

INVESTIGATIONS ON THE ROLE OF WILD RODENTS AS RESERVOIRS OF HUMAN SCHISTOSOMIASIS IN THE TAVETA AREA OF KENYA, EAST AFRICA¹

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Abstract: These investigations were carried out in some of the villages around Taveta Town, Coast Province, Kenya, during the dry seasons of 1974, 1975 and 1976. The authors examined 83 wild rodents from villages where there is a high infection rate of *S. mansoni* and/or *S. haematobium*. The number and species of the rodents collected were as follows: 41 *Pelomys* sp., 2 *Arvicanthis* sp., 6 *Dendromus* sp., 5 *Thamnomys* sp., 1 *Rattus rattus* from Jipe, 4 *Pelomys* sp., 3 *Arvicanthis* sp., 3 *Mastomys* sp. from Eldoro, 1 *Pelomys* sp., 10 *Arvicanthis* sp., 7 *Mastomys* sp. from Kivalwa. Among them, 18 *Pelomys* sp. (43.9%) from Jipe and 1 *Pelomys* sp. (25.0%) from Eldoro proved to be infected with *Schistosoma* flukes. These flukes were identified as *S. mansoni* on the basis of their morphological features as well as the infectivity to their transmitters. In the experimental exposure of *Biomphalaria sudanica* to miracidia obtained from *Pelomys* sp., a number of cercariae were observed. This snail also proved to be infected with *S. mansoni* from human infection. From these investigations, it was suggested that the creek rodent, *Pelomys* sp. may play the role as a reservoir host of *Schistosoma mansoni* in this area.

INTRODUCTION

For a long time it was generally believed that in Africa the transmission of *Schistosoma mansoni* and *S. haematobium* was entirely interhuman. However, in 1952 a schistosome of man was found by Kuntz in a rodent and this stimulated a great deal of laboratory and field investigations on rodents as reservoirs of human schistosomiasis in Africa.

According to the reviews by Nelson (1960) and Nelson *et al.* (1962), a variety of wild animals including wild rodents have been found naturally infected with *S. mansoni* or *S. haematobium*, but up to the time of the present investigation there was no

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evidence to suggest that rodents played a part in the transmission of human schistosomiasis in Africa.

During the dry seasons of 1974, 1975 and 1976, the authors carried out field and experimental investigations on the role of wild rodents as reservoirs of human schistosomiasis in the Taveta area of the Coast Province of Kenya. The present paper reports the results of these investigations and records a high infection rate of *S. mansoni* in wild rodents.

