Schistosomiasis in north-western Ghana

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A survey of 8 274 people in the Ghana-2101 project area showed that 12% were passing ova of Schistosoma haematobium *in the urine, the infection rate rising to a peak of 34% in males 15–19 years of age.* S. mansoni, *despite the wide distribution of its potential intermediate host, was not encountered in 1 698 boys examined for it. Urinary schistosomiasis in northern Ghana is focal in character and is usually contracted in standing water during the dry season. A method of control was developed that depends on the identification of localities subject to relatively intense and prolonged transmission, followed by dry season mollusciciding of the water sources in each locality infested with the snail hosts. Two such control cycles were carried out in 30 localities. The results suggest that selective, dry season, focal control of schistosomiasis can be effective in reducing transmission.*

The schistosomiasis pilot control project known as Ghana-5 (later Ghana-2101) was a joint Ghana Government—World Health Organization exercise that included, as a specific objective, the determination of the most effective and economical means of controlling schistosomiasis under Ghanaian conditions. The project was established at Wa in north-western Ghana in 1962, and its development up to 1965 has been summarized by McCullough.[a]

Before the pilot control scheme was set up an epidemiological survey of the human host was carried out in 1967–68 to determine the prevalence and distribution of urinary and intestinal schistosomiasis in the project area. Part I of this report describes the survey and Part II the control trial.

I. EPIDEMIOLOGICAL SURVEY

The project area as described by McCullough[a] was modified in 1966 by the elimination of about 40% of its surface area; Wa town was also excluded but remained the headquarters of the project. It is estimated that the revised project area covers some 1166 km^2 and at the time of the survey it contained approximately 39 500 people living in 118 villages (34 per km^2). In its revised form it lies between 9°48′ and 10°7′ N and 2°26′ and 2°45′ W. There are only 4 towns with more than 1000 inhabitants; most of the population lives in villages of 100–300 inhabitants. It is a purely agricultural area, the crops being those usually associated with the Guinea savannah of West Africa of which it is typical. The climate is characterized by a long dry season from November to March or April. The average annual rainfall is 110.5 cm, most of which occurs in August and September.

After reviewing existing data on the prevalence of urinary schistosomiasis in children in this area, and taking into account the time and staff available, it was decided to examine a 25% single-stage sample of the population of the project area. The sample was obtained by random selection of villages, their populations being accumulated until the number of individuals just exceeded 25% of the estimated total population of the project area. In the case of villages with more than 500 inhabitants only 50% were accumulated and every second house was visited; otherwise all the occupants of every house were examined. In all, 43 of the 118 localities were represented in the survey.

METHODS

Urine examination

A preliminary study had confirmed that, as elsewhere, a slightly higher yield of urine samples posi-

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[a] McCullough, F. S. (1965). Unpublished assignment report AFRO/BILHARZ/12.

tive for *S. haematobium* could be expected if the examinations were carried out in the early afternoon. However, since the survey coincided with farming activity there was no alternative but to collect samples as early in the day as possible; most of the samples were obtained between 06 h 00 and 08 h 00.

Qualitative examinations only were made: a single sample of 10 ml of urine was centrifuged on a hand centrifuge for 5 min and the terminal drop, after removal of the supernatant, was examined for ova. Note was taken of the presence or absence of macroscopic blood and, in the final preparation, of red blood cells.

Repeated daily urine examinations of a group of children by means of the method described above but with the addition of egg-counts have shown that on average 78% of infected (i.e. ova-positive) persons are detected by a single urine examination, and that the probability of being detected increases with the intensity of infection (G. R. L. Lyons, unpublished data, 1969).

Stool examination

Initially faecal specimens were taken from all boys up to 14 years of age, but owing to lack of time this was later restricted to every second boy in this age-group included in the urine survey; in all, 1 698 stools were examined. The specimens were obtained under strict supervision and, like the urine samples, were examined in the field.

Approximately 1 g of stool was suspended in 10 ml of normal saline. After centrifugation for 2 min the supernatant was replaced with fresh saline and the sediment was again suspended by stirring and then recentrifuged. The process was repeated until the supernatant had become clear; a drop of the final sediment was then examined. This method, although it is not outstandingly sensitive, was selected on its reputation for being simple, reliable and rapid (1).

RESULTS

Urine examinations

Representativeness of the sample. Urine samples were obtained from 8 304 people in the course of the survey; for 30 of these the information entered on the record forms was deficient in some respect and they were rejected. The remaining 8 274 individuals represented a 20.9% sample of the estimated population of the project area.

