Snail control in urban sites in Brazil with slow-release hexabutyldistannoxane and pentachlorophenol *

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Slow release formulations of hexabutyldistannoxane (TBTO) and pentachlorophenol (PCP) were tested for the control of Biomphalaria tenagophila *in 52 urban sites in Rio de Janeiro. TBTO acted faster and lasted longer than PCP and at 15 g/m² it eliminated snails from 76% of the treated sites for 1 year. Water pollution and rate of flow had no significant influence on the molluscicidal properties of either compound, but alkalinity lowered the activity of TBTO. Failure to control snail populations was due mainly to human interference and to the non-treatment of adjacent breeding sites that were temporarily dry and therefore overlooked.*

In spite of the existence of sewage disposal facilities, large cities in endemic areas of schistosomiasis remain among the most serious transmission areas. Four urban areas in Brazil each with over one million inhabitants are known to harbour snails infected with *Schistosoma mansoni* and, although the proportion of the human population with autochthonous infection may be much smaller than in rural areas, the actual number of locally infected persons is probably much higher (*1*; A. G. Borges, unpublished data, 1974). Foci of infected snails have been found in the centres of cities such as Salvador and Belo Horizonte, although the economically poorer suburbs contain the majority of the transmission sites. One of the difficulties of effective treatment lies in the location and regular inspection of these sites, which are highly subdivided, are frequently in enclosed private property, and are subject to continual modification. Most consist of stagnant or slow-moving water, which is normally highly polluted. Conventional molluscicides are often ineffective and repopulation occurs rapidly from unnoticed adjacent sites.

For long-term molluscicidal action, slow release of the chemical is essential. Two molluscicides, hexabutyldistannoxane (TBTO) and pentachlorophenol (PCP) are organosoluble and therefore suitable for incorporation in an organic matrix.

In previous studies (*2–5*), TBTO in a slow-release formulation was shown to provide long-term control of *Biomphalaria* spp. following a single application; doses of the active ingredient ranged from 0.2 to 300 g/m². Although such very low doses as 0.2 g/m² are satisfactory in clean water, preliminary studies in polluted city sites showed that even ten times this dose was totally ineffective. The present study was conducted to establish the TBTO level appropriate for the control of *B. tenagophila* in Rio de Janeiro, and to compare it with PCP at a similar level.

MATERIALS AND METHODS

TBTO was formulated in Underseal,[a] a quick-drying asphalt–rubber–asbestos–clay paste, to which extra powdered rubber (motor-tire) waste and clay was added. After extrusion in 2 mm-diameter rods and drying in air, the formulation contained from 4% to 18% TBTO. PCP was similarly formulated, the concentration of active ingredient ranging from 14% to 32%.

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[a] Manufactured by Minnesota Manufatureira e Mercantil Ltda, Sumaré, São Paulo, Brazil.

Sites were located by means of a primary school health educational campaign in the areas under study, the sites being reported by the pupils through their school staff. In Madureira, a typical, entirely built-up suburban district of Rio de Janeiro, 30 independent foci of *B. tenagophila* totalling over 10 000 m^2 were mapped. None was part of any major canal or river, the majority being small ditches (17) with an average area of 135 m^2 and marshy areas (8) with an average area of 947 m^2. The rest were watercress plantations (4) with an average area of 67 m^2 and a pond of 1 m^2.

The rate of water flow at these sites was estimated as average, slow, very slow, or nil, corresponding approximately to 6–15, 1–5, and <1 m/min and zero flow. Such readings were so variable with rainfall that they had only relative significance. Pollution, which was also highly variable, was registered as high, medium, or low. The presence of fish was noted and the pH of the water was measured.

The molluscicides were applied as evenly as possible by hand at 5, 10, or 15 g/m^2 of the active ingredient. This dose range was calculated from preliminary studies. Marginal marshy areas were treated when recognized as potential breeding sites for snails, even when dry at the time of treatment. Snail populations were estimated before treatment and at intervals of 7, 14, 21, 30, 60, 90, and 180 days, 1 year, and 1½ years. The snails were counted by first locating the points of maximum population density in the site and then recording the number of snails that could be collected at these points in 1 min. All readings were made by the same individual. Fish mortality was observed and snails were not reintroduced into treated sites. The number of observed sites decreased with time as low areas were filled or as streams were piped into sewage or pluvial drainage systems underground. Untreated sites in the same geographical area served as controls.

