Control of schistosomiasis in the new Rahad Irrigation Scheme of Central Sudan

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Summary

As the new Rahad Irrigation Scheme in Central Sudan began its first agricultural season in 1978, the Blue Nile Health Project was being developed to prevent schistosomiasis and other water-associated diseases in the Rahad and Gezira–Managil schemes. Taken as an indication of overall transmission in the Rahad scheme, the prevalence of infection among children in the newly established schools was found initially to be 14% for *Schistosoma mansoni* and 1% for *Schistosoma haematobium* in 1980. In the older Gezira–Managil irrigation system nearby, where transmission had not been controlled there was also little *S. haematobium* but the prevalence of *S. mansoni* in school-aged children was rising above 70%. To avoid a similar future in the Rahad scheme an integrated control strategy was implemented in 1980 using chemotherapy and snail control, supported by safe water supplies in every village. Under this strategy the prevalence of *S. mansoni* in the schoolchildren was reduced below 10% by 1983 at an annual cost of less than $4 per capita, about $300 per square kilometer. *S. haematobium* remained at 1% in the schoolchildren in 1983. The major cost was for village water supplies with about 20% of the total going for snail control and 10% or less for chemotherapy. Over a third of the cost was for equipment and supplies purchased abroad, requiring hard currency. Economically feasible prevention of transmission in the long-term will require reduction of the annual cost to about $1 per capita. Cost reductions should be made primarily in operation and maintenance of the water supply systems and in snail control.

Introduction

In many new irrigation systems of the tropics, public health programmes must be developed to prevent serious transmission of water-associated diseases among the agricultural populations. This problem arises because the reservoirs, canals and drains of the irrigation systems become habitats for mosquitoes and snails which transmit human diseases, and because the people are intensively exposed to contact with the irrigation water.

In 1978 the new Rahad Irrigation Scheme in Central Sudan began its first agricultural season, deriving its water from the Rahad and Blue Nile Rivers (El Din 1975, Benedict *et al.* 1982). Because of experience in nearby irrigation systems it was expected that schistosomiasis, malaria, and diarrhoeal diseases would become serious problems among the new settlers if preventive measures were not initiated early. When the Blue Nile Health Project was conceived in 1978 to control these diseases in irrigation systems along the Blue Nile River, the project adopted, as one of its primary objectives, the prevention of the diseases in the new Rahad scheme (Figure 1). The Gezira–Managil scheme was also part of the Blue Nile Health Project, representing an old irrigation scheme where disease transmission was firmly established in a population of more than two million people (Amin & Fenwick 1977, Amin *et al.* 1981).

This report documents the impact and cost of the programme to suppress transmission of schistosomiasis in the new Rahad Irrigation Scheme. It gives an account of control methods selected primarily for reasons of operational suitability, with a pragmatic adap-