The age and sex composition of the sample is shown in Table 1 in the same age-groups as those of the national census, together with the 1960 census figures for the Wala Local Council Area to which the project area belongs. Not surprisingly, since it is easier to obtain census data in respect of small children than it is to obtain urine samples from them in the field, both males and females less than 1 year old were underrepresented; a number of older people were also apparently omitted. The disparity between the sample examined and the population as a whole was, however, most marked at ages 1–4 and 5–9, and it would appear that the ages of some children under 4 years may have been over-estimated.

Table 1. Age and sex distribution of the sample examined compared with that of the Wala Local Council Area (1960 census)

Age (years)	Males				Females			
	sample examined		Wala Local Council		sample examined		Wala Local Council	
	No.	%	No.	%	No.	%	No.	%
<1	85	2.0	2 607	4.0	92	2.3	2 722	4.1
1–4	419	9.8	10 900	16.9	422	10.6	11 136	16.8
5–9	1 180	27.5	11 425	17.7	818	20.5	9 740	14.7
10–14	606	14.1	6 927	10.7	341	8.6	5 014	7.5
15–24	465	10.8	7 869	12.2	517	13.0	9 796	14.7
25–44	936	21.8	15 815	24.5	1 385	34.8	21 622	32.5
45–64	515	12.0	6 450	10.0	382	9.6	4 828	7.3
⩾65	85	2.0	2 525	3.9	26	0.7	1 597	2.4
total	4 291	100	64 518	100	3 983	100	66 455	100

Table 2. Age and sex distribution of infections with *S. haematobium*

Age (years)	Males			Females			Total		
	No. examined	positive	%	No. examined	positive	%	No. examined	positive	%
≥4	504	10	2.0	514	8	1.6	1 018	18	1.8
5–9	1 180	106	9.0	818	81	9.9	1 998	187	9.4
10–14	606	182	30.0	341	56	16.4	947	238	25.1
15–19	284	97	34.2	235	63	26.8	519	160	30.8
20–24	181	54	29.8	282	61	21.6	463	115	24.8
25–29	233	59	25.3	474	71	15.0	707	130	18.4
30–34	231	33	14.3	375	25	6.7	606	58	9.6
35–39	259	25	9.7	278	21	7.6	537	46	8.6
40–44	213	13	6.1	258	14	5.4	471	27	5.7
45–64	515	27	5.2	382	16	4.2	897	43	4.8
≥65	85	3	3.5	26	1	3.8	111	4	3.6
total	4 291	609	14.2	3 983	417	10.5	8 274	1 026	12.4

Age and sex distribution of infected persons. In all, 4 291 males were examined of whom 609 (14.2%) were found to be infected with *S. haematobium*; of 3 983 females 417 (10.5%) were infected. The prevalence in the entire sample amounted to 12.4%. In Table 2 the age distribution of infection with *S. haematobium* is shown for each sex in 5-year groups to age 44, and for those aged 45–64 and ≥ 65 years. The curve of infection with age resembles in its general form those obtained in other surveys of *S. haematobium*.

Blood visible to the naked eye was recorded in only 17 urine samples (14 of them in boys 8–15 years of age) and each case was associated with the presence of ova of *S. haematobium*; this represents 1.7% of all positive urine samples.

Red blood cells were present in 2 368 (28.6%) of the 8 274 urine samples. In only 1 026 (43.3%) of these were ova of *S. haematobium* also seen. This finding reflects the presence of the numerous light infections which are typical of much of the project area, as well as the error involved in diagnosis by the examination of a single urine sample.

Variability of prevalence rates between villages. Great variation in prevalence was observed between the villages studied. When classified by the percentage of autochthonous infections, no transmission was apparently taking place in 7 of the 43 villages and in 21 others the autochthonous prevalence was less than 10%.

Prevalence as related to source of water. The diversity of water sources used at different times is characteristic of the area and obscures the risk of infection associated with each. Of the 1 277 individuals using *only* rivers, streams and pools 218 (17.6%) were infected; of those using dams only 51 out of 627 (8.1%) were infected; and of the 161 people who relied on ponds, shallow wells or borrow-pits for all purposes 14 (8.7%) were infected. Of 1 506 individuals with access to bore-holes or deep wells only 5 relied on them exclusively; consequently the prevalence of *S. haematobium* in those who used a bore-hole or deep well was not significantly lower than in those without such an amenity.

The reservoirs, most of which had been built within the previous 15 years, were present in 11 of the localities. Most of these appeared to offer unstable conditions for the snail hosts and, although several had become infested with *Bulinus* (*Bulinus*) *truncatus rohlfsi*, the snail had disappeared from others. There is no doubt that at the present time the great majority of infections with *S. haematobium* are contracted through contact with rivers and streams at points other than where they have been impounded.

