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Results of three years of cercarial transmission control in the Volta Lake*

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After three years of cercarial transmission control using focal application of niclosamide and weed removal in water contact sites (WCSs) in the project area of the Volta Lake, the numbers of WCSs infested with cercariae and infected snails were reduced by over 90% in areas of both high and low endemicity. This, combined with selective population chemotherapy, reduced the prevalence of Schistosoma haematobium *infection by 72% in the area of low endemicity and 40% in the area of high endemicity. The intensity of infection in the villages was reduced by 78% in both areas. The overall annual cost of the cercarial transmission control programme was US $1.09* per capita.

A WHO/UNDP project was established in 1971 to study the epidemiology of schistosomiasis in the area of the man-made Volta Lake, Ghana, and to investigate methods for controlling the disease. The intermediate host of *Schistosoma haematobium* in the lake is *Bulinus rohlfsi*. Schistosome-infected snails are almost exclusively confined to human water contact sites (WCSs) (*1*), and within these sites are concentrated near the shore (*2*). The levels of cercarial (*3*) and miracidial transmission (*4*) are determined by the shape of the WCS within emergent vegetation, and the type and density of this vegetation, which, in turn, are determined by the seasonal level of the lake. The main transmission season occurs during the first few months of the year when the lake begins its annual phase of drawdown. During this period, pocket-shaped WCSs form an ideal environment for expanding snail populations and high numbers of infected snails are found. During the low water phase, transmission occurs only in WCSs where the submerged weed, *Ceratophyllum demersum*, grows (*3*, *5*).

Preliminary trials of focal molluscicide and *Ceratophyllum* removal were carried out to test and assess the transmission control methods developed (*6*), after which the campaign was extended to the whole project area in May 1975. Chemotherapy was begun later in that year.

The present report describes the results of three years of schistosome transmission control in the Volta Lake, and presents a cost analysis of this selective snail control programme.

PROJECT AREA

The project area is located on the Pawmpawm branch and the south-east section of the Afram branch of the Volta Lake and comprises 26 villages or "study units" (Fig. 1). Ecologically, the project area can be divided into two sections: 12 villages on the Afram branch, an area of high endemicity, and 14 villages of lower endemicity on the Pawmpawm branch. The Afram branch contains moderate to heavy growths of *Ceratophyllum* and transmission of the disease can occur throughout the year. The Pawmpawm branch villages (study units 1–14) are now

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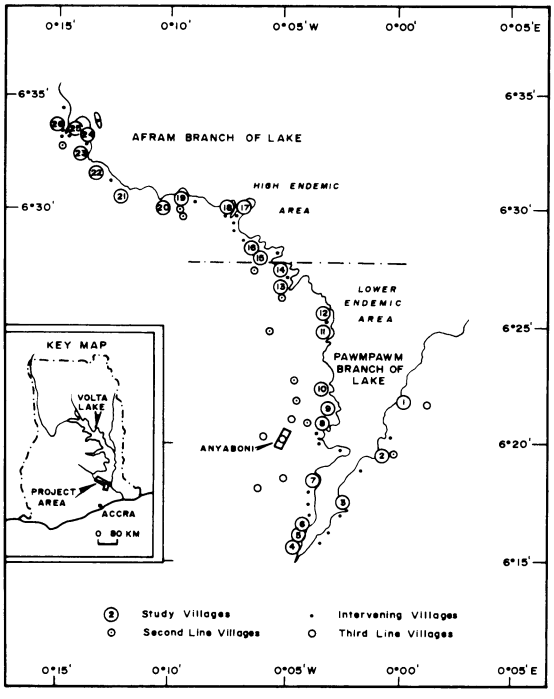

Fig. 1. The project area of the Volta Lake.

largely devoid of the weed and transmission is limited to the first 2–4 months of the year.

Approximately 7500 people in the study area and intervening villages, plus a further 7500 inhabitants of the hinterland communities who use the lake as a source of water, are exposed to schistosomiasis.

