Techniques for estimating densities of *Bulinus truncatus rohlfsi* and its horizontal distribution in Volta Lake, Ghana

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Bulinus truncatus rohlfsi *is the intermediate host of urinary schistosomiasis, which is highly endemic in the man-made Volta Lake. In 1971, a WHO/UNDP schistosomiasis project was established in the Pawmpawm branch and part of the Afram branch of Volta Lake. Malacological findings of the preliminary phase indicated that the snails were distributed in the littoral zone of the lake, and that this distribution was correlated with the presence of vegetation, especially* Ceratophyllum. *Transmission nearly always occurred in "water contact sites", i.e., places where people come into contact with water.*

A snail-sampling technique with palm-leaf mats was developed and standardized after it had been shown in sensitivity trials to compare favourably with a modified version of the "man–time" sampling method, in which the number of snails collected per man-hour is recorded. It is recommended that both these methods should be used to conduct ecological studies of B. rohlfsi *in water contact sites.*

In biological studies of schistosomiasis in Lake Volta, it was necessary to obtain precise data on the numbers and the distribution of *Bulinus truncatus rohlfsi*, the intermediate host of *Schistosoma haematobium*.

The selection of a snail-sampling method depends on the objectives of the study, the circumstances in which the work is carried out, the nature of the habitat, and the resources available (*2*). A WHO/UNDP schistosomiasis project was established on the Pawmpawm branch of Volta Lake to study the epidemiology and methods of schistosomiasis control in man-made lakes. The study of the snail *B. rohlfsi* in its natural habitat was considered of immediate importance. Odei (*4*) made some preliminary observations on the distribution of bilharzia host snails in Volta Lake and found *B. rohlfsi* to be widely distributed.

Before the final selection of a snail-sampling method, the horizontal distribution of the snail in the lake was investigated by means of a survey.

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HORIZONTAL DISTRIBUTION OF *B. ROHLFSI*

The survey on horizontal dispersion covered the littoral and limnetic zones in the Pawmpawm branch of Lake Volta.

Shallow water along the shore

Snails in this ecological zone were first collected by using dip-nets or long forceps to pick up vegetation. *B. rohlfsi* specimens and other snails were found with these techniques. It soon became clear that snail abundance was focal, related to the presence and type of vegetation. Most of the snails were found on *Ceratophyllum demersum*, but large numbers were also found attached to the under surface of decayed palm fronds. Fewer snails were collected from leaves, stems, and roots of other plants, such as *Polygonum senegalense* and *Ludwigia (Jussiaea)*.

Bottom substrates without vegetation in deeper water

This snail survey work was carried out in early May 1972 with an Ekman grab and an Emery dredge operated from a motorboat. Zones stretching into the limnion along five villages were selected, since the littoral regions there were already known to be

infested with snails. Approximately 700 substrate samples was taken at a depth of 1–7 m. They contained mainly decayed twigs, silt, and mud. Only one snail was found, and that at a depth of 1 m. Close to where this specimen was collected, more snails were found on *Ceratophyllum* closer to the shoreline.

Bottom substrates with Ceratophyllum

Snails were collected with palm-leaf mats at bottom depths down to 2.5–3.0 m where *Ceratophyllum* was present.

The above-mentioned surveys revealed that *B. rohlfsi* infests the littoral zone of the lake.

SNAIL-SAMPLING TECHNIQUES

Once the horizontal distribution of *B. rohlfsi* was established, it was necessary to select or develop snail-sampling techniques that would be sensitive and standardized. Hairston et al. (*2*), in an evaluation of techniques for estimating snail populations, pointed out that it was difficult to establish a uniform technique applicable to all situations for the quantitative study of schistosomiasis vector snail populations, for ecological research, for the study of transmission potential, and for snail control evaluation.

The Volta Lake water level changes from month to month, as do the snail habitats, which differ from one another with respect to depth, nature of the bottom substrate, and amount and type of weed. Few of the sampling techniques available (*2*) could be considered suitable for our purposes. The possibility was considered of collecting population data by recording the number of snails collected per man per minute with a standard collecting instrument and procedure in a marked area (*6*). But owing to monthly ecological changes it is difficult to mark a definite area for sampling. Furthermore, in one month a given area might be devoid of weeds and snails and might take 5 minutes to search, whereas in another month the search might take several hours. Odei (*4*) modified the method by recording the number of snails collected per man-hour (" man–time " sampling method).