As the dry season progresses the larger seasonal rivers contract into long pools, some of which contain water until the beginning of the following rainy season; *B.* (*B.*) *truncatus* is collected in the pools from about November to May. *B.* (*Physopsis*) *globosus* is typically associated with the smaller seasonal streams, many of which have a steep, step-like profile; they flow rapidly when heavy rain falls but soon revert to a chain of narrow pools. *B.* (*P.*) *globosus* is responsible for most of the active transmission in the area between the end of the rains and the drying up of these smaller pools. The data from snail sampling, as well as the present survey, have continued to support the opinion of McCullough[a] that in this part of its course the Black Volta, which forms the western boundary of the project area and is the only perennially flowing river, is not associated with schistosomiasis transmission.

Prevalence as related to activities involving water contact. In order to facilitate the comparison of prevalence rates in those who were exposed to infection in the course of each activity with those who were not, the findings which follow are based on the 6 341 people who had contact for any purpose with the water of rivers, streams, or pools.

Almost all the people who use the rivers obtain water from them for washing as well as for drinking, so that it has not been possible to assess the relative risk associated with these two activities.

The overall infection rate was significantly higher in those who swam (or bathed) in streams, rivers, or pools than in non-swimmers of both sexes. The different age-composition of the 2 groups invalidates the overall comparison, however, and when the data are restricted to those aged 10–29 years there is no significant difference for either sex. This is partly due to the scattered distribution of the snail hosts which allowed many of the waters to be used for swimming without risk of infection, and partly to the fact that in many villages swimming in the pools was prohibited during the dry season.

There was some indication that fishing exposed adult males to an increased risk of infection; the dry-season use of the purse-seine net and the practice of suspending nets between stakes sunk in the mud of the larger pools involved the greatest exposure to infected water. Significantly higher rates of infection were recorded among those involved in the dry-season activity of fetching water and mixing clay for building blocks and earthenware utensils.

Prevalence as related to size of community. A significant inverse relationship was found between the village size (i.e., population) and prevalence of infection with *S. haematobium*, the infection rates in the villages of $\leqslant 100$, 100–249 and $\geqslant 250$ inhabitants being, respectively, 20.7%, 16.0%, and 8.9% ($\chi^2 = 128$, $P < 0.001$; 2 d.f.). It was suspected that this finding might be related to the fact that reservoirs, bore-holes and deep wells were more readily available in the larger communities. However, examination of the data shows that the relatively low prevalence in localities having $\geqslant 250$ inhabitants existed whether safe water was available or not, and in the smaller villages the prevalence was actually higher where there was such a facility.

Prevalence as related to ethnic group. Of the principal ethnic groups represented in the area much lower infection rates (5.5%) were found in Walas than in Lobis (14.7%) or Dagartis (13.9%). This finding is undoubtedly related to the fact that 85% of the Walas live in the larger villages and towns with which lower infection rates are associated, compared with 41% of the Lobis and 38% of the Dagartis.

Prevalence as related to school attendance. There were no significant differences in infection rates between children who attended school and those who did not.

Stool examinations

None of the 1 698 stools examined contained ova of *S. mansoni*. The absence of *S. mansoni* infections in the 43 villages studied is noteworthy in view of the fact that the potential vector, *Biomphalaria pfeifferi gaudi*, is present in large numbers in some of the larger seasonal rivers, attaining its maximum density in pools during the late dry season. The reason for the failure of *S. mansoni* transmission to become established was not fully investigated but it may be noted that, since compounds are not built on the flood-plains of these rivers, the dwellings are generally at a considerable distance from the infested habitats during the dry season and the likelihood of faecal contamination of the water is correspondingly reduced. Furthermore, even were defaecation to occur on the banks of the river the absence of rain during the period at which *Biomphalaria* is most abundant would reduce the probability of viable eggs being washed into the water. The transfer of ova of

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[a] McCullough, F. S. (1965). Unpublished assignment report AFRO/BILHARZ 12.

S. mansoni to water may take place in several other ways, however, and since scattered foci of this parasite are already present in northern Ghana it is probable that at least localized transmission will occur in the future in an area where the snail hosts are so widely distributed.

II. CONTROL TRIAL

McCullough (2, 3) and Odei (4, 5) noted that the local snail hosts of *S. haematobium* were most abundant at the end of the rains or during the early dry season (October–December); Odei (4) considered that the risk of human infection was greatest in the dry season. More recently monthly observations on cercarial infection rates in the snails have confirmed that transmission takes place mainly at this time, but that in suitable habitats it may commence as early as September. Since most infections are contracted in standing water during the dry months it was considered that the application of molluscicide at this time would be the logical and most economical means of interrupting transmission in the selected localities.

