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Observations on the Transmission of *Schistosoma haematobium* and *Schistosoma bovis* in the Lake Region of Tanganyika

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Previous investigations have shown that in the Lake Region of Sukumaland, Tanganyika, where Schistosoma haematobium *is highly endemic,* Bulinus (Physopsis) nasutus *is responsible for the transmission of that schistosome in small, temporary rain pools. This area is one of low rainfall, and large artificial reservoirs are the chief source of water in the dry season. The role of these reservoirs in* S. haematobium *transmission was studied over a period of about a year.*

Previous work in South Africa had indicated the potential danger of bovine schistosomes to man. S. bovis *is a very common parasite in cattle in the Lake Region, and a search for its intermediate host or hosts, previously unidentified, was therefore also made.*

The results of this double investigation suggest that large bodies of water are relatively unimportant in the transmission of both S. haematobium *and* S. bovis. Bulinus (Physopsis) africanus *is shown to be a second intermediate of* S. haematobium *and a vector of* S. bovis *as well. Transmission of these parasites by this snail takes place principally in streams.*

Schistosoma haematobium is endemic in the Lake Region of Sukumaland, at the southern end of Lake Victoria (Jordan, 1961). Webbe (1962) studied in detail the bionomics of *Bulinus (Physopsis) nasutus productus* Mandahl-Barth and its infection rate with *S. haematobium* in a 6-square-mile (15 km²) area in the region and demonstrated the seasonal nature of transmission corresponding to the temporary existence of the habitats—small rain pools—of the molluscan intermediate host.

Rainfall is low in the area, about 30 inches (75 cm) a year, and there is an acute shortage of water during the long dry season from July to November. This has led to the impounding of water by different methods. The undulating nature of the country permits the building of dams across valleys and seepage areas while on the more level ground, " tanks " are excavated in the ground. The capacity of these reservoirs varies considerably, from several hundred million gallons (e.g., Sola dam) to a few hundred thousand.

The work reported in this paper was undertaken by the author, with the help of a technician, as part of the research programme of the East African Institute for Medical Research. It was particularly intended to supplement and extend the observations of Webbe (1962) into permanent waters and to cover a wider area of Sukumaland (see map). The present observations were made from July 1962 to August 1963, thus covering both the dry and the rainy seasons.

In addition to *S. haematobium* being endemic in the area, bovine bilharziasis occurs and 58% (37/64) of the cattle examined over a period of six months at the Mwanza abattoir were infected. All the eight cattle examined on three occasions at Nzega, and all the six examined on three occasions at Bariadi were infected. Both *Schistosoma bovis*, a more northerly, and *Schistosoma mattheei*, a more southerly species, occur in this region, East Africa being a transitional zone (Dinnik, personal communication). In spite of the high prevalence of bovine bilharziasis, however, no infected snails were found among the many thousands that were examined, over a number of years, during studies on *S. haematobium* (Webbe, 1962). It

