Focal, seasonal and behavioural patterns of infection and transmission of *Schistosoma haematobium* in a farming village at the Volta lake, Ghana

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**Summary**

Integrated sampling for human prevalence, intensity, and incidence of *Schistosoma haematobium*, as well as for human water contact and snail distribution and density was carried out in the Volta lake farming village of Agbenoxoe at various times between 1978 and 1980. Nucleopore filters were used for determining egg output. Snail sampling was by the man-time method. A new system of recording human water contact was introduced for the peculiar condition at Agbenoxoe. Results indicated significant focality of infection and transmission in the compact village, concentration in the 5- to 19-year-old age group, and distinct seasonality of transmission. Water contact was frequent but of short duration. Only a few children under the age of 5 entered the water, and age-specific curves for duration of water contact paralleled the curve for geometric mean of egg counts (log₁₀ of eggs + 1) for males and the prevalence curve for females. Water contact for males was of longer duration than for females and included more time playing and wading. These activities probably accounted for the much higher incidence and prevalence rates recorded for males over females in the village. The concentration of infection, transmission, and water contact in the 5- to 19-year-old age groups at Agbenoxoe and villages like it supports a control strategy of treating only this age span with drugs.

**Introduction**

The formation of the man-made Volta lake from 1964 to 1967 led to a major epidemic of *Schistosoma haematobium* around its 5000 km shoreline in at least 950 lakeside and hinterland communities (Jones 1973). Detailed field studies on the infection at the lake took place between 1971 and 1981, although only one report on the epidemiology has been published (Scott et al. 1982). The study area included 26 semi-nomadic fishing and farming villages ranging in size from 50 to 370 people in 1974, along 60 km of contiguous shoreline. As the project was winding down and more became known of the lake as a whole, it remained unclear whether or not conclusions reached on the status of *S. haematobium* and the strategy for its control in the small study area would be valid for other parts of the lake. With WHO sponsorship, Klumpp (1983) studied the epidemiology and transmission of the infection in eight different branches of the Volta lake between 1978 and 1980. Part of this research involved a study of *S. haematobium* in an old, stable Volta lake farming village of over 1000 people, with no tradition of fishing. In many respects, it was similar to other large farming villages and towns around the lake, none of which had ever been studied in depth for schistosomiasis. Thus, the study's objective in this non-fishing village was to collect information on patterns of infection and transmission, and to study the focality and seasonality of transmission from four integrated approaches: prevalence and intensity, incidence, snail sampling, and human water contact.

The work took place at the village of Agbenoxoe (pronounced Ag-ben-oh-kwé) in the Volta region of Ghana. The purpose of this report is to present the main findings of these studies, and describe how infection and...
transmission in the village was distinctly focal, seasonal, and related to duration of certain water contact activities.

**Village description**

Agbenoxoe is located at a small inlet on the eastern shore of the Volta lake, 5 km from the regional town of Kpandu and about 220 km north of Ghana's capital, Accra. Mid-day air temperatures near Agbenoxoe range from 22 to 37°C in the main rainy season months of April-October, and from 23 to 40°C in the dry season months of November-March. The average rainfall per year in the area is about 1300 mm.

Mid-day surface water temperatures in that part of the Volta lake vary from 25 to 33°C. In 1979 the village, which is over 200 years old, had a population of 945 living in 95 family compounds ($\bar{x} = 11.1$, s.d. = 7.8). All but 43 were indigenous, 'northern' Ewe (EH'-vay) people. Almost all of the rest were nomadic fishing folk of the Efutu tribe. In 1980, only 15 long-term residents died or moved away permanently, and the total population grew to 1070. Of the 70 residents who died or moved away permanently, and the total population grew to 1070. Of the increase, 69 were either new births or returning indigenous villagers, and 71 were newly-arrived Efutus. The overall male to female ratio that year was 1:1.6, and the age pyramid showed the typical broad base and narrow peak.

