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Schistosomiasis: Water Contact Pattern and Snail Infection Rates in Opa Reservoir and Research Farm Ponds in Obafemi Awolowo University, Ile-Ife, Nigeria

[1]O.J. Owojori, [2]S.O. Asaolu and [2]I.E. Ofoezie
[1]Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria
[2]Institute of Ecology and Environmental Studies,
Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: Human water contact pattern and *Schistosoma* infection rates in snails were studied in Opa Reservoir and Research Farm Ponds in Obafemi Awolowo University campus for a 12 month period covering both seasons of the annual cycle. This is with a view to know the water contact pattern and relate this to the potential for schistosomiasis transmission in the water bodies. Generally, water contact activities were more diverse and longer in the reservoir than in the ponds. Seasoual and daily variations were pronounced with water contact being most intense in the rainy season and in the early hours of the day till about noon. The water contact behavior in this area were quite age and sex related. The frequency and duration of contacts made by males were significantly higher than those of females ($p<0.01$). Although most water contacts were either personal or domestic, economic and recreatioual contacts dominated the duration and are therefore identified as risky contacts. Water contact of an economic nature peaked in the 20-29 years age group while that of recreatioual was maximum in the 10-14 age groups. The study on snail infection with *Schistosoma* showed that no infected snail was found in the ponds but infected snails were found in the reservoir in a site, S3, in November and December, 2002. Water contact pattern in this study was site specific with 76.1% of the total contacts made at the site where human *Schistosoma* type cercariae were also found. The implications are discussed.

Key words: *Bulinus*, infection, Schistosomiasis, snail, human water contact, cercariae

Introduction

An estimated 200 million people in 74 countries have schistosomiasis, 85% of whom live in sub-Saharan Africa where *Schistosoma haematobium*, *S. intercalatum* and *S. mansoni* are endemic (Chitsulo *et al*., 2000). Schistosomiasis has been shown to be endemic in Ile Ife where transmission is reported to persist in Opa Reservoir for over two decades (Adewunmi, 1990). In spite of this, there has been no evidence of water contact patterns in the area.

Several of such studies in other areas have been used to elucidate those patterns that affect transmission hence ways and means of sustainable control. Generally, the objective of any human water contact study is to observe the proportion of a study population that visits natural water bodies, the purpose and duration of visits and the degree of exposure during each visit (Jordan and Webbe, 1993). The data obtained are then analysed to define the relative risks of different types of contact. In transmission studies, information from water contact observations is used with those on snail studies to identify transmission sites and in combination with findings on human parasitological profile helps to elucidate the relationship between risk and actual infection in a community.

Corresponding Author: O.J. Owojori, Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

Thus, schistosomiasis infection and water contact pattern are essentially linked (Husting 1983, Kvalsvig and Schutter, 1986) and levels of infection are determined by complex interplay between level of exposure to snail infested water and age related acquired resistance (Hagan, 1992; Gryseels *et al*., 1994). Knowledge about water contact pattern is thus essential to elucidate the disease pattern and therefore for prevention of risky contact. Human contact studies are therefore an inevitable component of a sustainable control strategy.

This study therefore presents the results of a baseline human-water contact study carried out as part of an overall pre-control investigation of schistosomiasis transmission in the Opa River basin. The objectives of the investigation were to determine the water contact pattern and snail infection rates in Opa Reservoir and Research Farm Ponds in Obafemi Awolowo University Campus with a view to identify the risky contacts and transmission sites of schistosomiasis in the river Basin.

Materials and Methods

Study Area

This study was carried out in Opa Reservoir (OR) and Research Farm Ponds (RFP) at Obafemi Awolowo University (O.A.U) Ile-Ife located between Lat 7°30′-7°35′N and Long 4°30′-4° 35E′. According to Akinbuwa and Adeniyi (1996), Opa Reservoir (Fig. 1) was established in 1978 by the impoundment of Opa River which took its source from Oke Opa Hills. It has a catchment area of about 116 km^2 which is characterized by a rainy season of about eight months (March-October) and a dry season of about four months (November-February), a mean annual precipitation of 1000-1250 mm (Oguntoyinbo, 1982) and a mean annual temperature of about 27°C (Ndifon and Ukoli, 1989). The reservoir was primarily created to supply potable water to the university community.