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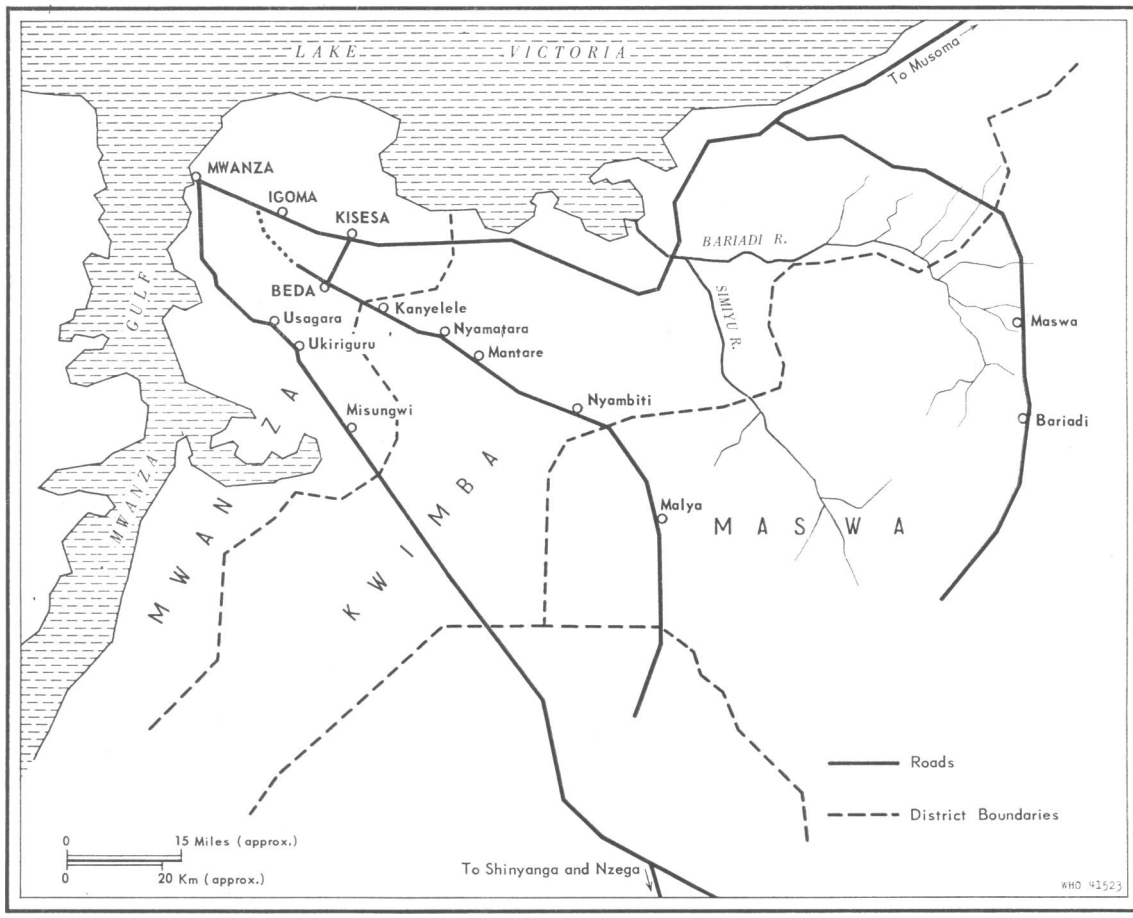
THE LAKE REGION OF SUKUMALAND, TANGANYIKA



was hoped, therefore, that observations on the reservoirs which supply most of the water for livestock, bathing and domestic consumption in the dry season would reveal the intermediate host or hosts of the bovine schistosomes. An intermediate host of *S. bovis* was later found in a stream and observations were extended to this type of habitat.

THE ROLE OF PERMANENT WATER RESERVOIRS

For the purpose of the present study water reservoirs are divided into (*a*) large dams, and (*b*) " hafirs ". Technically the distinction between a dam and a " hafir " is based on the gradient across which a reservoir is built, dams being across the steeper slopes and " hafirs " across the more gentle ones. Here "hafir " is used to mean a dam with a water surface of about 0.25-0.5 acre (about 1000-2000 m²) and a capacity of about 1 million UK gallons (or about 4500 m³). " Dams " are much larger bodies occupying 5 acres (2 ha) or more and containing several thousand million gallons of water.

The habitats

A general characteristic of " hafirs " is the open water surface owing to the removal of vegetation, especially at the onset of the dry season, when they come in use by man and his livestock. When present, vegetation comprises largely marginal grasses and the emergent water lettuce, *Pistia* sp., which also tends to grow round the margins. Large dams, on the other hand, may have much more vegetation, including water lettuce, water lilies, sedges and grasses. Eleven " hafirs " and three large dams in

Mwanza district were chosen for regular observations. In Kwimba district four " hafirs " were visited periodically as was one large dam in Maswa district. In addition a number of other dams were examined. Habitats under regular or periodic observations are numbered 1-19 to facilitate the recording of results.

Habitat No. 1. A " hafir " situated at Ukiriguru. Considerable human and cattle contact in the dry season. *B. (Ph.) nasutus productus* and *Bulinus (Bulinus) forskalii* (Ehrenburg) were the only bulinid snails present.