MATERIALS AND METHODS

About 230 water contact sites were in regular use in the 26 study villages, an average of 8–9 per village. From May 1975, monthly visits were made to each WCS in the villages of lower endemicity while the important WCSs in the Afram branch were visited once every 2–3 weeks.

Each WCS was classified according to its ecological type, the type and amount of vegetation, the degree of human water contact, snail density, and the presence of infected snails. The two latter criteria had also been assessed by pre-intervention sampling of the site. Scattered *Ceratophyllum* in a habitat was removed using rakes. If treatment was necessary, a niclosamide molluscicide (containing 70% active ingredient) was applied at a calculated concentration of 0.5–1.0 mg/litre with a hand sprayer. When it was found necessary to spray an open beach type of WCS where the scattered *Ceratophyllum* were more difficult to remove, a

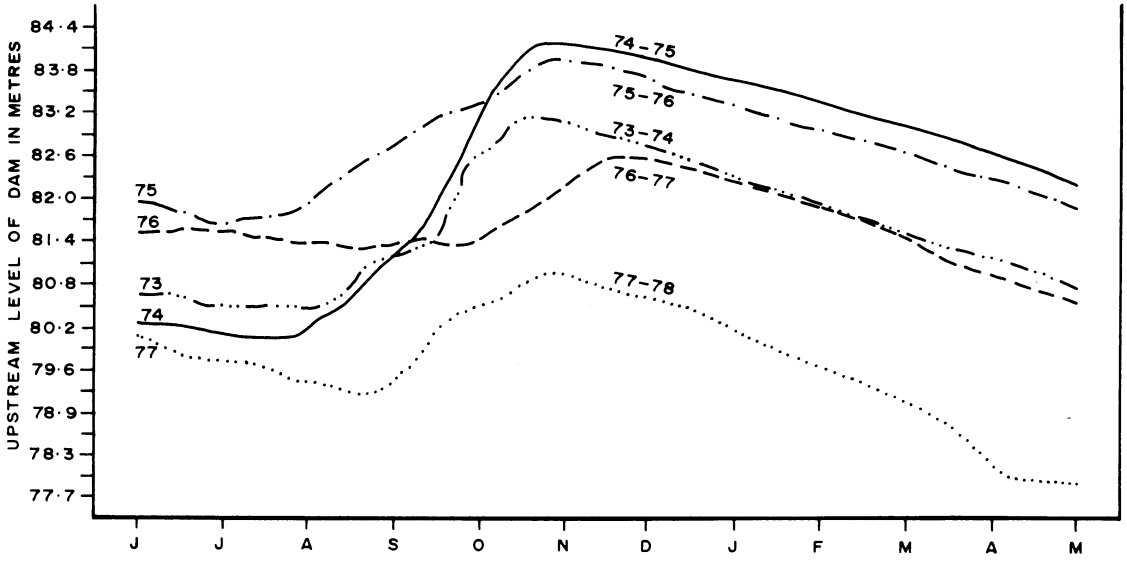

Fig. 2. Fluctuations in the lake water level between 1973 and 1978.

plastic curtain was set in the water to cordon off the treated area from the open lake. Details of this work are presented elsewhere (*6*).

For the assessment of control efforts, snail samples were taken each month from 33 WCSs in 10 villages of low endemicity and 16 WCSs in 6 villages of high endemicity, using palm-leaf mats and the modified man-time method (*3*). Other sites were checked occasionally. A WCS was considered positive if any snail was found to be infected with mature *S. haematobium* cercariae.

Because there was considerable inter-village movement, it soon became apparent that people in the study unit villages could become infected in the intervening villages where no molluscicide had been conducted. Therefore, from June 1977, the most important WCSs in the intervening villages were also treated with molluscicide on a monthly basis, and sampled for infected *B. rohlfsi* from time to time.

To assess the combined effect of chemotherapy and transmission control, an epidemiological index was defined as the product of the disease prevalence rate in man and the geometric mean number of *S. haematobium* eggs per 5 ml of positive urine, divided by 100. This epidemiological data was taken from project records.

