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Distribution of *Helisoma duryi*, an introduced competitor of intermediate hosts of schistosomiasis, in an irrigation scheme in northern Tanzania

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Summary

Helisoma duryi is a planorbid snail, which has been suggested as biological control agent against the intermediate hosts of schistosomiasis. This snail species has been present in a sugar estate in nothern Tanzania since 1972. In January 1981 a snail survey was done in this area in order to determine the distribution and abundance of *H. duryi* relative to other freshwater snail species. The distribution of *H. duryi* was found to be restricted to a few drains, while *Biomphalaria pfeifferi*, *Bulinus natalensis*, and *Lymnaea natalensis* were widespread. However, where *H. duryi* was found, no or very few *B. pfeifferi* were recorded indicating either competitive interactions between the two species or perhaps differences in the ecological preferences of the two species. No competitive interactions were indicated between *H. duryi* and *B. natalensis*. The apparent failure of *H. duryi* to spread in the area might be due to regular molluscicide application to the canal system and drainage canals, where *H. duryi* did not occur.

Key words: schistosomiasis; biological control; *Helisoma; Biomphalaria; Bulinus.*

Introduction

Helisoma duryi (Wetherby, 1879) is a planorbid snail species which has been proposed as a biological control agent against the intermediate hosts of schistosomiasis (for a review see Frandsen and Madsen, 1979).

In 1972 *H. duryi* was introduced in some experimental field canals at a sugar estate, Tanganyika Planting Company (T.P.C.), at Arusha Chini, Moshi,

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Tanzania, in an attempt to control *Biomphalaria pfeifferi* (Krauss, 1848), the intermediate host of *Schistosoma mansoni* Sambon (Rasmussen, 1975). However, the experiments were stopped in 1974 and the results obtained were not conclusive.

In May 1975 *H. duryi* was released into some drains at T.P.C. and snail sampling has since been done weekly in these drains. The canal system and the drainage system apart from the drains where *H. duryi* was introduced have been treated regularly with Frescon or occasionally Bayluscide. In January 1981 the present snail survey was undertaken at T.P.C. in order to determine the distribution and density of *H. duryi* populations as compared to the distribution of other freshwater snail species in the area. At the same time it was attempted to establish which trematodes occurred in the various snail species. In addition, reports kept at T.P.C. on the routine collection of snails in drains containing *H. duryi* populations were looked through in order to get some idea of the population fluctuations over the last five years.

Description of the study area

Water for irrigation is taken at two intakes from the Weru-weru river (Fig. 1) and is led through open canals and reservoirs. This form of irrigation is used in the central and southern areas, while in the northern area sprinkler irrigation by ground water is used.

The drainage system (Fig. 1) is composed of open drains, often very deep and with steep sides. At the time of the survey many drains were completely dry and some collection sites were of quite limited extension.

Camps for labourers are situated in the central and southern areas and here molluscicide (Frescon) is applied regularly. The canal system is treated by application at the intakes four times a year. The reservoirs and drainage system are surveyed regularly for snails and sprayed with Frescon, except for the drainage canals selected for *H. duryi*. No snail control is done in the northern area.

Material and Methods

Snail sampling was done over the entire irrigation scheme (Fig. 1), but owing to recent Frescon application (December 1980) at the water intakes, snail densities were generally very low in the canal system and the reservoirs. Consequently, snail sampling was concentrated to the drainage system.

Collection of snails was done using a kitchen sieve (diameter 18 cm) mounted on a rod (1.5 m long) for 15 minutes at each collecting site, which, if possible, covered 5–10 m along the canal.

At each collecting site observations were made on vegetation, substratum, amount of detritus present, and water velocity. In addition, water samples from some collecting sites were analysed for pH and conductivity.

Snails were examined for cercarial shedding by placing them, either individually in small test tubes (12.5 ml), or five together in larger containers (60 ml) with dechlorinated tapwater for 18 hours. Cercariae were preserved in 4% formalin and identified at the Danish Bilharziasis Laboratory.

