	0	0	0
Stachyris policephala	3	0	0	0	0
Terpsiphone paradisi	1	1	0	0	0
Total	35	2 (5.7 %)	0	2 (5.7 %)	3 (8.6 %)
Bats					
Balionycteris maculata	3	0	0	0	0
Cynopterus brachyotis	2	0	0	0	0
Cynopterus horsfieldi	2	0	0	0	0
Hipposideros bicolor	2	0	0	0	0
Hipposideros diadema	2	0	0	0	0
Hipposideros galeritus	1	0	0	0	0
Kerivoula hardwickii	11	0	0	0	0
Kerivoula minuta	4	0	1	0	0
Megaerops ecaudatus	7	0	0	0	0
Murina suilla	2	0	0	0	0
Penthetor lucasi	1	1	0	0	0
Phoniscus atrox	1	0	0	0	0
Rhinolophus acuminatus	9	0	0	1	0
Rhinolophus affinis	26	0	0	3	0
Rhinolophus lepidus	2	0	0	0	0
Rhinolophus stheno	2	0	0	0	0
Rhinolophus trifoliatus	5	0	0	0	0
Total	82	1 (1.2%)	1 (1.2%)	4 (4.9%)	0

Table 1 (continued).

Host species	No. caught	No. of host infested			
		Ticks	Mesostigmatids	Chiggers	Others
Small mammals					
Leopoldamys sabanus	4	4	2	1	1
Maxomys rajah	2	1	2	0	0
Maxomys whiteheadi	7	1	7	2	0
Maxomys surifer	1	1	1	0	0
Sundamys muelleri	6	6	6	4	0
Tupaia glis	1	1	0	1	0
Total	21	14 (66.7 %)	18 (85.7 %)	8 (38.1 %)	1 (4.8 %)
Reptilia					
Aeluroscalabotes felinus	1	0	0	0	0
Cyrtodactylus consobrinus	2	0	0	0	0
Cyrtodactylus quadrivirgatus	1	0	0	0	0
Dendrephis pictus	1	0	0	0	0
Draco volans	3	0	0	0	0
Gehyra mutilata	2	0	0	0	0
Gonocephalus grandii	3	0	0	0	0
Gonocephalus sp	1	0	0	0	0
Lycodon subcinctus	1	0	0	0	0
Ptychozoon kuhlii	1	0	0	0	0
Ptychozoon lionotum	2	0	0	0	0
Sphenomorphus maculatus	1	0	0	0	0
Total	19	0	0	0	0
Insects and others					
Centipede	1	0	0	0	0
Millipede	1	0	0	0	0
Total	3	0	0	0	0
Grand total	161	16 (9.9 %)	19 (11.8%)	14 (8.6%)	4 (2.5%)

Numbers in parentheses is the percent of host group infested

was represented by *H. nadchatrami* and *H. semermis*. *Amblyomma testudinarium* was the only species found for the genera *Amblyomma* and was found on vegetation (2.0%).

Mesostigmatid mites

Ten Laelapid species of Mesostigmatid mites were recovered from non-volant small mammals inhabiting this area. Those mites were found on all the small mammals caught except *Tupaia glis.* A family of Mesostigmatid mites, Spinturnicidae was recovered from bats. Spinturnicid mites, which were found on a bat *Kerivoula minuta,* could not be identified locally and will be sent overseas for further identification. None of the Mesostigmatid mites recovered was of known medical importance.

Chiggers

Five species of chiggers were recovered from the eye-lids, ear-lobes and bodies of small mammals. The species were *Gahrliepia (Gahrliepia) fletcheri*, *Gahrliepia (Walchia) naniparma*, *Leptotrombidium deliense*, *Whartonia caobangensis* and *Walchiella oudemansi* (Table 2). In this survey, *Gahrliepia* species was found to infest rodents only.

Walchiella oudemansi and *L. deliense* were the two species of chiggers infesting the birds, *Pitta granatina* and *Trichastoma malaccense,*

Table 2

Ectoparasites found on birds, bats, small mammals and reptiles in Ulu Muda Forest Reserve, Kedah (23-29 March 2003).