Habitats No. 2-4. " Hafirs " at Nyamatala. No. 2 had *B.(B.) forskalii* and *B.(Ph.) nasutus productus.* No. 3 *B.(B.) forskalii,* and No. 4 *B.(B.) forskalii* and *B.(Ph.) nasutus productus.* No. 4 may dry out in prolonged drought. There was considerable human and cattle activity around all four.

Habitats No. 5-10. " Hafirs " situated at Kitumba village near Kisesa. *B. (Ph.) nasutus productus* was present in No. 6, 7 and 8; *Bulinus (Physopsis) africanus ovoideus* (Bourguignat) in No. 9 and 10; *B.(B.) forskalii* sporadically in No. 5, 7 and 9. A bulinid intermediate between *Bulinus (Bulinus) coulboisi* (Bourguignat) and *Bulinus (Bulinus) tropicus* (Krauss) was present in No. 5.

Habitat No. 11. A " hafir " at Igoma cattle dip. Considerable bathing and cattle contact. *B.(Ph.) nasutus productus* and, sporadically, *B.(B.) forskalii* were present.

Habitat No. 12. A pair of very similar " hafirs " on the Nyambiti-Malya road, Kwimba district. In drought only very muddy water remained at the bottom. *B. (Ph.) nasutus productus* and *B. (B.) forskalii* were present.

Habitat No. 13. Three similar " hafirs " close together, situated about 10 miles (16 km) along the Mantare-Nyambiti road. Water volume subject to great fluctuations. *B. (Ph.) nasutus productus* and, sporadically, *B. (B.) forskalii* were present.

Habitat No. 14. A " hafir " about half a mile (800 m) below No. 13 on the same slope. Fluctuations of smaller volume than in No. 13. *B. (Ph.) nasutus productus* was present. There was considerable human and cattle contact.

Habitat No. 15. A " hafir " close to a large dam situated about 6 miles (9.5 km) from Mantare on the Nyambiti road, near a cattle dip. There was much human and cattle contact. *B. (Ph.) nasutus productus* was present.

Habitat No. 16. A large dam at Misungwi. Covers approximately 21 acres (8.5 ha) with a capacity of about 30 million UK gallons (or about 13 600 m^3). There was little direct human or cattle contact. *B. (Ph.) africanus ovoideus* was present.

Habitat No. 17. A large dam at Kisesa, slightly smaller than No. 16. There was much human and cattle contact. No bulinid snails were found.

Habitat No. 18. A large dam at Kanyelele, with little human and cattle contact. " *B. (B.) coulboisi-tropicus* " intermediate was present in the body of the dam, and *B. (Ph.) nasutus productus* and *B. (B.) forskalii* in an inlet and a spillway during the rains when flooding occurred.

Habitat No. 19. A large dam at Sola near Maswa District Headquarters with a capacity of about 100 million UK gallons or 360 acre-feet (about 454 600 m^3) and area of about 85 acres (34.5 ha). There was much human and cattle contact. *B. (Ph.) africanus ovoideus, B. (B.) forskalii and the* " *B. (B.) coulboisi-tropicus* " intermediate were present.

Methods

Habitats under regular observation were visited about once a fortnight in the case of " hafirs " and once a month in the case of large dams. In an attempt to detect any seasonal fluctuations in bulinid snail population densities in these habitats, as well as changes in infection rates with mammalian schistosomes, snails were collected in as uniform a manner as possible. Using a hand net, the same man collected steadily for 20 minutes in each " hafir " and for two hours in a dam. Snails were brought into the laboratory and examined individually for infection in about 2.5 cm of water in tubes 3×1 inches (7.5×2.5 cm) which were placed under a strong electric light. Golden hamsters and mice were exposed to any mammalian schistosome cercariae shed and dissected about three months later for the identification of the infection. Snails were returned to their habitats within 24 hours in the case of " hafirs " in Mwanza (i.e., No. 1-11), but the very small numbers of bulinids collected from the large dams were discarded as it was considered these made little difference to the population density of snails in these habitats. Snails from outside Mwanza district were also not returned to their habitats, because of the distances involved.