RESULTS

Ecological changes

Fluctuations in the lake water level during the period 1973–78 are shown in Fig. 2. The peak level occurred in late 1974 when some lakeside compounds at Akokoma, Kwabia, Asakeso, and Akotui West were flooded, leading to the abandonment of some WCSs and the creation of new ones. Since 1975, the lake level has dropped each year.

Table 1. Proportion of cercaria-infested WCSs and infected *B. rohlfsi* found in monthly surveys in the area of low endemicity 1973–78. Percentages are given in parentheses.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total
Pre-intervention													
1973–74													
WCS	1/25 (4.0)	0/25 (0)	2/25 (8.0)	0/25 (0)	1/25 (4.0)	4/25 (16.0)	4/25 (16.0)	10/33 (30.3)	5/33 (15.15)	6/33 (18.18)	2/33 (6.06)	0/33 (0)	35/340 (10.29)
Snails	1/106 (0.94)	0/190 (0)	3/59 (5.08)	0/1 (0)	1/37 (2.7)	6/102 (5.88)	19/152 (12.5)	26/213 (12.21)	11/147 (7.48)	13/93 (13.98)	3/84 (3.57)	0/87 (0)	83/1271 (6.53)
1974–75													
WCS	1/33 (3.03)	2/33 (6.06)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	3/33 (9.09)	2/33 (6.06)	3/33 (9.09)	5/33 (15.15)	3/33 (9.09)	1/33 (3.03)	20/396 (5.05)
Snails	1/38 (2.63)	3/26 (11.54)	0/20 (0)	0/31 (0)	0/20 (0)	0/39 (0)	3/61 (4.92)	6/81 (7.41)	4/170 (2.35)	16/110 (14.55)	4/96 (4.17)	1/36 (2.78)	38/728 (5.22)
Post-intervention													
1975–76													
WCS	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	1/33 (3.03)	0/33 (0)	0/33 (0)	1/33 (3.03)	2/396 (0.51)
Snails	0/10 (0)	0/5 (0)	0 (0)	0/3 (0)	0/7 (0)	0/19 (0)	0/39 (0)	0/22 (0)	5/38 (13.16)	0/4 (0)	0/4 (0)	1/30 (3.33)	6/181 (3.31)
1976–77													
WCS	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	1/33 (3.03)	0/33 (0)	0/33 (0)	0/33 (0)	1/396 (0.25)
Snails	0/2 (0)	0/2 (0)	0/1 (0)	0 (0)	0 (0)	0/2 (0)	0/11 (0)	0/17 (0)	1/44 (2.27)	0/34 (0)	0/3 (0)	0/1 (0)	1/117 (0.85)
1977–78													
WCS	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	1/33 (3.03)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	0/33 (0)	1/396 (0.25)
Snails	0 (0)	0/18 (0)	0 (0)	0/3 (0)	0 (0)	1/1 (100.0)	0/20 (0)	0/27 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1/69 (1.45)

As the water level fell, the number of snail-bearing *Ceratophyllum* in the Pawmpawm branch of the lake also dropped (*5*). Therefore, cercarial transmission in this area decreased naturally in the year before intervention began and has remained at a low level. The weed has now completely disappeared from the lake at all the lakeside villages up to study unit 16.

Effects of transmission control

Tables 1 and 2 show the number of snails with mature infections and the number of cercaria-infested WCSs in the areas of low and high endemicity between 1973 and 1978. In the area of low endemicity, natural reductions in these parameters in 1974 were due to the disappearance of *Ceratophyllum* (*5*). Similar reductions in the area of high endemicity during the same year were mainly caused by the flooding of the lake at Asakeso and Akotui West, which forced people to move away from the WCSs.

In the first year of intervention, the number of positive WCSs was reduced by 90% in the area of low endemicity, and by 83% in the area of high endemicity. After three years, reductions of 95% and 96%, respectively, had been achieved. The numbers of infected snails were similarly reduced to 3% and 1% of pre-intervention levels in areas of low and high endemicity, respectively, after three years of transmission control.

Table 3 presents the prevalence and intensity of infection in the villagers after three years of control measures. There was a large drop in epidemiological index in each village, which paralleled the percentage reduction in the numbers of infected snails during the same period.