The indigenous Agbenoxoe people were primarily farmers of yams, cassava, palm nuts, bananas, and plantain. The inundation of the Volta lake between 1964 and 1967 destroyed some low lying houses in the village and forced the relocation of about 100 residents to other parts of the village. The final stabilization of the lake brought the shoreline to a high water range of about 50 to 150 m from all permanent Agbenoxoe compounds (Figure 1).

Between 1978 and 1979, the lake receded to such low levels that the old bridge across the Kple River inlet was above water and could be used again for road traffic to the neighboring village of Kpandu Dafor. At that time, only two water contact points (WCPs) in the village were in use: WCPs 1 and 2. From July to November 1979, the lake rose 5.1 m, its highest ever seasonal flood, and the inlet filled to a horizontal level about 20 m wider than the level shown in Figure 1. During this period, a seasonal stream on the west side of the village filled up and was used for some water contact, mainly fetching water. It contained no *B. rohlii* and was not used after it stopped flowing in November, at which time WCPs 3 and 4 came back into use. From that time, through June 1980, WCP 4 was the most heavily used site, followed by WCPs 1, 3, and 2.

Not included in Figure 1 is the large Christian grotto in the south-western corner of the village. This contains numerous statues and carvings depicting events of the Crucifixion, and is famous throughout Ghana and parts of Togo. Religious groups make frequent pilgrimages to the grotto, and on special occasions, thousands of people flock to the village to see the statues and pray. Nearly all of the indigenous residents are Catholics, baptized at infancy, and since these baptisms are recorded, correct determination of age is easy.

Despite two public lavatories at the grotto, much urination still takes place in the lake. Two bore wells were drilled in the village in the early 1970s, but the hand pumps broke down frequently, and within a few years, the wells were permanently inoperative. In 1973, Jones, surveyed 229 children in the primary and middle schools for *S. haematobium* and recorded an overall prevalence rate of 25.1% (Jones 1973). Soon afterwards, most of the positives were treated once with niridazole by a Ghana health team. Just before the present study began, 56 school children, aged 8 to 14, were examined for *S. haematobium*. The prevalence rate was 76%, indicating that there has been active transmission of the infection since the incomplete chemotherapy.

Agbenoxoe, with its stable population and compact size, had many advantages as a study village: accessibility and close proximity to the lake, medium snail populations along the entire shoreline during much of the year, known ages of the residents, high initial prevalence rates of *S. haematobium* in the school children, and excellent cooperation from the inhabitants. From July 1979 to June 1980, RKK and three field assistants lived in the village for about 2 weeks every month to conduct the research. Before epidemiological sampling began, the
The incidence study was of a cohort of 104 collection.
later, the other 35 children, aged 3 and 4, were all of the egg counts at the field laboratory with aid counting. RKK and an assistant performed compound microscopes, normally on the day of diameter and 12 urn pore-size; precision-lined modifications: Nuclepore niters were of 25 mm ei al. (method of Peters and from pupils at the two schools.

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ation work in the village. Overall compliance for Ministry of Health, which also took over evalu-
tion took place once-a-month from examination took place from January and June 1980, always in the same week that the four main sites were being sampled. Thus, in that 6-month period, it was possible to monitor den-
sected filters were examined carefully for any S. haematobium ova. The calculation of incidence rates followed the method of Faroog and Hairston (1966).

### Materials and methods

**COLLECTING AND EXAMINING URINE SAMPLES**

**Community surveys.**

Single urine specimens were collected from all age groups of the Agbenoxoe population in June–August 1979, and in May 1980, and examined for the presence and number of *S. haematobium* ova. All samples were collected between 1000 h and 1400 h; from adults and non-school children in individual households, and from pupils at the two schools.

**Processing and egg counting** followed the method of Peters et al. (1976), with the following modifications: Nuclepore filters were of 25 mm diameter and 12 urn pore-size; precision-lined glass gritules were placed over the filters to aid counting. RKK and an assistant performed all of the egg counts at the field laboratory with compound microscopes, normally on the day of collection.