The project area originally comprised the 4 sectors shown in Fig. 1. In 1966 two of these were discarded because of a lack of schistosomiasis cases. Of the 2 remaining, sector II, consisting of 84 villages and representing about two-thirds of the surface area and total population, was used for the control trial; the adjacent sector IV, with 34 villages, was used for comparison.

In 1968 and 1969 urine surveys were carried out in all the villages of both sectors, only boys 5–14 years of age being examined. In these and all subsequent surveys egg-counting was included, the method being essentially that of Jordan (6). The place of birth of each child was recorded, as well as his movements prior to the survey. With this information it was possible to establish with reasonable accuracy the prevalence of autochthonous infections, an autochthonous case being defined as one in a child born in the locality concerned who had not lived elsewhere for more than one week. In general, it is true of the project area that those who leave it do so for long periods; those who move within the area normally return within a week.

It was decided that, to qualify to be controlled, a locality should have a minimum of 5% of autochthonous cases among the boys aged 5–14 years, together with a minimum arithmetic mean egg-count in these cases of 40 eggs of *S. haematobium* per 10 ml urine. The data from the urine surveys indicated that at these levels a number of villages with insignificant degrees of transmission could be excluded from the control programme, as well as those where there was apparently none. Of the 84 villages of sector II 30 qualified to be treated; 16 of the 34 villages in sector IV fulfilled the same criteria and were therefore regarded as comparable.

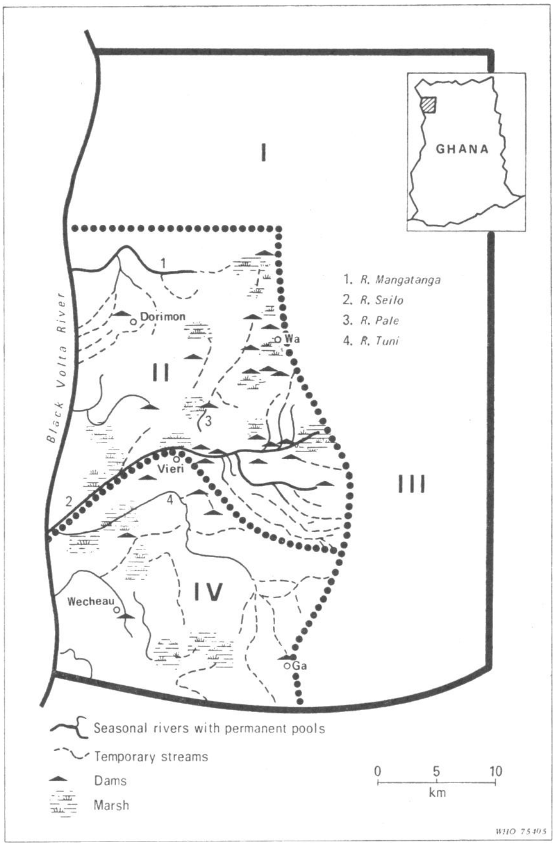

Fig. 1. Boundaries of original Ghana-5 project area and water courses and dams in the two sectors which comprise the revised area.

METHODS

The identification of water sources

In 1967 sector II was photographed by an aerial survey team then working in northern Ghana. Two sets of black-and-white photographs were supplied to the project (scale 1 : 10 000), one of which was issued to the field teams in the form of locality mosaics. Having identified the available sources of water in each of the localities to be treated it was then necessary to confirm by questioning and observation which sources were actually in use at the time of the teams' visits.

The identification of snail infested habitats

Since infection rates in snails are generally low the presence of either of the local intermediate hosts (*B.* (*P.*) *globosus* or *B.* (*B.*) *truncatus*) rather than the finding of infected snails was the indication for initiating control in the 30 selected localities. All static bodies of water in use in each of the 30 villages were sampled monthly.

The sampling implement was a long-handled sieve. Restricted habitats (less than about 200 m in circumference) were sampled in their entirety at the rate of 3 dips per m of circumference; in dams and large riverine pools only the water contact points were sampled and treated. In this case the bank was sampled for a distance of 20 m on either side of the contact point, the rate of dipping being increased to 10 per m to compensate for the generally lower snail densities. The collectors sampled as far from the bank as the depth of the water permitted. The total habitats/contact points sampled monthly ranged from 174 to 375.

Application of the molluscicide

The molluscicide used was niclosamide 70% wettable powder. It was applied with Hudson X-pert pressure sprayers in the nozzles of which were inserted metal disks with a central aperture of approximately 1.5 mm.

