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Molluscicides in schistosomiasis control

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Although mollusciciding can be a cost-effective method of controlling schistosomiasis transmission, only one organic molluscicide, niclosamide, is now being produced commercially, and only a few compounds are at present being tested in the laboratory. In future, improved cost-effective use of molluscicides will require more precise knowledge of schistosomiasis transmission patterns in each endemic area and improved application techniques. In snail control studies using controlled-release formulations only the organotins, especially tributyltin oxide (TBTO), have given satisfactory long-term results. However, large-scale field trials of organotin formulations have not been implemented and their use cannot be recommended as their chronic toxicity in mammals has not yet been determined. The development of molluscicides of indigenous plant origin deserves support. Endod, derived from the berries of the climbing plant Phytolacca dodecandra, *is the most extensively tested plant molluscicide, but data on its chronic toxicity to non-target organisms are lacking. The mode of action of molluscicides has not been extensively studied, though knowledge of the properties required of molluscicidal molecules has contributed to the discovery and development of niclosamide and nicotinanilide. In general, molluscicides probably cause stress on the water balance system, which in gastropods is thought to be under neurosecretory control.*

During the past decade numerous schistosomiasis control projects in Brazil, Egypt, Ghana, Madagascar, Philippines, Zimbabwe (Southern Rhodesia), United Republic of Tanzania, Venezuela, and elsewhere, have shown that snail control by molluscicides, either alone or in combination with other methods (chemotherapy, environmental measures, health education, etc.) can be a rapid and efficient means of reducing or eliminating transmission. Snail control procedures, including mollusciciding, must therefore remain among the methods of choice for the control of schistosomiasis, even though selective population chemotherapy may, in future, play a leading role in integrated control strategies in many endemic areas. In 1965, the World Health Organization supported the preparation and publication of guidelines for the screening and evaluation of molluscicides.[a] The methods and recommendations established at that time remain valid today.

The cost-effectiveness of mollusciciding is greatest where the volume of water to be treated *per capita* at risk is small. It is, therefore, particularly well suited to relatively arid areas where, apart from large irrigation schemes and other major man-made water impoundments, most of the important transmission sites are relatively small and seasonal. Mollusciciding can also be effective in large, flowing, or static waterbodies now that it is generally recognized that schistosomiasis transmission tends to be focal rather than widespread. Even in some large irrigation schemes, where human population density is high and where water-management mechanisms are sophisticated, area-wide mollusciciding can be cost-effective; this method is still being employed in middle Egypt.

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[a] *Bulletin of the World Health Organization*, **33**: 567-581 (1965).

The cost of mollusciciding operations may differ markedly from one endemic area to another; in terms of persons protected, figures of 1–4 US dollars *per capita* annually have been reported. However, rigorous data on cost-effectiveness of mollusciciding operations are few and the adequacy of some costing procedures may be questionable, which tends to make realistic evaluation difficult. In short, valid cost-benefit analyses of mollusciciding operations are not available at present.

In recent years, a major trend in molluscicide research has been towards improved or new delivery systems, especially the use of slow-release matrices, in order to improve cost-effectiveness and reduce adverse effects on the environment. Another trend has been the development of target-selective compounds. But perhaps the most marked change during the last few years has been the switch in strategy from area-wide to focal and seasonal control of the snail hosts and of transmission based on the realization that, in most endemic areas, even including large irrigation schemes, transmission of the infection is mainly seasonal and takes place at well-defined water-contact sites. However, in most countries throughout the world where schistosomiasis is endemic, a striking paucity of information on the sites and times of maximum transmission jeopardizes the implementation of adequate and relevant control strategies even where the public health infrastructure is sound and the national commitment undeniable.

CHARACTERISTICS OF AVAILABLE AND CANDIDATE MOLLUSCICIDES

During the last decade, the four available compounds listed in the report of the 1972 meeting of the WHO Expert Committee on Schistosomiasis Control[b] have been reduced effectively to one, namely niclosamide. With regard to the others, Yurimin is no longer produced or marketed in Japan; sodium pentachlorophenate is now seldom used as a molluscicide; while *N*-tritylmorpholine can be supplied only if large quantities are ordered in advance, as a special production plant must now be set up at the factory. However, nicotinanilide has fairly recently been added as a candidate synthetic molluscicide, and laboratory assessment of the molluscicidal activity of 2,5-dichloro-4-bromophenol, a new inexpensive compound named B-2, against *Oncomelania nosophora*, shows many promising features.[c]