The RFPs are located at the University Teaching and Research farm, about 4km from the central campus (Fig. 2). There are two ponds in the farm, here designated as Ponds A and B. Pond A was formed by the impoundment of Elerin and Omifunfun streams in 1967 (Adeniyi, 1971) while Pond B was established downstream of Pond A in 1981. The primary purpose of the ponds was to supply water for agricultural activities of the farm such as irrigation, fisheries, poultry and cattle watering.

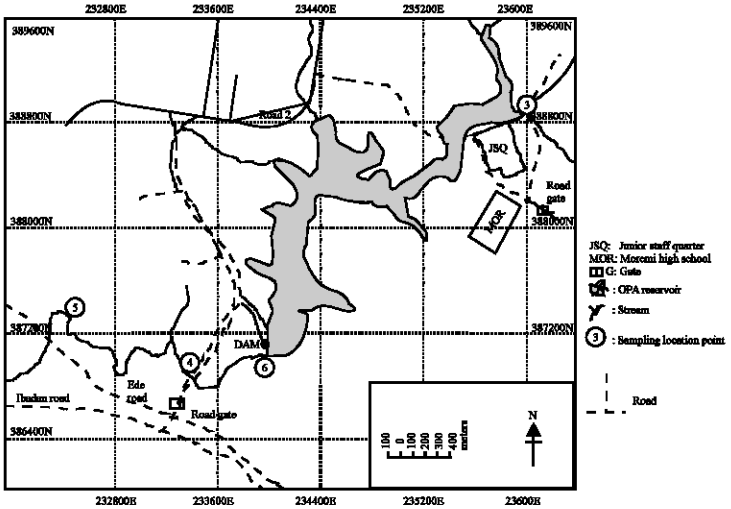

Fig. 1: Opa Reservoir at Obafemi Awolowo University, Ile-Ife showing the sampling points

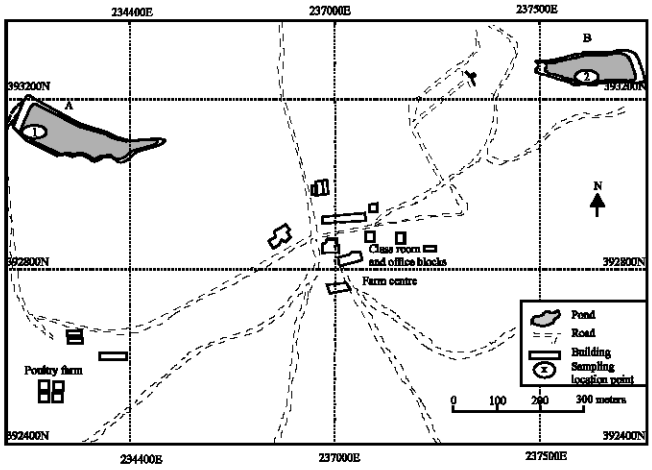

Fig. 2: Teaching and Research Farm Ponds at Obafemi Awolowo University, Ile-Ife showing the sampling points

Methods

Human Water Contact Patterns

Observations on human water contact patterns were made in six water contact sites in Opa Reservoir and Research Farm Ponds. Two of the sites (S1 and S2) were located on the ponds while the other four sites (S3, S4, S5, S6) were on the reservoir. All the sites were easily accessible although they varied in ecological characteristics including macrophyte coverage and characteristics of the substratum.

Each selected site for water contact studies was visited once every month for 12 months (July 2002-June 2003). Observation in each day for each site covered a period of 10 h (8:00-18:00 h). This amounts to 120 h of observation per site and 720 h of observation for all sites. During each observation, individual bio-data (sex, age), types of contact (i.e., activities performed), degree of contact (i.e. proportion of body immersed) and duration of contact (i.e., time expended) were taken. The various types of contact activities were categorised on the basis of the general purpose of contact. Thus personal contact (washing limbs, bathing), domestic contact (washing clothes and fetching), recreational (swimming and playing), religious (baptism) and economic (fishing, washing farm produce and tools). Degree of exposure was also categorised as partial (involving only parts of the lower or upper limb for a short period of time), limited (involving most parts of the lower or upper limb for a long period of time) and complete exposures (involving a total exposure for a long period of time).