Ponds and smaller riverine pools (up to ±200 m in circumference) were treated with sufficient chemical to provide a concentration of 0.5 mg/litre. In the large habitats the concentration was increased to 1 mg/litre and the chemical was applied for a distance of 40 m on either side of the contact point, the treatment being repeated if and when sampling showed that the snails had reappeared within 20 m of the contact point. The large habitats were sprayed to a distance of 10 m from the bank or to the outer edge of the emergent vegetation, whichever was the greater distance; inflatable rubber boats were available for measurement of water volume and molluscicide application when necessary.

Only when the emergent vegetation was so thick as to interfere seriously with the contact of the molluscicide with the water was it cut off to surface level before spraying.

Public acceptance of the control measures was generally good, and only towards the end of the dry season was it necessary on a few occasions to suspend sampling and treatment of water in villages relying on a single source.

EVALUATION

Operational evaluation

Two cycles of control were carried out, from October to April 1969–70 and from October to May 1970–71. The follow-up data for the treated habitats are summarized for both cycles of control in Table 3.

Of the 41 habitats requiring retreatment in either cycle, reinfestation was due to flooding from upstream at the onset of the rains (and possibly the emergence of some aestivating snails) in 31; in 3 rain fell within a few hours of molluscicide application and flooded the habitat. Of the remaining 7, 5 had extremely dense vegetation which prevented adequate penetration by the molluscicide (in 3 of these the snails were nevertheless absent from the contact points for 2 months), and in 2 it is thought that subsurface movement of the water caused loss of the chemical downstream.

In general, the results indicate a high level of operational efficiency and justify the decision to restrict mollusciciding of the larger habitats to those points at which the population had contact with the water.

Epidemiological evaluation

Evaluation was based on the examination of boys 5–14 years of age in 3 groups of localities, as follows:

a. The 30 treated villages of Sector II.

b. The 16 untreated villages of Sector IV.

c. 27 (i.e., 50%) of the villages of sector II which did not qualify to be treated; these last, which were selected at random, were included with the object of observing any change in their epidemiological status over the years.

The age distribution of the boys examined in 1969, 1970, and 1971 is shown in Table 4. Pre- and post-control data in respect of prevalence (total and autochthonous), egg-counts of the autochthonous cases, the annual incidence of new cases, and the rate of reversion from positive to negative are shown in Table 5. The following points should be noted:

Table 3. Follow-up data for the treated habitats; volume of water treated; and consumption of niclosamide in each cycle

Type of habitat	Control cycle			
	1969-1970		1970-1971	
	No. habitats treated	No. requiring 2nd application	No. habitats treated	No. requiring 2nd application
large riverine pools (contact points)	93	17	73	3[a]
dams (contact points)	1	0	7	0
small riverine pools (less than approx. 200 m. in circumference)	61	10	74	11[a]
ponds[b]	6	0	4	0
" pockets "[c]	1	0	0	—
total	162	27 (16.7 %)	158	14 (8.9 %)
total molluscicide applications	189		174	
total volume of water treated (m^3)	43 120		20 112	
total consumption of niclosamide (kg)	53		26	

[a] One required 3 applications.

[b] Natural or man-made depressions unconnected with watercourses.

[c] Stagnant inlets at margin of flowing water.

1. The annual incidence of new cases has been calculated from the formula: Incidence $= 1 - x^{(12/y)}$, where x = the proportion of boys negative at the beginning of the year who were still negative at the end of it, and y = the average interval in months between the examinations (7, 8).

2. In calculating incidence and reversion rates no account was taken of movements during the previous year since a negligible number of boys had stayed outside their villages and then returned in time for reexamination.

3. The egg-counts were based on the number of eggs seen in a 50-mm^3 sub-sample taken after centrifuging 10 ml of urine and removing the supernatant fluid to 0.2 ml (or, if the deposit was copious, to 0.3 or 0.4 ml). The arithmetic mean count was calculated on confirmed cases only, the geometric mean count was calculated on all boys examined, a x + 1 transformation being applied to accommodate zero counts.

4. Of necessity all urine samples were collected between 06 h 00 and 08 h 00 and were examined in the field. The pre- and post-control counts were unavoidably performed by different personnel who were, however, trained and supervized in the same manner. The routine microscopists, on whose results prevalence and incidence were calculated, remained unchanged throughout.

The data from the three groups of villages are considered separately below.

Data from the treated villages of sector II. An attempt was made to maintain the size and age composition of the groups. Boys who had reached the upper age limit were replaced with the new 5-year-olds. However, boys of other ages dropped out for various reasons and it was impossible to keep the age composition constant. Considering separately the boys 10–14 years of age in the treated villages, among whom there was no significant change in age structure, a decline in prevalence occurred from 48.5% in 1969 to 41.8% in 1971, a reduction just short of significance at the 95% level of probability ($\chi^2 = 2.8, 0.05 < P < 0.10$).