While copper salts have been largely discarded in most snail control programmes, some work is at present being undertaken to improve their efficacy in the field by incorporating them in glass as a controlled-release formulation. However, it seems that the molluscicidal efficacy of copper, irrespective of method of application (in some slow-release matrices, in chemical barriers, in compounds of different anionic nature, etc.) has so far been less than satisfactory. Granule and pellet formulations of 50% copper sulfate monohydrate applied in the field at concentrations of active ingredient higher than 50 mg/litre did not, for example, control *Biomphalaria glabrata* in St Lucia. Moreover, the cost-effectiveness of copper sulfate, in spite of its low purchase price, has been shown to be unacceptably high in comparison with that of niclosamide.

The high molluscicidal activity of a number of organotin compounds has long been known. Activity appears to be limited to the trisubstituted molecules, as has been demonstrated against *Bulinus* spp., *Biomphalaria* spp., and certain operculate freshwater

[b] WHO Technical Report Series, No. 515, 1973.

[c] KAJIHARA, N. ET AL. *Japanese journal of medical science and biology*, 32: 185-188 (1979).

molluscs. The organotins have not proved so effective against the amphibious oncomelaniid snails, perhaps because of the lack of appropriate formulations or the relative insolubility of the compounds in water. Certain organotin compounds have been incorporated in slow-release rubber formulations, which permit low dosing rates over long periods of time with possible selective action and a reduction in application costs and in harm to the environment. However, insufficient information is at present available to assess chronic toxicity to man and his domestic animals of water treated in this way. A review of the toxicology, pharmacology, and other relevant aspects of the organotins has recently been published.[d]

The highest activity against mammals is associated with triethyltin which orally has an LD_{50} of 4 mg/kg body weight in the rat. Increase in alkyl chain length, however, leads to a decrease in mammalian toxicity, while the molluscicidal property remains unchanged. Tributyltin oxide (TBTO), triphenyltin acetate (TPTA), and triphenyltin hydroxide (TPTH) have been particularly investigated as molluscicides, and the former compound has been most involved in controlled release technology.

TBTO has an acute LD_{50} of 150–250 mg/kg body weight when administered orally in the rat and can produce skin irritation and corneal opacities in the rabbit. Although some deaths did occur among rats fed for 30 days on a diet containing 320 mg/kg, in another trial rabbits survived a daily intake of 12 mg/kg body weight six days a week for six weeks and the biochemical changes that occurred during this period reverted to normal as soon as the compound was withdrawn. A diet containing 20 mg/kg caused cerebral oedema in rats, similar to triethyltin poisoning, but this symptom also disappeared once administration of the compound was stopped. This latter finding is presumably consistent with the rapid clearance of TBTO from mouse tissues and a possible catabolic route has been indicated. The compound is also known to be poorly absorbed by mammals.

Certain adverse effects of TBTO in fish have been demonstrated in laboratory experiments at levels recommended for slow-release formulations in snail control, but these results are unlikely to be applicable under field conditions. Field trials, in fact, suggest that these formulations may be lethal specifically to snails owing to the hydrophobic character of the molluscicide which causes it to adsorb to surfaces frequented by the snails. Moreover, it has been observed that TBTO can react with carbon dioxide in plant material to give bis(tributyltin) carbonate, which would also explain its removal from water. The half-life of TBTO in pond water is reputed to be 16 days.

In many respects, therefore, TBTO has the potential of being a very effective molluscicide. Unfortunately, definitive long-term toxicological studies on TBTO are lacking and the compound cannot yet be recommended for field use. The standard to be met is that used for any substance added to food. Such tests normally include carcinogenicity studies.

Oral administration of a daily dose of TPTA of 0.464 mg/kg body weight (the maximum tolerated dose) for a total of 18 months did not give rise to an increased incidence of tumours in the mouse; in fact, the compound may even inhibit the growth of tumours. Similarly, TPTH has not proved to be carcinogenic in rats and mice and neither TPTA nor TPTH could be shown to be mutagenic when examined by the dominant-lethal assay test employing rats. These latter compounds might, therefore, be suitable alternatives to TBTO; the acute oral LD_{50} values for male and female rats are, respectively, 136 and 491 mg/kg body weight for TPTA and 171 and 268 mg/kg body weight for TPTH.