**Incidence study**

The incidence study was of a cohort of 104 initially negative children. Of these, 71 aged 5 to 14, were screened in August 1979. Three weeks later, the other 35 children, aged 3 and 4, were screened in the same manner. The first follow-up occurred in December 1979; the second and last in June 1980. At each screening, a single urine sample (10 ml to bladder full) was collected from each available subject on each of 3 consecutive days, between 0800 h and 1200 h. The urine was injected by plastic syringes through the same type of Nuclepore filters used in the previous March and April surveys. All con-
served filters were examined carefully for any S. haematobium ova. The calculation of incidence rates followed the method of Faroog and Hairston (1966).

**SNAIL SAMPLING**

Snail sampling, crushing, and microscopic examination took place once-a-month from September 1978 using the man-time method developed for use in the Volta Lake (Klump & Chu 1977). The only modification was that at Agbenoxoe sampling took place within a 5 m zone from shore. RKK and three other experienced snail samplers comprised the Agbenoxoe team, and the same men worked together in every site sampled except during January–March 1979 when RKK was away. Apart from the latter period when three men searched for 20 min apiece per site, the standard sampling protocol was for each person to search actively for 15 min per WCP or area to equal 1 man-

**WATER CONTACT OBSERVATIONS**

The purpose of the study was to record the frequency, duration, and type of water contact of different age groups at WCP 4, and to integrate these data with those from epidemiology and snail sampling. From November 1979 to June 1980, seven observations a month were made, each on a different day of the week. Time of observation was continuous from 0600 h to 1800 h.

Two observers from Agbenoxoe were trained for data collection, and were supervised closely throughout the study. Each knew the names of almost all of the village residents before observations began, and soon became familiar with the names and age groupings of all people using WCP 4 regularly. Their presence did not seem to affect normal water contact behaviour, except perhaps for urination above the water level. Each observer worked for 6 h during the day of data collection, in shifts from 0600 h to 1200 h and 1200 h to 1800 h. Earlier trials with single 12 h shifts by one or two observers proved too tiring. Equipment included a stop-

**Results**

**PREVALENCE AND INTENSITY SURVEYS**

The results of the two surveys for prevalence and egg output of *S. haematobium* are summar-

In both surveys, participation rates were between 83% and 100%, for the 5- to 19-year-

old age span, and less than 65%, only among 0- to 4-year-olds.
Prevalence results reveal no infections in the 0- to 4-year-old group, a rapid build-up of infection to age 14, the peak between age 15 and 19, and then a rapid decline. There was virtually no difference between the surveys, but in each, prevalence rates were higher in males than in females for almost every age group. Using the Mantel-Haenszel test for age standardization, the overall sex differences were found to be significant (χ² = 29.1, P < 0.001 in 1979; χ² = 32.8, P < 0.001 in 1980).

Geometric means of egg output for all infected males and females in 1979 and 1980.

EVIDENCE OF NON-RANDOM DISTRIBUTION OF INFECTION AT AGBENOXOE

Even in this compact village, distribution of infection was clumped. It can be seen in Figure 1 that the main street divided Agbenoxoe into clear east and west sections, partially related to clan differences. After the lake formed, indigenous residents on the west side used site 4 most frequently, except during the 1978-1979 drought, when they used site 1 because the micro-inlet at site 4 dried up. Historically, east side residents used sites 1 and 3 most regularly. The small nomadic Efutu fishing community was scattered throughout the village, but used sites 1 and 2 almost exclusively. Snail sampling in all four Agbenoxoe WCPs between November 1979 and June 1980 showed that the number of infected B. rhossili at WCP 4 was 3.4 times the number at WCP 3, 4.9 times that at WCP 2, and 9.1 times that at WCP 1. The 1980 age-specific prevalence rates of all east and west-side inhabitants surveyed are shown in Table 1. Table 2 presents the corresponding geometric means of positives. Both tables highlight the much higher levels of infection among almost all age groups of the west-side residents.