Snail Study

Each of the six sites was sampled once every month for twelve months (July 2002-June 2003). Sampling in each site involved 30 passes of kitchen scoops supplemented by a manual search for 30 person- minute (WHO, 1985; Ofoezie, 1999). The scoops were attached to a 2 m pole and were usually dragged from the 2m-mark towards the researcher. The 30 passes were systematically thrown at about 1 m distance along the 25 m stretch of each site. Each scoop was thoroughly searched and all snails present collected and kept in pre-labelled plastic containers containing damp and decaying leaves. The containers were later covered with perforated lids and returned to the laboratory where they were sorted, identified to species according to Brown and Kristensen (1993) and Brown (1994) and counted to determine the number of each snail species collected per site per month. The potential intermediate host species of schistosomiasis were further examined for cercariae infestation by the crushing method (Teesdale *et al.*, 1986)

Statistical Analysis

Contingency tests were used to determine differences in the frequency of contact between sites, time of day, seasons and age groups. For differences in duration of contact, Mann Whitney test was used when testing for two groups while Kruskal-Wallis one way analysis of variance was used for factors with more than two levels (Siegel and Castellan, 1988).

Results

Human Water Contact Studies

General Pattern of Water Contact In OR and RFP

Water contact observations in the six sites covered a total of 43, 200 min during which 9 primary water contact activities involving 624 exposures for a total of 9,541 min were recorded (Table 1) The primary activities recorded included fetching, washing farm produce, washing farm tools, washing clothes, washing limbs, bathing, swimming and playing fishing and baptism. Mean duration of individnal contacts ranged from about 1 min of washing limb to more than 5 h of fishing (Table 1)

A breakdown of the 9,541 min of total contact showed that 1070 (11.2%) were spent on personal (i.e., washing limb, bathing), 752 (7.9%) on domestic (washing cloth and fetching) 1,736 (18.2%) on recreational (swimming and playing), 90 (0.9%) on religious (Baptism) and 5893 (61.8%) on economic (fishing, washing farm produce and tools) contacts.

Also 440 of the 624 overall contacts involved partial exposures for 1815 (19.0%) min, 121 involved limited exposures for 5313 (55.7%) min and 63 complete exposures for 2413 (25.3%) min. Although the combined frequency of limited and complete exposures was only 29.5% of the total observed contacts both accounted for 81% of the total duration. Also of the 624 contacts males made 419 (67%) for 7533 (79%) min and females made only 205 (33%) for 2008 (21%) min.

Variation in Human Water Contact Between Sites

The distribution of observed contacts among the various sites investigated is presented in Table 2. The pattern of water contact was highly dependent on relative proximity to human residence and the nature, accessibility and suitability of each site for human contact activities. The sites most frequently visited were the least covered by vegetation, less swampy or with gravel-covered bottom and easily very accessible.

Figure 3 shows the relative importance of personal, domestic, recreational, religious and economic contacts at the different sites. More than 3 in every 4 contacts were made in S3 (76.1%), which was also the most frequently visited site for nearly all types of contact activities. This site on OR is located at about 100 m away from the Junior Staff Quarters O.A.U., Ile-Ife. Farming activities were seen all round its bank. People going and coming from the farm were most times seen washing their limbs, clothes, farm produce and tools at the site. Children from nearby schools were found swimming after the school hours and during time off at school.

Fishing was the predominant activity in S2 and S4 and to a lesser extent in almost all other sites except S7 and S8. Baptism was observed only in S7, which was the site closest to the University gate.

Variation of Contact Behaviour by Age and Sex

Water contact behaviour in the sampling stations was clearly age and sex related (Table 3). Although both males and females of all age groups participated in most types of water contact activities, some were clearly sex dependent (Table 1). Generally, males significantly made more frequent contacts than females and the duration of contact is higher in males than in females ($p<0.05$).

The age related pattern of water contact is shown in Fig. 4. Generally, the rate of contact increases sharply from the first decade of life to peak in the second to fifth decade before declining to near zero in age group older than 60 years. People of age group 40-49 dominated personal and domestic activities, which involved partial exposure of the body while children of age group 10-19 dominated

Table 1: The relative importance of different types of water contact recorded at 6 water contact sites at Opa Reservoir and Research Farm Ponds, O.A.U, Ile-Ife (July 2002-June 2003)