Over a decade ago, attention was drawn to the molluscicidal activity of nicotinanilide. Studies of quantitative structure–activity relationships for a series of substituted nicotinanilides have shown that the parent compound is the most active member of the series (LC_{50} = 0.16 mg/litre against *B. glabrata*). Recent work has shown that nicotinanilide is ovicidal in continuous applications at 0.01 mg/litre for about two weeks and that

[d] DUNCAN, J. *Pharmacology and therapeutics*, **10**: 407-429 (1980).

0.005 mg/litre will considerably delay maturation and hatching of *B. glabrata* egg masses. A major attraction of nicotinanilide is its target specificity. It is not acutely toxic to goldfish, the tropical food fish, *Sarotherodon mossambicus*, *Daphnia* or *Aedes aegypti* larvae, nor does it affect tadpoles, frogs, or water weeds in field applications. Mice tolerate 2 mg/kg body weight given parenterally and rabbits respond minimally in skin and eye irritation tests. Further development of this candidate molluscicide is now in progress, including substitution of the molecule, laboratory and field trials of a slow-release formulation, development of a residue analysis method, and procedures for commercial synthesis.

Niclosamide is now the molluscicide of choice and is virtually the sole commercially available compound at the present time. In Egypt, several hundred metric tons are applied annually. Its greatest disadvantage is its rising cost, which is linked to the escalating price of petroleum products. The usual formulations (70% wettable powder or 25% emulsifiable concentrate) are both highly effective. Granule, sand, and gelatin formulations have been applied with some success in specific situations, such as simulated banana drains in St Lucia or in Lake Victoria, Tanzania, against *Biomphalaria choanomphala*, a lacustrine snail host of *Schistosoma mansoni*.

Molluscicides of plant origin

Recently, there has been a resurgence of interest in the study of vegetable molluscicides of local origin. The attraction is largely based on the philosophy of self-reliance and, not least, on savings of hard currency. Many vegetable molluscicides (e.g., the fruits of *Sapindus saponaria*, *Swartzia madagascariensis*, and *Balanites aegyptiaca*, and the bark of *Entada phaseoloides*, for all of which the active ingredients are saponins; the roots of *Derris elliptica*; the pulp of the sisal, *Agava sisalana*; the leaves of *Schima argentea*) have been reported in the literature; all are harmful to the environment, perhaps not surprisingly, as most have been discovered because they are potent fish poisons, and few have been adequately tested under simulated field conditions. Long-term toxicological studies have not, as yet, been undertaken on any vegetable molluscicide, but there is no reason to assume that public health and legislative authorities would not apply the same regulations in regard to their acute or chronic toxicology as they do these characteristics of synthetic products.

The best-studied molluscicide of plant origin is undoubtedly from the berries of endod, the Ethiopian name for the climbing plant *Phytolacca dodecandra*. Various species of *Phytolacca* grow in East, West, Central, and South Africa and southern Europe, as well as in different parts of Asia and South America. The molluscicidal potential of the berries of the different species has not been adequately studied, but even different lots of crude endod berries, sold in Ethiopian market places, show detectable variation in molluscicidal potency.[e]

An aqueous solution of dried and powdered endod berries is lethal to planorbid snail hosts within 24 hours at concentrations of 15–30 mg/litre. This solution is stable between pH 5 and 9, and to irradiation with ultraviolet light. Its acute toxicity to mammals and plants is low, but it is lethal to fish at molluscicidal concentrations. Its chronic toxicity has not been adequately investigated, but in a preliminary restricted investigation, using a bacterial plate test devised by Ames, no mutagenic properties were detected. The active molluscicidal component of endod berries is a triterpenoid saponin, oleanolic acid glucoside. This component is rapidly biodegraded, probably by bacterial action, and the crude powdered berry, or the butanol extract, when suspended in water loses its molluscicidal potency in a few days; such rapid biodegration may be both an advantage and a limitation.

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[e] A compilation of recent literature on endod has been prepared by A. Lemma, D. Heyneman, & H. Kloos under the title *Studies on molluscicidal and other properties of the endod plant, Phytolacca dodecandra*. The compilation is obtainable free of charge on request to Department of Epidemiology and International Health, University of California, San Francisco, CA 94143, USA.