RESULTS AND DISCUSSION

Overall result

The treated sites may be divided into three categories: those where control was complete, those where a long-lasting and substantial reduction of the snail population was observed, and those where repopulation occurred to a level equal to or greater than 20% of the original population.

Table 1 shows the percentage of sites from which snails were totally eliminated. At the 15-g/m^2 level, control with TBTO was achieved 1–3 months after treatment and began to decline after 1 year, whereas control with PCP declined steadily after 6 months. After 18 months, two-thirds of the sites treated with TBTO, but only 20% of those treated with PCP, remained snail-free. The results obtained with 10 g/m^2 were probably not significantly different from those obtained with 15 g/m^2 for both molluscicides, but the fact that control was not achieved with 5 g/m^2 TBTO in one site with low pollution and no water flow seemed to indicate that this dose would be too low for the average site of high pollution and slow water flow.

Partial or total failure of molluscicidal activity occurred in 25% of the treated sites within 6 months

Table 1. Percentage of sites entirely free of *B. tenagophila* 1–18 months after treatment

Molluscicide	Dose (g/m^2)	No. of sites	Percentage of snail-free sites after: [a]					No. of failures [b]
			1 month	3 months	6 months	12 months	18 months	
TBTO	5	3	66.7	66.7	66.7	33.3	0 (2)	1
	10	6	50.0	83.3	83.3	100 (5)	100 (3)	1
	15	25	60.0	72.0	76.0	76.4 (17)	66.7 (9)	1
PCP	5	2	50.0	0 (1)	0 (1)	0 (1)	0 (1)	2
	10	9	55.6	77.8	75.0 (8)	75.0 (8)	85.7 (7)	2
	15	7	14.3	22.6	57.1	42.9	20.0 (5)	3

[a] The number of sites observed is shown in parentheses when less than the original number.

[b] Failures are considered as sites with a corrected population of 20 % or more of the original population in at least one observation between 1 and 18 months (TBTO) or between 2 and 12 months (PCP) after molluscicide application.

after treatment. Although continual human interference made it impossible to establish fixed control foci, an average snail population (c) for a wide variety of untreated sites in the area was established for each bimonthly period and used as a control. Thus (c) ranged from 77 snails/min collected from 4 sites in one summer period (December 1973–January 1974) to 18 snails/min collected from 14 sites in a late winter period (August–September 1974). The average collection over 28 months from 106 sites was 34 snails/min. In order to estimate molluscicidal activity, collections must be corrected for this seasonal variation and the percentage residual population at time t (r_t) is described by the equation:

$$r_t = \frac{100\, p_t \times c_o}{p_o \times c_t}$$

where p_o is the population (snails/min) before treatment, c_o is the average control population at that time, p_t is the population at time t, and c_t is the average control population at time t. (Such a correction is considered valid when conditions are such that populations never approach zero, and a definite repeating pattern is observed from year to year).