Results

The densities of bulinid populations were very low in both " hafirs " and dams, being lower in dams than " hafirs ". Table 1 shows the total numbers of

TABLE 1
TOTAL MONTHLY NUMBERS OF *PHYSOPSIS* FROM ALL HABITATS AND NUMBERS INFECTED

Snail	No. of snails	1962						1963								
		July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
B. (Ph.) nasutus productus	Collected	846	31	231	98	244	75	3	408	722	469	87	106	93	448	
	Infected	1	0	5	1	5	0	0	5	1	4	0	5	3	5	
B. (Ph.) africanus ovoideus	Collected	3	0	19	16	3	0	10	0	51	0	2	66	243	257	269
	Infected	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0

Physopsis spp. collected monthly and their rates of infection with mammalian schistosomes. The differences between monthly figures do not indicate fluctuation in the snail population as, for different reasons, not all habitats could be visited each month. Table 2 shows the contribution of each habitat to the total number of snails collected and the proportion infected with mammalian schistosomes. The number of collections made at each habitat includes those occasions when no snails were found. This indicates the relative densities of the snails in the various habitats.

TABLE 2
TOTAL NUMBERS OF *PHYSOPSIS* TAKEN FROM EACH HABITAT AND NUMBERS INFECTED

Snail	Habitat No.	No. of snails collected	No. of snails infected	Total collections made
B. (Ph.) nasutus productus	1	319	3	16
	2	462	11	18
	4	56	1	16
	6	13	0	13
	7	42	0	13
	8	511	1	13
	11	34	0	13
	12	1 231	6	7
	13	439	0	8
	14	507	11	4
	15	247	2	5
	Total	3 861	35	
B. (Ph.) africanus ovoideus	9	7	1	13
	10	808	1	7
	16	24	0	10
	19	100	1	5
	Total	939	3	

Identification of the infections was made difficult by the small numbers of infected snails, since hamsters or mice exposed to cercariae pooled from fewer than four snails almost always returned unpaired male schistosomes and there is no reliable character for distinguishing males of *S. haematobium* from those of *S. bovis*. However, *B. (Ph.) nasutus productus* was experimentally found refractory to *S. bovis* (Kinoti, 1964) and unpaired males were therefore identified as *S. haematobium*. Table 3 shows the schistosomes recovered from various habitats.

B. (B.) forskalii has a widespread but very sporadic distribution in the habitats and is probably of little epidemiological significance. Its susceptibility to the local *S. haematobium* has not been tested but Cridland (1955) was unable to infect it in Uganda. None of the 5000 specimens examined by Webbe (1962) was found infected. It is experimentally susceptible to *S. bovis* (Kinoti, 1964), but none of the several hundred wild specimens examined during the present study was found shedding mammalian schistosome cercariae.

A bulinid described by Dr Mandahl-Barth (personal communication) as being intermediate between *B. (B.) tropicus* and *B. (B.) coulboisi* had a more limited distribution than the other snails. It was present in habitats No. 5 and 18. In both habitats it had a low density during most of the period of study. In habitat No. 5, however, its density built up from three in March 1963 to about 200 snails per minutes' search in September. It is not known to be susceptible to *S. haematobium*, *S. bovis* or *S. mattheei*. In one exposure of 50 laboratory-bred progeny of this snail, originally from Shinyanga, to the local *S. bovis*, no infections were obtained.