One of the most serious disadvantages of endod is its lack of ovicidal effect at levels that are lethal to adult snails. Thus for effective snail control operations, the frequency of application must be doubled. Nevertheless, during a large-scale field trial of endod over a five-year period in Adwa, northern Ethiopia, with a population of 17 000, the incidence and prevalence rates of *Schistosoma mansoni* infection were reduced considerably, apparently as a result of the snail control efforts. Moreover, repeated applications of endod did not appear to show any permanent harmful effects on the biota of the two streams concerned.

In spite of this successful pilot demonstration of the practical use of endod for schistosomiasis transmission control, its continuous application on a nationwide scale would, as with other plant molluscicides, be dependent on well-organized cultivation and harvesting of the plants, to ensure reliable supplies of the berries. Such an undertaking is not an easy one, requiring not only stable socioeconomic conditions, but also sophisticated management.

In addition to endod, several other plant molluscicides that have been studied in recent years deserve brief mention. The relatively high molluscicidal potency of the seeds of two species of croton (*Croton tiglium* and *C. macrostachys*) has been noted by several authors. Croton grows abundantly in the Philippines and southern India, for example, and possibly in southern Sudan. In India and the Sudan, the plant is sold in the market places as a traditional medicine for the treatment of intestinal parasites and as a purge. While croton seeds have some interesting molluscicidal characteristics (e.g., they are, for unknown reasons, much more active against *Bulinus truncatus* than against *Biomphalaria* spp., the LC_{90} values being 0.1 mg/litre and 20 mg/litre, respectively) their widespread use seems to be impracticable as croton oil is known to be potentially carcinogenic.

At the present time, the World Health Organization is supporting laboratory and field evaluations of the molluscicidal activity of the seeds of *Jatropha curcas*, which grows abundantly in the Philippines and produces seeds almost throughout the year. In respect of *Oncomelania quadrasi*, the LC_{50} of the crude natural product of *J. curcas* is about 20 mg/litre for an exposure period of 48 hours. Studies are presently in progress to observe its stability under various physico-chemical conditions and to determine the active ingredient, with the object of undertaking further field trials in Leyte, Philippines.

For several years, Egyptian workers have drawn attention to the promising potential of the herb *Ambrosia maritima* (locally called damsissa), which grows commonly in parts of Egypt, the Sudan, and probably also in neighbouring countries with similar soils and climate. The active molluscicidal component, which occurs in the leaves and flowering tops, remains unidentified, but is is unaffected by drying. An infusion at a concentration of 1 mg/litre (on a crude, dry basis) caused 100% mortality of planorbid snails and their egg masses as well as schistosomal miracidia and cercariae after 24-hours' exposure. Its acute toxicity against other biota (fish, insects, mammals) appears to be low at concentrations lethal to the snail hosts. A positive feature of damsissa is that it seems to grow easily and reaches maximum growth at the period of peak transmission of schistosome infection. However, further rigorous laboratory and field studies are necessary in order to determine the exact role of this readily available plant molluscicide in schistosomiasis transmission control throughout the vast irrigated areas of north-east Africa and neighbouring zones.

No doubt, in parallel with the attraction for studies on the biological control of the snail hosts, observations on vegetable molluscicides will continue to gain support, but it would be rather unrealistic to expect any dramatic breakthrough in the years immediately ahead.

Mode of action

Research on the mode of action of molluscicides has followed two main paths. First, the biochemistry and physiology of snails have been studied with the object of explaining molluscicidal activity, or of demonstrating unusual features of molluscan metabolism or organization which molluscicides might be used to exploit. While these seemingly logical approaches have not, as yet, led to the identification of any new agent, they have demonstrated other noteworthy relationships. Second, research on the bioassay of groups of related compounds has been undertaken with the aim of elucidating chemical structure–biological activity relationships. This approach has indicated some of the properties required of molluscicide molecules and has led, for example, to the discovery and development of niclosamide and nicotinanilide.

Among interesting correlations revealed by biochemical studies, the following deserve brief mention. Low concentrations of pentachlorophenate uncouple oxidative phosphorylation in *Lymnaea stagnalis* cell fractions. In addition, while very low concentrations of niclosamide or pentachlorophenate, added to *Biomphalaria alexandrina* homogenates, stimulate oxidation of such substrates as succinate, citrate, glutamate, and reduced tetramethylparaphenylene diamine, higher concentrations actually inhibit oxidation; copper sulfate, on the other hand, causes inhibition at all concentrations. The results of later studies on succinate oxidation suggested that inhibition due to pentachlorophenate could be caused by accumulation of oxaloacetate, while inhibition due to niclosamide could be only partly explained by this activity. Inhibition by copper sulfate was attributed to its effect on enzymic sulfydryl groups, the inhibition being reduced in the presence of cysteine.