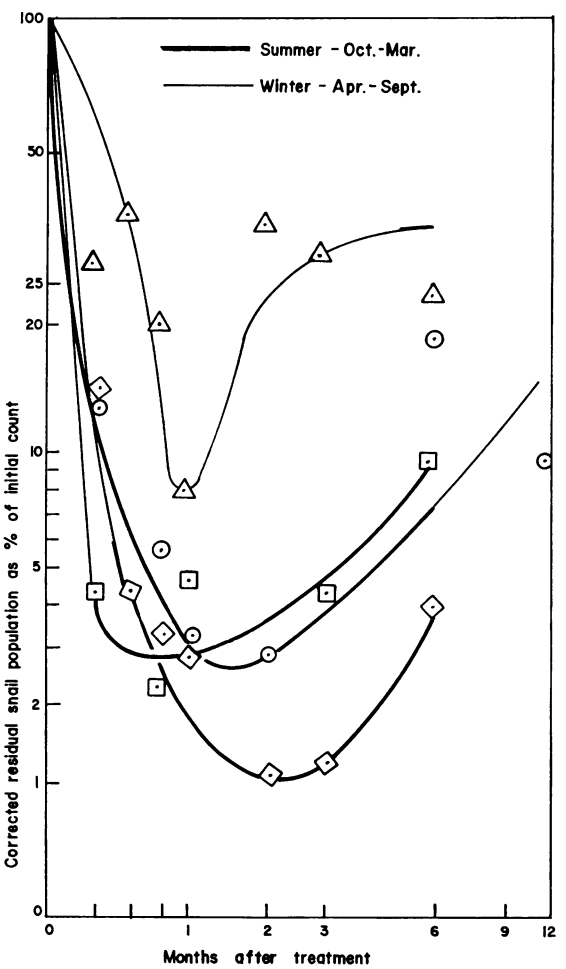

Fig. 1. Corrected residual snail populations in partially controlled sites after one application of slow-release TBTO at 15 g/m². Scale: vertical, log $(1+r)$; horizontal, log $(1+t)$.

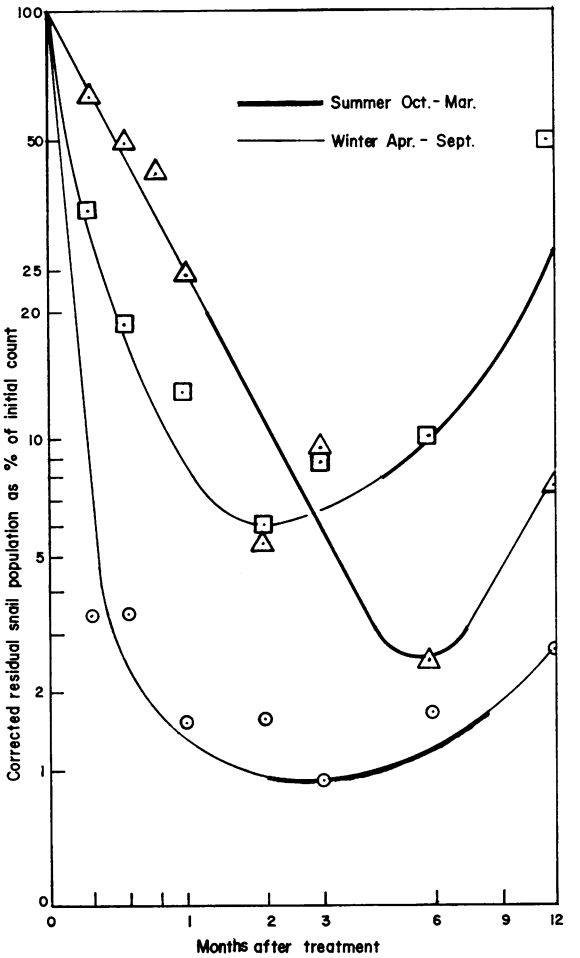

Fig. 2. Corrected residual snail populations in partially controlled sites after one application of slow-release PCP at 15 g/m². Scale as for Fig. 1.

Plots of the seven sites partially controlled with 15 g/m² of molluscicide (Fig. 1 and 2) show that TBTO acts more rapidly than PCP and that even when failure occurs a reduction of the original population to 1–3% is achieved with either chemical. Control was at least as good in summer as it was in winter.

Factors influencing slow-release molluscicidal activity

Other factors that were analysed for the 52 treated sites were: the concentration of active ingredient in the slow-release matrix, the degree of pollution, the water flow rate, and the pH of the water. The first, within the described range, had no effect. Pollution, although in our experience a strong counteractant to slow-release molluscicidal activity, did not influence the results obtained in this series. In fact, only three sites with relatively clean water and seven with moderate pollution were found; in these, the results were not superior to those in the 42 highly polluted foci. Water flow (nil to 100 litres/min) also had no measurable influence, but it should be noted that this is very variable in an area subject to torrential rains followed by periods of rapid evaporation. The only factor for which a definite correlation was observed was alkalinity, which lowered the activity of TBTO (at 15 g/m², 14 out of 14 sites were totally controlled at pH 6–7. 5 and only 5 out of 11 at pH >7.5 during a 12-month period). The pH had no measurable influence on slow-release PCP.