Species	Birds																			
	Actenoides concretus	*Alcedo euryzona*	*Arachnothera longirostra*	*Ceyx rufidosa*	*Criniger bres*	*Criniger phaeocephalus*	*Hypsipetes criniger*	*Malacocincla malaccense*	*Malacopteron magnum*	*Muscicapa daurica*	*Otus bakkamoena*	*Pellorneum capistratum*	*Phylloscopus plumbeitarsus*	*Pitta granatina*	*Prionochilus maculatus*	*Pycnonotus cyaniventris*	*Pycnonotus erythropthalmus*	*Stachyris policephala*	*Terpsiphone paradisi*	*Balionycteris maculata*
Ticks																				
Dermacentor spp																			/	
Haemaphysalis spp														/						
Ixodes granulatus																				
Ixodes spp																				
Ornithodoros spp																				
Mesostigmatids																				
Laelaps aingworthae																				
Laelaps echidninus																				
Laelaps flagellifer																				
Laelaps insignis																				
Laelaps nuttalli																				
Laelaps sanguisugus																				
Laelaps scuplturatus																				
Laelaps sedlaceki																				
Longolaelaps longulus																				
Longolaelaps whartoni																				
Spinturnicid mites																				
Chiggers																				
Gahrliepia (G) fletcheri																				
Gahrliepia (Walchia) naniparma																				
Leptotrombidium (L.) deliense								/												
Walchiella oudemansi														/						
Whartonia caobangensis																				
Others																				
Malophaga spp		/		/																
Polyplax spinulosa																				

Species	Bats															
	Cynopterus brachyotis	*Cynopterus horsfieldi*	*Hipposideros bicolor*	*Hipposideros diadema*	*Hipposideros galeritus*	*Kerivoula hardwickii*	*Kerivoula minuta*	*Megaerops ecaudatus*	*Murina suilla*	*Penthetor lucasi*	*Phoniscus atrox*	*Rhinolophus acuminatus*	*Rhinolophus affinis*	*Rhinolophus lepidus*	*Rhinolophus stheno*	*Rhinolophus trifoliatus*
Ticks																
Dermacentor spp																
Haemaphysalis spp																
Ixodes granulatus																
Ixodes spp																
Ornithodoros spp										/						
Mesostigmatids																
Laelaps aingworthae																
Laelaps echidninus																
Laelaps flagellifer																
Laelaps insignis																
Laelaps nuttalli																
Laelaps sanguisugus																
Laelaps scuplturatus																
Laelaps sedlaceki																
Longolaelaps longulus																
Longolaelaps whartoni																
Spinturnicid mites							/									
Chiggers																
Gahrliepia (G) fletcheri																
Gahrliepia (Walchia) naniparma																
Leptotrombidium (L.) deliense																
Walchiella oudemansi												/				
Whartonia caobangensis													/			
Others																
Malophaga spp																
Polyplax spinulosa																

Species	Small mammals						Reptiles												Others		
	Leopoldamys sabanus	*Maxomys rajah*	*Maxomys whiteheadi*	*Maxomys surifer*	*Sundamys muelleri*	*Tupaia glis*	*Aeluroscalabotes felinus*	*Cyrtodactylus consobrinus*	*Cyrtodactylus quadrivirgatus*	*Dendrolapjis pictus*	*Draco volans*	*Gehyra mutilata*	*Gonocephalus grandii*	*Gonocephalus* sp	*Lycodon subcinctus*	*Ptychozoon kuhlii*	*Ptychozoon lionotum*	*Sphenomorphus maculatus*	Centipede	Millipede	*Rhychophorus* sp
Ticks																					
Dermacentor spp	/		/	/	/																
Haemaphysalis spp	/	/		/																	
Ixodes granulatus					/																
Ixodes spp	/		/		/	/															
Ornithodoros spp																					
Mesostigmatids																					
Laelaps aingworthae		/		/																	
Laelaps echidninus					/																
Laelaps flagellifer			/																		
Laelaps insignis		/	/																		
Laelaps nuttalli	/	/	/	/	/																
Laelaps sanguisugus				/																	
Laelaps scuplturatus		/	/																		
Laelaps sedlaceki					/																
Longolaelaps longulus		/	/	/																	
Longolaelaps whartoni		/		/																	
Spinturnicid mites																					
Chiggers																					
Gahrliepia (G) fletcheri	/		/		/	/															
Gahrliepia (Walchia) naniparma			/		/	/															
Leptotrombidium (L.) deliense					/																
Walchiella oudemansi					/																
Whartonia caobangensis																					
Others																					
Malophaga spp																					
Polyplax spinulosa	/																				