TABLE 3
SCHISTOSOMES RECOVERED FROM VARIOUS HABITATS

Habitat No.	Date	Snail host	Schistosomes recovered	Remarks
1	Sept. 1962	*B. (Ph.) nasutus*	Males only	*S. haematobium* [a]
2	Sept. 1962	*B. (Ph.) nasutus*	Males only	*S. haematobium* [a]
2	May 1963	*B. (Ph.) nasutus*	Males only	*S. haematobium* [a]
4	Oct. 1962	*B. (Ph.) nasutus*	Unidentified	Too few cercariae for inoculation of hamsters
8	April 1963	*B. (Ph.) nasutus*	Males only	
12	July 1962	*B. (Ph.) nasutus*	Unidentified	Mouse died prematurely
12	Feb. 1963	*B. (Ph.) nasutus*	*S. haematobium*	Pairs in hamsters
12	March 1963	*B. (Ph.) nasutus*	Unidentified	
12	April 1963	*B. (Ph.) nasutus*	Males only	*S. haematobium*
14	Nov. 1962	*B. (Ph.) nasutus*	*S. haematobium*	Pairs in mouse and hamsters
14	Feb. 1963	*B. (Ph.) nasutus*	Males only	*S. haematobium*
14	Aug. 1963	*B. (Ph.) nasutus*		
15	Sept. 1962	*B. (Ph.) nasutus*	Males only	*S. haematobium* [a]
15	Nov. 1962	*B. (Ph.) nasutus*	Males only	*S. haematobium* [a]
10	June 1963	*B. (Ph.) africanus*	Unidentified	
19	Sept. 1962	*B. (Ph.) africanus*	Males only	*S. haematobium* or *S. bovis*

[a] So attributed because *B. (Ph.) nasutus productus* has been found refractory to *S. bovis* (Kinoti, 1964).

THE ROLE OF STREAMS

The majority of rivers and streams of Sukumaland are markedly seasonal. In the rains they are flooded in their lower courses but in the dry season their volume is greatly reduced, with flow ceasing altogether in the smaller rivers, leaving extensive sand beds. Before drying up completely some of these streams and rivers are reduced to a series of pools, the duration of which depends largely on their situation. In the upper courses particularly, where little or no silting occurs, these pools may last throughout the dry season. In some localities these form the main water supply for man and livestock.

Occurrence of B. (Ph.) africanus ovoideus *in streams and its infection with* S. haematobium *and* S. bovis

In November 1962, *B. (Ph.) africanus ovoideus* were collected from two streams at Bariadi in North Maswa. These streams feed the Bariadi river which in turn flows into the Simiyu river. Snails were collected from both streams; 33 of 214 (15.4%) specimens from one and 11 of 1158 (0.9%) from the other emitted large numbers of mammalian schistosome cercariae. Several hamsters and mice were exposed to cercariae pooled from all the snails. Paired *S. bovis* adults were recovered from the mesentery and liver, and typical *S. bovis* ova from the liver, of a hamster dissected 52 days after exposure. Ova and adults of *S. haematobium* were found in another hamster dissected about three months after exposure. The other hamsters and the mice returned *S. bovis* and *S. haematobium.*

Following the observation that *B. (Ph.) africanus ovoideus* transmitted both *S. haematobium* and *S. bovis* at Bariadi, a number of other streams were examined for this snail. In Mwanza District the snail was found in:

(*a*) Misungwi stream, where *S. haematobium* infection rates of up to 10% have been recorded.

(*b*) Beda stream near Fela railway station, where on two occasions snails have been found shedding mammalian schistosome cercariae.

(*c*) A stream near Misungwi. No snails were infected.

In Kwimba it has been recorded from:

(*a*) The Korimije tributary of Ngongwa river. No snails were infected.

(*b*) The first tributary of the Nyambehu river on the Mantare-Nyambiti road. Here one specimen was found shedding schistosome cercariae in May. Male schistomes were recovered from a hamster exposed to these cercariae.

In Maswa only streams in the Bariadi area were examined. Here *B. (Ph.) africanus ovoideus* is the major molluscan host of *S. bovis* and *S. haematobium*.

It should be noted that the surveys of these streams, with the exception of Bariadi and Misungwi, were carried out during or shortly after the rainy season, when snail populations are generally at their lowest level.

The transmission pattern of schistosomes in streams

It was not possible in the present study to make detailed quantitative observations on the snail populations or cercarial infection rates in any stream. Periodic visits to Misungwi and the Bariadi streams have, however, shown a transmission picture correlated to fluctuations in snail populations.