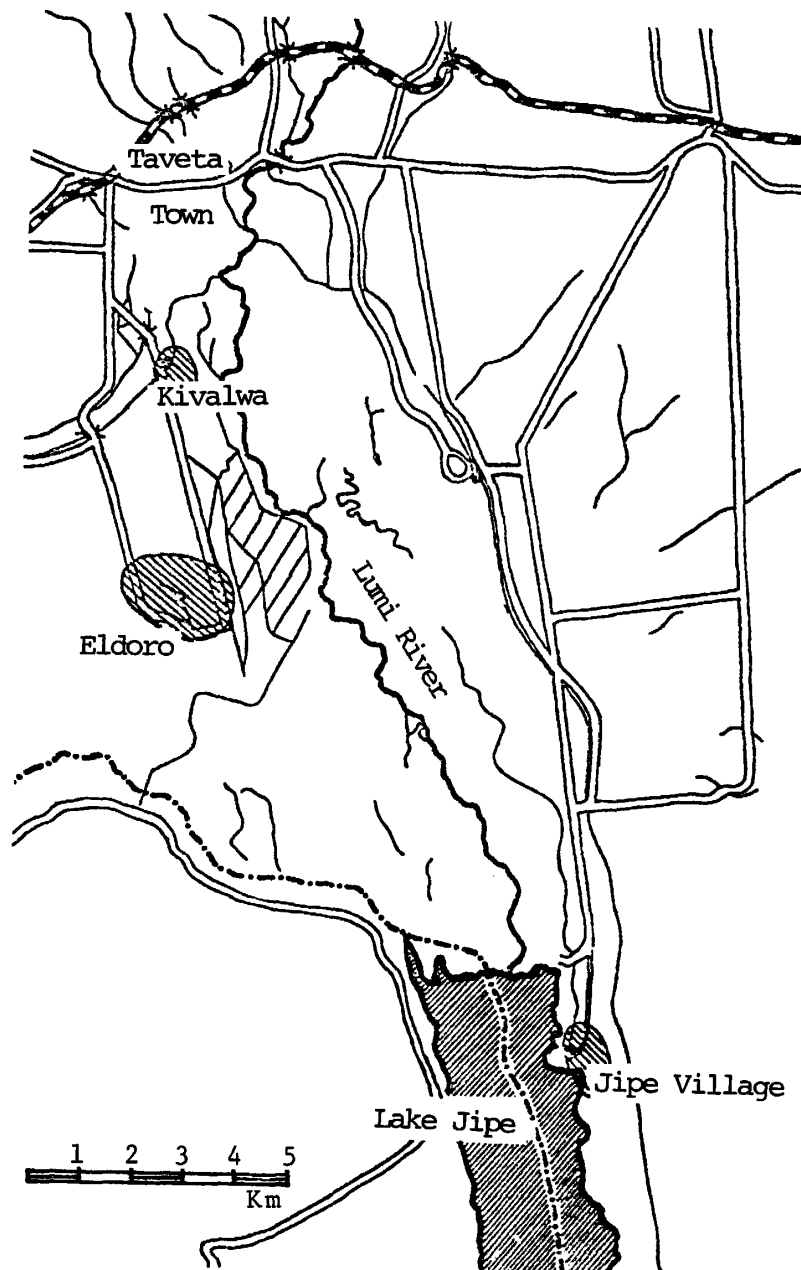


Figure 1 Map of the Taveta area, Coast Province, Kenya showing the locations of villages studied.

MATERIALS AND METHODS

Most of the wild rodents were captured by cage traps in the papyrus swamp along the Lake Jipe shore (Figure 1). The traps were also set in the sugar cane field along the irrigation canals in the villages Kivalwa and Eldoro.

The technique used in examining the rodents in 1974 was to crush the liver and portal veins between glass plates under a dissecting microscope to search for adult schistosome flukes and to crush pieces of liver and intestine between slides and examine them with a higher objective for eggs.

In 1975, the wild rodents were anaesthetized with Nembutal and the adult schistosomes were perfused from the portal veins and livers with citrated saline. The adults obtained were washed in saline and then fixed in Bouin's solution with slight pressure under a cover slip at the room temperature. These adults were preserved in 70 per cent ethanol. After sending them to Japan, they were stained with Carmine and mounted.

In order to collect the eggs of the schistosomes, the liver and intestine of the rodent were washed with saline and homogenized. After separating the residues, they were washed several times. The residues were examined under a dissecting microscope and the eggs were collected with a Pasteur pipette. These eggs were measured and compared with those from human infections.

Miracidia were hatched from the eggs obtained from the infected rodents, and were exposed to *Biomphalaria sudanica* that originated from Lake Jipe.

RESULTS

(1) Natural infection of wild rodents with schistosome

The results of the field investigation are summarized in Table 1. As shown in

Table 1 Natural schistosome infections in wild rodents in the Taveta area

Species of rodent	Villages surveyed	1974			1975			Total		
		No. ex- amined	No. in- fected	(%)	No. ex- amined	No. in- fected	(%)	No. ex- amined	No. in- fected	(%)
<i>Pelomys</i> sp.	Jipe	27	12	(44.4)	14	6	(42.9)	41	18	(43.9)
	Kivalwa				1	0	(0)	1	0	(0)
	Eldoro				4	1	(25.0)	4	1	(25.5)
<i>Arvicanthis</i> sp.	Jipe	2	0	(0)				2	0	(0)
	Kivalwa				10	0	(0)	10	0	(0)
	Eldoro				3	0	(0)	3	0	(0)
<i>Mastomys</i> sp.	Kivalwa				7	0	(0)	7	0	(0)
	Eldoro				3	0	(0)	3	0	(0)
<i>Dendoromus</i> sp.	Jipe	6	0	(0)				6	0	(0)
<i>Thamnomys</i> sp.	Jipe	3	0	(0)	2	0	(0)	5	0	(0)
<i>Rattus rattus</i>	Jipe	1	0	(0)				1	0	(0)