Rationale of using palm mats

Initial findings showed that some snails were found attached to decaying palm fronds in various littoral zones along the lake shore. Palm trees are abundant in the study area. Since palm-leaf traps have long been successfully used in the Eastern Mediterranean region (*1*, *7*) and in Algeria (*3*) for qualitative assays of aquatic snails, we thought we could develop a similar technique for quantitative sampling in this project. Thus, one might be able to collect snails consistently from a variety of habitats, even those shifting as a result of water fluctuation, if one placed standardized collecting surfaces in the water, left them there for a time, and then recorded the number and size of snails that anchored themselves to the surfaces. The area sampled would always be the same, the duration of collection could be standardized, snails of all sizes would be collectable, and the mat surfaces could be placed in essentially any type of habitat.

Loss rate of palm mats in the field

Fresh and decayed palm leaves, compared for efficiency in attracting snails, gave equally good results. However, for convenience, fresh palm leaves were used thereafter.

Trials were performed to test the loss rate of mats per day for up to 11 days of exposure in field sites. Findings revealed that the loss rate increased with exposure time, but within an exposure period of 3 days the rate of loss, usually due to string breakage or float detachment, would not normally exceed 10%.

Exposure time

Palm mats were made of fresh leaves woven within a frame 43×43 cm. Four different habitats were selected. The first was a semi-protected pocket full of dense *Ceratophyllum* in a water depth of 0.5–1 m. Ten mats were placed on top of this weed growth at various locations. The second habitat was a shallow open beach with only a small amount of *Ceratophyllum* scattered on the bottom. The same number of mats were sunk in a parallel line 2 m from the shoreline. The third location was in an area 2 m deep, bordered with floating masses of grass. Within this habitat ten mats were positioned at least one metre apart, just beneath the water surface on roots of vegetation in a line running parallel to the shore.

The first three sampling runs took place at low water level in 1972. The final habitat sampled was at the same location as the second habitat, though at the high-water season of 1972, when it was dotted with *Polygonum* and *Sacciolepsis* beyond a broad, solid, shoreline mass of *Polygonum*. In water 1–2 m deep, 30 mats in 3 rows of 10 were sunk to the bottom of the lake. The inner row was situated along the base of the *Polygonum* " fence "; the central row

in medium depth parallel to the first row; and the last row in the outer margin of the sparse vegetation in deeper water. The distance between mats was 5 m.

Collection of snails

In all four studies, the daily retrieval procedure was the same: the mats were collected, the number of attached snails counted, and the mats returned to their previous sites without removing the snails.

Table 1. Daily number of snails found clinging to the palm mats in a *Ceratophyllum* pocket

Exposure (days)	Mat No.										
	1	2	3	4	5	6	7	8	9	10	Total
1	0	3	2	12	0	5	2	5	2	0	31
2	4	2	9	21	6	7	3	14	7	4	77
3	13	7	9	16	3	13	1	20	6	4	93
4	33	10	9	16	33	19	3	17	7	2	149

Table 2. Daily number of snails found clinging to the palm mats on a shallow open beach

Exposure (days)	Mat No.										
	1	2	3	4	5	6	7	8	9	10	Total
1	0	3	1	0	0	0	0	0	0	0	4
2	0	3	0	0	0	0	0	1	0	0	4
3	0	3	5	1	0	0	0	2	0	0	11
4	0	5	2	1	0	0	0	1	0	0	9

Table 3. Daily number of snails found clinging to the palm mats placed on the roots of floating vegetation in a deep habitat

Exposure (days)	Mat No.										
	1	2	3	4	5	6	7	8	9	10	Total
1	1	0	1	0	1	0	1	2	1	1	8
2	5	3	1	0	1	0	1	1	1	4	17
3	3	1	2	1	2	2	2	2	0	2	17
4	4	1	1	2	2	1	0	2	2	2	17

Table 4. Daily number of snails found clinging to the palm mats placed at the bottom of an open beach at high water level

Row of mats	Exposure (days)	Mat No.										
		1	2	3	4	5	6	7	8	9	10	Total
inner	1	–[a]	2	1	4	2	L[b]	4	–[a]	0	6	19
	2	–[a]	0	0	4	1	L[b]	3	–[a]	4	2	14
	3	1	1	0	2	L[b]	L[b]	2	3	3	3	15
central	1	L[b]	7	0	2	5	4	4	0	12	6	40
	2	L[b]	5	0	1	3	3	1	0	2	2	17
	3	L[b]	2	9	2	2	1	1	0	3	3	23
outer	1	0	0	–[a]	0	0	0	0	1	0	1	2
	2	0	0	1	0	0	0	1	1	11	4	18
	3	0	0	1	0	1	0	2	1	11	3	19

[a] Temporarily lost.
[b] Permanently lost.