/indicate/present

Table 3
A comparison of acarine ectoparasites found on domestic animals (Lancaster, 1939) and wild animals in Gunung Jerai (Domrow and Nadchatram, 1963) and Ulu Muda Forest Reserve (UMFR) in Kedah.

Species of ectoparasites	Presence of ectoparasites		
	State of Kedah (1939)	Gunung Jerai (1963)	UMFR (2003)
Ticks			
Amblyomma clypeolatum	+	-	-
Amblyomma integrum	+	-	-
Amblyomma sublaeve	+	-	-
Amblyomma testudinarium	+	+	+
Aponomma spp	+	-	-
Boophilus australis	+	-	-
Dermacentor astrosignatus	-	-	+
Dermacentor auratus	+	+	+
Dermacentor compactus	-	-	+
Dermacentor steini	-	-	+
Dermacentor taiwanensis	-	-	+
Haemaphysalis bispinosa	+	-	-
Haemaphysalis flava	+	-	-
Haemaphysalis hystricis	-	+	-
Haemaphysalis nadchatrami	-	-	+
Haemaphysalis semermis	-	-	+
Haemaphysalis wellingtoni	+	-	-
Ixodes granulatus	-	+	+
Ornithodoros spp	-	-	+
Rhipicephalus haemaphysaloides	+	-	-
Rhipicephalus sanguineus	+	-	-
Mesostigmatid mites	Screening was not made		
Aetholaelaps sp		+	-
Echinonyssus nasutu		+	-
Haemolaelaps gallinarii		+	-
Haemolaelaps traubi		+	-
Laelaps aingworthae		-	+
Laelaps echidninus		-	+
Laelaps flagellifer		+	+
Laelaps insignis		-	+
Laelaps nuttalli		+	+
Laelaps sanguisugus		-	+
Laelaps sculpturatus		+	+
Laelaps sedlaceki		-	+
Longolaelaps longulus		+	+
Longolaelaps whartoni		+	+
Tricholaelaps vitzthumi		+	-
Spinturnicid mites		-	+

Table 3 (continued).

Species of ectoparasites	Presence of ectoparasites		
	State of Kedah (1939)	Gunung Jerai (1963)	UMFR (2003)
Chiggers	Screening was not made		
Ascoschoengastia sp		+	-
Doloisia browningi		+	-
Doloisia domrowi		+	-
Doloisia intermedia		+	-
Gahrliepia (G) elbeli		+	-
Gahrliepia (G) fletcheri		+	+
Gahrliepia (Walchia) disparunguis		+	-
Gahrliepia (Walchia) enodis		+	-
Gahrliepia (Walchia) naniparma		-	+
Gahrliepia (Walchia) rustica		+	-
Helenicula mutabilis		+	-
Leptotrombidium (L.) deliense		+	+
Trombicula (Microtrombicula) spicea		+	-
Neoschongastia gallinarum		+	-
Nihelia quinta		+	-
Walchiella impar		+	-
Walchiella lacunosa		+	-
Walchiella oudemansi		-	+
Whartonia caobangensis		-	+

respectively. Chiggers on bats were identified as *W. oudemansi* and *Whartonia caobangensis*. The latter was present only on a species of bat, *Rhinolophus affinis* (Fig 3). Only two species of Rhinolopid bats were infested although these bats have been identified as important hosts of chiggers (Audy *et al*, 1960).