Table 2 Summarized data of the positive cases of naturally infected creek rodent, *Pelomys* sp. with schistosomes in 1975

Rodent No.	Date captured	Date autopsied	Eggs in faeces	Eggs in liver	Adults found
10*	Sept. 4	Sept. 5	—	—	4 ♂
15**	Sept. 7	Sept. 7	—	—	1 ♂
21*	Sept. 14	Sept. 14	—	+	4 ♂, 3 ♀
28*	Sept. 17	Sept. 17	—	+	2 ♂, 2 ♀
S-3*	Oct. 8	Nov. 5	+	+	2 ♂, 2 ♀
S-6*	Oct. 16	Nov. 11	+	+	8 ♂, 2 ♀

* captured from Jipe. ** captured from Eldoro.

Faecal examination was done at the date autopsied.

this Table, only the creek rodent, *Pelomys* sp. proved to be infected with schistosomes. During the two periods of observation, 18 out of 41 (43.9%) *Pelomys* sp. collected from the Lake Jipe shore were infected with *S. mansoni* and one out of four from Eldoro. Table 2 shows the number and sex of flukes recovered in six infected *Pelomys* sp. in 1975. The largest number of adult flukes was 10 (8 ♂, 2 ♀) and the smallest was one (1 ♂). It should be noted that the results of faecal examination of infected *Pelomys* sp. with schistosomes were negative for viable eggs until October and were positive after that. Other wild rodents such as *Arvicanthis* sp., *Mastomys* sp., *Dendromys* sp., *Thamnomys* sp. and the house rat, *Rattus rattus* were all negative for *Schistosoma* infection.

(2) Diagnostic features of schistosome found in *Pelomys* sp.

Adult flukes (Figures 2 and 3): The intestine of the male divides immediately posterior to the oesophageal gland into two intestinal crura which reunite to form a single caecum at approximately two-fifth or two-sixth of the total length of the intestine from the anterior end of the fluke. The number of testes is five to seven. In the female, the ovary lies in the anterior half of the body. Only one egg at a time is found in the uterus.

Eggs (Figure 4): The majority of eggs recovered from liver, intestine or faeces of the rodents are generally oval in shape and bear a lateral spine. The length and width of the 100 eggs averaged 143.2 ± 12.19 microns and 57.7 ± 6.58 microns, respectively. The measurements of the eggs of schistosomes found in *Pelomys* sp. and those of *S. mansoni* from human infections are shown in Table 3. The differences of length and width of the eggs are not statistically significant.

Finally, these flukes found in *Pelomys* sp. were identified as *S. mansoni* on the basis of the morphological features of the adults as well as those of the eggs.

(3) Experimental infections of snails and hamsters with schistosome found in *Pelomys* sp.

B. sudanica experimentally exposed to miracidia obtained from the eggs of *S. mansoni* parasitic in *Pelomys* sp. were transferred to Japan and observed. Two of the three snails which survived 56 days after exposure produced *S. mansoni* cercariae