Only snails attached on the last day were collected and brought back to the laboratory for determination of infection. The results of this work are presented in Tables 1, 2, 3, and 4.

In the first habitat with floating *Ceratophyllum*, where snail density was high, the number of snails clinging to the mats increased with exposure time. In the second habitat, the highest snail catch was obtained on days 2, 3, and 4, while, in the third habitat, the catch was the highest on the second day. In the fourth habitat, both the inner and central rows yielded the highest snail catches after the first day of exposure, while the outer row produced the greatest number of snails after 2–3 days. It is possible that in all sites except in the presence of high densities of *Ceratophyllum* the palm traps attracted the entire population in the zone of influence within the first few days. Thus no further increases occurred. But where *Ceratophyllum* was dense, and snail populations very large, the maximum possible retrieval was not reached. It was therefore decided that a 2-day exposure period should be the standard time interval for all subsequent snail sampling operations.

Snail holding power on mats

It was observed in the previous experiments that snails were occasionally dislodged and lost in the process of retrieving the mats. Further experiments

were subsequently conducted to determine the extent of such losses.

In varying water depths, mats to which a given number of snails were clinging were then individually lowered and raised in one continuous operation. In water 1–2 m deep, snail loss was as great as 30%. In shallow water, the loss rate was less.

These results clearly showed that, in any sampling operation with palm-leaf mats, some snails are likely to become dislodged as they are lifted out of the water. Careful handling of mats is therefore required during such recovery work.

Comparison of palm-mat and man–time methods

The palm-mat method is described above. The modified man–time method involved the collection of snails during a given period by a given number of persons using a dip-net, long 48-cm forceps, a pair of rubber gloves, and a small snail-specimen container. Searches were conducted either on foot or from a canoe. The findings of the two methods are shown in Table 5.

On a time basis, the palm-mat method allowed more snails to be collected than the man–time technique in all four habitats sampled. This was especially the case in the open beach habitat of deeper water. There, the snails possibly lived at the bottom of the lake, attaching themselves to leaves, stems, and roots during that season, so that the dip-nets could not properly reach the bottom substrate where the vegetation was anchored. Therefore, the snail catch was much lower by the man–time method. In shallower waters, the man–time technique yielded snails on fresh or decayed leaves of plants other than *Ceratophyllum*.

Standardization of palm mats for snail sampling

Palm mats of different sizes were tried and finally standardized. A standardized mat was a square 0.18 m² in area, constructed as follows. Ribs of fresh palm fronds were cut into sections 42.5 cm long and stored until dry. Four sections were joined to make a square frame, secured by metal wires through holes drilled in the fronds. Nylon cord was strung in seven paralled lines between two opposite sides of the drilled frame. One day before use, fresh palm leaves about 43 cm long were interwoven parallel to each other through the nylon cords within the frame. On each of two opposite side, a stone was fixed as a sinker. An expanded-polystyrene float was attached with a nylon string to the centre of the finished mat. The length of this string varied with the depth at which the mat was placed in the water.

Palm mats were placed in three basic positions: (1) anchored to the bottom substrate and vegetation; (2) secured to floating masses of vegetation; and

Table 5. Results of snail sampling with palm mats and the man–time method in four habitats

Habitat	1	2	3	4
snail habitat	open beach	pocket	pocket	pocket
vegetation	p[a] + S[b]	P + S	P + T[c]	P + Sr[d]
depth (m)	1–2.5	0–1.3	0–1	0–1
area examined (m²)	500	300	250	240
Palm-mat method				
No. of mats used	30	30	20	30
exposure (days)	2	2	2	2
No. of snails collected	61	15	5	6
Man–time method				
No. of persons	3	3	3	3
time consumed per person (min)	60	60	50	30
No. of snails collected	12	14	3	3

[a] *Polygonum*.
[b] *Sacciolepsis*.
[c] *Typha*.
[d] Sorghum (wild).

(3) placed directly on top of *Ceratophyllum*, thus floating slightly below the water surface. The mats were carefully lifted from the water by hand one by one at the end of the two-day exposure period. In deep water and at periods of high water level the operation was conducted from a canoe.