	No. of contact			Duration of contact (min)		
Activity	M	F	Total	Min	Max	Total
Primary						
Fetching	89	8	97	1	5	170
Washing farm produce	26	67	93	1	59	1013
Washing cutlass	2	0	2	2	4	6
Washing cloth	1	7	8	10	150	582
Washing limb	226	104	330	1	5	987
Bathing	11	4	15	3	10	83
Swimming and playing	33	13	46	12	116	1736
Fishing	23	0	23	20	341	4874
Baptism	8	2	10	1	16	90
p-value			0.000[1]			0.000[4]
Total	419	205	624	1	341	9541
Purpose						
Personal	237	108	345	1	10	1070
Domestic	90	82	105	1	120	752
Recreational	33	8	46	3	116	1736
Religious	8	7	10	1	16	90
Economic	51	0	18	20	341	5893
p-value			0.000[2]			0.000[5]
Total	419	205	624	1	341	9541
Degree						
Partial	309	131	440	1	13	1815
Limited	64	57	121	4	341	5313
Complete	46	17	63	2	120	2413
p-value			0.000[3]			0.000[6]
Total	419	205	624	1	341	9541

Result of One sample Chi-square test for differences in frequency of contact, Kruskal-Wallis test differences in duration between the different activities 1. $\chi^2 = 1251$ df = 8, p = 0.000, 2. $\chi^2 = 396.2$, df = 4, p = 0.000, 3. $\chi^2 = 396.2$, df = 2, p = 0.000, 4. $\chi^2 = 334.7$, p = 0.000, 5. $\chi^2 = 167.5$, p = 0.0, 6. $\chi^2 = 165$, p = 0.000

Table 2: Number of water contact activities recorded at 6 sites on Opa Reservoir and Research Farm Ponds, O.A.U., Ile Ife (July 2002- June 2003)

	No. of contact							
Activity	S1	S2	S3	S4	S5	S6	Total	% of overall
Fetching	1.0	0.0	13.0	2.0	81.0	0.0	97	15.5
Washing farm produce	0.0	0.0	92.0	0.0	1.0	0.0	93	14.9
Washing cutlass	0.0	0.0	2.0	0.0	0.0	0.0	2	0.3
Washing cloth	0.0	0.0	3.0	1.0	4.0	0.0	8	1.3
Washing limb	0.0	0.0	320.0	7.0	3.0	0.0	330	52.9
Bathing	0.0	0.0	12.0	0.0	3.0	0.0	15	2.4
Swimming	0.0	0.0	32.0	12.0	0.0	0.0	44	7.1
Playing	0.0	0.0	0.0	2.0	0.0	0.0	2	0.3
Fishing	6.0	3.0	1.0	0.0	0.0	13.0	23	3.7
Baptism	0.0	0.0	0.0	10.0	0.0	0.0	10	1.6
Total	7.0	3.0	475.0	34.0	92.0	13.0	624	100.0
% overall contact	1.1	0.5	76.1	5.5	14.7	2.1	100	

Result of contingency test on differences in the frequency of the various activities between the 2 sites at RFPs, $\chi^2 = 0.476$, df = 1, p = 0.490, 4 sites at OR, $\chi^2 = 1259.4$, df = 24, p = 0.000, all the 6 water contact sites $\chi^2 = 1270.2$, df = 40, p = 0.000

recreational which involved total exposure of the body. Although, both children and adult are involved in economic activities, which involved longest stay in water, young adult of age group 20-29 dominated these activities.

Daily and Seasonal Pattern of Water Contact

The hourly variation in number and duration (minutes) of water contacts from 8.00 am to 6.00 pm are presented in Table 4. The data reveal a unimodal trend in frequency and duration of contacts with maxima at 11-12, for frequency and 8-9, for duration. The 11-12 peak for frequency

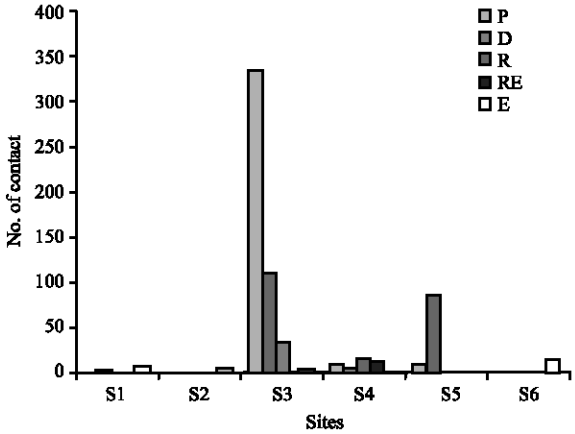

Fig. 3: Frequency of personal, domestic, recreational, religious and economic water contact activities by site at Opa Reservoir and Research Farm Ponds at Obafemi Awolowo University, Ile-Ife (July 2002-June 2003)