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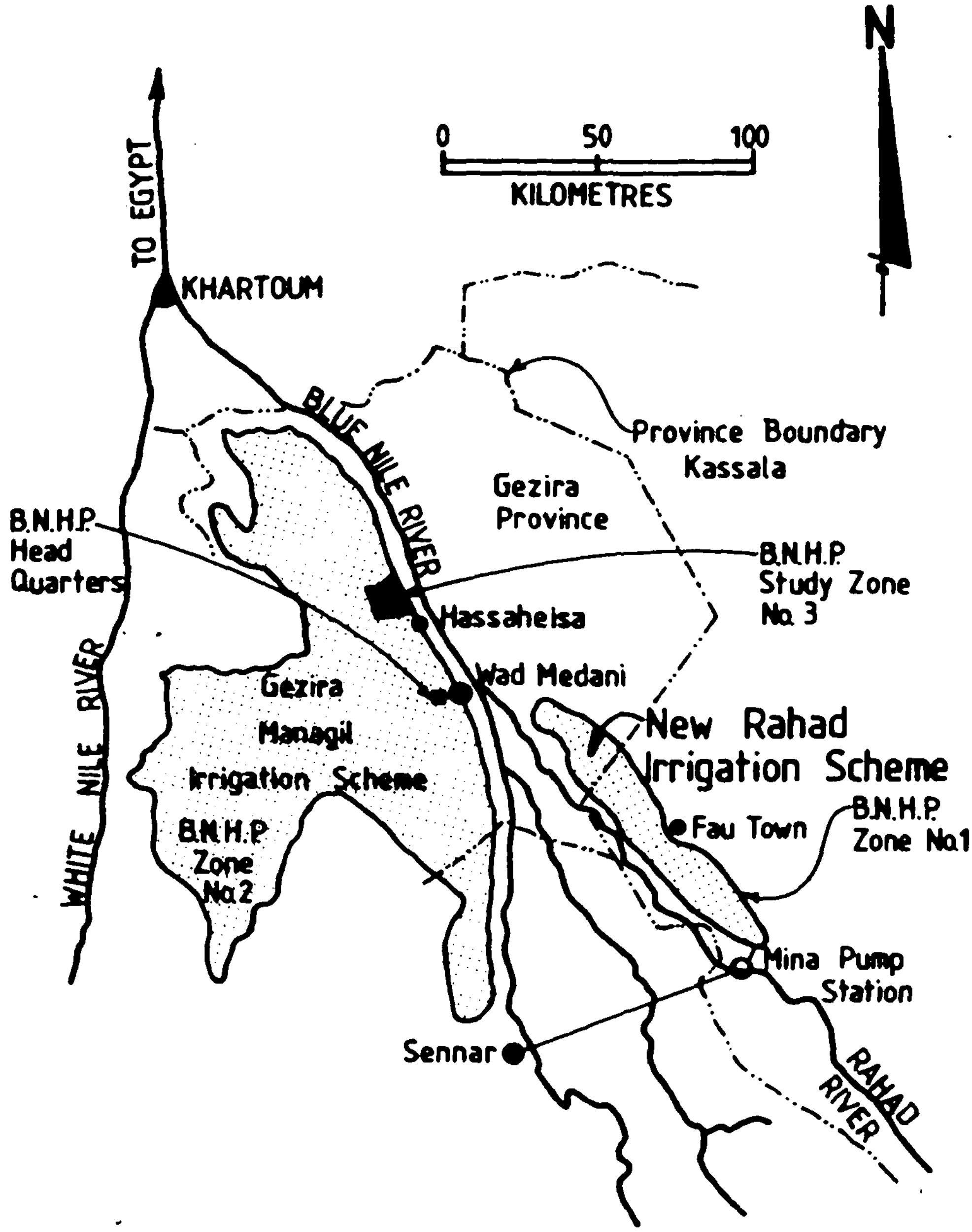

Figure 1. Blue Nile Health Project in the Sudan.

tation of new methods as they become available.

The Rahad Irrigation Scheme, located on the east bank of the Rahad River, is 140 km long and 15 to 25 km wide. The main canal stems from the Blue Nile River at Sennar. The population grew from 50 000 in 1978 to 100 000 in 1982 when the agricultural area of 300 000 feddans (126 000 ha) was completely developed.

Materials and methods

The epidemiological evaluation of schistosomiasis transmission in the Rahad scheme was based on an annual survey of all schoolchildren for incidence and prevalence of schistosome infections as an indication of overall transmission patterns. For comparison, the population of the Gezira–Managil scheme was randomly sampled in 1981 and 1982. Twenty-eight comparison villages were mapped and a 20% household sample taken from a complete list of the households.

In both the Rahad and Gezira–Managil surveys, urine was collected in bottles with screw caps while faeces were collected in covered plastic containers. Faecal specimens were processed fresh by the modified Kato technique and urine specimens processed fresh by centrifugation (Teesdale & Amin 1976).

Chemotherapy was conducted with the current drugs of choice, given only after positive diagnosis made by microscopical examination of faeces or urine. Initially, in 1980 oxamniquine was used for intestinal schistosomiasis (40–60 mg/kg body weight given in four doses over 2 days) while metrifonate was given in urinary schistosomiasis in three doses of 10 mg/kg with 2-week intervals. From 1981 on, praziquantel was used for both infections, at a total dose of 40 mg/kg. It was given in two oral doses 5 h apart until mid-1983 after which the total amount was given in one dose.