The most common cause of failure was almost certainly omission of part of the breeding site during treatment. One such focus among those treated with PCP at 10 g/m² was investigated for us by Dr E. Penna Franca and M. A. M. Leal of the Federal University of Rio de Janeiro by means of radioactive marking techniques. It was found that a population of the order of 5000 snails per month, rising to 18 000 during the summer, was passing through the site, which was a ditch terminating in a municipal drain. The half-residence time was from 1 to 2 days in the examined area (10 m long). Failure was therefore due to continuous repopulation from an unrecognized breeding site that was dry when treatment was made but which contained buried snails in aestivation. Short exposure to an aged slow-release molluscicide was not immediately lethal to the snails and repopulation therefore occurred at this site when, owing to rain, the adjacent latent breeding areas became active sites of snail production. This observation not only emphasizes the enormous turnover of snails in quite a small area, where from 200 to 1000 snails per m² are renewed every few days, but indicates that better control might be obtained by massive localized dosage of non-flowing or semi-dry breeding areas, with no molluscicidal treatment at all of the actual ditches that drain them.

Other aquatic life

Guppies, which are often present even in highly polluted sites, normally suffer some mortality at the beginning of molluscicidal treatment but in general they tolerate it well. No lasting effect on the plant or insect life was observed. The ability of an unidentified fungus to grow profusely in the presence of TBTO leads us to believe that microbiological life continues in treated areas.

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RÉSUMÉ

LUTTE CONTRE LES MOLLUSQUES DANS DES SECTEURS URBAINS DU BRÉSIL, À L'AIDE D'HEXABUTYLDISTANNOXANE ET DE PENTACHLOROPHÉNOL À LIBÉRATION LENTE

Les foyers urbains hébergeant des mollusques infectés de *Schistosoma mansoni* sont probablement des endroits d'importance majeure pour la transmission de la schistosomiase en raison de la densité élevée de la population humaine. Le traitement des secteurs de ce type à l'aide de molluscicides à libération lente semble la meilleure solution dans l'immédiat, en attendant que soit assuré un drainage convenable. Dans la présente étude, deux molluscicides, l'hexabutyldistannoxane (TBTO) et le pentacholorphénol (PCP) ont été choisis en raison de leur

solubilité dans le support organique et du fait qu'ils se prêtaient par conséquent à une libération lente à partir de pastilles solides.

Les sites éprouvés, peuplés par *Biomphalaria tenagophila*, ont été localisés grâce à un programme d'éducation sanitaire dans les banlieues de Rio de Janeiro, les élèves des écoles primaires signalant les localités infestées par l'intermédiaire du personnel enseignant.

Le degré élevé de pollution dans 42 des 52 sites traités, rendant inefficace les doses faibles, la comparaison a été faite sur les doses de 5, 10 et 15 g/m² respectivement de deux produits actifs. Le TBTO a été préparé à une concentration de 4 à 18% et le PCP à celle de 14 à 32% dans des mélanges d'asphalte-caoutchouc-amiante-argile qui ont pu être extrudés en baguettes de 2 mm de diamètre. Ces dernières ne sont pas solubles dans l'eau et, si l'homme ne les déplace pas, elles restent dans le foyer pendant de longues périodes.

A raison de 15 g/m², la formulation de TBTO est venue à bout des mollusques pendant 18 mois dans les deux tiers des lieux traités. Le PCP a donné des résultats plus faibles, le repeuplement se produisant au bout de 6 mois. Néanmoins, même le PCP à libération lente est considéré comme supérieur à tout molluscicide dispersable dans l'eau, au point de vue de l'action à long terme. Le degré de destruction obtenu était le même en été (période de reproduction rapide à Rio de Janeiro) et en hiver. Il s'est révélé que l'alcalinité diminue les effets de la formulation de TBTO mais ne modifie pas ceux du PCP.

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