A very satisfactory fall in the incidence of new infections followed the first cycle; although this was consolidated it was not much improved upon by the second cycle. The residual incidence in 1970–71 was attributable to: (i) false negatives in 1970—8 of the 30 " new " cases in 1971 already presented red blood cells without eggs in the urine in the 1970 examination; (ii) early cessation of the rains in 1970 which

Table 4. Pre- and post-treatment examinations of the indicator-group: number and percentage of boys examined

Age (years)	Treated villages of sector II						Untreated villages of sector IV						Untreated villages of sector II					
	1969		1970		1971		1969		1970		1971		1969		1970		1971	
	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total	No. examined	% of total
5	76	10.6	102	15.1	82	12.6	55	10.8	65	14.1	30	7.5	77	12.9	85	14.6	79	14.2
6	57	8.0	63	9.3	85	13.1	35	6.9	48	10.4	53	13.2	47	7.9	67	11.5	73	13.2
7	88	12.3	51	7.6	55	8.4	72	14.2	32	6.9	46	11.4	72	12.1	45	7.7	57	10.3
8	96	13.4	77	11.4	46	7.1	71	14.0	63	13.7	30	7.5	77	12.9	65	11.2	41	7.4
9	100	14.0	87	12.9	72	11.1	64	12.6	58	12.6	60	14.9	81	13.6	70	12.0	60	10.8
10	75	10.5	86	12.8	79	12.1	40	7.9	56	12.1	49	12.2	67	11.2	73	12.5	63	11.4
11	64	8.9	62	9.2	81	12.4	50	9.8	31	6.7	48	11.9	58	9.7	60	10.3	60	10.8
12	55	7.7	55	8.2	56	8.6	35	6.9	42	9.1	27	6.7	42	7.0	51	8.8	49	8.8
13	52	7.3	47	7.0	52	8.0	48	9.4	30	6.5	38	9.5	38	6.4	35	6.0	46	8.3
14	53	7.4	44	6.5	43	6.6	38	7.5	36	7.8	21	5.2	37	6.2	31	5.3	27	4.9
total	716	100	674	100	651	100	508	100	461	100	402	100	596	100	582	100	555	100
average age	9.1		9.5		9.6		9.7		9.5		9.7		9.5		9.4		9.4	

Table 5. Pre- and post-treatment examinations of the indicator-group: summary of results in the treated villages of sector II, the untreated comparative villages of sector IV, and the untreated villages of sector II

	Treated villages of sector II			Untreated villages of sector IV			Untreated villages of sector II		
	1969	1970	1971	1969	1970	1971	1969	1970	1971
Prevalence									
total									
No. examined	716	674	651	508	461	402	596	582	555
No. positive	274	214	189	165	166	129	56	49	38
percentage	38.3	31.8	29.0	32.5	36.0	32.1	9.4	8.4	6.8
autochthonous									
No. examined	606	609	576	464	428	368	465	488	478
No. positive	235	192	173	153	155	119	38	31	24
percentage	38.8	31.5	30.0	33.0	36.2	32.3	8.2	6.4	5.0
Egg-counts, autochthonous									
No. of counts	197	190	172	133	152	119	34	31	24
arithmetic mean count	228	75	134	134	80	83	16	33	19
geometric mean count	1.892	1.026	1.119	1.221	1.292	1.199	0.090	0.101	0.075
Incidence rate[a]									
No. negative in year indicated	315	346	380	278	232	239	461	455	452
No. negative in previous year	397	380	410	349	286	255	482	478	460
average interval in months	11.3	12.1	12.0	11.8	11.7	12.1	11.4	12.3	12.0
incidence (% per year)	21.8	8.9	7.3	20.7	19.3	6.2	4.6	4.7	1.7
Reversion rate[a]									
No. positive in year indicated	194	193	172	94	122	129	37	30	29
No. positive in previous year	221	233	199	112	143	147	54	45	37
average interval in months	11.2	12.1	12.1	11.7	12.3	12.2	11.4	12.5	12.1
reversion (% per year)	13.1	17.0	13.5	16.5	14.4	12.1	32.9	32.3	21.5

[a] Since a negligible number of children had lived elsewhere in the interval between examinations no account has been taken of movements in the calculation of incidence and reversion rates.

allowed transmission to become established briefly before the second cycle commenced; (iii) a few cases possibly becoming infected at isolated foci remote from the village. None of the new cases in 1971 had lived elsewhere during the previous year.