INCIDENCE STUDY

The main results are shown in Table 3. Only one of the 3- to 4-year-olds converted to positives in the first follow-up period. This was an Efutu boy who spent much time at WCP 1 with his fisherman father. Among the ages 5-9, there was one conversion to positive after the first 114 days (low transmission season) and nine others after a further 198 days (high transmission season). Of the 10-14-year-olds, three converted in the low transmission period and three became positive in the high transmission season. Since other observations in this report will show that water contact was in general extremely low among children less than 5 years old, the best comparison of seasonal incidence rates at Agbenoxoe is among the 5- to 14-year-olds. In this group, the annual incidence rate was 17.9%, between August and December 1979, and 36.1%, from December to June 1980 (assuming a 2-months' incubation period of worm maturation).

Among 5- to 14-year-olds, 10 of the 25 males in the study converted in either December or June, giving a total annual incidence rate of 46.0%. In the same period, six out of 27 females converted, an annual incidence rate of 22.2%.

Of the 17 children who converted to positive in either December or June, 59%, detected on the first day of examination, 24% on the second day, and 17% on the third day. Six of these had a maximum of 1-5 eggs per 10 ml of urine per examination; two, 15-40 eggs; and two, 104-172 eggs. Six children who converted showed eggs on all 3 days; five on 2 days; and three on 1 day. The remaining three positives provided urine on 2 of the 3 days, and showed eggs on 1 day.

Two of the five children that were positive in December were still positive in June; two reverted to negative; and one was absent on all 3
SNAIL SAMPLING
Results of 21 months of snail sampling in WCPs 1 and 2 showed that transmission in the site was relatively low and distinctly seasonal. Between September 1978 and June 1979, 17 infected snails (mature S. haematobium cercariae) were found in WCP 1, and 11 in WCP 2, giving infection rates of 4.5% and 12.5%, respectively. In the same period the second year, seven and 13 infected snails were collected in the respective sites (2.9% and 5.9%). Only one infected snail was found in each site in the flood season of July–October in the 2 years. For seasonality of transmission, 70%, of all infected snails came in November to January (early lake drawdown), 24%, in February to June (mid to late drawdown), and 6%, during the flood period.

After the 5.1 m rise of the lake between July and October 1979 when sites 3 and 4 filled up, snail populations built up slowly in all 4 WCPs, but then rose rapidly to relatively high levels from January to March. Table 4 lists the snail sampling results over 8 months, beginning in November 1979, when the four sites were sampled together. It can be seen that 64 and 19 infected snails came from WCPs 4 and 3 respectively (62% and 18% of total infected snails found in all four sites). Thus, there were much higher transmission potentials in the village in 1980 than in 1979. In 1980, the high transmission season was extended to April. The reason for the high numbers of snails in WCP 4 was that the aquatic weed, Ceratophyllum demersum, grew in thick patches there from December to April. The importance of this weed in promoting transmission of S. haematobium in the Volta lake is well documented (Klumpp & Chu 1977; 1980). Except for light scattered patches the weed was absent from the other sites, when standardized for numbers per metre of shoreline sampled, the densitities of infected snails inside and outside of the WCPs were 0.105 and 0.026 respectively, or four times higher where human water contact was concentrated. The only area outside of a WCP where infected snails were significant was the shoreline of the lake; these snails were found so close to the recognized side boundary of WCP 4 that they could have been part of the site. The mean density of infected snails per metre of shoreline in areas B–F was eight times lower than in WCPs 1–4.

