Molluscicide Control of Snail Vectors of Schistosomiasis

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A review of the methodology recommended by the World Health Organization for the use of molluscicides for the control of snail vectors of schistosomiasis is presented. Discussion of the principle mollusçicides used, their advantages and disadvantages, the techniques and equipment required for their application and evaluation of effect as well as the biological control of snails is included.

Key words: schistosomiasis mansoni - control - snail vectors - molluscicide

Schistosomiasis or Bilharziasis is a complex of helminthic infections that affect man. Some 200 million individuals in 74 tropical countries are infected (Iarotski & Davis 1981, WHO 1985, Sleigh & Mott 1986).

Five species of *Schistosoma, S. japonicum, S. mansoni, S. haematobium, S. intercalatum* and *S. mekongi* which are taxonomicaly and epidemiologicaly distinct, utilize one or more species of intermediate snail host parasitise thousand of individuals.The first three species listed are of greatest medical importance and the latter two have a restricted distribution in regions of Africa and around the Mekong river in South East Asia respectively.

Snail control by means of molluscicides is today considered an auxiliary method within integrated control of schistosomiasis (Mc Cullough 1992).

The Expert Committee of the WHO (1985) listed three phases in the control of schistosomiasis: (1) *Planning*: collection of epidemiological data, organization of a national plan of action and allocation of recourses for the program; (2) *Intervention-attack:* a period of active intervention operations are intense and continually evaluated. This phase results in a rapid reduction of prevalence; (3) *Maintenance*: maintenance is then required in many situations.

THE OBJECTIVES OF SNAIL CONTROL BY MOLLUSCICIDE APPLICATION

The inclusion of the definition of objectives in control programs is essential. According to Mc Cullough (1992) the principle objectives are: (a) to contribute, preferentially in combination with chemotherapy and other measures, to the significant reduction of the transmission of schistosomiasis through the destruction intermediate host populations, principally infected snails, in habitats selected during peak transmission. The reduction recommended by Mc Cullough (1992) is 95% and this level should be maintained during the period of peak transmission; (b) the destruction of the snails in a number of breeding sites that contribute significantly in increasing the population density in neighboring foci; (c) prevention of transmission in tourist areas;(d) to achieve a community involvement in the activities associated with transmission control; (e) to drastically reduce the intensity of transmission in sites used for high risk occupations such as fishing and agriculture; (f) to prevent the introduction of new potential vectors; (g) in certain types of habitats to totally eliminate snails in order to prevent the risk of transmission; (h) to avoid whenever possible the establishment of new breeding colonies in new irrigation systems.

ADVANTAGES AND DISADVANTAGES OF THE USE OF MOLLUSCICIDES

In general the advantages of the selective use of molluscicides in control operations are: (a) interruption of transmission; (b) the desirable but not essential involvement of the community; (c) reasonable efficiency and cost; (d) simple equipment that can also be used in the control of other vectors; (e) although good supervision is essential the methods of application are general simple and do not require specialized operational schemes; (f) the selection of foci where application is required can usually be based on the patterns of water usage of the population; (g) low toxicity for man and other animals; (h) health education programs are used to reinforce the results achieved.

The disadvantages are: (a) the need for repeated applications since snail eradication is difficult; (b) the implementation and evaluation of control is time consuming; (c) the effect on schistosomal morbidity, even when snail control are efficient and in the absence of chemotherapy, is delayed; (d) the technical capacity required to decide appropriate application procedures in view of the great variation in transmission sites.

CHARACTERISTICS OF A GOOD MOLLUSCICIDE

The perfect molluscicide does not yet exist. A list of the desired characteristics in a molluscicide has been given by the WHO (1965). The minimum requirements are: (a) toxicity for snails at low concentrations; (b) absence of toxicity for mammals, neither presenting acute or chronic problems of toxicity; (c) lack of adverse effects if it enters the food chain; (d) stable in storage for at least 18 months.

