

Field trials of low dose Bayluscide on snail hosts of schistosome and selected non-target organisms in sahelian Cameroon

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More than 85% of all cases of schistosomiasis in Cameroon occur in the northern sahelian half of the country representing 20% of the population. Several workers have advocated the integrated approach to schistosomiasis control, including snail control, but the death and decay of aquatic organisms, and fish kill that often follows Bayluscide application at the dose of 1 g/m³ decrease its acceptability. The present study was designed to assess the effect of lower Bayluscide doses on snail host and non-target fish, frog, the tadpole kill. Bayluscide was applied to study ponds at concentrations of 0, 0.25, 0.5, and 1 g/m³ (ppm). Pre and post application assessment of snails hosts of schistosomes, fish, frog, and tadpole kill were carried out. All 0.25, 0.5, and 1 g/m³ Bayluscide concentrations reduced snail population significantly. Bayluscide concentration of 0.50 g/m³ applied in two rounds of 0.25 g/m³ resulted in high snail mortality and low lethality to fish, frogs, and tadpoles. Further studies are needed to assess the cost-effectiveness of Bayluscide in the control of schistosomiasis following the simplified approach.

Key words: schistosomiasis - water contact - molluscicide - integrated approach - Cameroon

Schistosomiasis is a parasitic disease affecting 200 millions people in tropical and subtropical countries. It is responsible for 754 million disability adjusted life years among children in Africa (WHO 2002). Its prevalence is rapidly increasing with the extension of water development projects (Hunter et al. 1996). Snail host control measures are best considered as part of an integrated approach in schistosomiasis morbidity control activities, dominated by population-based chemotherapy (Ripert 2003, Clennon et al. 2004). Molluscicides have been used to control schistosomiasis since the 1950s, but this strategy has been criticized for its high cost and the damage that molluscicides cause to non-target organisms. Bayluscide, the most used synthetic molluscicide is effective against all developmental stages of snails and schistosomes (Tchounwou et al. 1991, 1992, Abu-Elyazeed et al. 1993, Lowe et al. 2005). At molluscicidal concentrations, Bayluscide is lethal to fish unless they can escape to unaffected parts of waterbodies (Evans 1983, Goll et al. 1984). Focal mollusciciding is a cost effective method for schistosomiasis control, particularly in arid regions where transmission sites are small and seasonal (Klumpp & Chu 1987, Sarquis et al. 1997). Bayluscide application following the simplified technique (Greer et al. 1996) is effective at 0.5 g/m³, half the recommended dose. The advantage of the simplified technique resides in the fact that heavier doses of the concentrate are applied to the margins of the water bodies where most snail hosts are found. Unfortunately, the death and putrefaction of non-target aquatic organisms such as fish, tadpoles, frogs, and earth worms

reduce the acceptability of molluscicide application. The present study was designed to field test whether a lower dose (0.25 g/m³) of Bayluscide would kill fewer nontarget organisms, while maintaining its effect on snail host.

MATERIALS AND METHODS

The present investigations were carried out in the locality of Lara in the Mayo Kani Division of the sudano-sahelian zone of Cameroon from July to October 1998. This study site was selected for its high prevalence of urinary schistosomiasis, its focal transmission in temporary habitats which are ideal conditions for mollusciciding. During a preliminary visit, health, administrative and village authorities were contacted and explained the goal of the project. Community consent was obtained from the traditional authorities. Ethical clearance was obtained from the Ministry of Health and the Ethical Committee of the Faculty of Medicine & Biomedical Sciences. All study procedures followed were in accordance with the the Helsinki Declaration of 1975, as revised in 1983.

In order to assess the effect of Bayluscide on snail populations, water contact sites were identified, test and control ponds randomly assigned. Niclosamide or Bayluscide wettable powder 70% active ingredient (a.i.) was applied to study ponds at concentrations of 0, 0.25, 0.5, and 1 g/m³, following the simplified technique. The weight of niclosamide required for each application was derived from estimates of pool volumes assuming that the contours of pools approximated a segment of a sphere. The volume of water in each pond was determined based on a paced measurement of circumference from a standard scale developed earlier (Greer et al. 1996).

The dose of niclosamide was divided into four parts and one part applied to the margin of each of the pond quadrants. Ponds that were treated with 0.25 or 0.5 g/m³ were retreated if live snails were found 24 h after Bayluscide application. Scoops made with a large kitchen strainer mounted on an iron support and attached to a

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broomstick were used for sampling snails. Ten scoops were sampled from each of the pond quadrants to assess snail population before treatment, 24 h, 28 days and 56 days post treatment. Snails were determined to be alive or dead, separated by species and counted (Brown 1994). All ponds that were treated with 0 or 0.25 ppm that harboured snail hosts 24 h post application were treated with Bayluscide at 0.5 ppm. The efficacy of Bayluscide on snail population was assessed by computing the average number of live snail count in standard 40 dip scoops for each of the test Bayluscide concentrations (Hairston 1965).