Chemical control of snails was achieved with the molluscicides Bayluscide and Frescon. Although a supply of Frescon had been available initially, Bayluscide was used because of superior cost-effectiveness, starting in 1980 during the cotton picking season. Spraying of canals was limited to identifiable sites of human water contact near the villages, only when host snails were found. The Bayluscide, as a 25% emulsifiable concentrate, was mixed in portable pressure sprayers and sprayed from the canal banks. It was applied at 2 mg/l in running water and 0.6 mg/l in stagnant water.

The supply of Frescon was used in 1982 and 1983 in continuous flow applications to major canals during the colder times of year when the number of snail eggs was minimal. This decreased the inherent disadvantage of Frescon due to its low toxicity to eggs. Frescon was applied in a 16.5% emulsifiable concentrate. Normally the concentrate was applied at 1 l/min aiming at 0.3 mg/l concentration.

A standard water yard including slow sand filter, storage tanks, pumps and preliminary distribution systems was completed in all villages (Figure 2). Initial design of the systems was aimed at providing 100 litres per capita served per day. The water for Fau Town, and for most of the common villages was taken from the irrigation canals. Other villages close to the Rahad River used ground water pumped from deep wells.

Costs of all operations relating to schistosomiasis control were recorded monthly on detailed forms, and summarized in monthly memoranda.

Results

The results of the control activities in the Rahad scheme were summarized in terms of the control effort, and the epidemiological impact.