WATER CONTACT OBSERVATIONS
There was a clear seasonal trend in the frequency and duration of water contact at WCP 4 (Figure 3). The total number of entries increased each month as the dry season progressed (November to April), and decreased sharply when the heavy rainy season began (May). The curve for the total time spent in the

TABLE 1. Details of children in the cohort converting to positive, and overall incidence rates according to season

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Starting number in cohort</th>
<th>Number becoming positive between each of the two periods of examination over total number who were negative at the start of each period (incidence rates in per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0/10</td>
<td>September–December (92 days)</td>
</tr>
<tr>
<td>2</td>
<td>0/10</td>
<td>December–June (189 days)</td>
</tr>
<tr>
<td>3</td>
<td>0/10</td>
<td></td>
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<tr>
<td>4</td>
<td>0/10</td>
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<td>15–14</td>
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</tbody>
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Figure 3. Degree of water contact by month. (i) Total number of entries into lake. (ii) Total number of minutes in water.
water showed a similar rise and fall, but had an early peak in January, the main transmission month, a small drop-off in February, and a second peak in March.

During the rainy season, about two-thirds of the families frequently collected rain water in 200 litre drums from roof-top drainage. Sixty-five per cent of all main family buildings had aluminium alloy roofs, and one to three drums per house. When the drums were placed below real or makeshift gutters at times of heavy downpours, each filled up in a matter of minutes.

Variation in water contact by time of day
Results of total frequency and mean duration of water contact for all people using WCP 4 during the study are analysed by hour of day, Figure 4. Greatest frequency of contact occurred in the 0600 to 0800 h and 1600 to 1800 h periods, involving almost entirely children collecting water in buckets for later use in their households. During these peaks, individuals commonly carried an open metal water bucket. Small children also carried a calabash cup. Over 90% of all water collection occurred between 0600 to 0800 h and 1600 to 1800 h.

The mean duration of water contact by age, sex and activity per population at risk is presented in Figure 6. The histograms illustrate a number of points. First, the shape of the curve for females is similar to the female prevalence curves in the 1979 and 1980 village surveys: a rise to age 15-19, a rapid drop-off for ages 20-29, and then a slower, more erratic reduction after age 30. The shape for males mirrors the geometric means of infected males in the village: a rapid buildup to age 10-14, and then a very rapid decline to age 30 before levelling off. Second, unlike water contact frequency, there was little overall difference between females and males in duration of contact: 20.4 min and 19.0 min, respectively. This was because males of all age groups averaged between 1.5 min and 2.5 min in the lake per entry compared with an average near 1.0 min for all age groups of females. For the important 5-9 and 10-14 age groups, males spent more time in the water per unit population at risk. Third, while collecting water was the most time-consuming activity for all age groups of females, washing or playing in the water was the most time-consuming activity. The mean duration of washing clothes was 0.94 min, with little variation by age or sex. The mean duration for wading or playing per entry for males was close to 7.0 min for all ages. There were only 19 total entries for 5- to 14-year-old females washing or playing. Fourth, washing of clothes or utensils was primarily a female activity, and most frequent among girls ages 15 to 19. Mean duration per contact of this activity was 7.1 min for females and 7.5 min for males.

Almost all people at Agbenoxoe used the same method of collecting water from the lake. They would wade into the WCP to about mid-thigh depth, carrying an open metal water bucket. Small children also carried a calabash cup. Adults usually filled the bucket directly and placed it on their heads before starting back to their compounds. The children would squat down, with the bucket on their heads, and fill it with the cup. Over 90% of all water collection occurred between 0600 to 0800 h and 1600 to 1800 h. During the morning and evening peaks the water in the lake was crowded with people and constantly agitated. Thus, the probability of infection of H. haematobium cercariae at these times was probably low regardless of season.

By contrast, 74%, of recorded wading and playing in the water took place between 1100 h and 1600 h when cercarial densities were at

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**Figure 4.** Degree of water contact by hour of day. (C) Total number of entries into lake; (O) total number of minutes in water per entry.

**Figure 5.** Frequency of water contact (total number of entries into lake/total population at risk). (—) Males; (-----) females.

