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Elimination of *Biomphalaria pfeifferi, Bulinus tropicus* and *Lymnaea natalensis* by the ampullarid snail, *Marisa cornuarietis*, in a man-made dam in northern Tanzania

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Summary

Marisa cornuarietis is a well known ampullarid competitor/predator of *Biomphalaria glabrata* in Puerto Rico. For the first time in Africa a flourishing population of *Marisa* has been established in a small, permanent, man-made dam at Kisangara, near Moshi, Tanzania. Prior to the release of *M. cornuarietis* in June 1977, this dam supported thriving populations of the pulmonate snail hosts *Biomphalaria pfeifferi* and *Lymnaea natalensis; Bulinus tropicus* and the melaniid *Melanoides tuberculata* were also common. Some 24 months after the establishment of *Marisa* the three pulmonate species had been eliminated; only *M. tuberculata* remained at about the same population density as originally recorded. *Marisa* has not caused any obvious adverse environmental impact in the dam. There is at present no valid evidence that this ampullarid would be a threat to local rice production, which is the only crop at risk, but carefully designed field trials should be undertaken to confirm or refute this view. In view of the vast number of permanent, lentic habitats throughout the Afrotropical region, which act as important transmission sites of schistosomiasis and fascioliasis, the role of *Marisa cornuarietis* as a cost-effective biological control agent in integrated control operations deserves henceforth to be energetically explored.

Introduction

Opinions for and against the potential efficacy of biological control of snail intermediate hosts are many and are almost entirely based on the results of

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laboratory studies. The recent reviews by Hairston et al. (1975), Jordan et al. (1980) and McCullough (1981) are pertinent. Among the many proposed biocontrol agents (see Michelson, 1957), the most promising to date are other snail competitors and/or predators such as *Marisa cornuarietis*, *Helisoma* spp. and the melaniid snail *Thiara granifera*. Of these snails, the ampullarid *M. cornuarietis* has been the most extensively studied under field conditions, but so far only in Puerto Rico (Ferguson, 1978).

The efficacy of *M. cornuarietis* in displacing *Biomphalaria glabrata* in certain habitats on this island is undisputed. Persistence of effort, however, was needed to ensure maintenance of *Marisa* in certain transmission sites, but overall costs were estimated to be about a third of that of applying the best synthetic molluscicide (Jobin and Berrios-Duran, 1970; Jobin et al., 1977).

Marisa cornuarietis is autochthonous to habitats in the Magdalena and Orinoco river systems draining Colombia and Venezuela. It is reported to occur also in Guiana, Surinam, Panama, Costa Rica, in certain Caribbean islands, as well as in Florida, USA. The biology and ecology of *Marisa* have been well described by Ferguson (1978), who has also drawn attention to its usefulness in the control of aquatic weeds.

In Africa, laboratory studies on *Marisa* have been undertaken only in Egypt and Tanzania. In the former country, Demian and coworkers (see references) have carried out many investigations and have also demonstrated its efficacy against *Bulinus truncatus* populations under semi-field conditions (Demian and Kamel, 1973). In Tanzania, Msangi and Kihaule (1972) confirmed that *M. cornuarietis* could eliminate *Bulinus nasutus* and *Lymnaea natalensis* in laboratory aquaria.

In the present communication, we report the first successful establishment in Africa of *Marisa cornuarietis*[3] in a man-made dam located at Kisangara, northern Tanzania, and as a consequence, the elimination from that habitat of *Biomphalaria pfeifferi*, *Lymnaea natalensis* and *Bulinus tropicus*, the former two species being snail hosts of trematode infections of major socio-economic importance.

The main aims of releasing *Marisa cornuarietis* in Kisangara dam were, (a) to determine its survival under local natural conditions, (b) to observe its effect on some important snail hosts of Tanzania and (c) to provide a source of material for other biological control studies. For various reasons, which will later be briefly discussed, it was considered that the release of *Marisa cornuarietis* would not have any adverse environmental impact; nor since its release in Kisangara dam has there been any evidence to this effect.