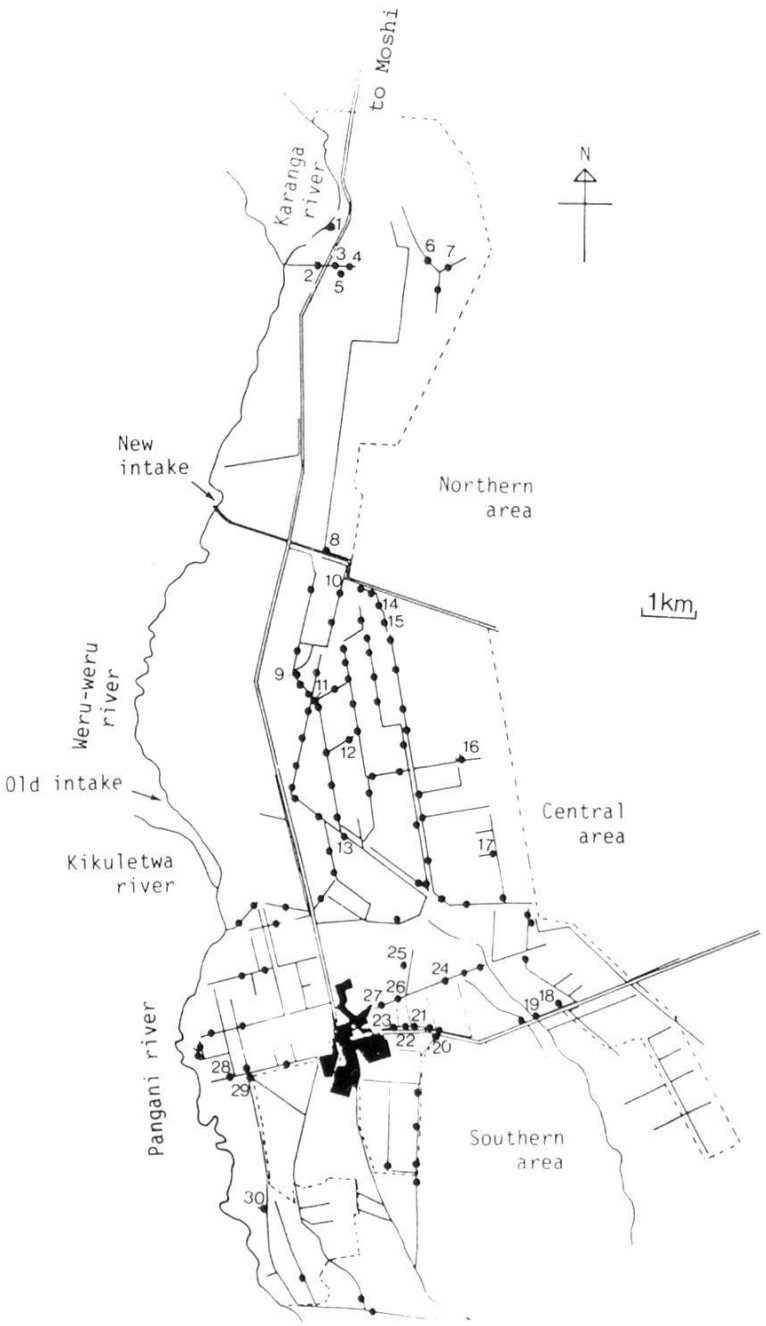

Fig. 1. Showing the drainage system at Tanganyika Planting Company. Dots indicate collecting sites and those numbered are included in Table 2.

Snail samples were preserved in 70% ethanol and identifications of *H. duryi* and *B. pfeifferi* were verified at the Danish Bilharziasis Laboratory using anatomical characters (i.e. presence of a preputial gland in *H. duryi*), because the two species may be difficult to separate on shell morphology alone (Madsen in prep.).