Trials of palm mats in water contact sites

Previous trials had been conducted at sites away from human activities and all snails recovered were found to be negative for schistosome infection.

Human activities connected with water took place mainly at lake shore sites (referred to in this paper as " water contact sites "). Because lake water levels change from month to month, the ecological conditions of water contact sites are also subject to change. Trials of palm-mat sampling at these sites were therefore deemed necessary. Sampling was carried out from November 1972 to February 1973. In November and December, 4 out of 54 snails captured from the main water contact sites of Asakeso were found to be infected with schistosome cercariae.

Table 6. Summarized infection rates of snails collected at five villages, January and February 1973 [a]

Village	Month	Water contact site No.				
		I	II	III	IV	V
Poakwe Pawm-pawmnya	Jan.	0	0	0/26	2/7	0/1
	Feb.	0	0	0/1	0/15	0
Fatem	Jan.	0/1	0	0	0/1	
	Feb.	0	0	0	0	
Kasa	Jan.	0/2	0/2	0/1		
	Feb.	0/11	0/2	0		
Kuma Kuma	Jan.	0/4	0/2	2/20	0/13	
	Feb.	2/16	0/3	0/3	0/6	
Akotui West	Jan.	5/54	3/14	13/15		
	Feb.	11/54	2/16	1/23		

[a] Numerator = snails infected with mature *S. haematobium* cercariae; denominator = No. of snails collected.

The results of the January and February trials are presented in Table 6. The findings indicated that infected snails occur only in water contact sites.

DISCUSSION

The results of this study indicate that *B. rohlfsi* are distributed along the shore of Volta Lake and that their abundance is closely related to that of the weeds growing there. The latter finding agrees with the observations of Odei (*5*) who recovered snails that had attached themselves to the aquatic weed *Ceratophyllum* at a depth of 4 m. With the palm-mat method, we recovered snails from *Ceratophyllum* at a depth of 3 m.

While the water level was high, the lake shore was densely overgrown with vegetation and the only access to and from the lake was the water contact sites. Since human contact with water was therefore limited, transmission was concentrated at those sites. When the water level was low, the lake was accessible mostly at open beaches, where snail density is low and human contamination diffuse. Therefore, transmission also is low and diffuse. The findings of the present study and of work carried out subsequently (R. K. Klumpp & K. Y. Chu, unpublished data) showed that infected snails were found at water contact sites but rarely elsewhere along the shore. These data also confirmed the findings of H. Paperna (unpublished observations, 1967), who classified the lake shore as an undisturbed unpopulated area and the shoreline as an area populated by fishermen. He reported that, in the former, schistosome-infected snails were rarely found, whereas, in the latter, infected snails could be collected. Thus the transmission of urinary schistosomiasis in the lake appears to be essentially focal, occurring at sites of human contact with water. At such sites, we were able to carry out snail sampling with the palm-mat and modified man–time methods. The former yielded results that were more objective and sensitive, but it was less economical than the latter. Furthermore, the palm-mat method failed to detect the breeding seasons and weed preferences of snails.

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RÉSUMÉ

TECHNIQUES D'ÉVALUATION DES DENSITÉS DE *BULINUS TRUNCATUS ROHLFSI* ET DISTRIBUTION HORIZONTALE DE CE MOLLUSQUE DANS LE LAC VOLTA

Des mollusques ont été trouvés dans la zone littorale du lac, leur densité étant en relation étroite avec la présence de végétation. Ils étaient extrêmement rares dans les substrats au fond des eaux profondes en l'absence de végétation, mais on trouvait des mollusques jusqu'à une profondeur de 3 m là où poussait *Ceratophyllum*.

Une technique d'échantillonnage des mollusques à l'aide de nattes de feuilles de palmier a été mise au point. On a étudié le taux de perte par natte, le temps d'exposition dans l'eau, et la capacité des mollusques de se retenir aux nattes. La méthode d'échantillonnage a été standardisée, avec un temps d'exposition de deux jours, et elle a été comparée à une méthode dans laquelle on enregistrait le nombre de mollusques recueillis par homme-heure.

On a effectué des essais de l'échantillonnage au moyen de nattes de feuilles de palmier en des points où il y avait contact entre l'homme et l'eau. Des mollusques infectés ont été trouvés exclusivement dans ces endroits et non dans d'autres secteurs du lac.

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