DISTRIBUTION AND ECOLOGICAL CONSIDERATION OF *BREINLIA BOOLIATI* INFECTING WILD RODENTS IN MALAYSIA

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INTRODUCTION

The discovery of a new species of filarial worm, *Breinlia booliati* (Filaroidea: Onchocercidae) in a forest rat *Rattus sabanus* by Singh and Ho (1973) has been followed by several investigations on this parasite. Ho *et al.*, (1973) successfully transmitted the parasite from naturally infected *R. sabanus* to laboratory white rats using several species of mosquitoes including *Aedes aegypti*, *A. togoi* and *Armigeres subalbatus*. In addition, detailed studies on the development of *Breinlia booliati* in *Aedes togoi* were described by Ho *et al.*, (1973); Mak and Lim (1974) found this parasite in several rodent hosts in Sarawak, East Malaysia, and Lim and Mak (1974) reported new records of the parasite on the east coast of Peninsular Malaysia. The present study deals with the distribution of the parasite in rodents from different ecological habitats in Peninsular Malaysia.

MATERIALS AND METHODS

Wild rodents were collected throughout the states of Peninsular Malaysia from 1973 to 1974. Animals were collected by trapping from six different habitats in each of the states sampled (Fig. 1). All animals were killed and examined for worms. Adult worms were found in the lungs, liver and intestines of infected animals. They were fixed in 5% glycerine-alcohol and then slowly brought into pure glycerine for morphological study.

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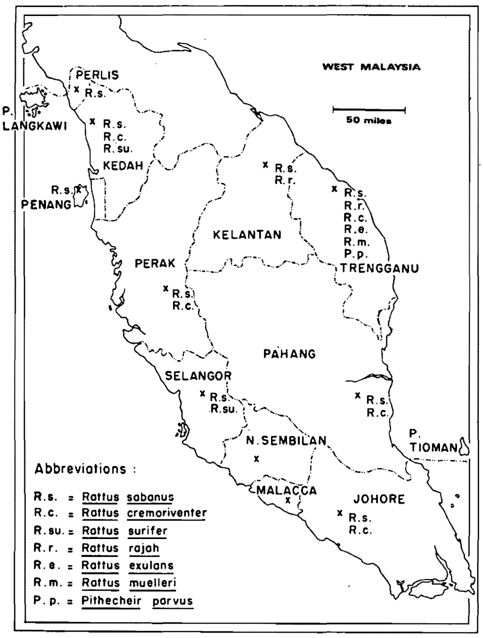

Fig. 1—Animals examined from various states throughout Peninsular Malaysia.

DESCRIPTION OF TRAPPING HABITATS

Primary forest: The primary forests sampled in this study showed no sign of lumbering on any scale. The canopy was from 80 to over 150 feet in height. Ground cover was sparse, consisting of palms and small trees.

Secondary forest: The secondary forest sampled had sustained some commercial timbering and most of the large trees had been removed. The ground cover was denser than in the primary forest, with an abundance of small trees forming a lower canopy.

Swamp forest: The swamp forests sampled had high water tables with exposed water frequently occurring among the trees. The trees were not as tall as in the primary forest, but the canopy was complete.

Edge habitat: This was an early stage of forest regeneration, known also as belukar. These areas resulted from clear cutting. With the exception of occasional taller trees, the vegetation was about 30 feet high, consisting mostly of fast growing species of trees which are characteristically primary invaders of such cut-over areas. These trees were inter-mixed with wild banana, wild ginger, vines and herbaceous vegetation, forming a dense cover which was difficult to penetrate.

Cultivated field: These areas were characterized by organised cultivation such as oil palm, rubber, and fruit trees. The ground cover was sparse, often including some grass and weeds.

Human habitation: Included here were sites within villages, and sites adjacent to towns or cities. Animals were collected both from outside and inside human dwellings.

RESULTS

A total of 231 arboreal mammals representing eight species of squirrel was examined. They were as follows: 65 *Callosciurus notatus*, 40 *C. caniceps*, 18 *C. nigrovittatus*, 19 *C. prevostii*, 21 *Sundasciurus tenuis*, 15 *S. lowii*, 25 *Ratufa bicolor*, 18 *R. affinis* and 10 *Lariscus insginis*. None of the above squirrels were found to be infected with *Breinlia booliati*.

A total of 1,317 murids representing 18 species were examined. They were placed into four main habitat groups (Table 1). With the exception of the house and field rats, montane forms, and some of the canopy forms which are highly habitat specific, most of the lowland terrestrial forest rats were found intermingling in other habitats adjacent to their own. The results showed that natural infection with *B. booliati* was found in both terrestrial and semi-arboreal forest murids. None of the montane or field and house rats was found to be naturally infected with the parasite. The only infected *Rattus exulans* was trapped in the lowland forest.