Leptotrombidium deliense, was found on a common Short-tailed Babbler, *Malacocincla malaccense* and a rodent, *Sundamys muelleri*. The latter is a common host for *L. deliense* but not the former.

Other ectoparasites

Other ectoparasites found were *Malophaga* spp and *Polyplax spinulosa.*

Comparison of data with previous surveys

A comparison of species found from previous surveys and UMFR is listed in Table 3. Detail comparisons were made only to Gunung Jerai and UMFR as there was no specific locations described by Lancaster (1939). Moreover, those ectoparasites were extracted from wild animals caught in similar type of ecology *ie* forest reserves. Gunung Jerai, which is near to the coast of Kedah, is located at 100º24′E 5º34′N, whereas UMFR is more inland in the north-east of the state at 100º48′E 6º04′N.

DISCUSSION

Surveys of ticks and other ectoparasites in Kedah were reported by Lancaster (1939) and Domrow and Nadchatram (1963). The former described ticks associated with domestic animals in the entire state of Kedah while the latter reported ectoparasites of wild animals caught in forest of Gunung Jerai (Kedah Peak).

It was not surprising to recover many species of *Dermacentor* ticks from vegetation due to the signs of frequent visits to these places by wild pigs, *Sus* spp. This is because the wild pig

Fig 2–Two larval *Dermacentor* spp attached on the same rachis of a bird, Asian Paradise Flycatcher, *Terpsiphone paradise.*

Fig 3–A species of chigger, *Whartonia caobangensis* on the wing of a bat, *Rhinolophus affinis.*

has been identified as the chief host of *Dermacentor* in Malaysia and the most common host of *Dermacentor* in tropical Asia (Hoogstraal *et al*, 1972; Hoogstraal and Wassef, 1984; Petney and Keirans, 1996). There were many piles of ginger leaves, family *Zingiberaceae* such as *Zingiber* spp, *Etlingera* spp, and *Alpinia* spp, which were used by the pigs during the breeding seasons and many places where soil had been disturbed by wild pigs. Besides wild pigs, Sambar deers (*Cervus unicolor*) have also been identified as another common host of *Dermacentor* in Malaysia. The presence of these two common hosts in the study area had been confirmed by a rapid assessment study of terrestrial vertebrates using camera traps conducted by World Wildlife Fund (WWF) Malaysia in 2003 (Sharma, personal communication).

Most of the ticks recovered from this area were larvae and nymphs of *Dermacentor* spp and thus not identified beyond the genus level due to the unavailability of relevant taxonomic keys. Efforts were made to rear these immature stages in the laboratory to the adult stage for confirmation of species. However, these efforts were unsuccessful due to problems with feeding the nymphal stages.

Two medically important species of ticks, *D. auratus* and *I. granulatus,* were identified in this area. *Dermacentor auratus* has been reported to cause distress, paralysis and severe local irritation to humans (Hoogstraal and Wassef, 1985; Gothe and Neitz, 1991). In Malaysia, the Lanjan virus (Kaisodi serogroup) was originally described from this species (Tan *et al*, 1967). It is still unknown whether other species of *Dermacentor* are associated with the epidemiology of the virus. The Lanjan virus is probably maintained in a tick-rodent cycle in forest areas (Tan *et al*, 1967). This is because the virus has also been isolated from *I. granulatus* and *H. semermis* (Hoogstraal *et al*, 1972). Besides the Lanjan virus, *I. granulatus* also harbors the virus causing Langat encephalitis (Hoogstraal, 1966). *Ixodes granulatus, Dermacentor* spp and *Haemaphysalis* spp have been shown to be involved in the cycles of tick typhus and Q-fever in the forests of Malaysia (Marchette, 1966).