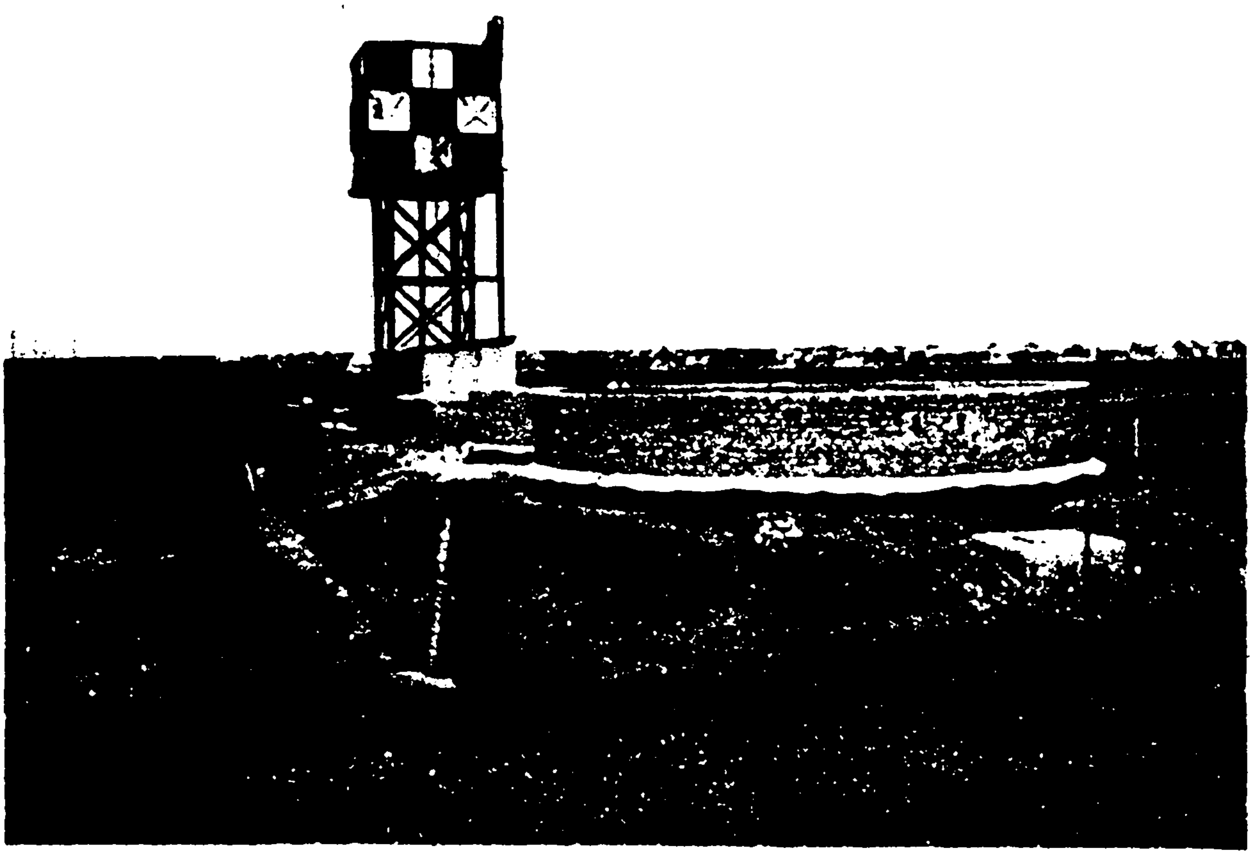

Figure 2. Typical village water supply system in Rahad scheme showing sand filters, pumphouse and storage tank, with

Table 1. Schistosomiasis chemotherapy with praziquantel in Rahad zone, 1980–1983

Year	Total population	Persons treated for schistosomiasis
1980	49 000	2200*
1981	80 000	1244
1982	100 000	1584
1983	100 000	2926

*Treatment with oxaminiquine; additionally 150 persons were treated with metrifonate.

Table 2. Volume of water treated in the Rahad scheme and amounts of molluscicides used, 1980–1983

Year	Total volume of water treated (1000 m^3)	Bayluscide used (l)	Frescon used (l)
1980	313	437	0
1981	3 288	4051	0
1982	11 212	1133	15 000
1983	12 463	7567	10 000

CONTROL EFFORT

The control operations involved chemotherapy, snail control and provision of safe water, and were summarized in terms of annual costs.

Chemotherapy

The chemotherapy programme began in 1980, after the first census and diagnostic survey was made in Fau Town, villages 1–30, and all schools. After each village was surveyed, a list of positive cases was prepared and infected persons were treated. About 2200 doses of oxamniquine were administered, using a total of 5400 g of drug, and about 150 doses of metrifonate were used (Table 1). In 1981, as a continuation of the chemotherapy screening of all villages, the newly established villages (numbers 31–46) were mapped and censused. Praziquantel was given to 1244 infected persons, most of whom were in villages 30–40.

To strengthen the laboratory services five microscopists were recruited and trained in the diagnosis of schistosomiasis in 1982. Two of them were stationed in new hospitals where laboratories were established, and in 1983 the others went to the hospital at Fau Town and at village 27. A surveillance system was developed for accurate diagnosis, treatment and recording of new schistosomiasis cases. Praziquantel in 1982 was given to 694 schoolchildren discovered in the annual school survey, 355 individuals of different ages diagnosed in a special survey of village 30, and 535 individuals at Fau Hospital, many of whom came from outside the Rahad scheme. An increased chemotherapy effort continued in 1983 at the three hospitals, in schools, and in special surveys. A total of 2926 individuals were treated.

Snail control

Intensive snail surveys and control with Bayluscide were started in May 1980. A total of 437 litres of Bayluscide was used in 1980, and 4051 litres were used in 1981 (Table 2). In 1982 continuous application of Frescon was made for several days. The routine focal application of Bayluscide was continued during the other months as in previous years, using 1133 litres of Bayluscide. Blanket molluscicidng of major canals with Frescon was conducted again in January 1983, finishing the remaining chemical. Focal molluscicidng with Bayluscide was continued but only at identifiable water contact sites near villages, when snails were discovered. The total amount of Bayluscide used was 7567 litres. Snail surveys indicated stable populations of snails, probably aided by increased weed growth in the canals.

Water supply

By 1980 when control operations began, water supply systems and public latrines had been completed in Fau Town, the ginning factories and villages 1–30. By the beginning of 1982 systems were completed in all villages, but performance was unsatisfactory in many of them. Improvements were begun in 1982 and continued through 1983 with $200 000 worth of modification to be completed by 1984 (Figure 3).