Seven of 18 species of murids were found naturally infected with *B. booliati*. Of these, 888 out of the total 1,317 murids examined were trapped from the six different kinds of habitats previously described (Table 2). Natural infection of the parasite was observed in *R. sabanus* and *R. cremoriventer* from four

Table 1

Infection rates with *Breinlia booliati* in wild rats of different ecological groups.

Species	No. exam. p/n	% inf.
Lowland terrestrial forest rat		
Rattus sabanus	16/215	7.4
Rattus muelleri	2/196	1.0
Rattus surifer	3/133	2.3
Rattus rajah	1/127	0.8
Rattus whiteheadi	0/90	-
Rattus annandalei	0/22	-
Rattus exulans	1/21	-
Lowland semi-arboreal forest rat		
Rattus cremoriventer	12/78	15.6
Rattus canus	0/5	-
Pithecheir parvus	1/5	20.0
Chiropodomys gliroides	0/35	-
Montane forest rat		
Rattus edwardsi	0/12	-
Rattus fulvescens	0/35	-
Rattus inas	0/15	-
Field and house rat		
Bandicota indica	0/15	-
Rattus argentiventer	8/55	-
Rattus tiomanicus	0/115	-
Rattus exulans	0/29	-
Rattus r. diardii	0/118	-

p = positive, n = total examined.

Table 2

Natural infection with *Breinlia booliati* in rats from different habitats.

Species	Habitat						%
	Primary forest p/n	Secondary forest p/n	Swamp forest p/n	Belukar p/n or edge habitat	Cultivated field p/n	Human habitated area p/n	
Rattus sabanus (terrestrial)	12/173	2/25	1/12	1/5	-	-	7.4
Rattus muelleri (terrestrial)	1/118	1/38	0/15	0/25	-	-	1.0
Rattus surifer (terrestrial)	3/85	0/25	0/10	0/13	-	-	2.3
Rattus rajah (terrestrial)	1/98	0/13	0/8	0/8	-	-	0.8
Rattus exulans (terrestrial)	1/21	0/15	0/9	0/32	0/48	0/12	0.7
Rattus cremoriventer (semi-arboreal)	8/46	1/15	1/13	2/4	-	-	15.4
Pithecheir parvus (semi-arboreal)	1/2	-	-	-	-	-	50.0

p = positive, n = total examined.

different habitats. The highest rate of infection was found in the primary forest in both cases. *Rattus muelleri* from both primary and secondary forest was found naturally infected. The remaining four species, *R. surifer*, *R. rajah*, *R. exulans* and *Pithecheir parvus* were found to be naturally infected only when captured in primary forest. None of the rats examined from cultivated and human inhabited areas were found to be naturally infected with the parasite. No marked difference in the infection rate was found in rats from secondary, swamp and edge habitats, but the rate of natural infection in rats from the forest was observed to be significantly higher than in the other habitats ($X^2 = 7.1$, $p > 0.01 < 0.001$).

Table 3 gives the mean adult worm load from all seven species of infected rats. *Rattus sabanus*, *R. surifer* and *R. cremoriventer* showed higher mean worm loads and greater ranges in worm loads than the other species. The differences in mean worm load among these three species were rather slight. The recovery of adult female worms was found to be significantly higher than for male worms ($X^2 = 8.35$, $p > 0.01 < 0.001$).

Table 3

Recovery of adult *Breinlia booliati* from naturally infected forest rats.

Species	No. of rats infected	No. of worms recovered		Mean worm-load p. inf. rat	Range
		♂	♀		
Rattus sabanus	16	55	84	8.7	8 - 19
Rattus muelleri	2	2	5	3.5	3 - 14
Rattus surifer	3	18	13	10.3	4 - 19
Rattus rajah	1	3	4	-	-
Rattus exulans	1	0	1	-	-
Rattus cremoriventer	12	48	91	11.6	6 - 16
Pithecheir parvus	1	1	3	-	-

Rats from every state except Malacca and Negri Sembilan were found infected with *B. booliati* (Fig. 1). Frequencies of natural infection appeared to be common in *R. sabanus* and *R. cremoriventer* throughout these states. In Trengganu the parasite was found in four other species of rat which lacked the parasite in other states.

DISCUSSION

The mammalian fauna of Malaysia is very diverse. Only a fraction of the species known to occur was obtained in the sample of over 1,548 mammals trapped throughout the country in the few habitats under study. The failure to procure certain of the small carnivores, insectivores, primitive primates, flying squirrels and large squirrels may be attributed to trapping techniques and the limited number of habitats sampled. Thus, the known host-parasite relationship for *B. booliati* is limited to the rodent group in the present study.

