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# Effect of Short-Term Exposure to Copper on Survival of Apple-Snails in an Integrated Control Program[1]

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## INTRODUCTION

The Argentine apple-snail, *Pomacea canaliculata* (Lamarck 1822), was proposed as a possible biocontrol agent (Cazzaniga 1981, 1983) in a program of integrated control of aquatic weeds (mainly *Chara contraria* A. Braun ex Kütz.) in drainage channels of southern Buenos Aires Province, Argentina (Fernández et al. 1987a).

The herbicides used successfully in the channels were acrolein and copper sulphate (Fernández et al. 1987b). Only the latter is feasible due to economic constraints, however it has marked molluscicide effects (van Dinther 1956, van Overbeek et al. 1959).

Copper sulphate is probably the cheapest chemical used as a herbicide in aquatic environments (Blackburn 1974), but in flowing water, such as streams or channels, continuous application is generally needed to control aquatic vegetation, and the large amounts of chemical used may render the treatment uneconomical. Fernández et al. (1987b) tried to make the application of copper in such environments more economic by shock treatments, with high concentrations and brief contact times (less than 6 hours) and obtained a good control of *Chara spp.* Surprisingly, the experimental population of *P. canaliculata* thriving in one of the so treated channels was not depleted after copper treatment and adult snails were observed alive and egg clutches were laid the next summer.

Laboratory experiments were then carried out to determine the resistance of the snails to short exposures to high copper concentrations and to assess the possibility of their simultaneous application in the drainage system.

## MATERIALS AND METHODS

Young, adult snails, and egg clutches were collected from the Saavedra park pond at La Plata city (Buenos Aires Province). The shell length range of four age classes of snails were as follows: adult 35-50 mm long; young 10-25 mm long; 10 day old 4.5-5.3 mm long, and newly born animals were 2.5-3.5 mm. long.

Aquaria were arranged for each age class with increasing $CuSO_4.5H_2O$ (PCS) concentrations, from 1 to 12 ppm PCS (i.e. 0.225 to 3.05 ppm of Cu ion) for the newly hatched and ten day old snails; 3 to 12 ppm PCS for the youngs and adults. The solutions were prepared with tap water (hardness = 96 ppm $CaCo_3$). Ten snails were placed in each aquarium and four hours later they were washed and placed in tap water, until mortality was recorded 24 hours later. Snails less than 5.3 mm long were scrutinized under stereoscopic microscope and the lack of active heart beat was the death criterion. The larger snails which remained retracted and immobile were considered dead. The alive adult and young snails were then pooled in 45-l aquaria where they were kept up for several weeks. The experiments were made by triplicate at room temperature (20-22 C). The results are expressed in ppm of Cu ion.

The number of snails alive (expressed as a proportion of the initial ones) at different concentrations of PCS was subjected to an analysis of variance to determine the amount of trial-to-trial variability. The arrangement of the treatments was factorial (4 ages x 9 concentrations). Data were transformed to $x' = \arcsin \sqrt{x}$ to make the mean-variance independent. Variance homogeneity was probed (Sokal and Rohlf 1978) and the Basic program by Abou-Setta et al. (1986) was used for the log-probit determination of LC50 and LC90.

## RESULTS AND DISCUSSION

The resistance of snails to PCS increases considerably with age to a 10 mm length (corresponding to young snails) ($F = 22.28$, $P < 0.01$) where survivorship of the latter do not significantly differ from that of the adults ($F = 1.05$, $P > 0.05$).

The 4-h LC90 were 3.48 ppm Cu for the newly hatched snails (Figure 1, A), and 5.05 ppm Cu for 10 day old snails (Figure 1, B). LC90 for young and adult apple-snails were not calculated since the survivorship with a concentration of 3.05 ppm Cu was already of 60%. The latter is a much higher concentration than the one normally used for weed control (Bartley & Gangstad 1974, Whittaker et al. 1978). No significant mortality was recorded in the breeding aquarium after the first 24 hours.

Though PCS is known to be a powerful molluscicide, the LC90 for 24 hours for different species differs consid-