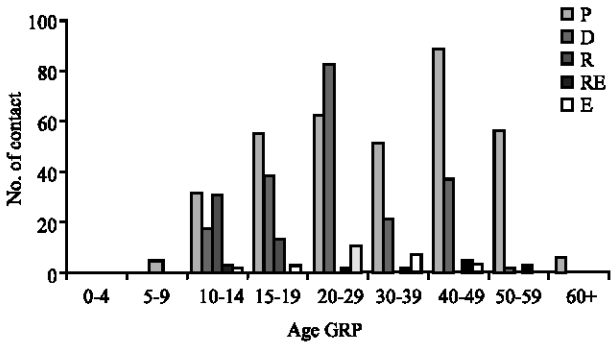

Fig. 4: Frequency of personal, domestic, recreational, religious and economic water contact activities by age at six sites on Opa Reservoir and Research Farm Ponds at Obafemi Awolowo University, Ile-Ife (July 2002-June 2003)

Table 3: Age and Sex related pattern of human water contact at Opa Reservoir and Research Farm Ponds, O.A.U., Ile-Ife (July 2002- June 2003)

	Total contacts			Total duration		
Age GRP	M	F	Total	M	F	Total
0-4	0	1	1	0	6	6
5-9	0	1	1	0	5	5
10-14	38	14	52	815	340	1155
15-19	62	34	96	1433	583	2016
20-29	119	23	142	3402	301	3703
30-39	88	47	135	586	224	810
40-49	89	72	161	1203	494	1697
50-59	17	13	30	68	55	2123
60+	6	0	6	26	0	26
p-value		0.000		0.000		
Total	419	205	624	7533	2008	9541

Result of contingency test for differences in frequency of contact, Mann-Whitney test for differences in duration between males and females 1. $\chi^2 = 38.0$, df = 8, p = 0.000, 2. Z = -3.5, p = 0.000

involved mainly people returning from the farms. This peak however is site-specific primarily taking place in site 3, the only site close to farms. The 8-9 major peak for duration involved fishing activities in sites 1, 2 and 6. Contingency test shows that there are significant differences in frequency of contact and duration between the different hours of the day.

Table 4: Variation in the pattern of human water contact between 8:00 am and 6:00 pm at Opa Reservoir and Research Farm Ponds, O.A.U., Ile-Ife (July 2002-June 2003)

Time of day	Total contacts	Total duration
8-9	52	3406
9-10	79	1958
10-11	89	1285
11-12	117	1450
12-13	87	582
13-14	70	393
14-15	49	262
1516	33	89
16-17	38	100
17-18	10	26
p-value	0.000	0.000
Total	624	9541

Results of contingency test for differences in frequency of contact, Kruskal-Wallis test for differences in duration of contact among the various hours of the day at Opa Reservoir and Research Farm Ponds at Obafemi Awolowo University, Ile-Ife Total contact $\chi^2 = 251.8$, df = 81, p = 0.000, Total duration $\chi^2 = 38.134$, p = 0.000

Table 5: Monthly variations in water contact pattern at 6 sites on Opa Reservoir and Research Farm Ponds, O.A.U., Ile-Ife (July 2002-June 2003)

Months	Total contacts	Total duration
Jul	64	1008
Aug	78	2184
Sep	83	1210
Oct	74	1709
Nov	43	137
Dec	28	196
Jan	42	180
Feb	27	161
Mar	22	105
Apr	59	531
May	45	344
Jun	59	1257
p-value	0.000	0.000
Total	624	9541

Result of contingency test for differences in frequency of contact, Kruskal-Wallis test for differences in duration of contact among the different month of observation 1. $\chi^2 = 291.3$, df = 99, p = 0.000, 2. $\chi^2 = 34.5$, p = 0.000