The results indicated that *B. booliati* in rodent hosts appeared to be largely confined to the murids, and that certain species of murids were preferred over others in different habitats. This is also true of other species of nematodes, particularly *Angiostrongylus cantonensis (= A. malaysiensis)* which is more confined to field rats and some forest rats (Lim *et al.*, 1965; Lim and Heyneman, 1965; Lim, 1967). The absence of this parasite in Sciuridae (squirrels) may be due to ecological segregation of the Sciuridae and the Muridae (rats). The former animals are diurnal and arboreal while the latter are nocturnal and terrestrial or semi-arboreal in habits. The vectors' (mosquitoes) normal activity cycle and/or their vertical stratification in the forest may separate them in time and/or space from the squirrels. Host specificity may also play a role here. Related studies on blood protozoa, *Plasmodium* and *Hepatocystis* in two species of nocturnal flying squirrels, *Petaurista petaurista*, and *P. elegans*, and two species of diurnal giant tree squirrels, *Ratufa affinis* and *R. bicolor*, showed that the nocturnal flying squirrels have a high rate of *Plasmodium* but no *Hepatocystis*, whereas the reverse was true in the diurnal squirrels (Muul *et al.*, 1973). They attributed the presence of *Plasmodium* or *Hepatocystis* to be related either to the activity pattern of the host or to host species specificity of the parasite. It is possible that the same kind of situation exists in the infection of these two unrelated rodent families with *B. booliati.*

Among the murids naturally infected with the parasite, *R. sabanus* and *R. cremoriventer* were found to be frequently infected. Low rates of infection were observed in *R. muelleri*, *R. surifer*, *R. rajah*, *R. exulans* and *P. parvus*. It was interesting to note that infections occurred among the lowland terrestrial and semi-arboreal murids only; infections were not observed among the highland murids. How much of this correlation is due to the susceptibility of the hosts is not known. In murids from the highland, field and human-inhabited areas, lack of infection may have been due to greater scarcity of the vectors and/or to the activity cycle of the hosts in these areas.

Although all seven naturally infected species of lowland terrestrial and semi-arboreal murids mainly inhabit primary forest, their range of habitats has been found to extend to secondary, swamp and edge forest (Lim, 1970; Medway, 1969). The extensive habitat range of these animals accounts for the dispersion of the parasite into varied habitats having suitable vectors. The significantly higher rate of natural infection among the murids in the primary forest suggests that the parasite originally evolved there. *Rattus exulans* is the most adaptable species, being found from the forest habitat to human habitation (Harrison, 1962), and the fact that the only infected *R. exulans* came from the forest (Table 2) further supports the hypothesis that the parasite is of forest origin. The absence of this parasite in rats from cultivated field and human habitation (Tables 1 and 2) was possibly due to the absence of suitable vectors in those areas rather than to differences in the susceptibility of the hosts.

All the infected species of rats with the exception of *P. parvus* (Table 2) are abundant and widely distributed throughout the country (Lim, 1970; Medway, 1969; Harrison, 1966), and the pattern of dispersion of this parasite is governed by the distribution of these hosts. *R. sabanus* and *R. cremoriventer* appeared to be the most common hosts infected with the parasite (Fig. 1). The high worm load observed in these two species in particular, and also in *R. surifer* (Table 3), supported this view and also indicated that these rats were probably more suitable hosts than the others. It was interesting to note that in Trengganu the parasite infects a wider range of hosts (Lim and Mak, 1974) than in other states throughout the country (Fig. 1), a phenomenon which is hard to explain without a further investigation to study the natural vectors involved in the transmission of this parasite. Since *B. booliati* can easily be maintained and transmitted by laboratory mosquitoes, and can develop to maturity in laboratory white rats (Ho *et al.*, 1973), the potential of this parasite as a laboratory model for chemotherapeutic and other studies is very good. Further studies should be done to clarify the role of this parasite among various vertebrates in the tropical ecosystems and to relate their niches to the transmission cycle.

SUMMARY

Seven of the 18 species of lowland forest terrestrial and semi-arboreal murids were found naturally infected with *Breinlia booliati*. Of these, two species, *Rattus sabanus* and *R. cremoriventer*, were found to be the most preferred hosts. None of the murids from the highland, field or human-inhabited areas was infected. This could have been due more to the greater scarcity of the vectors in these habitats than to the susceptibility of the hosts. The absence of this parasite in the squirrels examined may be attributed either to host specificity or to the normal activity cycles or vertical stratification of the vectors, separating them in space and/or time from the squirrels. The pattern of dispersion of the parasite is influenced by the wide distribution of suitable hosts, and the hypothesis that the parasite is of forest origin is discussed.

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