In addition, live specimens from some *Bulinus* populations were send to the Danish Bilharziasis Laboratory for determination of chromosome number and for electrophoretic analysis. The number of chromosomes in these *Bulinus* was 2n = 36 (Jelnes, pers. comm.). The mesocones of the first lateral teeth of the radula were mainly arrowhead shaped, wherefore the species was identified as *B. natalensis*. Identification of *B. natalensis* may be difficult because of morphological intergradation with *B. tropicus* (Brown et al., 1971). Egg proteins showed no differences between *B. natalensis*

Table 1. Snail species recorded from the Tanganyika Planting Company in January 1981. A total of 108 samples were taken and the frequency (%) at which species occurred in these samples is given.

Snail species and author	Frequency (%)
Helisoma duryi (Wetherby, 1879)	13
Biomphalaria pfeifferi (Krauss, 1848)	42
Bulinus natalensis (Küster, 1841)	36
Bulinus forskalii (Ehrenberg, 1831)	7
Lymnaea natalensis Krauss, 1848	43
Ceratophallus natalensis (Krauss, 1848)	5
Gyraulus costulatus (Krauss, 1848)	3
Segmentorbis angustus (Jickeli, 1874)	2
Cleopatra ferruginea (Lea and Lea, 1850)	54
Melanoides tuberculata (Müller, 1774)	13

and *B. tropicus* when analysed by electrophoresis (Brown et al., 1971) and also electrophoresis of the *Bulinus* from T.P.C. showed the same pattern as *B. tropicus* (Jelnes, pers. comm.), but the typical arrowhead shaped mesocones of the lateral teeth should justify the identification as *B. natalensis.*

Results

A total of 108 snail samples were taken covering most of the drainage system (Fig. 1). In addition sporadic searching was done in canals and dry drainage canals. Table 1 shows the snail species recorded and the frequency at which they occur in samples. Fig. 2–5 show the distribution of *H. duryi, B. pfeifferi, Bulinus natalensis* (Küster, 1841) and *Lymnaea natalensis* Krauss, 1848.

The distribution of *H. duryi* was limited to a few drains, whereas *B. pfeifferi, B. natalensis* and *L. natalensis* were widespread in the area. Except in a few drains, the density of *B. pfeifferi* and *B. natalensis* was generally very low. Most biotopes containing dense *Biomphalaria* populations in the central area were relatively small drains which probably were overlooked during the molluscicide application. In the canal system, high densities of *B. pfeifferi* or *B. natalensis* were occasionally found in the concrete-lined parts, where the off-takes to field channels are found. When irrigation is stopped prior to the harvesting of the sugar cane, these concrete-lined parts may contain stagnant water and the snails present avoid exposure to molluscicide.

The distributions of *H. duryi* and *B. pfeifferi* were only slightly overlapping and very few *B. pfeifferi* were recorded from sampling-sites with *H. duryi*, i.e. 1 from site no. 22 and 2 from site no. 26 (Table 2).

B. natalensis was found in 6 out of 13 collecting sites containing *H. duryi* and in one (site no. 26) the population density was fairly high (Table 2).

L. natalensis, Cleopatra ferruginea (Lea and Lea, 1850) and *Melanoides tuberculata* (Müller, 1774) were also recorded from some sampling sites where high densities of *H. duryi* were found.