Cost of control

For all control operations, the primary costs were for water supply, followed by molluscicidng and then chemotherapy. One-third of the annual cost of domestic water supply apportioned to schistosomiasis control for construction, operation and maintenance was $314 000 in 1980, dropping to $136 000 by 1983. This decrease in real value reflected a loss in value of the Sudanese pound, not a decrease in the actual government budget for the Rahad Corporation (Table 3). There was a subsequent curtailment in purchasing power for spare parts and fuel, leading to possible deficiencies in the near future. The major component of water supply cost was for construction, about 60% of the total. Only one-third of total costs for water supply were apportioned to the schistosomiasis control effort because the other two-thirds were apportioned to diarrhoeal diseases and to labour savings.

For all activities the principal cost item was

Figure 3. Village standpipes were of extra sturdy construction, and about 10 were provided for each village of 1000–3000 people. Photo WHO/Henrioud

Table 3. Annual costs for prevention of schistosomiasis in Rahad Irrigation Scheme, 1980–1982, in 1983 US dollars

	1980	1981	1982
Total costs	542 492	430 327	355 803
By cost category			
Personnel	158 746	93 610	103 165
Transport	11 692	3 796	6 015
Supplies	372 054	332 921	246 623
By control activity			
Water supply	382 951	326 813	225 026
Snail control	22 216	81 146	109 205
Chemotherapy	116 383	9 546	16 972
Supervision	20 942	12 822	4 600

Table 4. Per capita cost of preventing transmission of schistosomiasis in Rahad zone by year, in 1983 US dollars

Year	Cost	Estimated population	Per capita cost
1980	542 492	80 000	6.78
1981	430 327	90 000	4.78
1982	355 803	100 000	3.56

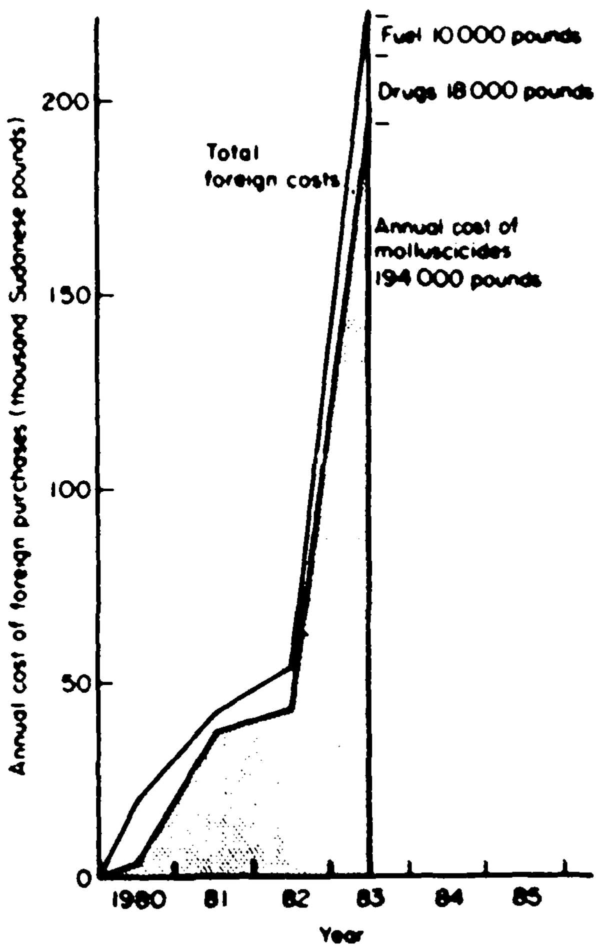

Figure 4. Total cost of foreign commodities for Rahad control programme in Sudanese pounds.

for supplies and equipment, mainly the construction cost for the water supplies (Table 3). In 1981, an average year, almost $330 000 were spent on water supply, $80 000 on snail control, $10 000 on chemotherapy and $13 000 on direct supervision, a total of about $430 000. Of this total over $330 000 was for supplies and equipment, $4000 for transport and less than $100 000 for personnel. About one-third of the total expenses was paid in hard currency. As the programme expanded, the expenditure devoted to water supply decreased, and more money was spent on mollusciciding.