Bariadi streams. These streams were first examined in November 1962, which is the end of the dry season. The two streams examined consisted of large pools connected by a very gentle flow of water. Many of the pools contained large numbers of *B.(Ph.) africanus ovoideus*, with a schistosome infection rate of up to 15% in one stream.

The streams were again visited towards the end of January 1963, after about two months of rain. A third stream was also surveyed. They were flowing quite fast and the pools had been obscured by the flow. Snails were much more difficult to find than previously, and only two of the 156 specimens of *B. (Ph.) africanus ovoideus* recovered from the original two streams shed mammalian schistosome cercariae. During this visit a number of temporary pools were examined for *B. (Ph.) nasutus productus* in the area. This snail was found in two large pools. Most of the pools appeared to be too temporary for the establishment of snails in them. Streams are the main source of water, even in the rainy season, in the area covered by these observations. None of the 90 *B. (Ph.) nasutus productus* collected from the two pools shed mammalian schistosome cercariae.

When the streams were finally visited in June, their rate of flow had slowed down considerably, and pools were becoming more clearly marked along the original two streams. Large numbers of young snails and egg masses were present in them. No snails or egg masses were found in the third stream, which was flowing much more swiftly than the others. Four of the 80 adult snails collected were infected.

Misungwi stream. The large dam (Habitat No. 16) is built across this stream but in the rains two spillways connect the body of the dam and the stream below the dam wall. The stream, especially just below the dam, is used intensively for bathing and washing clothes by the inhabitants of Misungwi village throughout the year. Cattle are watered further down the stream. In the dry season it is reduced to a series of pools, which contain large numbers of *B. (Ph.) africanus ovoideus*.

It was first examined in the dry season (October 1962), when three of 30 *B. (Ph.) africanus ovoideus* collected from a pool were found infected with *S. haematobium*. Examinations of the upper mile in the middle of November and in January (rainy season) showed the presence of snails on marginal vegetation. The stream was flowing quite fast and in many places pools had been obliterated. In May and July flow was more gentle and there was a clear increase in the numbers of snails, especially of the young ones. Only one of the 130 large snails recovered during those visits was infected.

In September pools along most of the stream had formed and contained large numbers of snails. Infection rates had also increased—seven out of a total of 129 adult snails taken were infected. When these observations were terminated in August 1963 it was too early to identify the infection by dissection of hamsters exposed to the cercariae, but it is mostly likely to be *S. haematobium* as this part of the stream is intensively used by man and has little contact with cattle.

Teesdale (1962) found that in Kitui, Kenya, flood conditions greatly reduced the numbers of *B.(Ph.) africanus ovoideus* and other snails in streams and that as the dry season progressed snail populations built up and cercarial infection rates increased. The same general picture would seem to prevail in the Misungwi and Bariadi streams, and is probably applicable to many other streams in this region. The transmission of the liver fluke, *Fasciola gigantica*, in the Bariadi area is reported by the veterinary station there to be markedly seasonal, with a peak around September-November, at the end of the dry season.

Aestivation of B. (Ph.) africanus ovoideus

In April 1963, a pool in an old gravel quarry, supporting a large number of *B. (Ph.) africanus ovoideus*, *Biomphalaria pfeifferi* and two operculates (*Pila ovata* and *Bellamya* sp.) was discovered in the higher of the two spillways of the Misungwi dam. The pool had been left behind when outflow from the dam had stopped and, having a gravel bottom and sides, dried up rapidly. In June, when the pool had been dry for about a month, four aestivating *B. (Ph.) africanus ovoideus* and three *P. ovata* were found under stones and dry leaves. On being placed in water the snails extended within two hours. The *Physopsis* were kept in the laboratory and started laying egg masses after about a week. Collections were again made in July and September, i.e., two and four months after the drying up of the habitat. On the first occasion four *B. (Ph.) africanus ovoideus* were collected and one was alive, and on the second occasion 10 were collected and one was alive. Operculates collected on both occasions were alive. In the September collection a foam containing numerous young operculates which had not yet hatched at the time the habitat had dried up was taken. The young operculates emerged when the foam was left in water overnight and started feeding on boiled lettuce a day later.