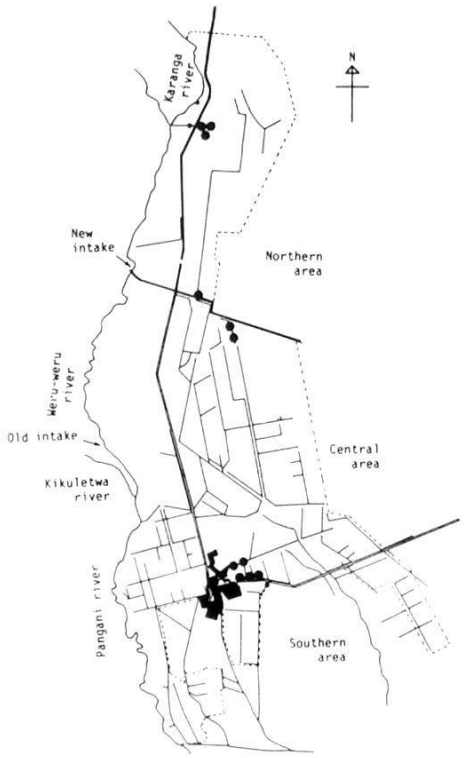

Fig. 2

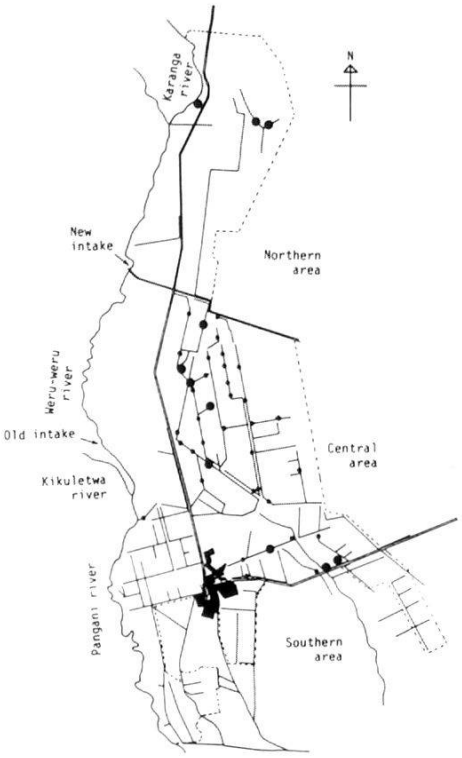

Fig. 3

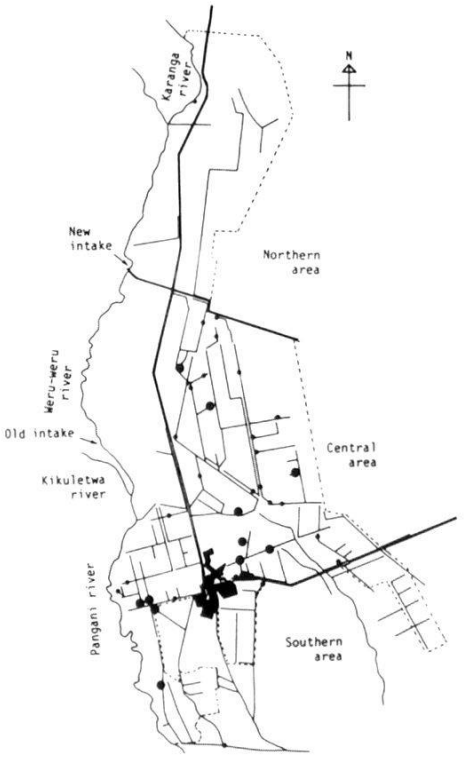

Fig. 4

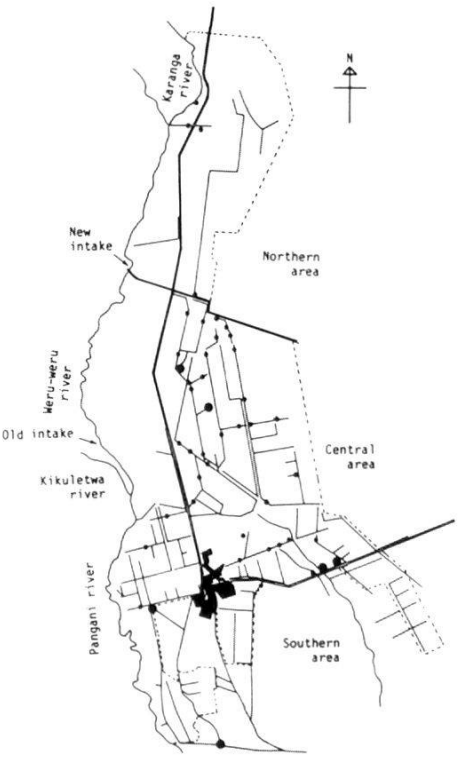

Fig. 5

Fig. 2. Distribution of *Helisoma duryi*. Small dots indicate less than 20 snails collected during standard sampling (see text) and large dots more than 20 snails.
Fig. 3. Distribution of *Biomphalaria pfeifferi* (symbols as in Fig. 2).
Fig. 4. Distribution of *Bulinus natalensis* (symbols as in Fig. 2).
Fig. 5. Distribution of *Lymnaea natalensis* (symbols as in Fig. 2).