In addition to these characteristics, low cost, proven efficacy, specificity for snails, low toxicity for other organisms, a variety of formulations and easy measurement of concentrations in breeding sites are desirable.

CURRENTLY USED MOLLUSCICIDES

There are a series of compounds with molluscicides action that are used in the control of schistosomiasis. Between 1946 and 1955 some 7,000 chemical products were tested as potential molluscicides (Ritchie 1973). Amongst these, pentachlorophenol (NAPCP) was identified as being promising however, this was subsequently discarded due to its toxicity for other organisms and is only currently used in China. Compounds containing lead and tin are highly active but are also toxic for various organisms. In Japan, Yurimin (3,5-dibromo-4 hydroxy-4-nitroazobenzene) replaced NaPCP but its fabrication was stopped after only a few years of use. The same happened with Frescon (N-tritylmorpholine), one of the most active molluscicides for adult snails but which was not active against eggs. Copper was also widely used although in the presence of organic material, elevated pH and certain solids in the water it lost activity. In Japan, a compound named B-2 (sodium 25, dichloro-4-bromophenol) was tested against the amphibian snail *Oncomelania nosophora* (Kajihara et al. 1979). In the People's Republic of China, one of the most effective molluscicides Fluoroacetamide and its analogs bromocetamide and chloracetamide were identified. These compounds have high molluscicides activity and low toxicity for fish, are soluble in water, stable and easily applied

Tin compounds, particularly tributyltin oxide, were shown to be highly active but are not used due to their toxicity for aquatic fauna.

At present, the only viable molluscicide in terms of efficacy and complete evaluation is Bayluscide (Mc Cullough 1992). The usual formulation of Bayluscide powder is 70% active material and in the form of emulsifiable concentrate 25% active material. Both are highly effective against adult snails and egg masses. In practice, a concentration of 0.6-img/l is recommended and a time of exposure of 8 hr (WHO 1973), or 0.33 mg/l for 24 hr (Barnish & Prentice 1981). The effect persists for 8 hr after application. A 25% suspension can be mixed with diesel oil at a proportion of 8.5 parts to 1.5 parts of oil. Bayluscide is lethal for fish. There is no evidence of resistance by the snails to the compound.

Some compounds containing tin, copper lead and niclosamide have been used impregnated in latex or other support materials for slow release into ditches, pools or streams containing snails. Tributyltin oxide was found to be highly effective in this form exhibiting toxicity for more than six months (Souza & Paulini 1969).

MOLLUSCICIDES OF VEGETABLE ORIGIN

The study of plants exhibiting snail toxicity has been encouraged with the aim of finding alternatives for use in the fight against snail vectors. The World Health Organization has published reviews of this work listing plants with recognized molluscicides activity (Marston & Hostettman 1985, Kloos & Mc Cullough 1987, Mott 1987). These plants and compounds with molluscicide activity were also reviewed by Mc Cullough (1992). These molluscicides of vegetable origin, however, exhibit low toxicity for snails embryos.

MOLLUSCICIDE APPLICATION

Molluscicide application is the most important method of aquatic snail elimination particularly of the genera *Bulinus* and *Biomphalaria*. Snails of the *Oncomelania* genus, hosts for *S. japonicum*, are more difficult to destroy using molluscicides as they are amphibious and environmental alterations are more effective .

Types of habitat of aquatic snails: (a) *Natural*: represented by shallow water with slow or moderate current and strong solar illumination; (b) *Opportunistic*: occur in certain appropriate areas where there is sufficient vegetation and which are due to the spread of snails by the current as on the margins of streams and rivers; (c) *Artificial*: represented by irrigation ditches, tanks and furrows of low current gradient which are continuations of streams, lakes or reservoirs used for pisisculture, horticulture or agriculture.

They are responsible for the high prevalence of schistosomiasis in endemic areas and are thus called epidemic habitats (Freitas 1968).

The type of habitat and the various types of aquatic plants found in each, in addition to other variables, affect the application and dispersion of molluscicides. The methods of application in still or running water are different.