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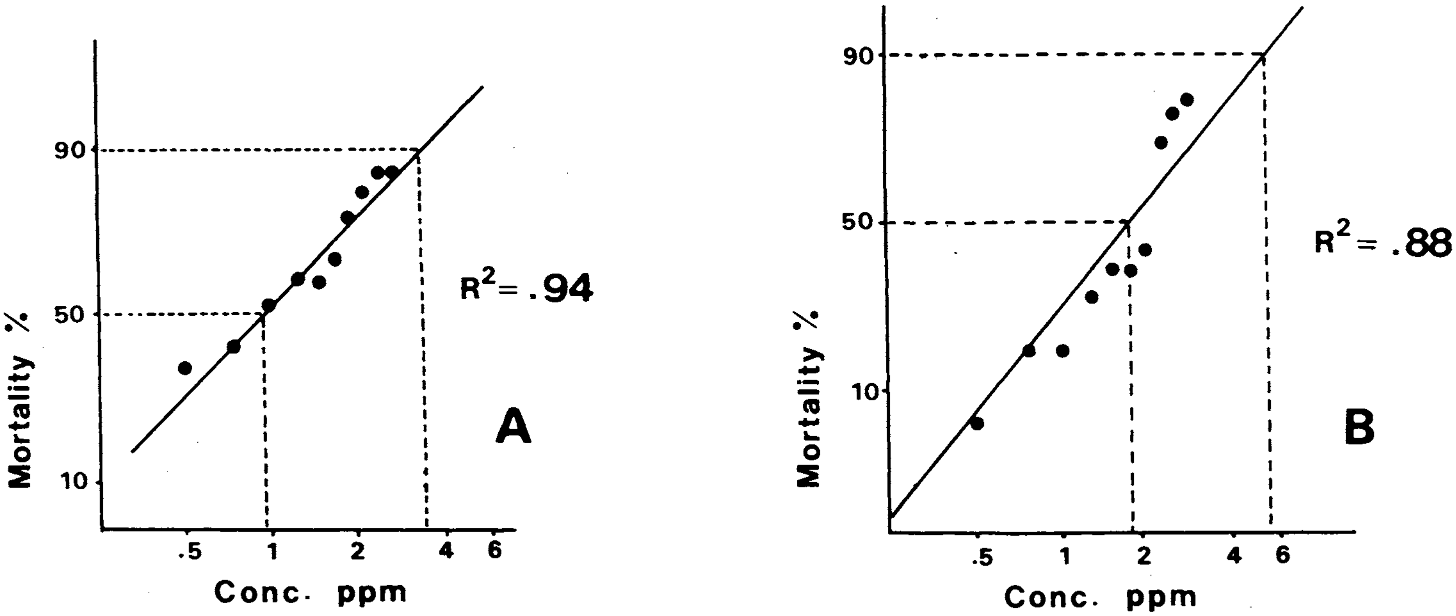


Figure 1. A. Log-probit curve relation and correlation of the survivorship of newly hatched *Pomacea canaliculata* with different PCS concentrations (4 hour contact), and B. Log-probit curve relation and correlation of the survivorship of 10 day old *Pomacea canaliculata* with different PCS concentrations (4 hour contact).

erably and it varies with the temperature (Hoffman and Zakhary 1951, Malek and Cheng 1974).

According to our data, the snails show different resistance to the herbicide depending on the age, the newly hatched being the least tolerant.

Van Dinther (1956) assessed the effect of Cu on *Pomacea lineata* (Spix) from Suriname (a very close species to *P. canaliculata*, cf. Cazzaniga 1987). He asserted that the newly hatched snails of that species were slightly harder to kill than the older and full grown snails. His data are originally expressed as mg of the chemicals per water surface areas, with different depths. If they are transformed to ppm of active Cu, there is no difference among the two groups: the mean 24 h-LC90 for newly born snails is 0.29 ppm Cu (from PCS, n=6, confidence interval $P<0.05$ = 0.17-0.41 ppm), and 0.44 ppm Cu (from a colloid Cu 20%, n=6, confidence limits $P<0.05$ = 0.25-0.63); LC90 for the adults were 0.24 and 0.31 ppm Cu respectively. Thus the resistance of both groups appears to be the same.

Crossland (1965) made up very limited trials, using only two ampullariid snails (*Lanistes ovum* Martens, from Swaziland) by concentration. He recorded no deaths up to 20 ppm of $Cu_2SO_4$ (11.39 ppm Cu), with 24 hours contact. It is probable that this unusual resistance is due to the water insolubility of the cuprous salt used by this author. In our experiment 3.05 ppm Cu (from PCS) killed up to 40% of the adults in only 4 hours.

An increase of LC90 is obtained for newly hatched snails when the contact time is reduced. Malek y Cheng (1974) referred similar answers to different chemicals for other gastropods. Cazzaniga (1981) determined a 24-h LC90 = 0.13 ppm Cu for newly hatched *Pomacea canaliculata*. It is within the same magnitude order as van Dinther's (1956) data, and it is far smaller than the 4-h LC90 of 3.48 ppm found in this paper.

These results lead us to the conclusion that the resistance of *P. canaliculata* to Cu action is age dependent, up to a certain point, and it is inversely related to exposure times.

*The control of the muskgrass problem. Chara contraria* is the most important weed in the drainage system of southern Buenos Aires Province. It shows biomass peaks in spring and summer (Fernández et al. 1987a) when there are snails of all sizes (2.5 to 75 mm long) present in the channels.

Fernández et al. (1987b) found that one application of ca. 5 ppm Cu during less than 6 hours in the channels with low velocity (<0.2 km $h^{-1}$) controlled *Chara*. This shock treatment would possibly kill most of the very young apple snails and less than 50% of the adults. Notwithstanding, substantial parts of the snails populations are generally able to escape pesticide treatments in flowing waters, since these snails live in the vegetated borders of the watercourse where pesticide concentrations remain low. Such "ecological escape" may also contribute to greater survival in channels than those observed in laboratory.

Since eggs of *P. canaliculata* are aerial they are not affected by the treatment. Also, the females lay eggs up to ten times a summer, even without a new copulation,[5] so their repopulation would be likely.

*Pomacea canaliculata* are active and reproduce in spring-summer and overwinter burrowed in mud. Their activity during these months could prevent the recolonization of the bottom by germinating weeds, as a complement of the shock chemical control.

The results support the hypothesis of Cazzaniga (MS) that *Pomacea* snails could be integrated with chemical control as reducers of weed regrowth. It appears feasible to find a time-concentration relationship that would allow an attack to the weeds using copper and apple snails simultaneously.

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