The geometric mean egg-count fell sharply after the first control cycle. A comparison of the within-sample variances showed that the distributions in 1969 and 1970 were not homogeneous, so that the significance of the fall in the mean count cannot be assessed (Table 6). Nevertheless, the change in the

Table 6. Comparison of the variances of the geometric distributions of egg-counts of the boys in the treated villages in 1969 and 1970

Year of observation	Sum of squares	Degrees of freedom	Variance	F
1969	429.6938	567	0.5447	1.86
1970	234.1456	606	0.2922	

distributions was due to a reduction in the higher counts and this in itself is suggestive of a successful first cycle of control. A slight but not statistically significant rise in the geometric mean egg-count was recorded in 1971.

Owing to the marked fall in the geometric mean in 1970, and also to the need to exclude the possible influence of changed age composition and the departure from the area of some boys with high counts, the data of 1969 and 1970 have been reworked using data only from those individuals who were present in both years. Despite the upward shift in the average age of the group in the interval, the mean arithmetic and geometric counts fell from 216 to 88 and from 1.710 to 1.252, respectively; once again the geometric distributions were heterogeneous.

Data from the untreated comparative villages of sector IV. The indicator group in these villages underwent a similar change in age composition. The prevalence and geometric mean egg-counts of the autochthonous cases remained virtually unchanged after 2 years, but there was a dramatic drop in the incidence of new cases.

Data from the untreated villages of sector II. In these villages, in which transmission was believed to be minimal or absent, prevalence, egg-counts, and the incidence of new cases all tended to decline. Also, total prevalence always exceeded the prevalence of autochtonous cases. The decline in the rate of reversion from positive to negative in 1970–71 seems to be inconsistent with the rest of the findings but may be due to the relatively small number of positives available for reversion.

DISCUSSION

For a control scheme such as that described above three procedures are necessary, namely: Location of the water-bodies in use in each locality; confirmation of the presence of the snail species locally responsible for transmission; and effective application of the molluscicide to the infested habitats. For the last of these the follow-up snail surveys provided evidence of a satisfactory degree of operational efficiency; for the first two evidence of success depends on the demonstration of a reduction in the transmission of the disease. Taken by themselves the results from the treated villages suggest that, in general, the infested bodies of water in use were correctly identified and that local transmission was effectively curtailed or terminated. However, in 1970–71 a fall in incidence also occurred in the comparative localities. It is believed that the untreated villages used for comparison were not in fact comparable for the following reasons:

a. The three or four comparative villages most productive of cases relied on shallow temporary pools during the early dry season and later resorted to wells. At such sites transmission is prolonged by heavy and prolonged rains and ceases early—or may not be possible at all—following an early ending of the rains. The incidence of new cases in the comparative villages in 1968–1969 was much inflated as a result of the heavy rains of 1968 (151 cm, the second highest rainfall since records began in Wa in 1917), whereas 1970 produced the lowest rainfall on record in Wa (75 cm) and several known transmission sites were already dry by October.

b. By setting the criteria at a minimum level of prevalence and egg-counts it was intended to separate the villages in both sectors that had a schistosomiasis problem from those in which little or no transmission was taking place. While this objective was satisfactorily achieved the criteria which were selected did not distinguish sufficiently clearly the variations in *intensity* of transmission which existed among the more highly infected villages. On average, the minimum values were exceeded by a wider margin in the treated than in the comparative villages. Had the criteria been set at a higher level, particularly with regard to the egg-counts, the comparative villages with unstable transmission dependent upon exceptional rainfall would have been eliminated and the remainder would have been more genuinely comparable to those remaining in the sector to be treated.

c. In several of the comparative localities it became evident that transmission had ceased before the trial began with the result that, although the overall autochthonous prevalence and mean egg-counts qualified them as comparative villages, new infections were not appearing among the boys up to 8 or even 10 years of age. A number of pools in these villages which formerly yielded the intermediate hosts (F. S. McCullough, unpublished data) do so no longer, for reasons which are not known.

Although it is accepted that the results from the comparative localities failed to supply statistical evidence of the success of the control measures in the treated villages, this fact should be kept in perspective. An analysis of the results of 2 cycles of control showed that control of the snail hosts had been highly successful; an immediate reduction in the incidence of new infections was recorded in the treated villages, which was sustained over 2 years and for which there appears to be no other explanation than that it resulted from the use of molluscicides. It is considered that selective, dry season, focal control of infested habitats is the logical means of controlling schistosomiasis under the conditions of the project area, and that it deserves to be tested in other areas of the interior savannah of West Africa.