Investigation of fish, frogs, and tadpole kill was adapted from standard guidelines (APHA 1985). The kill was determined based on the number of dead tadpole, fish or frog per 2000 adjusted paces of the pond circumference as nil (0), minor (1-100 dead), moderate (101-1000 dead) or major (> 1000 dead).

RESULTS

Before Bayluscide applications, all study ponds harboured *Bulinus globosus* and *B. senegalensis*, snail hosts of schistosome. However *B. globosus* was the main host. Two other freshwater snails were found, *Lanistes ovum* in two ponds and *Ferrissia* sp. in one pond.

The concentration of 0.5 ppm worked just as well as the 1 ppm ($p > 0.10$). The concentration of 0.25 ppm was less effective than either 0.50 or 1 ppm (Table I).

Bayluscide was applied to 16 ponds at concentrations of 0 (4 ponds), 0.25 (5 ponds), 0.5 (4 ponds), and 1 g/m³ (3 ponds). All 0.25, 0.5, and 1 g/m³ Bayluscide concentrations reduced snail population significantly. The decrease in snail count was 100% only in one case for the 0.25 ppm concentration (Table II).

The degree of fish, frogs, and tadpoles kill was minimal at 0.25 ppm and increased with Bayluscide concentration (Table III). During a spot visit 24 h post application at one of the pond (#4) which was treated with 0.50 ppm Bayluscide, we found many life frogs.

No fish kill was observed 24 h after a fish pond (#16) was treated with Bayluscide at 0.5 ppm, in two rounds of 0.25 ppm. The reduction in snail population was significant one month (80%) and two months (97%) after treatment.

DISCUSSION

It is probable that the detection of live snails in some ponds after treatment with 0.25 ppm could have been due to underdosing. The Bayluscide scale used was based on the assumption that all ponds in the region have similar shapes. In fact, some of the pools were rather deep, leading to underdosing. Nonetheless, the application of Bayluscide at 0.25 ppm in such ponds led to a significant reduction in snail population.

The low fish kill observed at 0.25 ppm in the Lara fish pond and the significant reduction in snail population confirms the efficacy of the simplified procedure. This is a major achievement of the present study. Human populations living in endemic areas have generally been resentful of molluscicides because they are lethal to fish stock. The fact that 0.50 ppm applied in two rounds of 0.25 ppm, following the simplified procedure (Greer et al. 1996) was

lethal to snails, but not to fish, frogs, and tadpoles rekindles the issue of schistosomiasis control through mollusciciding. As the quantity of Bayluscide used per unit of pond margin is reduced, the cost of mollusciciding may be lowered, thus improving its acceptability and cost-effectiveness in schistosomiasis control. The advantage of the simplified procedure is that the villagers can easily be trained on safety guidelines, to recognise transmission sites and apply Bayluscide at effective regimens (Greer et al. 1996).

The effect of Bayluscide on non-target water organisms depends on the motility of these organisms in water, but also on their sensitivity to Bayluscide (Harrison 1966, Gebremedhin et al. 1994). The rapid mortality of *B. globosus* and *B. senegalensis* snails is due to its acute toxicity. Frogs and fish are capable of rapidly moving to areas of low chemical concentration in deeper sections of the pond. Because snails are practically immotile, they remain in areas of higher concentrations of Bayluscide at ponds margins. This explains the higher mortality in snails and increased survival of fish and frogs that are a valuable source of protein for the human population. The differential susceptibility of aquatic organisms to Bayluscide has been used elsewhere to control nuisance organisms in the aquaculture industry (Francis-Floyd et al. 1997). The live snail count registered at 24 h post application in some ponds may be related to the fact that this period is still within the 48 h recovery period reported earlier for *Biomphalaria stramina* in Brazil (Giovannelli et al. 2002). Earlier reports of snail escape behaviour including water leaving and burrowing (Sarquis et al. 1997) were not investigated, but with the relatively heavy concentration of Bayluscide that were applied on pond margins, it is not feasible that any affected snail could have escaped. In the present study, the assessment of fish, frogs, and tadpole kill was limited by the fact that not all ponds harboured these organisms. It would have been useful to determine pre application estimation of non-target organism population, as the impact assessment would have then been stronger. Whereas this limitation may decrease the strength of our assertions, it does not decrease the validity of our observations. We used our observational evidence to determine the presence of these organisms, and believe these to be sufficient for our estimations. As labour costs and the cost of Bayluscide represents more than 75% of molluscicide programmes (Evans 1983), the implementation of the simplified procedure by villagers (Greer et al.

TABLE I
Comparison of the efficacy of various concentrations of Bayluscide on *Bulinus globosus* snail host

Bayluscide concentration	0.0 ppm	0.25 ppm	0.5 ppm	1 ppm
0.00 ppm	NS	***	***	***
0.25 ppm		NS	NS	***
0.50 ppm			NS	***
1 ppm				NS

NS: non significant difference; ***: highly significant difference ($p < 0.001$).

