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The Effect of Snail Surveillance IN NATURAL WATERWAYS ON THE TRANSMISSION OF SCHISTOSOMA HAEMATOBIIUM IN RHODESIA

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Snail control as a means of limiting the transmission of bilharziasis has been strongly supported by various committees of experts appointed by the World Health Organisation during the past few years, and the importance of molluscicides in achieving this has been reiterated (W.H.O., 1961, 1965a, 1965b). On the other hand, others (Pitchford, 1966) doubt the efficacy of snail control as a means of reducing transmission of schistosome parasites. It must be admitted, however, that until recently only scant evidence has been available that snail control will, in fact, reduce the incidence of bilharziasis in a human population. This is based on data mentioned in a W.H.O. report on molluscicides (1961) taken from the Warraq el Arab project in Egypt, where the percentage infestation in school children in 1954, before snail control, was compared with the situation in 1957, after three years of snail control. The results showed an overall reduction of both *Schistosoma haematobium* and *S. mansoni* in the age groups tested. However, numbers examined are not given and this does detract somewhat from the value of the data. Even the monograph entitled "Snail control in the prevention of bilharziasis" which was published by the World Health Organisation in 1965 does not provide any evidence as to the efficacy of the method. Nevertheless, it must be remembered that this type of evidence can only be obtained over a period of years and that few organisations in Africa could establish the continuity necessary to undertake such long-term research. However, preliminary data have been furnished indicating the potential success which can be expected using the system of snail control

described as snail surveillance (Clarke *et al.*, 1961; Clarke, 1964, 1966).

Essentially the problem of bilharziasis is an ecological one. Any association between an animal and its environment must lead to some form of stability, to an ecological balance in which the factors which influence mortality do not outweigh the capacity for increase, and vice versa. The natural tendency is towards harmony. This is equally true with regard to parasites, for it is of little survival value for a parasite to kill or incapacitate its host to a point where the host can no longer provide a satisfactory milieu for the parasite. With regard to the schistosomes, the recent history of agricultural development in Africa, the settling of the population and its subsequent increase, has caused an upset in this natural balance. In the past, permanent waterbodies were very sparse; most rivers were essentially seasonal in flow, with high floods in the rainy season followed by prolonged periods of drought. Thus a succession of flood and desiccation were the natural catastrophies to which an aquatic organism was exposed annually, and these factors influenced the distribution of the aquatic snails which serve as intermediate hosts for the schistosomes.

More recently, especially in Southern Africa, soil conservation and good farming practices have tended to cause a stabilisation of water flow in rivers. Dams have been constructed on a large scale. In Rhodesia, during the period 1950-1960, many thousands of small conservation dams were built and this has caused a major change to the general hydrological picture. Many rivers now carry water perennially and are not subject to excessive flooding. In the relatively stable waterbodies now formed there has been an overall increase in the populations of the medically important snails. These, in association with concentrations of human beings, have upset the ecological balances and led to a massive increase in the transmission of bilharziasis.

In Rhodesia the approach to the control of bilharziasis has been directed towards correcting this imbalance by concentrating effort on snail surveillance in order to reduce the snail population in natural waterbodies and reservoirs.

Snail surveillance entails the use of molluscicides in an orderly and controlled manner. There is no indiscriminate application of chemical to waterbodies, but only foci of snail populations are treated where they are found to occur. In this way there is very little interference with the freshwater biota which is, in any case, extremely resilient to any localised toxicity.

Studies have been made on the short-term (Shiff and Garnett, 1961; Shiff, 1966) and long-term (Harrison and Rattray, 1966) effects of snail surveillance and show that, apart from the disappearance of medically important snails, no permanent changes are noticeable within the biotope.

THE TECHNIQUE OF SNAIL SURVEILLANCE

Initial snail control experiments were carried out in Rhodesia by Blair and Alves as early as 1946, but expansion did not take place until the period 1958-1960, when Clarke and others (1961) introduced the method of snail surveillance. This forms the basis for present control measures which today extend over some 4,200 square miles of territory, comprising natural waterways, dams and major irrigation schemes.

Under snail surveillance the area is mapped and the location of all waterbodies is marked. The field officer in charge of the area must then get to know these waterbodies. (By field officer is meant a technician who has received, in service, training in aspects of snail ecology and in methods of snail surveillance and molluscicide application.) In order to reduce the overall snail population all the waterbodies are then blanket sprayed with a suspension of molluscicide, using either a stirrup pump or knapsack sprayer to effect complete surface coverage of the water. After completion of this, the second phase of surveillance is initiated. Teams of two snail rangers examine all waterbodies on a six-week cycle, the planning and supervision of which is the responsibility of the locally stationed field officer. Surveillance entails a detailed examination of waterbodies and is done by means of a scoop (Fig. 1) designed to assist in the detection of snails. Each surveillance team is equipped with spraying apparatus and molluscicide, and whenever any persisting foci of snails are found, the waterbody immediately surrounding them is treated. Surveillance on natural watercourses is carried out throughout the year, although for obvious reasons effective spraying cannot be carried out at the height of the rains.

