

to the problem of having prophylactic materials available at the earliest moment after exposure. However, until such banks are established, and in those parts of the world in which the serum banks would not be readily available, the direct use of human donors can be employed when hypersen-

sitivity to animal serum is encountered. Under these conditions the administration should be considered of a booster inoculation to one of two donors and the withdrawal of serum from the unboosted donor as soon as possible and from the second donor (who has received a booster) at 48 hours.

## Molluscicidal Qualities of Three Organo-tin Compounds Revealed by 6-hour and 24-hour Exposures against Representative Stages and Sizes of *Australorbis glabratus* \*

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A preliminary evaluation of certain organo-tin compounds indicated that several had considerable molluscicidal activity against *Australorbis glabratus*.<sup>a</sup> Three of the more promising compounds were subsequently tested more intensively against a stage-size array of *A. glabratus*. The results of this evaluation constitute the subject of this communication.

### Materials and methods

The following compounds were evaluated in this study: tri-n-propyl tin oxide, tri-n-butyl tin acetate, and tri-n-phenyl tin acetate. The propyl tin sample was a syrupy, water-clear liquid containing 80% active ingredient, while the other two compounds were fine, white powders of 95% active ingredient. All were soluble in methanol.

The methods used in these tests have been described in detail previously.<sup>b, c</sup> In the preparation of dilution series, stock solutions in methanol were diluted with dechlorinated tap water to the desired concentration of active ingredient. Tests were performed with two classes of incubated eggs (1-6 hours

and 4 days) and four classes of hatched snails (newly hatched not over 24 hours old, 3-5 mm adolescents, 8-10 mm juveniles, and 13-15 mm mature). Exposures were made for 6 hours or 24 hours, and mortality rates were determined after a 24-hour recovery period following exposure.

### Results

Tri-n-butyl tin acetate and tri-n-propyl tin oxide gave very similar results, except that the latter was relatively more effective against 4-day eggs. In 24-hour exposures (Table 1) the LC<sub>90</sub> value for either chemical did not exceed 0.115 ppm for hatched snails. Against 4-day eggs, however, the butyl tin had an LC<sub>90</sub> of 0.45 ppm, as compared with only 0.17 ppm for the propyl tin. Both chemicals were extremely effective against newly hatched and 3-5-mm snails, LC<sub>90</sub> values for these stages being only 0.04-0.05 ppm.

In 6-hour exposures tri-n-butyl tin acetate was somewhat more effective than tri-n-propyl tin oxide, but not significantly so, although again it was less effective against 4-day eggs (Table 2). With the butyl tin the maximum LC<sub>90</sub> values were 1.17 ppm for 4-day eggs and 0.38 ppm for 8-10-mm snails, while the propyl tin had maximum LC<sub>90</sub>s of 1.05 ppm for 13-15-mm snails and 0.37 ppm for 4-day eggs. Approximately the same concentration, 1.6 ppm, of either chemical killed all stages and sizes of snails tested.

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<sup>a</sup> Ritchie, L. S., Berrios-Duran, L. A., Frick, L. P. & Fox, I. (1964) *Bull. Wld Hlth Org.*, **31**, 147-149.

<sup>b</sup> Ritchie, L. S., Berrios-Duran, L. A., Frick, L. P. & Fox, I. (1963) *Bull. Wld Hlth Org.*, **29**, 281-286.

<sup>c</sup> Frick, L. P. & Jimenez, W. Q. de (1963) *Bull. Wld Hlth Org.*, **29**, 286-287.

TABLE 1  
COMPARISON OF MOLLUSCICIDAL ACTIVITY OF THREE ORGANO-TIN COMPOUNDS IN 24-HOUR EXPOSURES  
AGAINST REPRESENTATIVE STAGES AND SIZES OF A LABORATORY STRAIN OF PUERTO RICAN  
*AUSTRALORBIS GLABRATUS*<sup>a</sup>

Effect	Eggs		Snails			
	1-6 hours <sup>b</sup>	4 days <sup>b</sup>	Newly hatched	3-5 mm	8-10 mm	13-15 mm
Tri-n-butyl tin acetate						
LC <sub>50</sub> (95 % confidence limits)	0.031 (0.024-0.04)	0.23 (0.19-0.3)	0.019 (0.016-0.022)	0.041 (0.036-0.046)	0.074 (0.067-0.081)	0.085 (0.079-0.092)
LC <sub>90</sub> (95 % confidence limits)	0.072 (0.05-0.1)	0.45 (0.32-0.63)	0.041 (0.033-0.052)	0.056 (0.047-0.067)	0.105 (0.095-0.115)	0.115 (0.1-0.13)
100 % mortality	0.2	0.8	0.1	0.1	0.2	0.2
Tri-n-propyl tin oxide						
LC <sub>50</sub> (95 % confidence limits)	0.06 (0.05-0.07)	0.099 (0.08-0.12)	0.03 (0.027-0.033)	0.029 (0.028-0.031)	0.043 (0.035-0.053)	0.085 (0.079-0.091)
LC <sub>90</sub> (95 % confidence limits)	0.117 (0.092-0.139)	0.17 (0.128-0.225)	0.049 (0.044-0.054)	0.033 (0.031-0.035)	0.078 (0.061-0.099)	0.115 (0.1-0.13)
100 % mortality	0.2	0.2	0.1	0.04	0.2	0.2
Tri-n-phenyl tin acetate						
LC <sub>50</sub> (95 % confidence limits)	0.12 (0.098-0.15)	1.6 (1.5-1.76)	0.07 (0.06-0.08)	0.305 (0.27-0.35)	0.65 (0.61-0.69)	0.66 (0.53-0.83)
LC <sub>90</sub> (95 % confidence limits)	0.22 (0.17-0.28)	3.5 (3.0-4.0)	0.155 (0.124-0.19)	0.44 (0.37-0.52)	0.84 (0.8-0.88)	1.55 (1.15-2.1)
100 % mortality	0.5	4.0	0.2	0.5	0.9	4.0

<sup>a</sup> All concentrations expressed in parts per million of active ingredient.