[3] The origin of these snails and their introduction into Tanzania is described by Msangi and Kihaule (loc. cit.).

Materials and Methods

Kisangara dam

This permanent, rain-fed dam was excavated more than a decade ago by Kisangara Sisal Estate to conserve water for factory use. It is located near Kisangara village, about 56 km south-east of Moshi, in the Kilimanjaro Region, Tanzania. Kisangara is situated at an altitude of about 900 m and has a tropical equatorial climate. The annual rainfall is variable, averaging 120 mm, with a marked rainy season extending from November to May; the annual average temperature is around 23° C, but it may range widely according to season. The natural vegetation is described as orchard bush.

The dam, sited in laterite soil about 200 m from a stream but not connected to it, is about 100 m in diameter, 2–3 metres in average depth, generally steep-sided and with dense patches of emergent vegetation, mainly *Typha* sp. It has no outlet. Prior to introducing *Marisa*, the dam contained other aquatic vegetation, viz. *Cyperus* spp., but these were subsequently eaten by the ampullarid snails. Since its construction the dam is much used by the local population for bathing, washing and fishing. Both it and the nearby stream have been important potential transmission sites of *Schistosoma* and *Fasciola* species. *S. mansoni* and *S. haematobium* are highly endemic at Kisangara (Loum, 1974), and further data on prevalence and intensity of *Schistosoma* spp. in local primary schoolchildren are presently being recorded (Hess, personal communication). Before seeding *Marisa*, the dam supported flourishing populations of *Biomphalaria pfeifferi*, *Bulinus tropicus*, *Lymnaea natalensis* and *Melanoides tuberculata* (see Table 1).

Introduction of Marisa cornuarietis and snail population sampling methods

In late June 1977, 49 adult *Marisa*, together with some egg masses and newly hatched snails, were transferred from laboratory aquaria at Arusha, situated some 140 km from Kisangara, and released at several sites in the dam close to stands of aquatic vegetation. Both before and after the introduction of the ampullarids, estimations were made of the relative population densities of the different snail species occurring in the dam using a standardised sampling method. At 30 selected sites around the periphery of the dam, five sweeps of a long-handled snail collecting scoop are made mostly through aquatic vegetation or along bottom deposits. At each site, all snails collected were transferred into a white enamel tray, counted, and then returned to the dam. The same snail collectors were employed on all occasions. The presence of egg masses and dead shells was noted. This simple sampling procedure is considered sufficiently sensitive to provide valid comparative estimates of overall snail population densities in the dam; it would be, of course, inadequate for more rigorous ecological investigations. The summarized results are briefly described below.

Results

As shown in Table 1 the population density of the three pulmonates *B. pfeifferi*, *B. tropicus* and *L. natalensis* began to decline, but not markedly so, six months after the release of *M. cornuarietis*, which had by that time become well established. However, two years later, no living pulmonate snails could be found, while the density of *M. cornuarietis* had increased almost tenfold and that of the prosobranch *M. tuberculata*, which is not, of course, a snail host, had remained relatively stable. A fairly similar picture was recorded 30 months after the release of *M. cornuarietis* (Table 1). Moreover, during a site visit to the dam in December 1980, some three and a half years after the ampullarids were first seeded, no living pulmonates nor their egg masses could be found in the dam after an exhaustive search by scooping or by the careful examination of vegeta-

Table 1. Observations on population density of snails occurring in Kisangara dam before and after the introduction of *Marisa cornuarietis*

Period of observation	Total number of living snails collected				
	Biomphalaria pfeifferi	*Bulinus tropicus*	*Lymnaea natalensis*	*Melanoides tuberculata*	*Marisa cornuarietis*
10 June 1977	811	730	73	519	Released late June 1977
14 January 1978	606	24	18	182	1 478
2 July 1979	0	0	0	482	10 777
15 January 1980	0	0	0	699	6 294
16 December 1980	0	0	0	common	numerous

tion; on the other hand, *M. cornuarietis* were numerous and *M. tuberculata* were still common. In the nearby stream, which had recently been in spate, a few living *B. pfeifferi* were found, but there was no evidence that *M. cornuarietis* had become established in this stream, perhaps not surprisingly as this ampullarid does not readily survive in habitats subject to flushing, nor is the stream connected to the dam.