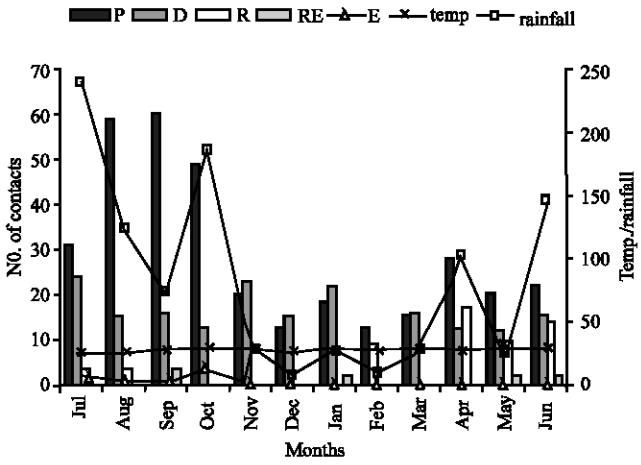

Fig. 5: Frequency of personal, domestic, recreational, religious and economic water contact activities at six sites in Opa Reservoir and Research Farm Ponds in relation to seasonal variation in temperature and rainfall at Obafemi Awolowo University, Ile-Ife (July 2002-June 2003)

Table 6: Density (number infected with *Schistosoma*) of snails in six sites at Opa Reservoir and Research Farm Ponds at Obafemi Awolowo University, Ile-Ife (July 2002-June 2003)

Snail species	S1	S2	S3	S4	S5	S6	Total
Bulinus globosus	0	0	90(3)	1(0)	2(0)	0	93(3)
Bulinus truncatus	12(0)	1(0)	0	0	0	5(0)	18(0)
Bulinus forskalii	1(0)	0	0	0	0	1(0)	2(0)
Biomphalaria pfeifferi	94(0)	4(0)	0	0	4(0)	15(0)	117(0)
Potadoma moerchi	1275	51	0	0	0	0	1326
Potadoma freethi	0	0	93	0	3	0	96
Melanoides tuberculata	0	0	4	227	351	2048	2720
Lanistes libycus	0	0	20	10	4	0	34
Gyraulus costulatus	0	0	1	0	1	0	2
Total	1402(0)	56(0)	208(3)	238(0)	365(0)	2069(0)	4338(3)

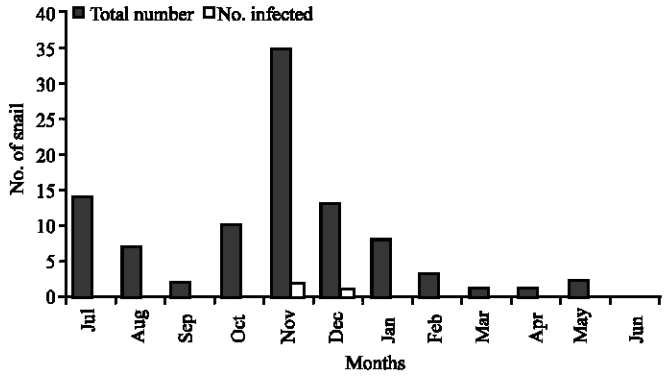

Fig. 6: Monthly variation in number of *B. globosus* collected and infected with *Schistosoma* in site 3 in Opa Reservoir at Obafemi Awolowo University, Ile-Ife (July 2002-June 2003)

Water contact pattern in the six sampling stations are also highly seasonal (Table 5). More contacts were observed in the rainy season than in the dry season. Frequency and duration of contact varied significantly between the seasons and between months. The highest number of contacts was observed in September while the lowest occurred in March. The longest duration was recorded in August and the shortest in March.

Figure 5 shows the frequency of personal, domestic, recreational, religious and economic exposures in relation to mean temperature and mean rainfall during each of the twelve months of study. Generally, water contacts are higher in the rainy season than in the dry season. Economic activities were seen only in the rainy season. Peak personal activities occurred in the rainy season but peak domestic activities occurred in the dry season Recreational contacts were mostly seen in the rainy season when water level is high while religious activities were comparable for both seasons. Comparatively, the frequencies of all types of contact are linked to rainfall rather than to temperature pattern. For instance, the number of personal contact increased as the amount of rainfall increases while no clear relationship was observed between temperature regime and pattern of contacts.

Snail Study

The density of snails per site and (number infected) is presented in Table 6. In all, nine species of snails were collected in the reservoir and the ponds during this study. Eight of the nine species were found in the reservoir while only four were found in the ponds. Of these, only four are believed to be potential intermediate host of schistosomiasis. They are *Biomphalaria pfeifferi*, *Bulinus globosus*, *B. truncatus* and *B. forskalii* and were the only species shed for *Schistosoma* infection. Brevifurcate

apharyngeate distome cercaria with no eyespot is confirmatory of the presence of infection with *Schistosoma.* Among these, only *B. globosus* was found with infection and this is site-specific being found only in S3 and in November and December of 2002 (Fig. 6).