<sup>b</sup> Incubation period before testing.

Under the conditions of the tests, tri-n-phenyl tin acetate was appreciably less effective than either of the aforementioned compounds and probably no longer merits consideration as a candidate molluscicide. In 24-hour exposures its activity varied widely according to the stage or size of the snail, with LC<sub>90</sub> values ranging from 0.15 ppm for newly hatched forms to 1.55 ppm for mature snails and 3.5 ppm for 4-day eggs (Table 1). Concentrations required for total kills in the same groups ranged from 0.2 ppm to 4.0 ppm. With 6-hour exposures all stages and sizes of snails except mature snails were killed within a range of 2.0-8.0 ppm. Tests with

mature snails were stopped when it was found that only 45% of the specimens were killed with 128.0 ppm.

Of the three compounds, only tri-n-butyl tin acetate exhibited an acceptable index of activity as determined by comparison between 6-hour and 24-hour exposures. In only one instance did the concentration required for the same observed effect (LC<sub>50</sub>, LC<sub>90</sub> or 100% mortality) in 6-hour and 24-hour exposures exceed a hypothetical ratio of 4 : 1. With tri-n-propyl tin oxide the ratio was less than 3 : 1 for eggs but ranged up to 10 : 1 for some classes of hatched snails. A similar situation also obtained for

TABLE 2  
COMPARISON OF MOLLUSCICIDAL ACTIVITY OF THREE ORGANO-TIN COMPOUNDS IN 6-HOUR EXPOSURES AGAINST REPRESENTATIVE STAGES AND SIZES OF A LABORATORY STRAIN OF PUERTO RICAN *AUSTRALORBIS GLABRATUS*<sup>a</sup>

Effect	Eggs		Snails			
	1-6 hours <sup>b</sup>	4 days <sup>b</sup>	Newly hatched	3-5 mm	8-10 mm	13-15 mm
Tri-n-butyl tin acetate						
LC <sub>50</sub> (95 % confidence limits)	0.094 (0.07-0.12)	0.56 (0.48-0.65)	0.074 (0.062-0.088)	0.088 (0.075-0.104)	0.2 (0.14-0.27)	0.19 (0.15-0.24)
LC <sub>90</sub> (95 % confidence limits)	0.17 (0.126-0.23)	1.17 (0.95-1.45)	0.185 (0.139-0.245)	0.14 (0.112-0.175)	0.38 (0.23-0.62)	0.3 (0.23-0.39)
100 % mortality	0.4	1.6	0.2	0.2	0.6	0.4
Tri-n-propyl tin oxide						
LC <sub>50</sub> (95 % confidence limits)	0.11 (0.09-0.13)	0.21 (0.17-0.26)	0.275 (0.12-0.59)	0.15 (0.13-0.17)	0.38 (0.32-0.44)	0.78 (0.71-0.85)
LC <sub>90</sub> (95 % confidence limits)	0.26 (0.17-0.35)	0.37 (0.28-0.50)	0.53 (0.198-1.4)	0.22 (0.176-0.275)	0.57 (0.47-0.68)	1.05 (0.91-1.21)
100 % mortality	0.4	0.8	0.8	0.4	0.8	1.6
Tri-n-phenyl tin acetate						
LC <sub>50</sub> (95 % confidence limits)	0.37 (0.3-0.44)	2.3 (2.2-2.4)	0.49 (0.40-0.59)	1.15 (0.98-1.35)	1.35 (0.98-1.86)	ND <sup>c</sup>
LC <sub>90</sub> (95 % confidence limits)	0.78 (0.65-0.94)	5.0 (4.76-5.25)	1.0 (0.77-1.27)	1.65 (1.3-2.0)	2.35 (1.54-3.6)	ND <sup>c</sup>
100 % mortality	2.0	8.0	2.0	2.0	6.0	ND <sup>c</sup>

<sup>a</sup> All concentrations expressed in parts per million of active ingredient.

<sup>b</sup> Incubation period before testing.

<sup>c</sup> ND — not done; see text.

tri-n-phenyl tin acetate, which also had an initial disadvantage of relatively high 24-hour exposure requirements.

In regard to other characteristics of the compounds, none presumably caused death rapidly since the majority of snails were still alive following either exposure period and most of the mortality occurred during the succeeding 24-hour recovery period. In order to avoid the possibility that such delayed deaths might be due to residual activity of the chemicals, precautions had been taken to ensure that snails were washed thoroughly before being transferred to fresh containers for the recovery period.

Although a deliberate effort was not made to ensure contact between snail and chemical at all times, casual observations made during the exposures suggested that the snails were not noticeably repelled by the chemicals, even in high concentrations.

Almost all snails died with the foot extended and much enlarged; only rarely was it contracted deeply into the shell, as is characteristic of snails exposed to many other compounds, e.g., Bayluscide and sodium pentachlorophenate. The distended, swollen condition became apparent during the exposure period and persisted until the death of the snail.