Table 2. Numbers of snails of various species collected in some sampling sites at T.P.C. Numbers in brackets indicate that only empty shells were found.

Site	*Helisoma duryi*	*Biomphalaria pfeifferi*	*Bulinus natalensis*	*Lymnaea natalensis*
A. *H. duryi* dominating or present				
2	(3)	0	0	(1)
3	290	0	0	0
4	50	0	0	0
5	281	0	0	1
8	140	0	23	5
14	109	0	0	8
15	45	0	0	+
20	2	0	5	1
21	(252)	0	(13)	0
22	563	2	24	0
23	230	0	2	0
26	279	1	115	8
27	759	0	0	0
B. *B. pfeifferi* dominating				
1	0	118	0	5
6+7	0	136	0	0
9	0	57	35	21
10	(1)	(35)	(3)	(2)
11	0	50	4	1
12	0	109	81	32
13	0	29	0	8
16	0	58	2	5
18	0	133	1	36
19	0	24	0	31
24	0	74	47	8
C. *B. natalensis* dominating				
17	0	3	27	2
25	0	0	113	1
28	0	0	71	6
29	0	0	120	64
30	0	0	48	0

The reports from the routine snail collections (Bilharzia-file at T.P.C.) indicated a wider distribution of *H. duryi* than was found during the present survey. In four drains, which according to these reports have been harbouring flourishing *H. duryi* populations from May 1975 to December 1980, no *H. duryi* were recorded from 21 collecting sites, while 70 *B. pfeifferi*, mainly juveniles, were found.

In the drain represented by samples 2, 3 and 4 in the present survey (Fig. 1), *H. duryi* has been present since December 1977 according to the data from T.P.C. This drain has been dry for two periods (December 1978 to March

Table 3. Number of snails examined for cercarial shedding, number infected and type of cercariae recorded

Snail species	No. examined	No. of collecting sites	No. infected	Type of cercariae	No. of collecting sites
H. duryi	618	9	0	–	–
B. pfeifferi	443	24*	4	xiphidiocercariae	3
			3	amphistome (Diplodiscinae)	1
			3	echinostome cercariae	1
B. natalensis	295	20*	3	strigea cercariae	3
L. natalensis	136	23*	1	echinostome cercariae	1
			6	xiphidiocercariae	4
C. ferruginea	210	30*	0	–	–
M. tuberculata	76	9*	0	–	–

* Some collecting sites represented with very low snail numbers.

1979 and September 1979 to March 1980) and apparently no new introductions of *H. duryi* have been necessary. *H. duryi* has been present in the drain represented by samples 26 and 27 since April 1978 (Bilharzia-file at T.P.C.).

Sampling site no. 5 was a small drain along a rice field and according to the field technician from T.P.C. *H. duryi* had been introduced a few months prior to the present survey. A high density of *H. duryi* was found in this drain and the population was almost exclusively composed of individuals having shells closely resembling shells of *Biomphalaria.* This shell form was occasionally found in other populations of *H. duryi.* A great inter-populational variation in shell morphology was observed for both *H. duryi* and *B. pfeifferi.*

The drain represented by samplings 6 and 7 was of relative recent construction, and no attempts had as yet been made to introduce *H. duryi.*

The ecological observations made at each collection site could not provide explanations to the distribution patterns observed.

Trematode infections in various snail species are recorded in Table 3. No *H. duryi* were found infected, while 3 types of cercariae were recorded from *B. pfeifferi,* one type from *B. natalensis* and two types from *L. natalensis.* Infection rates, however, were low (Table 3). No cercariae of *S. mansoni* were recorded.

Discussion

It can be concluded that *H. duryi* can maintain population for several years under natural tropical conditions. However, the distribution of *H. duryi* at T.P.C. ist limited to a few drainage canals where no molluscicide is applied. The

regular molluscicide application to the canal system and the other parts of the drainage system may have prevented *H. duryi* from spreading into new areas.