Cost analysis

The mean annual cost of the selective snail control programme amounted to 3.00 Cedis (¢) or $1.09 *per*

Table 2. Proportion of cercaria-infested WCSs and *B. rohlfsi* found in monthly surveys in the area of high endemicity 1973–78. Percentages are given in parentheses.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Total
Pre-intervention													
1973–74													
WCS	3/7 (42.86)	3/7 (42.86)	2/7 (28.57)	1/7 (14.29)	1/7 (14.29)	4/7 (57.14)	5/7 (71.43)	11/16 (68.75)	7/16 (43.75)	7/16 (43.75)	7/16 (43.75)	3/16 (18.75)	54/129 (41.86)
Snails	8/195 (4.1)	15/138 (10.87)	16/109 (14.68)	2/26 (7.69)	1/45 (2.22)	13/85 (15.29)	18/138 (13.04)	63/271 (23.25)	53/322 (16.46)	19/204 (9.31)	17/110 (15.45)	3/103 (2.91)	228/1746 (13.06)
1974–75													
WCS	2/16 (12.5)	5/16 (31.25)	4/16 (25.0)	1/16 (6.25)	0/16 (0)	0/16 (0)	2/16 (12.50)	8/16 (50.0)	8/16 (50.0)	6/16 (37.5)	6/16 (37.5)	6/16 (37.5)	48/192 (25.0)
Snails	5/94 (5.32)	15/202 (7.43)	7/101 (6.93)	1/20 (5.0)	0/28 (0)	0/68 (0)	8/95 (8.42)	56/774 (7.24)	37/495 (7.47)	21/241 (8.71)	7/70 (10.0)	9/98 (9.18)	166/2286 (7.26)
Post-intervention													
1975–76													
WCS	0/16 (0)	1/16 (6.25)	0/16 (0)	0/16 (0)	0/16 (0)	1/16 (6.25)	0/16 (0)	3/16 (18.75)	0/16 (0)	1/16 (6.25)	1/16 (6.25)	1/16 (6.25)	8/192 (4.17)
Snails	0/32 (0)	1/59 (1.69)	0/28 (0)	0/20 (0)	0/4 (0)	1/27 (3.7)	0/29 (0)	3/67 (4.48)	0/60 (0)	1/21 (4.76)	1/36 (2.78)	1/55 (1.82)	8/438 (1.83)
1976–77													
WCS	0/16 (0)	0/16 (0)	0/16 (0)	0/16 (0)	1/16 (6.25)	0/16 (0)	0/16 (0)	0/16 (0)	0/16 (0)	1/16 (6.25)	0/16 (0)	0/16 (0)	2/192 (1.04)
Snails	0/32 (0)	0/71 (0)	0/103 (0)	0/94 (0)	1/14 (7.14)	0/2 (0)	0/3 (0)	0/7 (0)	0/48 (0)	1/78 (1.28)	0/59 (0)	0/68 (0)	2/579 (0.35)
1977–78													
WCS	0/16 (0)	0/16 (0)	0/16 (0)	0/16 (0)	0/16 (0)	0/16 (0))	0/16 (0)	0/16 (0)	1/16 (6.25)	1/16 (6.25)	0/16 (0)	0/16 (0)	2/192 (1.04)
Snails	0/56 (0)	0/59 (0)	0/65 (0)	0/14 (0)	0/8 (0)	0/8 (0)	0/17 (0)	0/79 (0)	1/48 (2.08)	1/22 (4.55)	0/16 (0)	0/27 (0)	2/419 (0.48)

Table 3. Prevalence of schistosomiasis and egg output per 5 ml of positive urine in the 26 study villages before and after three years of control measures

Level of endemicity	Disease prevalence (%) (p)			Geometric mean egg output (per 5 ml of urine) (d)			Epidemiological index (p x d)/100		
	1974	1978	reduction (%)	1974	1978	reduction (%)	1974	1978	reduction (%)
Low	64.6	17.9	72.3	33.1	7.1	78.5	21.4	1.3	94.1
High	83.9	50.7	39.6	65.4	14.0	78.6	54.9	7.1	87.1

capita for the total population covered of 15 000. Personnel costs represented 32%, transportation 42%, and molluscicide 25% of the total. The evaluation team cost ₵2.26 or $0.82 *per capita* annually, giving a total annual cost for the combined teams of ₵5.26 or $1.91 *per capita.*