Thus *B. (Ph.) africanus ovoideus* is able to aestivate for at least four months. The ability to aestivate is by no means a rare occurrence among pulmonate gastropods (Morton, 1963), and, although these observations were not extended beyond September, there can be little doubt that aestivating snails would have survived for another two months or so, when rain was expected.

DISCUSSION

The results of work on " hafirs " (Tables 1 and 2) show that some transmission of *S. haematobium* takes place in these habitats. The amount of transmission occurring in these sites, however, is relatively unimportant in comparison with the situation in smaller habitats—rain pools (Webbe, 1962) or pools in streams such as Misungwi. Considering " hafirs " as a group no pattern of seasonal transmission or fluctuation of snail populations can be discerned. Several factors are responsible for obscuring such a pattern. In the first place, snail populations in many of the " hafirs " were too small to allow an accurate assessment of fluctuations in their densities. Secondly, the effects of human and cattle activities vary from one habitat to another. The intensity, duration and timing of those activities depend on the availability of other water, which in turn depends on such factors as the timing, duration and amount of rainfall and on the situation of the " hafir ". Thus, for instance, whereas the disturbance by removal of vegetation of habitat No. 2 reduced the catch from 112 snails in April to 55 in June, habitat No. 1 remained relatively undisturbed during this period owing to the presence of water in pools and ricefields in the surrounding ground and experienced disturbance in August when these pools and fields had dried out.

A consideration of individual " hafirs ", however, suggests that snail populations build up in the rainy season when disturbance by man and cattle is minimal. As drier conditions set in and increased use is made of " hafirs " there is an increase in cercarial infection rates until human and cattle activity seriously interfere with the snail population, when both infection rates and snail populations decline. As has been pointed out above, happenings in the various habitats are so staggered in time as to obscure a seasonal picture when " hafirs " are considered as a group.

In the large dams bulinid snail population densities are too low to allow detection of population changes by the sampling technique employed. *B. (Ph.) africanus ovoideus* was found in Sola (No. 19) and Misungwi (No. 16) dams but was absent from Kisesa (No. 17) and Kanyelele (No. 18). The "*B. coulboisi-tropicus*" intermediate form was the only bulinid recovered from four other dams examined—Nyambiti (Kwimba District), Sepewa and Mkulani (Maswa District) and one near Kolandoto (Shinyanga District). But even when present, the *B. (Ph.) africanus ovideus* population density is so low that, coupled with the dilution of any schistosome miracidia in these large water reservoirs, little, if any transmission, takes place in large dams.

It is interesting to note that *B. (Ph.) nasutus productus* has never been recorded from the body of large dams although during floods it may be found in spillways and channels leading into the dams. It is not known what factors limit its establishment in dams. *B. (Ph.) africanus ovoideus*, however, is found in both dams and " hafirs ". It appears to be essentially a riverine species and its presence in or absence from dams or " hafirs " seems to depend on the situation of these. The snail is found chiefly in the upper reaches of streams, where pools shaded by vegetation, particularly sedges and grasses such as *Typha* sp., form suitable habitats. Dams or " hafirs "

built across such streams or valleys are likely to contain the snail.

The evidence so far available suggests that *B. (Ph.) africanus ovoideus* is entirely responsible for the transmission of *S. bovis* in this region. No infected *B. (Ph.) nasutus productus* has ever been recorded from field studies. Experimentally it has proved refractory to the local *S. bovis* (Kinoti, 1964). Streams are the main habitats of *B. (Ph.) africanus ovoideus*, and it would therefore be expected that the transmission of *S. bovis* mostly takes place there. The observations on streams recorded in this paper do not cover a long enough period of time to reveal a definite transmission picture of this parasite, but they suggest that in pools snail populations build up rapidly in the dry season and with increased cattle watering cercarial infection rates go up. In the rainy season floods greatly reduce snail populations. The transmission of *S. haematobium* by this snail follows the same pattern as that for *S. bovis*.