TABLE II
Bayluscide concentration, cumulative *Bulinus globosus* and *B. senegalensis* snail host count per pond before and 24 h, 28 and 56 days after treatment of ponds in sahelian Cameroon

	Pond number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bayluscide concentration (ppm)	1	1	1	0.50	0.50	0.50	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0
Circumference (paces)	65	231	183	189	64	280	358	356	389	288	175	183	244	350	231	700
Estimated pond volume	55	309	438	388	55	374	478	242	265	831	290	438	430	468	309	1246
# of 50 g Bayluscide sachets	2	7	6	3	1	4	3	3	3	2	1	0	0	0	0	10
Pre application ^a																
<i>B. globosus</i>	25 (2)	38 (6)	70 (0)	142 (3)	5 (5)	15 (2)	8 (9)	20 (5)	0 (0)	29 (6)	26 (0)	75 (0)	8 (2)	30 (3)	31 (2)	240 (18)
<i>B. senegalensis</i>	1 (1)	4 (3)	1 (1)	3 (0)	6 (7)	1 (0)	8 (3)	0 (0)	6 (0)	17 (5)	0 (0)	0 (1)	3 (0)	0 (0)	2 (0)	0 (0)
24 h post application																
<i>B. globosus</i>	0 (244)	0 (20)	0 (20)	0 (59)	0 (2)	0 (0)	1 (8)	0 (211)	0 (9)	11 (22)	0 (5)	22 (7)	4 (3)	18 (2)	43 (2)	5 (45)
<i>B. senegalensis</i>	0 (0)	0 (7)	0 (0)	0 (1)	0 (0)	0 (0)	0 (1)	0 (0)	0 (0)	2 (4)	0 (0)	0 (0)	6 (0)	0 (0)	6 (0)	45 (270)
28 days post application																
<i>B. globosus</i>	0 (48)	0 (16)	0 (0)	0 (24)	0 (0)	0 (0)	0 (2)	1 (6)	0 (4)	0 (6)	0 (9)	22 (7)	ND	ND	ND	10 (440)
<i>B. senegalensis</i>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (4)	0 (0)	0 (0)	ND	ND	ND	0 (2)
56 days post application																
<i>B. globosus</i>	0 (0)	0 (0)	0 (2)	0 (25)	0 (0)	0 (25)	0 (0)	0 (0)	0 (4)	0 (6)	0 (0)	ND	ND	ND	ND	ND
<i>B. senegalensis</i>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (3)	0 (0)	ND	ND	ND	ND	ND

a: alive (dead); b: applied in two rounds of 0.25 ppm.

TABLE III
Bayluscide concentration, fish, frogs, and tadpole kill 24 h after treatment of ponds in sahelian Cameroon

	Pond number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bayluscide concentration (ppm)	1	1	1	0.50	0.50	0.50	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0.5
Tadpole kill	Massive	Moderate	None	None	None	Moderate	Minor	None	None	Minor	None	None	None	None	None	Minor
Fish and frog kill	Moderate	NA	None	None	None	Moderate	Minor	None	None	NA	None	None	None	None	None	None
Aquatic vegetation	Sparse	Sparse	Heavy	Sparse	Sparse	Sparse	Sparse	Light	Sparse	Sparse	Sparse	Sparse	Sparse	Moderate	Sparse	Sparse

NA: no evidence for fish or frogs upon spot visit of the pond.

1996), the reduced efficacious quantity of Bayluscide used per pond, mollusciding should have a greater cost-effectiveness and acceptability. Mollusciding has been reported to be a cost-effective community intervention strategy against schistosomiasis in temporary transmission foci, in conditions where water contact is intense and the prevalence among school children is over 50% (Pieri 1995). Such is the case in the sahelian zone of Cameroon which harbors over 85% of schistosomiasis cases where the transmission foci are relatively small seasonal waterbodies (Ratard et al. 1990, Greer et al. 1990). Unfortunately, because of earlier equivocal beliefs about mollusciciding, studies and interventions on snail control have been underrated (Sarquis et al. 1997). With the reduced quantity of effective molluscicide using the regimen described in the present study, further studies should be carried to assess the cost-efficiency and sustainability of Bayluscide application for the control of schistosomiasis in conjunction with other community based treatment methods (Chippaux & Massougbdji 2004). Bayluscide should be applied following the simplified procedure in two round of 0.25 ppm, so as to maintain its efficacy on snail hosts while reducing its effect on non target freshwater fish, frogs, and tadpoles. The simplified procedure may apply in areas where transmission is focal. It will also be effective in lentic habitats where most of the snail population is located on water body margins. This would be the case for lakes or dams. This approach is simple and could facilitate the integration mollusciciding for schistosomiasis control in the primary health care package.

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