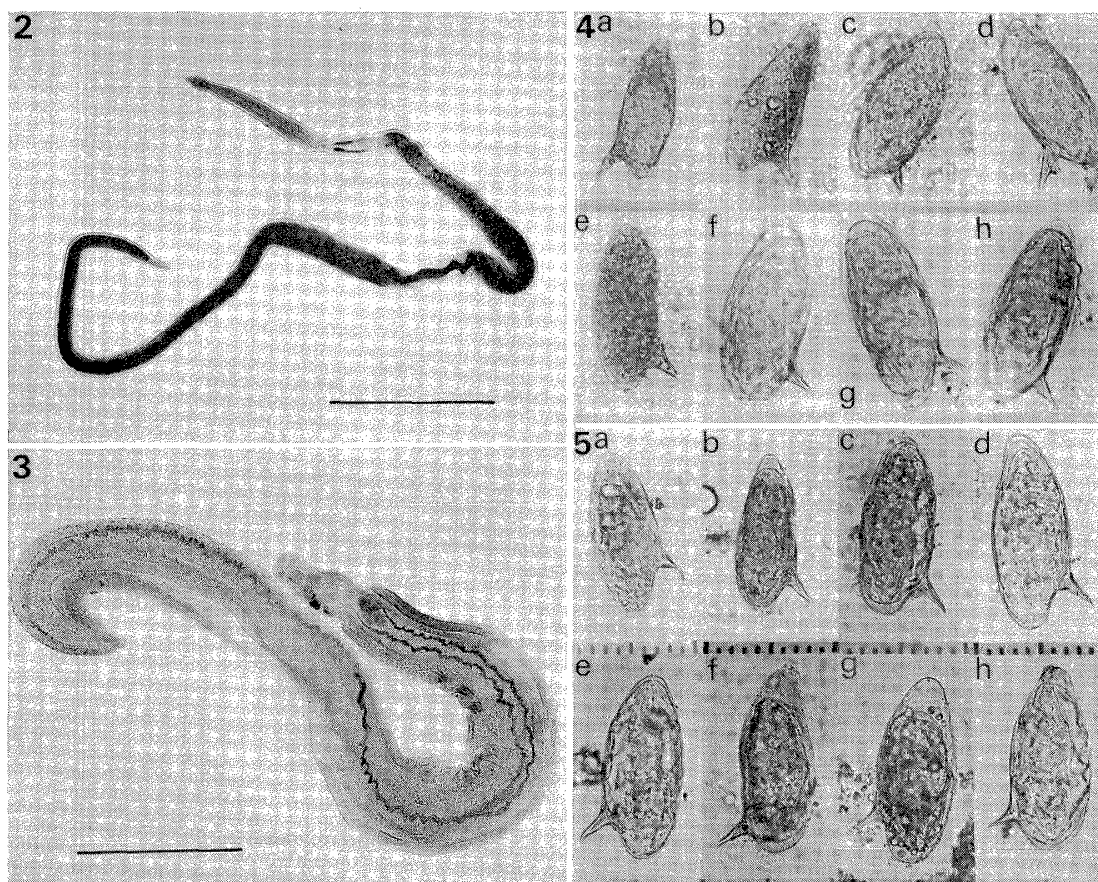


Figure 2 Adult *S. mansoni* (female) from wild *Pelomys* sp. (Scale 1.0 mm).

Figure 3 Adult *S. mansoni* (male) from wild *Pelomys* sp. (Scale 1.0 mm).

Figure 4 Eggs of *S. mansoni* from wild *Pelomys* sp. (Scale 10 microns).

Figure 5 Eggs of *S. mansoni* from the patient in the Taveta area (Scale 50 microns).

which were used to infect hamsters. Sixty-three days after exposure, the eggs of *S. mansoni* appeared in the faeces of the infected hamsters. The results of these experiments prove that *S. mansoni* obtained from *Pelomys* sp. is infective to *B. sudanica* and also to hamsters. At the same time, wild rodents were exposed to *S. mansoni* cercariae originating from human infections. In this experiment, one *Pelomys* sp. became infected. It was also shown that *B. sudanica* was susceptible to *S. mansoni* derived from human infection.