**Figure 6.** Histograms illustrate a number of points. First, the shape of the curve for females is similar to the female prevalence curves in the 1979 and 1980 village surveys: a rise to age 15-19, a rapid drop-off for ages 20-29, and then a slower, more erratic reduction after age 30. The shape for males mirrors the geometric means of infected males in the village: a rapid buildup to age 10-14, and then a very rapid decline to age 30 before levelling off. Second, unlike water contact frequency, there was little overall difference between females and males in duration of contact: 20.4 min and 19.0 min, respectively. This was because males of all age groups averaged between 1.5 min and 2.5 min in the lake per entry compared with an average near 1.0 min for all age groups of females. For the important 5-9 and 10-14 age groups, males spent more time in the water per unit population at risk. Third, while collecting water was the most time-consuming activity for all age groups of females, washing or playing in the water was the most time-consuming activity. The mean duration of washing clothes was 0.94 min, with little variation by age or sex. The mean duration for wading or playing per entry for males was close to 7.0 min for all ages. There were only 19 total entries for 5- to 14-year-old females washing or playing. Fourth, washing of clothes or utensils was primarily a female activity, and most frequent among girls ages 15 to 19. Mean duration per contact of this activity was 7.1 min for females and 7.5 min for males.
The activity was most frequent on Saturdays. Ovarial densities were low, or just building up. The main cleaning agent was ‘Omo’ detergent, along with commercial and locally made bar soap. Aluminium basins). Time spent in the water for this activity amounted to a series of 1- to 2-min entries (5 to 10 min), both activities were about the same.

Washing accounted for 14%, and 12% of total female and male time in site 4. Females washed household clothes and kitchen utensils while males generally washed their own clothes. Over 90% of all washing was done on shore (in aluminium basins). Time spent in the water for this activity amounted to a series of 1- to 2-min trips to collect water and rinse the soapy items. The main cleaning agent was ‘Omo’ detergent, along with commercial and locally made bar soap. Approximately 65% of all washing took place between 0800 h and 1100 h when cercarial densities were low, or just building up. The activity was most frequent on Saturdays.

Any effect of the detergent on snails and cercariae in the site could not be ascertained, but was probably negligible because of the high dilution in the lake. Because few canoes were kept at WCP 4, little canoe-related activity was observed. Bathing and swimming were also uncommon in the site. Few indigenous residents bathed anywhere along the shore, preferring to use water in buckets in bathing stalls at their houses. Almost all bathing in the lake was done in sites 1 and 2, mainly by Efuru males at sunrise and sunset.

Comparison of duration of water contact per person at risk, according to activity. (1) Collecting water; (2) wading or playing; (3) washing; (4) other.

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The extremely low levels of water contact for age groups could be sampled; and WHO project-0658 report 1979; Scott et al. 1982). The prevalence rates for all Agbenoxoe residents surveyed in 1979 and 1980 were 38.4% and 40.0%, respectively. These were lower than the overall rates in all but two of 59 Volta lake villages surveyed since 1973 where all age groups could be sampled (UNDP/WHO project-0658 report 1979; Scott et al. 1982). The extremely low levels of water contact for young Agbenoxoe children and all adults are necessary for the reducing congregation of cercariae in the site. The prevalence rates for all Agbenoxoe residents surveyed in 1979 and 1980 were 38.4% and 40.0%, respectively. These were lower than the overall rates in all but two of 59 Volta lake villages surveyed since 1973 where all age groups could be sampled (UNDP/WHO project-0658 report 1979; Scott et al. 1982). The extremely low levels of water contact for young Agbenoxoe children and all adults are necessary for the reducing congregation of cercariae in the site.

Discussion

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the primary reason for the lower rates. Snail populations and numbers of infected snails in the village were comparable to Volta lake fishing villages with overall S. haematobium prevalence rates exceeding 70%. Among ages 5 to 19, prevalence rate and geometric mean of positive egg counts was higher at Agbenoxoe than in 14 out of 29 other lakeside villages we surveyed between 1979 and 1980, and higher than in four of five villages with a population of over 1000. Almost all of the large villages around the lake were primarily farming and trading centres, and, as at Agbenoxoe, there was probably much more concentration of water contact and infection in the 5 to 19 age group than would be seen at any fishing village.