The distributions of *H. duryi* and *B. pfeifferi* at T.P.C. are clearly not overlapping and this may indicate differences in the ecological preferences of the two species or perhaps competitive interactions. No ecological differences between sampling sites with *H. duryi* and sampling sites with *B. pfeifferi* could be deduced from the ecological recordings done, but obviously there might be differences in other ecological parameters.

Sampling sites where *B. pfeifferi* is dominating are clearly interspersed between sites where *H. duryi* is dominating, and this might favour the competitive interactions as explanation for the observed distribution patterns. There is no evidence of competitive interactions between *H. duryi* and *B. natalensis* indicating that the two species are not ecological homologues and therefore able to coexist.

If *H. duryi* is superior to *B. pfeifferi*, a spread of *H. duryi* should be anticipated. However, this has not occurred during the period *H. duryi* has been present at T.P.C., partly because of the regular molluscicide applications.

Comparing reports from the T.P.C. (Bilharzia-file) with the present distribution of *H. duryi*, it can be seen that shortly before this survey, *H. duryi* has disappeared from 4 drains, where populations have existed since 1975. Accidental molluscicide application might explain this as also the density of *B. pfeifferi* was very low and mainly juvenile specimens were found. However, other explanations might exist.

It appeared that *B. pfeifferi* populations were starting to build up in the four drains from where *H. duryi* had disappeared, so apparently spreading capacity of *B. pfeifferi* is superior to that of *H. duryi*. However, as *H. duryi* populations in the area are few, the probability that it should spread into biotopes from where it has disappeared or to new biotopes is low. In addition *H. duryi* is obligatorily a cross fertilizer (Madsen et al., in prep.) and this may partly explain its low spreading capacity. *H. duryi* populations in other areas have also been noted not to spread (Appleton, 1977).

If *H. duryi* has a low spreading capacity, this should be an advantage in its use as a biological control agent against the intermediate host snails since unintended spreading will be easily avoided.

It has been suggested that *H. duryi* is less capable of aestivation than the planorbid intermediate hosts (McCullough, 1981). However, the reports from T.P.C. indicate that *H. duryi* can survive in drains regularly drying out (periods up to 5 months are recorded).

H. duryi is already found in a number of countries where schistosomiasis is endemic (Frandsen and Madsen, 1979). Recently, a dense population of *H. duryi* was recorded in a limited area in Qaha, 12 km from Qalyub, Egypt (Pflüger and Roushdy, 1980). *H. duryi* was exposed in this area in 1966, but there is no evidence that this population originates from the initial introduction

in 1966 (Pflüger and Roushdy, 1980). Roushdy and El-Emam (1981) found large numbers of *H. duryi* in the river Nile in the El-Kanater area, Egypt.

It thus appears that *H. duryi* is widespread in Africa and may have an even wider distribution since it is easily mistaken for *Biomphalaria* species (van Bruggen, 1974; Prentice et al., 1977; Madsen, in prep.). At T.P.C. *H. duryi* shows a great variation in shell morphology, ranging from scalarid forms to "*Biomphalaria*-like" forms (Madsen, in prep.).

The status of *H. duryi* as intermediate host for trematodes cannot be deduced from the present observations. However, no trematode infections were recorded from *H. duryi* although several types were recorded from the other pulmonate snail species (Table 3). There is no evidence that *H. duryi* should be intermediate host of schistosomes or other trematodes of medical or veterinary importance (see Frandsen and Madsen, 1979).

Since further introductions of *H. duryi* at T.P.C. were encouraged during the present survey, it would be interesting to do a follow-up at a later stage. At the same time, it would be interesting to make a similar survey in other regions, since field workers may not be aware of the possible presence of *H. duryi* in their area and because *H. duryi* is easily mistaken for *Biomphalaria* species. Especially Egypt appears to be an interesting possibility since some natural field populations have already been recorded (Pflüger and Roushdy, 1980; Roushdy and El-Emam, 1981).

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