When transmission is seasonal a minimum of three molluscicide applications per year are recommended: (a) the first immediately after the first rains; (b) the second around six months later; (c) the third in the dry season.

The time of molluscicides application may be determined by rainfall, temperature, water usage and the snail population density or may be based on chemotherapy programs. The decision should be made after a period of observation of the conditions in each geographical region.

Normally three people are required for molluscicides application: a technical field supervisor and two assistants.

The calculation of the quantity of product to be used in each breeding site is based on the volume of water and the rate of flow. Rate of flow is obtained by the following formula:

$$\text{flow} = \text{velocity} \times \text{width} \times 0.85 = m^3/\text{second}.$$

Volume is calculated by:

$$\text{volume} = \text{width} \times \text{depth} \times \text{length} = m^3.$$

Equipment used for molluscicides application: (a) in running water: containers of 20, 60 or 120 liters fitted with a tap, a spray pump or watering can; (b) in still water: spray pump or watering can.

Evaluation is made 24 hr after application by direct observation of the snails in the breeding site.

List of material used in the field: tape measure, string, long handled scoop, counter, paper, thermometer, stop watch (or watch), screen cages for placing sentinel snails, steak, screen, molluscicides, polystyrene, equipment for application, container for dilution of the molluscicides, funnel, overalls, alcohol, gloves and mask.

Mc Cullough (1992) has produced tables of calculations of the quantity of Bayluscide to be used according to the volume of water in breeding sites with still or running water.

EVALUATION OF MOLLUSCICIDE APPLICATION

For the most effective evaluation a number of snails captured in the breeding site to be treated should be placed in cages made of nylon screens or metal and put both in the area to be treated as well as in another treatment free area in order to act as controls for mortality. Twenty four hours after treatment mortality in the treated area should be high and nil or very low in the control area.

If cages containing snails are not used, the population density should be measured one week before treatment and one week after treatment using a long handled scoop for collection or alternatively wooden or metal pincers for a standardized time.

The amphibian snails of the genus *Oncomelania* are collected with pincers and the density calculated on the basis of the number of snails collected per person per minute (Mc Cullough 1992). During collection before treatment the risk of exposure to *Schistosoma* cercariae should be avoided.

In the future, new strategies will be necessary for using molluscicides formulated for slow release, amongst other modifications, as well as the development of molluscicides of vegetable origin in endemic regions (Mc Cullough 1992).

BIOLOGICAL CONTROL

An alternative method used in the control of snail vectors is the use of predatory organisms or competitors which can control the expansion of the snail population and eventually eliminate the snails from the breeding site.

Biological control has been undertaken principally with snails such as *Pomacea haustrum* (Milward de Andrade 1972) in Brazil and *Marisa cornuarietis* (Ruiz-Tibén et al. 1969) in Puerto Rico. In the northeast of Brazil a *B. straminea* strain resistant to *S. mansoni* has been used to combat *B. glabrata* (Barbosa et al. 1981). Another snail used as a competitor is *Helisoma duryi* (Abdallah & Nars 1973). A number of fish species such as *Tilapia melanopleura*, *Astronotus ocellatus*, have been used to control snails (Milward de Andrade & Antunes 1969, Motta & Gouvea 1971, Feitosa & Milward de Andrade1986) and aquatic birds such as ducks (Michelson 1957), chelonian (Coelho et al. 1975) have also been employed as snail predators. In addition, a number of other types of predators such as mosquito larvae and other diverse insects have also been described (Berg 1964).

In the laboratory a small leeche, *Helobdella triserialis lineata* and ostracods crustacia have been found to be good snail predators (Sohn & Hornicker 1972, Guimarães et al. 1983). In the field, however, these animals are found in snail breeding sites in an ecological equilibrium with the snails. Some aquatic plants such as *Characeae* have been used to combat snails vectors (Rennó 1958). The pathological action of bacteria such as *Bacillus pinotti* against *B. glabrata* has also been studied (Texera & Vicente Scorza 1954). Follow up studies were not able to confirm the action of the latter two possibilities.

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