Neurophysiological studies have shown that trifenmorph generates nerve impulses in isolated *L. stagnalis* ganglia. The impulses become grouped into spontaneous and random "Frescon bursts" with many cells firing synchronously. It seems that trifenmorph causes changes in intraneuronal chloride levels and that this may affect related cell characteristics, such as bicarbonate transport and pH. These changes could lead to the slight increase in excitability, which triggers the "burst" response. However, in addition to activity in nervous tissue, trifenmorph has also been shown to cause slowing of the heart rate of *Bulinus truncatus* and irreversible contracture in the isolated heart of the stylomattophoran *Archachatina marginata*.

It has long been observed that poisoning with molluscicides causes the snail either to retract into the shell and expel haemolymph or to become swollen and remain extended from the shell opening. The latter response is seen particularly with organotins and certain carbamates and suggests loss of water-balance control. The water balance of gastropods is thought to be under neurosecretory control. Trifenmorph has been shown to reduce neurosecretory activity in *B. truncatus*, while long-term exposure of the pulmonate, *Indoplanorbis exustus*, to barium chloride and copper sulfate also resulted in diminished neurosecretory activity. In addition, it has been shown that water flux through *B. glabrata* falls in the presence of a number of molluscicides at concentrations around their LC_{50} values. It may well be, therefore, that molluscicides cause stress on the water-balance system and that this alone can cause death of the snail, or that reduction of normal water flow through the snail precipitates other disturbances in metabolism or physiological function similar to those described above. It is of interest that the activity of some insecticides has been attributed to such multicomponent poisoning, caused by the release of neurohormones.

Finally, while the mode of activity of synthetic molluscicides has been to some extent investigated, that of plant molluscicides has scarcely been explored, as yet.

Toxicity, mutagenicity, and carcinogenicity testing

While all available, and almost all candidate, molluscicides have undergone adequate short- and medium-term (90 days) toxicity testing, few have been subjected to long-term toxicological studies. There is no strict correlation between acute toxicity and carcinogenicity (e.g., a chemical with high acute toxicity may be of low carcinogenicity or *vice versa*), and none of the existing molluscicides has undergone carcinogenicity testing according to the protocols established by WHO.

In regard to mutagenicity testing, the growing empirical relationship between mutagenicity and carcinogenicity does not imply that the two processes are identical, but mutagenicity testing does suggest itself as a rapid prescreening assay for carcinogenicity. With this reservation in mind, it is of interest that when *N*-tritylmorpholine, copper sulfate, sodium pentachlorophenate, and endod were recently tested for mutagenic properties in a bacterial system, none showed any evidence of mutagenic activity.

DELIVERY SYSTEMS

Apart from the conventional means of applying molluscicides by use of hand-operated or pressure sprayers, automatic and semi-automatic dispensers, etc., two other, more novel methods of delivery have been tried in the last few years. First, aerial application of *N*-tritylmorpholine has recently been studied in detail in the Gezira Irrigation Scheme, Sudan, where it was considered to be "the most effective, least troublesome, quickest and cheapest application technique". However, while high snail kills were achieved, the equivocal nature of the results of aerial spraying in reducing the incidence of human *S. mansoni* infection, has made it necessary to consider other combined control strategies based on the focal pattern of most transmission sites in the Gezira.

Secondly, the concept of controlled slow-release application has been extensively explored in recent years. The attractions of this approach include:

- substantial reduction in cost
- greater operational simplicity
- less harm to the environment
- destruction of free-swimming larval stages of the parasite
- particularly valuable in focal transmission control in static waterbodies.

Among the compounds that have been included in slow-release matrices, and which have been studied during the last few years, are the organotins, organoleads, copper salts, trifenmorph, and niclosamide. In general, the results have been most encouraging, but further studies are desirable, especially to take advantage of the rapid developments in controlled-release technology, which have not yet been applied to molluscicides and which may have profitable commercial applications. However, slow-release molluscicide delivery systems, especially if applied over wide areas for prolonged periods, may promote the development of molluscicide resistance, but this is a matter for debate.