Dams and large pools in rivers are sprayed while still full or nearly full during autumn and winter. At this time both species of intermediate

host snail lay few eggs and have a low capacity for increase (Shiff, 1964; Shiff and Garnett, 1967). This renders the populations particularly vulnerable to molluscicidal attack. The actual spraying of these larger waterbodies is undertaken by the field officers using motorised spraying apparatus operating from a boat. The officers are expected to cover all dams in their area at least once a year, and apart from this they must ensure that the rangers are carrying out snail surveillance in a satisfactory manner.

Each field officer controls a team of up to five pairs of rangers, and this unit can cope with an area of 400-600 square miles, depending on the terrain and the amount of water impounded in dams. The Norton-Selous Intensive Conservation Area is typical of the Rhodesian highveld and contains 158 dams of various sizes up to approximately 50-million gallon capacity; 650 miles of minor watercourses, 60 miles of perennial river and 55 miles of major river. The breakdown of cost to treat such an area on an annual basis is as follows: salaries and labour, £2,275; transport, £524; molluscicide, £1,258; extras, £475; making a total of £4,532 per annum. It is impossible to relate this to the number of people protected because the majority of them are not settled in the area, but merely work there. Furthermore, it is not feasible to relate it to the amount of water in the area as this is extremely difficult to judge objectively. The only practical way to relate cost and work is to assume that the area under consideration is average for

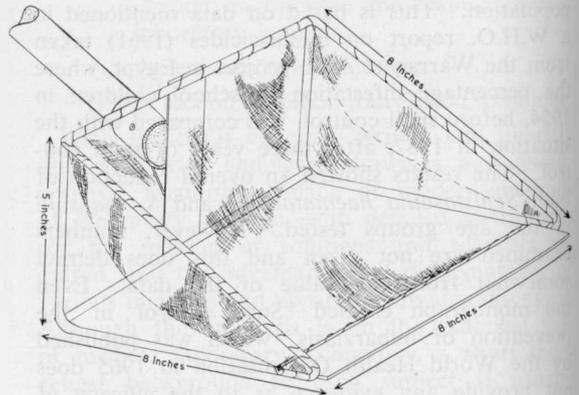


Fig. 1—Snail collecting scoop as used by field teams in Rhodesia. The shaft is 1 in. wood dowling and the frame is made of $\frac{1}{4}$ in. mild steel rod. The handle shaft is screwed into a 1 in. pipe fitting which is welded on to a 1 in. x $\frac{1}{8}$ in. mild steel plate. The leading edge is also 1 in. x $\frac{1}{8}$ in. mild steel plate. The scoop is lined with 14 gauge mosquito gauze which is sewn into position by thin, pliable copper wire. The overall weight is $3\frac{1}{2}$ lbs.

the Rhodesian highveld and correlate the cost to the area protected. In this way the annual cost of snail surveillance is of the order of £4,532 to cover an area of 712 square miles, the area of the above example—or 2.4 pence per acre per year.

The system of snail surveillance which is practised in Rhodesia has evolved from a study of snail behaviour and population dynamics both in the laboratory and in the field and observation of natural populations under the influence of molluscicides. The rationale for this technique is based on several factors:

- (i) Infected snails are more susceptible to molluscicides than healthy snails.
- (ii) If a population of snails reaches dangerous proportions it will easily be discovered by the ranger teams on their normal round.
- (iii) Uninfected snails surviving a surveillance cycle will, if exposed to miracidia, take an average of six weeks prepatent period prior to producing numbers of cercariae.
- (iv) As molluscicides are applied to restricted regions of waterbodies and seldom, if ever, to complete river systems, the interference with the biota will be minimal.

No attempt is made to eradicate the snail population, and because attention is paid only to intermediate host snails, other snail species sur-

vive within the control areas so that the ecological niche is not left vacant. The goal of surveillance is to keep the snail population to a level low enough to render the transmission of bilharziasis no longer a problem of public health importance.

ASSESSMENT OF SNAIL SURVEILLANCE

Assessment of results is a complex task and is based on twice-yearly examinations of the area to determine the extent of residual snail populations, and on annual examination of single urine specimens taken from approximately 400-800 individuals under the age of 16 residing in the control area. At this time an assessment team, based on the central laboratory, carries out an audit of the field officer and checks and reports on the state of snail populations in his area.