DISCUSSION

The feasibility of cercarial transmission control by focal intervention measures in a large man-made lake has been demonstrated in this project. A selective snail control programme was carried out, in which molluscicide and weed clearance were concentrated on the most dangerous transmission sites. In the area of low endemicity, less intervention work was done and interruption of transmission was greatly aided by the natural disappearance of the snail indicator weed, *Ceratophyllum*, just before the intervention period (*5*). In the area of high endemicity, intensive intervention work was conducted but interruption of transmission was severely hampered by a significant increase in *Ceratophyllum* near shore. The weed was always present in the deep stream inlets of the lake in this area, and the progressive drop in the lake water level simply shifted these deep water *Ceratophyllum* masses into shallow water. Nevertheless, local transmission was substantially reduced in the area by focal molluscicide of the most dangerous village WCSs 3 times every two months, and of the remaining sites at monthly intervals, supplemented when appropriate by weed removal.

It is of interest to note the different results in the areas of low and high endemicity (Table 3). In the former, the pre-intervention disease prevalence of 64.6% was reduced to 17.9%, a drop of 72.3%, while in the latter, the prevalence was reduced from 83.9% to 50.7%, a drop of 39.6%. However, the percentage reduction in the intensity of infection was equal in both endemic areas, as shown by a drop of 78.5% in the geometric mean egg density in urine samples. This indicates that cercarial transmission control was equally effective in both endemic areas.

During the project, it was found that the combined intervention effort had to be extended beyond the original project area villages to cover intervening villages, as well as villages up to 5 km away from the lake. Inhabitants of these hinterland areas depended solely on the lake for their water during most of the year, including the high transmission season, and also used the lake for washing and bathing throughout the year. They would thus have benefited most from a water supply programme.

It is difficult to compare the costs of schistosomiasis control projects around the world, because of national and international inflation, methods of analysis, species of schistosome, level of disease, type of terrain, etc. However, the $1.09 *per capita* cost of molluscicide and manual weed removal to control *S. haematobium* in the project area of the Volta Lake compares favourably with costs involved in other large-scale schistosomiasis projects, and is considerably lower than the $3.24 *per capita* cost reported in St Lucia for the control of *S. mansoni* by molluscicide alone (*7*).

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RÉSUMÉ

RÉSULTATS DE TROIS ANS DE LUTTE CONTRE LA TRANSMISSION DES CERCAIRES DANS LE LAC VOLTA

Le programme de lutte contre la transmission des cercaires dans la région du Lac Volta a débuté en mai 1975 dans 26 villages constituant des unités d'étude. Cette intervention a nécessité l'application focale de niclosamide et l'élimination de *Ceratophyllum* dont sont parsemés certains habitats.

Dans les villages de faible endémicité, chaque lieu de contact avec l'eau a été visité une fois par mois (unités d'étude 1–14), tandis que dans les villages de forte endémicité (unités d'étude 15-26), les visites étaient portées à trois tous les deux mois. Un technicien travaillant sur le terrain décidait immédiatement de la question de savoir si un lieu de contact avec l'eau devait être traité et de quelle façon.

Au bout de trois ans, le nombre des lieux de contact avec l'eau infectieux et le nombre des mollusques infectés avaient diminué de plus de 90% tant dans les régions de forte endémicité que de faible endémicité. La lutte contre la transmission des cercaires, associée à une chimiothérapie sélective de la population, a fait régresser la proportion des infections par *Schistosoma haematobium* de 72% dans la région de faible endémicité et de 40% dans la région de forte endémicité. L'intensité de l'infection dans les villages a diminué de 78% dans l'une et l'autre régions.

Le coût global annuel du programme de lutte contre la transmission des cercaires s'est élevé à US $1,09 par habitant.

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