It is interesting to note that a mesostigmatid mites, *W. oudemansi,* which has been described to infest only small mammals (Nadchatram and Dohany, 1974), infests three different hosts in this area, *ie* on a bird, *Pitta granatina*; a bat, *R. acuminatus* and a rodent, *Sundamys muelleri*. The ability to infest different types of hosts living in different types of ecology may ensure wider dispersal and survival of the species. Moreover, dispersal may occur all the time because of the involvement of diurnal and nocturnal species of hosts.

Leptotrombidium deliense has been reported as an important vector of scrub typhus in peninsular Malaysia (Nadchatram, 1970; Nadchatram and De Witt, 1976). *L. deliense*, feeding on a species of bird, *Malacocincla malaccense* has not been reported before in Malaysia. The bird could be an accidentally host in the absence of normal hosts and this is not surprising as this species has a very wide host range. Since *L. deliense* is an efficient vector of scrub typhus from rat to rat (Domrow and Nadchatram, 1963), it is possible that in the future it will also be an efficient vector from rat to bird. However, it seems unlikely that there is much local epizootiologic significance to the infestation of birds by *L. deliense* with respect to scrub typhus, even though a strain of *Orientia tsutsugamushi* has been recovered from migratory birds in Far East Russia (Somov and Polivanov, 1972). At most, birds might transport infected chiggers to new sites. Perpetuation of the scrub typhus agent depends solely on transovarial transmission in the mite vector (Traub and Wisseman, 1968).

In Ulu Muda Forest Reserve (UMFR), there were six species of ticks that were not found in the Gunung Jerai survey. *Haemaphysalis hystricis*, which was found on *Tupaia glis* in Gunung Jerai was not found in UMFR. This might due to the small number of *T. glis* caught in the present survey. About the same number of Mesostigmatid species were recovered. Five *Laelaps* spp which were present in UMFR were not found in Gunung Jerai; the species are *L. aingworthae, L. echidninus, L. insignis, L. sanguisugus* and *L. sedlaceki.* The hosts caught and examined were the same in both surveys except for an additional two species caught in UMFR, *Maxomys surifer* and *Sundamys muelleri.* This has proven for a wider distribution of hosts for *Laelaps* over time and these hosts have contributed to some differences of the species recovered. The present survey also found Spinturnicid mites which were not recovered in Gunung Jerai. The reason for not recovering these mites was that the host, *K. minuta* was not caught.

In the 1963 survey, 15 species of chiggers were recovered of which only two species were found in this survey. Three species which were not identified in the previous survey were *Gahrliepia (W) naniparma, W. oudemansi* and *W. caobangensis.* Again, this might also due to the differences in the species caught and examined. Some of the hosts were not caught in UMFR; the species were *Rattus jalorensis*, *Rattus edwardsi* and *Callosciurus notatus*. Moreover, the differences in altitude of the area surveyed contributed to another possible reason for recovering fewer species of chiggers. The altitude at which this survey was conducted in UMFR was much lower compared to the Gunung Jerai study, which covered areas above 500 m from sea level.

In conclusion, a total of nine species in five genera of ticks; 10 species in two genera of Mesostigmatid mites and five species of chiggers were identified from 20 species of birds, 16 species of bats, six species of non-volant small mammals and 12 species of reptiles. This survey produced the first list of ticks and other ectoparasites in UMFR and the third study of ectoparasites in Kedah. Fourteen species of these ectoparasites are new locality records; the species are *D. astrosignatus, D. compactus, D. steini, D. taiwanensis, H. nadchatrami, H. semermis, L. aingworthae, L. echidninus, L. insignis, L. sanguisugus, L. sedlaceki, Gahrliepia (Walcia) naniparma, Walchiella oudemansi* and *Whartonia caobangensis*. Further surveys need to be carried out in order to have a more comprehensive directory of ticks and other ectoparasites in UMFR, especially in the east of Sungai Lasor Base-camp, which borders Bang Lang National Park in Thailand. It is not impossible to find similar species of ectoparasites on both sides of the Malaysia-Thailand border due to cross-over of animal hosts that do not recognize national borders.

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REFERENCES

Audy JR, Nadchatram M, Lim BL. Host distribution of Malayan ticks (Ixodoidea). *Stud Inst Med Res Malaya* 1960; 29: 225-46.