Table I shows the prevalence of *S. haematobium* in the catchment of Kyle Dam near Fort Victoria. This area, some 1,434 square miles in extent, has been under snail control since 1960 and urine examinations have been carried out in 1960, 1962 and 1966. Apart from the overall reduction in each age group, it is significant to note the progressive absence of infection in the younger age groups.

In Table II can be seen the prevalence in a second area, the Norton snail control area of some 400 square miles, which has been under

Table I

THE RESULTS OF SINGLE URINE EXAMINATIONS IN THE KYLE CATCHMENT SNAIL CONTROL AREA FROM 1960-1966: CONTROL ORIGINATED IN 1960: EXTENT OF AREA—1,434 SQUARE MILES

Year of Assessment		AGE GROUPS						
		-4	4-5	6-7	8-9	10-11	12-13	14-15
1960	No. examined	403	590	611	578	209	144	106
	Per cent. positive	5	5	32.6	55.6	70.8	63.9	65.1
1962	No. examined	117	160	367	504	657	731	441
	Per cent. positive	0	3.1	22.0	35.0	43.7	46.1	56.9
1966	No. examined	17	20	75	187	276	275	113
	Per cent. positive	0	0	17.3	20.3	31.5	47.6	42.5

Table II

RESULTS OF SINGLE URINE EXAMINATIONS IN THE NORTON SNAIL CONTROL AREA FROM 1965-1966: EFFECTIVE SNAIL CONTROL COMMENCED IN 1964-65: EXTENT OF AREA—400 SQUARE MILES

Year of Assessment		AGE GROUPS					
		Under 4	4-6	7-9	10-12	13-15	16-20
1965	No. examined	8*	39	84	109	123	24
	Per cent. positive	—	51.2	65.4	70.6	68.3	54.2
1966	No. examined	19*	21	176	126	138	13*
	Per cent. positive	15.8	33.3	55.1	58.7	57.2	—

* Inadequate sample.

effective snail control since late 1964. Although not as marked, the downward trend of prevalence is evident in each age group.

Some proof of the efficacy of this method of transmission control can be obtained by transposing these data on to a curve computed by Macdonald (1965). He has investigated the theoretical pattern of the worm load in a population with a certain level of exposure, miracidial production, snail population and cercarial bombardment. He has shown how in the absence of any controlling factors the mean worm load per head of population rises to an asymptotic value which is distinctly related to either the exposure or to snail factors. If these are increased the value of the asymptote increases. Similarly, he has computed the fall of the mean worm load per head of population if the snail factor (snail population) is reduced to 1/15th. Fig. 2 shows the theoretical progress of the mean worm load in a population previously at saturation in relation to stipulated constants, when the snail factor is reduced to 1/15th. The mean worm load of the population sampled in Table I in 1960, 1962 and 1966 has been calculated from Macdonald's computer data and transposed on the graph in Fig. 2. It can be seen that the reduction achieved is reasonably close to the theoretical.

The use of molluscicides has often been criticised for its high and recurring expense, and that it is an artificial answer to a problem which should be solved by shifting the ecological balance slightly to the detriment of the parasite.

It has been shown here that in an experimental project control of the disease can be achieved under highveld conditions for 2.4 pence per acre. This cost cannot be applied to the intensely watered areas of an irrigation scheme; but then, as the resident population of such a region is considerably denser, the cost to protect each individual will not be very high.

Suggestions are often made of vague methods to shift the ecological balance one way or the other to effect snail control. It is a fact that no means of biological control has been applied effectively to an indigenous animal in its natural environment. Fish or aquatic birds may reduce numbers of snails within a particular waterbody, but this can be done only in isolated instances and has no general application. Even if an effective predator of snails is introduced from a new region, it would have to adjust to its newly-acquired niche and would itself soon be regulated by predators and parasites of its own.

It must be faced that, with regard to the rapidly increasing problem of bilharziasis in Southern