The contribution of *B. (Ph.) africanus ovoideus* to the over-all *S. haematobium* transmission in this region cannot at present be accurately assessed. Two types of evidence, however, point to its being at least significant. Firstly, the snail has been found naturally infected with *S. haematobium* in two streams and is easily infected experimentally. In addition, it appears to have quite a wide distribution. Although transmission may take place in some "hafirs" (three of 16 *B. (Ph.) africanus ovoideus* from a "hafir" in Maswa town were found infected with *S. haematobium* in September 1962), streams are the most important sites. Secondly, since evidence strongly points to *B. (Ph.) africanus ovoideus* being entirely responsible for an average *S. bovis* prevalence in cattle of about 60% of this region, it appears reasonable to suppose that this snail makes a significant contribution to *S. haematobium* transmission, particularly as the same sites are often shared by man and cattle. The role of *B. (Ph.) nasutus productus* and *B. (Ph.) africanus ovoideus* in the transmission of urinary bilharziasis probably varies from one locality to another. In the area studied by Webbe (1962), for instance, *B. (Ph.) nasutus productus* is the principal intermediate host, whereas *B. (Ph.) africanus ovoideus* appears to be the more important intermediate host at Bariadi. But, considering the lake region of Tanganyika as a whole, our knowledge of the biology of schistosomes of importance to man can be regarded as only qualitative until the relative importance of the various snail species is determined more precisely.

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RÉSUMÉ

Dans la Province des Lacs, au Tanganyika, de vastes réservoirs artificiels, certains de très grandes dimensions, d'autres plus modestes nommés « hafirs », ont été aménagés pour pallier la pénurie d'eau en saison sèche. La forte endémicité locale de l'infection à *Schistosoma haematobium* a incité l'auteur à étudier l'influence de ces installations sur la transmission de ce parasite et sur la transmission de *Schistosoma bovis*, parasite du bétail très commun dans la région. L'enquête a duré un an environ.

On a pu démontrer que, dans la zone étudiée, *Bulinus (Physopsis) africanus*, un des vecteurs de *S. haematobium*, est également l'hôte intermédiaire de *S. bovis*. En revanche, *B. (Ph.) nasutus* ne semble pas intervenir dans la transmission de ce dernier parasite. Dans les grands réservoirs, on a relevé la présence de *B. (Ph.) africanus* mais en petit nombre. Ce fait, et la très forte dilution des éventuels miracidies dans ces énormes masses d'eau font penser que la transmission des deux types d'infection y est très faible. Dans les « hafirs », une certaine transmission de *S. haematobium* s'effectue en saison sèche, par l'intermédiaire de *B. (Ph.) nasutus* et de *B. (Ph.) africanus*, par suite de la fréquentation des réservoirs par un plus grand nombre de personnes. Il apparaît que réservoirs et « hafirs » ne jouent qu'un rôle secondaire dans la

propagation des deux types d'infection et que la transmission des parasites a lieu essentiellement dans les rivières de la région.

On a par ailleurs observé que *B. (Ph.) africanus* est capable d'estiver pendant plus de 4 mois et il est vraisemblable qu'il peut survivre pendant toute la saison sèche. Ce vecteur est très répandu et on peut supposer qu'il intervient pour une grande partie dans la transmission de *S. haematobium* et de *S. bovis* aux endroits fréquentés à la fois par les humains et le bétail.

REFERENCES

Cridland, C. C. (1955) *J. trop. Med. Hyg.*, **58**, 1
Jordan, P. (1961) *Bull. Wld Hlth Org.*, **25**, 695
Kinoti, G. (1964) *Ann. trop. Med. Parasit.* **58**, 270
Morton, J. E. (1963) *Molluscs*, London, Hutchinson
Pitchford, R. J. (1959) *Trans. roy. Sec. trop. Med. Hyg.*, **53**, 285
Teesdale, C. (1962) *Bull. Wld Hlth Org.*, **27**, 759
Webbe, G. (1962) *Bull. Wld Hlth Org.*, **27**, 59