Domrow R, Nadchatram M. Two field collections of Malayan ticks and mites. *Malayan Nature J* 1963; 17: 145-64.

Gothe R, Neitz AWH. Tick paralyses: pathogenesis and etiology. *Adv Dis Vector Res* 1991; 8: 177-204.

Ho TM, Nadchatram M, Saleh I. Ectoparasites of rodents and bats from Taman Negara. *Trop Biomed* 1985; 2: 193-5.

Hoogstraal H. Ticks in relation to human diseases caused by viruses. *Annu Rev Entomol* 1966; 11: 261-308.

Hoogstraal H, Lim BL, Nadchatram M, Anastos G. Ticks (Ixodidae) of Gunong Benom and their altitudinal distribution, hosts and medical relationships. *Bull Br Mus Nat His Zool* 1972; 23: 167-86.

Hoogstraal H, Wassef H. *Dermacentor (Indocentor) compactus* (Acari: Ixodoidea: Ixodidae): wild pigs and other hosts and distribution in Malaysia, Indonesia and Borneo. *J Med Entomol* 1984; 21: 174-8.

Hoogstraal H, Wassef H. Dermacentor (Indocentor) auratus (Acari: Ixodoidea: Ixodidae): hosts, distribution, and medical importance in tropical Asia. *J Med Entomol* 1985; 22: 170-7.

Kohls GM. Ticks (Ixodoidea) of Borneo and Malaya. *Stud Inst Med Res Malaya* 1957; 28: 65-94.

Lancaster WE. Report of the Veterinary Department of the Federated Malay States. Kuala Lumpur: the Federated Malay States, 1939: 49-52.

Marchette NJ. Riketsioses (Tick typhus, Q-fever, Urban typhus) in Malaya. *J Med Entomol* 1966; 4: 339-71.

Mariana A, Ho TM, Saleh I, Indudharan R. Species distribution of ticks in two localities in Kelantan. *Trop Biomed* 1996; 13: 185-8.

Nadchatram M. Ectoparasites of Malaysian snakes. *Malayan Nature J* 1970; 33: 168-77.

Nadchatram M, Dohany AL. A pictorial key to the subfamilies, genera and subgenera of Southeast Asian chiggers (Acari: Prostigmata, Trombiculidae). *Bull Inst Med Res* 1974; 16: 1-67.

Nadchatram M, De Witt GF. Ticks, mites and health. *Perak Planters J* 1976: 79-84.

Petney TN, Keirans JE. Ticks of the genera *Boophilus, Dermacentor*, *Nosomma* and *Rhipicephalus* (Acari: Ixodidae) in Southeast Asia. *Trop Biomed* 1996; 13: 73-84.

Shabrina S. Ectoparasites of small mammals trapped at the Ulu Gombak Forest, Selangor Darul Ehsan. *J Wildlife Parks* 1990; 9: 9-16.

Shabrina S. Some ectoparasites of rodents and bats captured at Gua Musang, Kelantan. *J Wildlife Parks* 1991; 10: 33-42.

Somov GP, Polivanov VM. Isolation of *Rickettsia tsutsugamushi* from the organs of migrant birds in the Primorye. *Zh. Mikrobiol Epidemiol Immunobiol* 1972; 7: 6-9.

Tan DKS, Smith CEG, Mc Mahon DA, Bowen ETW. Lanjan virus, a new agent isolated from *Dermacentor auratus* in Malaya. *Nature* 1967; 214: 1154-5.

Traub R, Wisseman Jr CL. Ecological considerations in scrub typhus 2. Vector species. *Bull World Health Organ* 1968; 39: 219-30.

Wassef H, Hoogstraal H. *Dermacentor (Indocentor) steini* (Acari: Ixodoidea: Ixodidae): hosts, distribution in the Malay Peninsula, Indonesia, Borneo, Thailand, the Philippines, and New Guinea. *J Med Entomol* 1988; 25: 315-20.