The Rahad population rose from 80 000 in 1980 to over 100 000 by 1983, resulting in a mean per capita cost of less than $4 annually (Table 4). This expenditure was declining in per capita terms because of population increases but also because of the inflation of the Sudanese pound and periodic devaluations (Brittan 1982). The most alarming trend was the escalating cost of purchases of molluscicide which increased drastically in

Table 5. Prevalence of *Schistosoma mansoni* by sex in monitor villages of Gezira–Managil zone, 1981 and 1982

Year	Examined			Infected			Prevalence of infection with *S. mansoni*
	Males	Females	Total	Males	Females	Total	
1981	1719	1767	3486	992	789	1781	51%
1982	1718	1803	3521	1128	1027	2155	61%

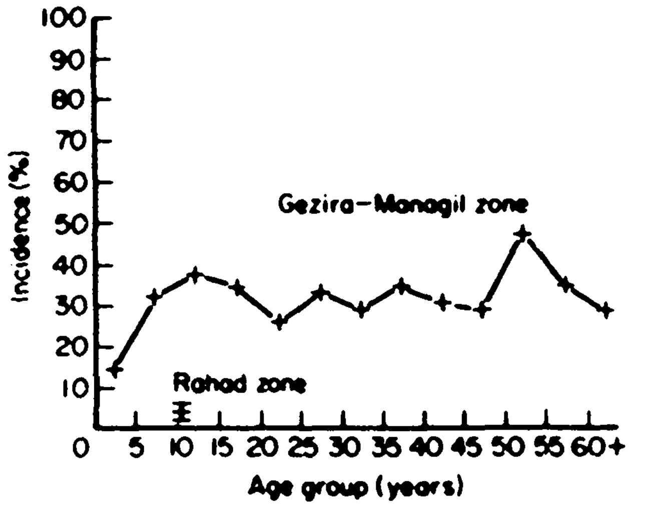

Figure 5. Incidence of *Schistosoma mansoni* infection by age-group 1981 to 1982.

to £194 000 in terms of Sudanese pounds (Figure 4).

EPIDEMIOLOGICAL EVALUATION

Gezira Comparison Area

In the Gezira–Managil scheme the result of the 1981 and 1982 surveys showed that the transmission of schistosomes could become severe if not controlled. The first epidemiological survey in November 1981 indicated a prevalence of *S. mansoni* of 51% with virtually no *S. haematobium* (Table 5). The second epidemiological survey was conducted in December 1982. All individuals found positive during the first survey in 1981 were treated in 1982 with praziquantel tablets in a split dosage of 40 mg/kg of bodyweight, after giving stool and urine samples for laboratory diagnosis. Due to the inducement of chemotherapy the response rate was 70% in 1982, higher than in the 1981 survey. In the 1982 survey 3521 people were examined and 2155 were found infected, a prevalence of 61% (Table 5). The incidence was 29% from 1981 to 1982 (Figure 5).

Rahad schoolchildren

Annual surveys were conducted since 1980 in the Rahad schools, with a response rate about 90% each year. The prevalence in the first survey of 1980 showed a peak of 22% among the 12-year-olds, almost all *S. mansoni*. The mean prevalence was 14% declining to 10% in 1982 and finally 9% in 1983 (Table 6).

Comparison of the prevalence and incidence in the Rahad and Gezira schemes showed that transmission was occurring at a high rate in the Gezira–Managil scheme, but was low and almost absent in the Rahad scheme (Figure 5). The annual cost for prevention of transmission of $4 per capita seemed reasonable but was probably more than the health authorities could maintain indefinitely.