The measures applied are intended to reduce the rate of superinfection, and hence morbidity, in those communities which are subject to exceptionally heavy transmission. Depending on the nature of the transmission site control would no doubt have to be applied annually in some cases, whereas in others it is probable that the effects would be more lasting and that the egg-counts would decline to a level which would justify control on a more intermittent basis. In either case chemical control is regarded as a useful palliative until more permanent measures can be introduced.

The urine surveys to select the treated and comparative villages cost approximately US$ 0.30–0.40 per head of population. The cost of the control operation alone, per water treatment (US$ 124 averaged over both cycles) or per m^3 of water treated (US$ 0.71), is extremely high owing to the expense of locating and sampling the water sources in use. The most useful unit cost is the cost per head of the population of the treated villages per annual cycle; this is estimated at US$ 2.34 per person per annum. By substituting ground reconnaissance for the aerial photographs, by placing snail sampling on a qualitative rather than a quantitative basis, and by wider spacing of the visits to each locality the annual *per capita* cost of control might be reduced to about US$ 1.50. There would, however, be a clear advantage in giving priority to the treatment of the larger communities, since the expense involved in mapping and sampling the water sources in use in small villages, and the time spent in travelling between them, is often disproportionately great in relation to the total number of people benefiting from a control scheme of this kind.

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RÉSUMÉ

LA SCHISTOSOMIASE AU NORD-OUEST DU GHANA

Il est ressorti d'une enquête portant sur 8274 habitants de la zone du projet Ghana-2101 que 12% d'entre eux éliminaient des œufs de *Schistosoma haematobium* dans leurs urines; le taux d'infection s'élevait jusqu'à 34% parmi les hommes de 15-19 ans. Malgré l'abondance de son hôte intermédiaire potentiel, on n'a trouvé *S. mansoni* chez aucun des 1698 garçons examinés. Au nord du Ghana, la schistosomiase urinaire revêt un caractère focal et se contracte dans les eaux stagnantes, durant la saison sèche. Etant donné la dispersion des mollusques hôtes et la nature transitoire de nombre des collections d'eau, les risques d'infection varient beaucoup d'un endroit à l'autre. Pour faire face à cette situation, on a mis au point une forme de lutte focale et sélective. Là où l'on a trouvé un minimum de 5% de cas autochtones parmi les garçons de 5-14 ans et où la moyenne arithmétique des nombres d'œufs chez ces sujets n'était pas inférieure à 40 œufs de *S. haematobium* par 10 ml d'urine, on a pratiqué deux cycles d'application de molluscicide pendant la saison sèche. Trente villages répondaient à ces critères; dans une zone voisine, 16 villages y répondaient également et ont été pris comme témoins. Dans les villages soumis aux mesures de lutte, des prélèvements mensuels ont été effectués dans toutes les collections d'eau couramment utilisées par la population et toutes celles que l'on a trouvées infestées par l'une des espèces locales de mollusque hôte ont été traitées au niclosamide en poudre à 70% dispersable dans l'eau. Les petits habitats ont été traités sur toute leur étendue; dans les plus grands, le molluscicide n'a été appliqué, à la dose de 1mg/litre, qu'aux points de contact de la population avec l'eau.

Les résultats obtenus sur le plan opérationnel ont été satisfaisants. Sur les 320 habitats traités, 41 seulement

ont dû recevoir une seconde application de molluscicide durant la même saison sèche. D'après la prévalence après traitement, les numérations d'œufs et la fréquence des cas nouveaux, on a tout lieu de croire que la transmission a pu être interrompue dans les villages traités. Dans les villages témoins, la fréquence des cas nouveaux a aussi diminué durant la seconde année, pour des raisons qui sont considérées comme étrangères à l'expérience.

REFERENCES

1. Watson, J. M. Medical helminthology. London, Baillière, Tindall & Cox, 1960, pp. 373-375.
2. McCullough, F. S. *Annals of tropical medicine and parasitology*, **51**: 235-248 (1957).
3. McCullough, F. S. *Bulletin of the World Health Organization*, **27**: 161-170 (1962).
4. Odei, M. A. *West African medical journal*, **13**: 60-70 (1964).
5. Odei, M. A. *Ghana medical journal*, **6**: 120-125 (1967).
6. Jordan, P. Periodicity of ova output and intensity of infection (*S. haematobium*). *In*: Annual report 1959–1960, East African Institute for Medical Research. Nairobi, Government Printer, 1960, p. 25.
7. Pesigan, T. P. et al. *Bulletin of the World Health Organization*, **18**: 345-455 (1958).
8. Farooq, M. & Hairston, N. G. *Bulletin of the World Health Organization*, **35**: 331-338 (1966).