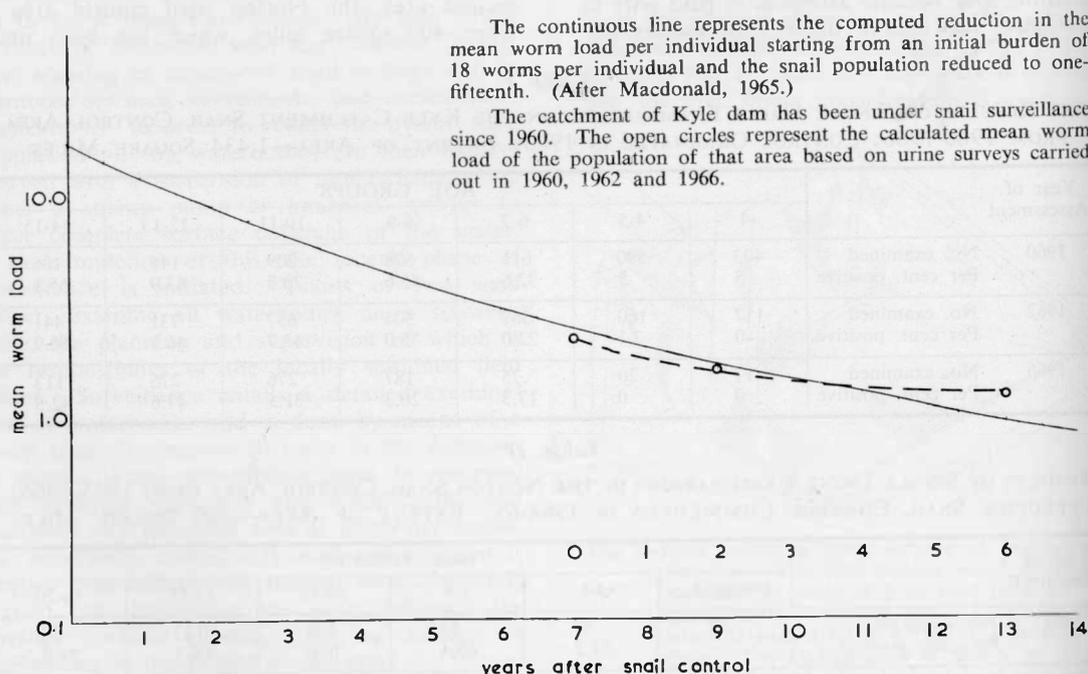


Fig. 2—A comparison between the theoretical reduction of mean worm load in an infected population after the introduction of snail control (after Macdonald, 1965) with the calculated reduction of the mean worm burden in a population actually protected by snail control for six years.

Africa, man has caused the ecological imbalance which has so favoured the widespread increase of the parasite. Because of this he must move to interfere with the biology of any of the organisms involved in such a way as to be detrimental to the parasite. This can be done effectively by restricting contact with infective water or reducing the infectivity of the water, or both. Snail control has been shown to be a method of reducing the infectivity of the water economically, and ecological studies by Harrison and Rattray (1966) have shown that of the fauna of the biotope, only planorbid and lymnaeid snails are affected by careful surveillance. Thus surveillance can be defined as the regulated use of toxic chemicals to manipulate the biotope in such a way as to make it unsatisfactory to the particular organism against which it is directed, with minimum effect on the environment.

These results demonstrate the success of the technique of snail surveillance in the reduction of the transmission of bilharziasis in natural waterbodies. This is shown by a decrease in the overall prevalence of the disease and by the drop in the worm burden of a rural population.

SUMMARY

The technique of snail surveillance as an ecological approach to snail control is outlined. The method is discussed and results of urine surveys of the past six years in the Kyle catchment show a reduction in the prevalence of *S. haematobium*. A comparison with parameters calculated by Macdonald (1965) indicate a reduction in the mean worm burden which approaches the theoretical expected when a population is protected by snail control. The costing of snail surveillance operations indicates that on the Rhodesian highveld the overall annual expenditure is 2.4 pence per acre of land protected.

REFERENCES

- CLARKE, V. DE V., SHIFF, C. J. & BLAIR, D. M. (1961). *Bull. Wld. Hlth. Org.*, **25**, 549.
- CLARKE, V. DE V. (1964). *Proc. 7th Inter. Cong. of Trop. Med. & Mal.*, **2**, 23.
- CLARKE, V. DE V. (1966). *Cent. Afr. J. Med.*, **12**, Supp. to No. 6.
- HARRISON, A. D. & RATTRAY, E. A. (1966). *S. Afr. J. Sci.*, **62**, 238.
- MACDONALD, G. (1965). *Trans. Roy. Soc. trop. Med. Hyg.*, **59**, 489.
- PITCHFORD, R. J. (1966). *S. Afr. med. J.*, Supp. to Vol. 40, No. 36.
- SHIFF, C. J. & GARNETT, B. (1961). *Bull. Wld. Hlth. Org.*, **25**, 543.
- SHIFF, C. J. (1964). *Ann. trop. Med. Parasit.*, **58**, 94.
- SHIFF, C. J. (1966). *Bull. Wld. Hlth. Org.*, **35**, 203.
- SHIFF, C. J. & GARNETT, B. (1967). *Archiv. Hydrobiol.*, **62**, 429.
- WORLD HEALTH ORGANISATION (1961). *Tech. Rep. Ser.* No. 214.

WORLD HEALTH ORGANISATION (1965). *Tech. Rep. Ser.* No. 299.

WORLD HEALTH ORGANISATION (1965). *Monograph Series* No. 50.

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