Precise determination of age and the significant exposure to infection of Agbenoxoe 5- to 19-year-olds, enabled us to apply a single, two-stage catalytic model to yearly groupings of this age span (1980 prevalence) to predict the rates at which they acquired and lost their infections. For this, the methods of Muensch (1959) and Hairston (1965) were followed. The predicted annual incidence rate came to 19.7°/,, and the predicted natural loss of infection ("occurrence") per year was 2.3°/,. The annual incidence rate recorded directly from the longitudinal study of all 5- to 14-year-olds came to 30.2°/,. The two sets of incidence rates correspond well considering the following: (1) sensitivity in detecting positives was greater in the cohort study; (2) true incidence rates probably declined after age 15; and (3) transmission was especially heavy in 1980-81.

The incidence study at Agbenoxoe confirmed the findings on seasonality of transmission from snail sampling in the village, which in turn, agreed with earlier long-term snail sampling results in the Volta lake (Klumpp & Chu 1977; 1980): the main transmission season always occurs between November or December and March or April, and transmission is always low and sporadic during the flooding season of August to October. An earlier incidence study on S. haematobium in Volta lake fishing villages had been conducted by Scott et al. (1982). It was somewhat flawed by incorrect calculation of incidence, high absenteeism, inter-village movement, and imprecise determination of age.

Nevertheless, the raw data agree closely with the Agbenoxoe incidence results on seasonal variation of infection, and show that despite quantitative differences in incidence between location and time, the basic, seasonal pattern of infection in the lake has remained stable.

Snail sampling along the entire Agbenoxoe shoreline answered a question never seriously addressed in studies at the Volta lake or at any other man-made lake: whether or not transmission potentials are significant outside of the main human water contact points. The present results indicate that in the "open beach" season of January to June, when human movement along the receding shoreline was largely unobstructed by vegetation, densities of infected snails per metre of shoreline were four times higher in the recognized water contact points than outside them. In this period, however, nothing more than sporadic water contact was observed in any littoral-zone area outside the four main WCPs: boys playing, men and boys setting fish nets, people growing vegetables along the open shore, and Efutu people bathing. From September to December 1979, a moderate zone of Paspalum, mixed with flooded cassava stalks and clumps of Vossia formed a fairly solid barrier outside of WCPs 1 and 2, which were then open pockets in the weed zone. This severely restricted human movement in areas A–F during that period, and further concentrated water contact in the main sites. When WCPs 3 and 4 came into regular use again in October and November, they too were pockets within the weed zone.

The findings on human water contact at Agbenoxoe differ in many respects from those of the study by Dalton and Pole (1976) at the small, semi-rural fishing village of Fatem, the only other water contact study previously conducted at the Volta lake. At Fatem, frequency and duration of water contact showed no seasonal variation, were significant among 0- to 4-year-olds and adults, highest for 5- to 9-year-olds, and greater for males than for females at all ages. There was also much more swimming, playing, and canoe-related contact.

Despite differences in water contact patterns between Agbenoxoe and Fatem, there were similarities. At Fatem, collecting water and washing accounted for the greatest overall percentage of water contact frequency, but for a much lower percentage of overall duration. Females engaged in these activities more frequently than males. For males the greatest duration of contact per entry was for swimming, playing, and working on fish nets around canoes. The geometric mean of positive egg counts at Fatem also correlated closely with mean duration of water contact for males and, as at Agbenoxoe, female egg output decreased faster with age than with their reduction in water contact. Their findings led Dalton and Pole (1976) to suggest the installation of piped water at Volta lake villages to reduce the time spent in the lake for activities such as washing and fetching water, thereby effectively controlling the transmission of schistosomiasis. However, evaluation of bore wells in the UNDP/WHO Project showed that they lasted only a few years (Klumpp 1983), and at Agbenoxoe, playing and washing in the lake—not fetching water or washing—were the activities with the greatest risk of infection. Therefore, safe and durable water supplies at the Volta lake may have more value in preventing waterborne infections other than S. haematobium.