Discussion

Marisa cornuarietis has flourished in a small, permanent, man-made dam near Moshi, Tanzania, since June 1977. In less than two years after its introduction, this ampullarid competitor/predator snail has, in all probability been responsible for the elimination of all three pulmonate snail species, *B. pfeifferi*, *B. tropicus* and *L. natalensis* from the dam; no other adequate cause for their demise can be proposed with any conviction and *B. pfeifferi* remained established in a nearby stream. After their eradication no further colonization of the dam by these pulmonate snails has been observed. Transmission of schistosomiasis and fascioliasis in this man-made dam has, therefore, been effectively controlled at virtually no cost.

The relatively slow disappearance of the pulmonates from Kisangara dam, and also the survival of the population of *M. tuberculata* is of interest. Parallel observations on these aspects have been reported in Puerto Rico (Ferguson, 1978). Significantly, this author has also noted that «the last size range to disappear in biological control trials consists of the largest bilharzia snails». The observed slow augmentation in population density of *M. cornuarietis* may be due to its slow intrinsic rate of increase (it is a "K" species), its tendency to remain in its own home range, as well as other possible biological and physical factors. Although much is already known of the biology of *Marisa*, its resistance

to drying under a variety of natural conditions, its capacity to survive in low-gradient streams, and optimum seeding methods deserve further careful investigation.

Apart from the objectives of the present study a decision to release *M. cornuarietis* in Kisangara dam was deliberately made for other reasons including the following:

- Human schistosomiasis and fascioliasis are problems of great socio-economic importance in Tanzania, which must be tackled by control procedures appropriate to national resources, and excluding, as far as possible, expenditure of hard currency. Increasing water resource developments are thus providing many permanent waterbodies (lakes, dams, canals) capable of acting as important additional sites of disease transmission. Economic control of snail hosts in such habitats, therefore, deserves high priority.
- In Puerto Rico, *M. cornuarietis* has proved to be a cost-effective bio-control agent of *Biomphalaria glabrata* in such large waterbodies as ponds, lakes and irrigation canals. Its capacity as an efficient consumer of some types of aquatic weed is an added bonus. This snail was first discovered in Puerto Rico, in 1952; it has since become quite widely established by deliberate release; there has been no evidence of adverse environmental impact, nor does it transmit any trematode infection of importance to human welfare.
- *M. cornuarietis* is a 'K' species, bisexual, of limited motility, not amenable to accidental or natural transfer from its habitat, preferring lentic waterbodies, and perhaps not exceptionally resistant when stranded out of water under prolonged dry tropical conditions. For these reasons, it is most unlikely to survive readily or be able to maintain successive populations in typical African ricefields, which, except for some sophisticated irrigation schemes, are flooded for less than three months each year. The danger of ampullarids such as *M. cornuarietis* as a serious crop pest has, according to Christie and McCullough (1981), been exaggerated. Unfortunately, this alleged threat has discouraged, more than any other constraint, the field testing of *Marisa* as a promising bio-control agent. The risk of this ampullarid becoming a pest of rice may well be remote, especially also as it does not consume rice leaves large enough for field planting (Msangi and Kihaule, 1972). Although *Marisa* will, when offered, eat young seedling rice (Ortiz-Torres, 1962), this is rarely likely to pose a practical threat (seedling rice being cultivated in small, easily protected plots) and should not, *per se*, contraindicate the release of this ampullarid in selected foci of transmission, either actual or potential, of schistosomiasis and fascioliasis. In any event, the decision to do so must obviously rest with national decision-makers.

It is hoped that the encouraging results obtained in Kisangara dam will stimulate further study of the efficacy of *M. cornuarietis*, in such major transmission sites as permanent ponds, dams and irrigation canals in many parts of Africa. There can be little remaining doubt that the judicious use of selected

bio-control agents has an important role to play in integrated control strategy of trematode infections in the Afrotropical region.

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