Table 3 Mean and standard deviation of measurements of the eggs of *S. mansoni* from rodent and human infections (in microns)

	Eggs from rodents (n=100)	Eggs from human (n=100)
Length	143.2 ± 12.19	140.1 ± 10.47
Width	57.7 ± 6.58	58.3 ± 5.45

DISCUSSION

In Africa two species and one variety of *Schistosoma* in the group with lateral

spined eggs have been reported: these are *S. mansoni* Sambon, 1907 and *S. rodhaini* Brumpt, 1931. *S. rodhaini* is common in rodents (Stijns, 1952; Schwetz, 1954), although it has never been found in human beings. According to the description of the eggs of *S. rodhaini* by Fripp (1967), the majority of eggs of *S. rodhaini* recovered from the liver, intestine or faeces of the mammalian hosts are generally oval and bear a prominent terminal or slightly subterminal spine usually directed laterally, with the angle of the direction varying from 0 to 90° to the long axis of the eggs, and at the opposite end of the eggs is a short blunt tubercle which may be straight or occasionally absent, but usually bends in a direction opposite to that of the spine. Schistosomes found in the rodents in the present study are distinguished from *S. rodhaini* by the shape of the eggs which are characteristic for typical *S. mansoni*. Schwetz (1953) found a new schistosome in wild rodents from the Albertville area of the former Belgian Congo and named it as *S. mansoni* var. *rodentorum*. This fluke produces lateral spined eggs similar to those of *S. mansoni* from which it is distinguished by several features. The differences were summarized by Schwetz (1953) as follows: in general appearance the eggs are elongated and sometimes slightly twisted, with one end rounded and the other narrowed. The spine bears near – sometimes very near – to the rounded end. The notch between the base of the spine and the body of the egg is distinct and is often wide and deep. Although some of the eggs in the present study were similar to those of *S. mansoni* var. *rodentorum*, living miracidia were not recognized in any of them (Figures 4a, b), and the eggs of normal appearance including living miracidia were identical in shape with those typical of *S. mansoni* (Figures 4 and 5 except 4a, 5). It seems that the egg of *S. mansoni* var. *rodentorum* might be an abnormal form of *S. mansoni* parasitic in rodents. In fact, Schwetz (1956) has already noted that *S. mansoni* var. *rodentorum* might be *S. mansoni* parasitic in rodents. Teesdale and Nelson (1958) also considered that *S. mansoni* var. *rodentorum* is nothing other than *S. mansoni* in rodents. According to the study by Taylor (1970), hybridisation occurred readily between *S. mansoni* and *S. rodhaini*, and the hybrids produced eggs which showed clear hybrid inheritance. The eggs of schistosome in the present study were not like those of the hybrids. As shown in Table 3, there were no differences in the sizes of the eggs of *S. mansoni* between human and rodent infections. Moreover, the morphological features of the adult flukes of schistosomes found in the rodents in the present study were identical with those of *S. mansoni* originating from human infection. Finally the flukes found in the rodents in the present study were identified as *S. mansoni* based on their morphology as well as their snail hosts.

In Kenya, Nelson (1960) examined 226 rodents from the endemic areas of schistosomiasis *mansoni* and schistosomiasis *haematobia*, and found a single male schistosome of the *S. mansoni* type parasitic in only one rodent, a *Dasymys*. He concluded that the evidence from Africa suggested that rodents played very little part in the transmission of human schistosomiasis. According to Nelson's opinion (1960), the few positive findings were usually "dead end" infections indicating an occasional zooanthroposis with man as the maintenance host and the rodent as an incidental host. In 1962, Nelson *et al.* reviewed the results of further surveys of the natural infection of rodents with schistosomes in Kenya where they examined more than