RESISTANCE TO MOLLUSCICIDES

Recently, preliminary and possibly debatable evidence has been reported from foci in Iran indicating increased resistance of *Bulinus truncatus* that had been subject, for about 10 years, to an annual treatment with niclosamide at a concentration of 1.0 mg/litre. Moreover, field populations of *B. truncatus* exposed to *N*-tritylmorpholine in Sudan have been shown to be more tolerant to the chemical and to take it up more slowly than snails from untreated areas.

With regard to the amphibious *Oncomelania* snail hosts, several studies have been undertaken by Japanese workers on resistance to molluscicides, mainly sodium pentachlorophenate (NaPCP). The results have been ambivalent, some providing evidence of resistance, while others have not done so, even among snail populations treated with NaPCP twice a year for more than 18 years.

Fortunately, from the practical viewpoint there is still no definite evidence that snail hosts can develop serious resistance to molluscicides, nor has this phenomenon yet hampered snail control operations. For diverse reasons, resistance to molluscicides will probably never attain the same socioeconomic importance as the problems arising from resistance to insecticides.

Nonetheless, based on the premise that a standardized methodology for monitoring possible resistance to mollusciciding is desirable and that very few commercial molluscicides are likely to be available in the foreseeable future, the World Health Organization, in collaboration with the Centre for Overseas Pest Research, London, is currently assembling a molluscicide resistance test kit for field use, which will first be carefully evaluated by a dozen research workers located in representative endemic areas throughout the world.

FUTURE ROLE OF MOLLUSCICIDES IN SCHISTOSOMIASIS CONTROL STRATEGY

While the future status of mollusciciding in schistosomiasis control will depend on the type of control strategy adopted, which, in turn, will be determined by the local ecological and socioeconomic conditions, there is general agreement that judicious mollusciciding must remain among the methods of choice in any comprehensive schistosomiasis control programme. Moreover, in certain situations the control of the snail hosts alone, whether by chemical or environmental means, can confer substantial protection, although it is seldom that any single control procedure can be advocated unreservedly. Among the advantages of mollusciciding operations the following are still apposite:

- rapid interruption of transmission can be obtained
- community acceptance is not required
- cost-effectiveness can be very satisfactory
- application equipment is usually simple and cheap and can be used for larviciding
- integration with other pesticide control programmes is possible
- application methods are normally simple, do not require special skills and are easily learned (good supervision is, of course, essential)
- selection of important transmission sites where molluscicide application is required, is usually uncomplicated, and is based on water-use patterns
- toxicity to non-target biota does not cause concern, the regimen being usually focal and periodic
- targeted chemotherapy and health education programmes are reinforced.

In the forseeable future, population-based chemotherapy together with focal and seasonal mollusciciding are most likely to spearhead schistosomiasis control operations in the endemic foci that merit high priority. In such programmes the main objectives of the mollusciciding operations should be to eliminate infected snails and to contribute significantly to the reduction of transmission potential below levels that give rise to serious disease manifestations. As eradication of the snail hosts is seldom a realistic goal and as the planorbids (but not the hydrobiids) have a very high intrinsic rate of natural increase, the application of molluscicides must be carefully planned to take advantage of focal and seasonal patterns of transmission; in particular, sustained efforts, demanding efficient management, well-trained and motivated staff, and a recurrent budget sufficient to fund all essential supplies and activities, will be mandatory.

In the future, improved strategies and delivery systems will be needed to improve the cost-effectiveness of mollusciciding. For example, there is a need to investigate potential new formulations of the available compounds, such as slow-release and bait mechanisms, and to explore the development of vegetable molluscicides in the endemic countries, if adequate local production can be ensured and if the degree of harm to the environment lies within acceptable limits. In addition, it is now necessary, in a wide variety of socio-economic situations, to explore carefully the role as well as the efficiency of the local community in the periodic application of molluscicides, bearing in mind that staff emoluments and logistic charges are by far the most expensive components of institutionally supported focal and seasonal mollusciciding operations.

In conclusion, it is necessary once more to draw attention to the shortage of all cadres (medical, scientific, and auxiliary) of personnel with suitable training and experience of schistosomiasis transmission and control, including all aspects of the application of molluscicides. Until this gap is filled the fear must remain that schistosomiasis will continue to advance, rather than recede, in distribution and intensity in most areas where the infection is actually or potentially endemic.