Discussion

Various studies investigated in area where schistosomiasis is endemic have revealed different patterns of water contact, reflecting different patterns of life and different characteristics of available water bodies (Farooq and Mallah, 1966; Dalton, 1976; Dalton and Pole, 1978; Husting, 1983; Kvalsvig and Schutte, 1986; Chandiwana, 1987, Ofoezie *et al*., 1988). Water contact activities observed in the reservoir were more diverse than in the ponds. The frequency and duration of contact were observed to be generally higher in the reservoir than the ponds because the reservoir is closer to human residence than the ponds and therefore more easily accessible. Swimming and fishing were the most intense activities involving total exposure for long periods of time and are therefore adjudged as risky contacts. This agrees with the work of Ofoezie *et al*. (1998) in two resettlement villages bordering Oyan Reservoir, in Nigeria.

Water contact pattern in this study area is age and sex related. In earlier studies, it was reported that females made more contact with water (Tayo and Jewsbury, 1978; Ofoezie *et al*., 1998) however, in this study, male dominated most contact activities in terms of frequency and duration suggesting a higher tendency of infection among males in this study area. This is because most risky contacts in this study area were either economic or recreational in which more males were involved (Tayo *et al*., 1980). The result of this study is in agreement with most other studies in that teenagers and young adults of age group 20-29 made most risky contacts (Jobin and Ruiz-Tiben, 1968; Dalton and Pole, 1978; Ofoezie *et al*., 1998) and are therefore expected to be more infected.

In the snail study, although four potential intermediate host species were found: *B. globosus* and *B. truncatus* which transmit *S. haematobium* (Doumenge *et al*., 1987; Ofoezie, 1997), *B. pfeifferi* transmits *S. mansoni* (Adewunmi *et al*., 1990) and *B. forskalii* probably transmits *S. intercalatum* (Arene *et al*., 1989), only *B. globosus* was found with human *Schistosoma* cercariae in November and December 2002. It is interesting to note that these infected snails were found only in S3 where 76.1% of all contacts were taking place. This implies that people returning from their farms and children from nearby schools who visit the water body stand a chance of contracting *S. haematobium* infection when they wade unprotected. A study of the circadian pattern in cercarial production has shown several variations in cercariae emission but with peak in the illuminated period of the life cycle (Theron, 1984) and this corresponds with the period of peak water contact in most endemic areas (Chandiwana *et al*., 1991; Jordan and Webbe, 1993; Ofoezie *et al*., 1998). Moreover, each species of *Schistosoma* in each locality has been reported to have a daily rhythm of cercariae emission which is often correlated with the period of the activity of the host that are most favourable to successful infection (Theron, 1986, Okulate and Ogbe, 1993).Although this study did not include shedding pattern, peak water contact occurred between the early hours of the day and noon suggesting a pattern of shedding with peak about noon. This however requires further investigation. However, the relationship between infection and human water contact pattern has been demonstrated to be very complex (Gryseels *et al*., 1994).

Adewunmi *et al*. (1990) had reported that *S. mansoni* was transmitted in the Opa dam but no infection was found in specimen of *B. pfeifferi* collected during this study. This also suggests that there may not be transmission of intestinal schistosomiasis in this area at the moment. This may be that the control strategy adopted with the use of *Tetrapleura tetraptera* has started yielding results for *B. pfeifferi* (Adewunmi *et al*., 1990) or that the rate at which *S. mansoni* eggs reach water bodies in this area has reduced drastically since children swimming and playing were found urinating but not defecating during this study.

Since most risky contacts in this area were either recreational or economic, which may not be affected by provision of safe water supply, it is advised that focal molluscicide should be adopted in this area especially in site 3 where infected snails were found. Also, children from nearby schools who are mostly involved in recreational activities should be health educated on the role of swimming and playing in water on the transmission of the disease and this could lead to positive modification in their attitude to recreation.

In conclusion, this study has therefore observed that transmission of urinary schistosomiasis is going on in Opa reservoir and has identified the tributary stream of Opa reservoir at the Junior Staff Quarters of the University as a transmission site of the disease in the study area. It has also identified swimming and fishing as the most risky contacts in this study area. It is therefore imperative that studies on human infection should be conducted to ascertain the current level of human infection in this study area so as to help in the mitigation measures against this disease.

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