Table 6. Prevalence of schistosomiasis in entire population of schoolchildren obtained prior to chemotherapy in Rahad zone, 1980 to 1983

Year	Number examined	Schistosome infections	Prevalence of *S. mansoni*
1980	2861	411	14.4%
1981	5399	364	6.7%
1982	7035	694	9.9%
1983	7910	735	9.3%

able 7. Comparison of cost of schistosomiasis control in Rahad and other irrigation schemes, in 1983 US dollars

rigation scheme	Country	Control methods	Evaluation of control results	Area protected (km^3)	Population protected	Annual cost of control reported ($)	Adjusted 1983 annual cost ($)		
							Total	Per capita	Per km^2
ihad	Sudan	Integrated	Initially successful	1260	100 000	400 000	400 000	4	300
orth Gezira	Sudan	Frescon	Inadequate	80	28 000	26 880	57 254	2	700
ile Delta	Egypt	Niclosamide	Inadequate	52	17 000	58 600	134 780	8	2500
iero	Kenya	Frescon	Initially successful	69	3 500	11 000	25 300	7	370
ppo Valley, iangle Estates	Zimbabwe	Niclosamide	Moderately successful	380	75 000–100 000	80 000	95 000	1	250

Discussion

It was not possible to find data on many similar prevention programmes in irrigated schemes, as the work in the Rahad scheme was rather unusual, an integrated programme in a large area where the transmission potential was high (Table 7). A previous trial in the northern portion of the Gezira Irrigation Scheme was less expensive but gave poor results probably because only molluscicíding was attempted (Amin *et al.* 1981). In the Egyptian Delta a mollusciciding programme had also been evaluated about 20 years previously (Farooq *et al.* 1966). The results were unsatisfactory because of a poor initial strategy and then a lack of good management. The costs in the Egyptian programme were significantly higher on a per capita basis, and enormously more costly per unit area because of the extensive canals and drains in the high-density cultivation system (Jobin 1979). An apparently successful programme in Kenya was able to prevent snail infestation in canals of the Ahero Irrigation Scheme, at least for the first 5 years of operations (Choudry 1975). An inferior molluscicide was used and costs were slightly higher than those experienced in the Rahad scheme. Snails never appeared in the Ahero scheme, thus it was difficult to assess the actual transmission potential which had been avoided.

Perhaps the most relevant comparison can be made between the results from the Rahad scheme and those from the long-term control programme in the Savi–Lundi River Valley south of Nyanda, Zimbabwe (Evans 1983). The climate and number of people were similar in both places, although the Zimbabwe irrigation scheme, completed about 1960, was constructed and operated somewhat differently, causing a noticeable difference in the epidemiology of schistosome transmission. *S. haematobium* was highly prevalent in Zimbabwe and could not be reduced in schoolchildren below a prevalence of 40%. In the Rahad scheme transmission of *S. haematobium* was virtually eliminated, despite the presence of *Bulinus truncatus* snails. It was not possible to reduce the prevalence of *S. mansoni* in Zimbabwe much below 20% with the molluscicide strategy, compared to the stable level below 10% achieved in the Rahad scheme. Disease control in both the Rahad and Zimbabwe schemes suffered from continuous population changes, with the result that the prevalence figures were determined partly by transmission occurring outside the schemes.

The cost of mollusciciding in Zimbabwe was low, about \$250/km^2 or \$1.00 per capita in 1983 US dollars, about the same as the \$114/km^2 or \$1.24 per capita expended in the Rahad scheme on molluscicides alone, 31% of the total control cost (Table 7). The advantages of an integrated strategy using water supply and chemotherapy are shown in the significantly lower prevalence of *S. mansoni* attained in the Rahad scheme. Because of the similar cost figures for both Sudan and Zimbabwe, they can be used with some confidence for planning control programmes for new irrigation schemes in Africa.

If transmission can be maintained in the Rahad scheme at the initial low level, it appears that the integrated strategy being used in the Rahad scheme is more cost-effective than the previous programmes in the Gezira using only molluscicides. None the less the \$4 per capita cost is high in comparison to the health budget of the region, which was £2.36 per capita in 1983, or US \$1.88 at the free market exchange rate. Thus the objective in the next few years in the Rahad project should be improvement of the strategy to maintain the low prevalence, but gradually introducing methods with lower costs such as community participation, appropriate water supply technology, biological control and environmental management.

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