Low transmission due to mollusciciding would not be necessary either at Agbenoxoe or in other Volta lake villages with low to moderate overall transmission. Unpublished evaluation of the UNDP/WHO Volta-lake project between 1979 and 1981 showed that chemotherapy alone could control S. haematobium in such villages once focal mollusciciding was stopped. The strategy for chemotherapy in every village in the UNDP/WHO project was to treat all infected people with metrifonate. While effective, it required considerable manpower and time to examine and treat each infected individual. Because of the high concentration of infection and the transmission potential of the 5- to 19-year-old population at Agbenoxoe, and presumably, other large farming villages like it around the lake, it would seem that at the primary health care level, the single most cost-effective way, initially, to control morbidity and transmission in such a village would be once-a-year drug treatment of the 5- to 19-year-old children only, using either metrifonate or, if reduced in price, praziquantel. First, treatment should not require extensive examination of urine samples, and should take place in primary and middle schools, which usually have enrollments of 60-80°, of the 5- to 19-year-olds in rural areas. Treatment of all targeted children could be undertaken if a quick test of positivity in a sensitive indicator sample such as 10 to 14-year-old males was above 60%, or so. A good time to treat school children for the infection in Ghana is in October, at the beginning of the dry season, when the peak malaria season is over and just before the start of the main transmission season for schistosomiasis. In Ghana, facilities are lacking for extensive urine testing, but metrifonate is available in the country on a large scale, and a primary health care infrastructure is developing for expanded treatment in rural areas.

To show the importance of transmission of the parasite among the ages 5 to 19 at Agbenoxoe and index of contamination potential was constructed. It follows similar indices developed in other schistosomiasis projects, in Leyte (Pesigan et al. 1958), Egypt (Farooq & Samaan 1967), and St Lucia (Jordan et al. 1980). Each included at least three basic age-specific parameters, in addition to prevalence rate, and arithmetic mean of positive egg counts. The product of these three parameters converted into relative percentages to indicate the importance of each group for spreading eggs in the water. For the Agbenoxoe results, a new parameter was added that made sense for any index of contamination potential: total duration of water contact for each age group. The assumption is that the longer people spend in the water, the more chance they have of spreading eggs.

The Agbenoxoe data in Table 5 referred to the population at risk whose main point of water contact in the village year after year had been WCP 1 of the UNDP/WHO project between 1979 and 1980. This represented 472 people, or 44.1%, of the total population in 1980. The results show that 95.8°/,, of the contamination potential of this
population came from 5- to 19-year-olds, with ages 10-14 being the most important (43.8%). Without the water contact data in the index, the contamination potential from ages 5 to 9 was 89.5%, and 15- to 19-year-olds were the largest contributors (39.9%). It was possible to construct the same type of index for the fishing village of Fatem in the Volta lake, from WHO computer printouts of the 1974 precontrol prevalence data, and from 1975-1976 water contact data of Dalton and Pole (1976). Even in this village, where water contact by small children and adults was far greater than at Agbenofoe, 90.7%, of the contamination potential was still caused by ages 5 to 19.

In the schistosomiasis research and control project in Machakos, Kenya, the strategy of treating only school children as the most cost-effective way to achieve community control of S. mansoni is being strictly evaluated against two other community-based treatment strategies: treating everyone with egg densities greater than 100 EPG, and treating everyone found positive with the infection (A. E. Butterworth, personal communication). We hope that the results of the present study in Ghana will lead to further evaluation of treating only school children for S. haematobium, which may be the simplest and cheapest way to achieve morbidity and transmission control at the community level.

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