1,000 rodents. According to their study, *S. mansoni* was found in one out of 63 *Otomys*, two out of 250 *Mastomys* and one out of four *Dasymys*. *S. rodhaini* was found in one out of 60 *Thallomys* and two out of ten *Lophuromys*. Moreover, *S. bovis* was found in one *Mastomys* and three *Lophuromys*. Again, the low natural infection rate found in the rodents suggested that they were of no importance as reservoirs of human schistosomiasis in Africa. However, they concluded that since rodents can maintain *S. rodhaini* in isolated foci the examination of more swamp rodents might reveal active foci of rodent transmitted *S. mansoni* in Africa. The same authors were evidently uncertain of the role of baboons as true maintenance hosts of *S. mansoni*, even though high prevalence rates were recorded in Kenya and Uganda. Subsequent studies by Fenwick (1969) in Tanzania have shown that baboons can maintain the infection in their own community and are the source of infection to man. According to the study by Schwetz (1954) in the former Belgian Congo, schistosomiasis of rodents is chronic and seems to be of low virulence and he suggests that rodents were infected for ages before man appeared and that they came to tolerate their schistosomiasis. When man began to frequent the same watercourse and was exposed to infection, the chronic infection seen in rodents became an acute infection in the human host. This hypothesis was not supported by Pitchford and Visser (1962) who investigated the role of naturally infected wild rodents in the epidemiology of schistosomiasis in the Eastern Transvaal. Although they found schistosomiasis in rodents in a highly endemic area in their initial investigation, the original 22 per cent infection rate dropped until eventually it was extremely difficult to find any infected rodents two years later. They concluded that rodents seem incapable of maintaining *S. mansoni* infection without additional human pollution. In the present study, it is still not clear whether man contributes to the presence of *S. mansoni* in rodents or whether rodents can maintain *S. mansoni* in the absence of man, but high infection rate of *S. mansoni* among the creek rodent, *Pelomys* sp. and its ability to pass viable eggs in the faeces suggest that this rodent may serve as a reservoir of human schistosomiasis mansoni in this particular area. These observations suggest that further studies would be of value to determine the role of the creek rodent in the transmission of *S. mansoni* to man.

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東アフリカ・ケニア，タベタ地区における住血吸虫症の
病原保有宿主としての野生ネズミ類に関する研究¹

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この研究は、1974年、1975年および1976年の乾期（9月—12月）にケニア南部のタベタ地区に於て行われた。マンソン住血吸虫の濃厚浸淫地である Jipe 部落の Jipe 湖畔においては *Pelomys* sp. 41 個体、*Arvicanthis* sp. 2 個体、*Dendromus* sp. 6 個体、*Thamnomys* sp. 5 個体、*Rattus rattus* 1 個体を採集した。このうち、*Pelomys* sp. 18 個体（43.9%）に住血吸虫の自然感染を認めた。マンソン住血吸虫とビルハルツ住血吸虫の両種の浸淫地である Eldoro 部落では *Pelomys* sp. 4 個体、*Arvicanthis* sp. 3 個体、*Mastomys* sp. 3 個体を採集し、そのうち *Pelomys* sp. 1 個体（25.0%）に住血吸虫の自然感染を証明した。ビルハルツ住血吸虫の濃厚浸淫地である Kivalwa 部落では *Pelomys* sp. 1 個体、*Arvicanthis* sp. 10 個体、*Mastomys* sp. 7 個体を採集したが、住血吸虫の感染は認められなかった。*Pelomys* sp. から得られた住血吸虫の成虫について、雄では腸管が食道腺の直後において2分し、虫体の前方から2/5ないしは2/6の位置において再融合するものが普通にみられた。精巣の数は5-7個であった。雌では単純な卵巣が体の前部に位置し、子宮内に認められる虫卵の数は1個であった。また、その卵の形態は卵円形を呈し、鈍角をなす卵殻端に近い側部に著しい棘を生ずる。その100個の計測値は長径 $143.2 \pm 12.19 \mu$ 、幅径 $57.7 \pm 6.58 \mu$ であった。更に孵化させて得たミラシジウムを Jipe 湖中に多数生息する *Biomphalaria sudanica* に実験的に感染させたところ、セルカリアまでの発育が認められた。これらの特徴をヒトから得たマンソン住血吸虫のそれと比較したところ、多くの点で一致がみられた。従って *Pelomys* sp. から得られた住血吸虫をマンソン住血吸虫と同定した。Jipe 部落にはマンソン住血吸虫による患者が多数みられ、この住血吸虫の病原保有宿主として、*Pelomys* 属のネズミが、疫学上、重要な役割を演じているものと推測された。

1 ケニアにおける住血吸虫症の研究（第3報）本研究は長崎大学熱帯医学研究所に対する文部省特別事業費により行われた。2 九州大学医療技術短期大学部医動物学研究室 3 長崎大学熱帯医学研究所寄生虫学部門 4 鹿児島大学医学部医動物学教室