Bull Environ Contam Toxicol (2007) 79:606–608
DOI 10.1007/s00128-007-9312-6

Influence of Copper on the Feeding Rate, Growth and Reproduction of the Golden Apple Snail, *Pomacea canaliculata* Lamarck

Silvia C. Peña · Glorina N. Pocsidio

Received: 7 June 2007 / Accepted: 25 October 2007 / Published online: 13 November 2007

Abstract The influence of copper on feeding rate, growth, and reproduction of *Pomacea canaliculata* Lamarck was evaluated. Ten days of exposure to copper of relatively high concentration (67.5 µg/L) reduced the snails' feeding rate and retarded their growth. Exposure to 20 µg/L after 36 days increased feeding rate to 28%. After 20 days of exposure at 30 µg/L, snail's growth was significant but thereafter declined. Growth of all snails including control was negligible by day 50 when snails were in the reproductive state. Copper did not affect reproduction.

Keywords *Pomacea canaliculata* · Copper · Snail · Feeding rate · Growth · Reproduction

The presence of heavy metals in the environment may pose a risk to both animal and plant life. Copper, though an essential heavy metal, has proven to be toxic in excess amount. Essential metals are only required in trace amounts and the excess concentration is regulated by homeostatic control mechanisms. However, if the supply concentration is too high, the homeostatic mechanism ceases to function and the intake of metal will impose acute or chronic effects to the organism (Engel et al. 1981).

Golden apple snails (*Pomacea canaliculata* Lamarck) are agricultural pests in Asia. They feed voraciously not only on rice but also on azolla, taro and lotus plants, causing much loss to the farmers (Saxena et al. 1987; Mochida 1988, 1991; Naylor 1996). They have become ubiquitous in aquatic habitats. Apple snails are soft-bodied animals that are very susceptible to metal toxicity (Humphrey et al. 1995). In this study, the influence of copper on the feeding rate, growth and reproduction of the snails was evaluated.

Materials and Methods

Several egg masses of *P. canaliculata* were collected from a field and placed on a polyethylene screen over a big basin half-filled with dechlorinated tap water. When they hatched, they were fed with young camote (*Ipomoea batatas*) leaves, as was used in a previous experiment (Lacanilao 1988). As they grew older, some hatchlings were transferred to other big basins to lessen mortality and to hasten growth. Water was changed daily and feeding was ad libitum. Eighteen 15-L polyethylene boxes were set up for the experiment. Three replicates of five different Cu concentrations (20, 30, 45, 67.5 and 101.25 µg/L) and of the control group were randomly laid out. These concentrations resulted from the range finding test (pre-test, Table 1). As only three snails survived out of the nine placed in 101.25 µgCu/L, this concentration was consequently discarded. Each box contained 4 L of each solution (except the control which contained only dechlorinated tap water) and three 3-month (90-day) old snails: 1 male and 2 females. Water was changed twice a week, as was recommended by Lacanilao (1988). The temperature during the experiment ranged from 26–29°C at a pH range of 7.9–8.2 under natural photoperiod. The experiment started on the 12th of November 2006 and ended on the 11th of February 2007. The snails were fed

S. C. Peña (✉)
Institute of Environmental Science and Meteorology, University of the Philippines, Diliman, Quezon City 1101, Philippines
e-mail: silvscp_55@yahoo.com

G. N. Pocsidio
Institute of Biology, University of the Philippines, Diliman, Quezon City 1101, Philippines

Table 1 Result of range finding test using four copper concentrations at two replicates with 10 snails in every replicate for 4 days

Copper concentration (µg/L)		Day 0	Day 1	Day 2	Day 3	Day 4
10	1	All snails alive	All snails alive	9 snails alive	9 snails alive	9 snails alive
	2	All snails alive	All snails alive	All snails alive	All snails alive	All snails alive
50	1	All snails alive	All snails alive	All snails alive	All snails alive	All snails alive
	2	All snails alive	All snails alive	All snails alive	All snails alive	All snails alive
250	1	All snails alive	All snails alive	6 snails alive	6 snails alive	5 snails alive
	2	All snails alive	All snails alive	All snails alive	8 snails alive	3 snails alive
1250	1	Closed operculum	All snails dead			
	2	Closed operculum	All snails dead			

with camote leaves ad libitum except on their 99th and 126th day when they were given 5 g and their feeding rate was measured. The time for the snails to consume everything was recorded. Growth was assessed by the measurement of shell length (from the shell apex to the aperture basal extreme) by means of a caliper (Estebenet 1995). Measurement was taken every 10 days until the reproduction period or 50 days after the initial exposure. During the reproduction period, the following endpoints were documented – number of egg masses laid, area (length × width) of the egg mass, number of eggs in each egg mass, incubation period, and hatchability.

The Repeated Measures ANOVA and post-hoc Tukey HSD test were used to analyze the data on the snails' feeding rates and growth. The Kruskall–Walli's Test was used on the data on reproduction endpoints.

Results and Discussion

Figures 1 and 2 show the influence of copper on feeding rates and growth of the snail.

Figure 1 shows that at age 126 days and with chronic exposure to copper, there was a trend of increased feeding rates that ranged from 50% to 200% ($p < 0.01$). Feeding rate was negatively affected by the highest concentration of copper used (67.5 µg/L). At this concentration, those aged 99 days (or those exposed for 10 days) had the feeding rate of only 25% of the feeding rate of the control snails and 24% of the snails exposed to 20 µg/L. In fact, it was observed that the snails exposed to the highest concentration had their operculated apertures closed almost all the time until when they started to feed more actively at age 126 days or at 36 days of exposure. Their feeding rates then increased by 200%. Nevertheless, this rate was a mere 28% of the rate exhibited by the snails of the same age but exposed to only 20 µg/L.

Figure 2 shows the deterrent effect of the very high concentration of copper to growth. Growth of the snails

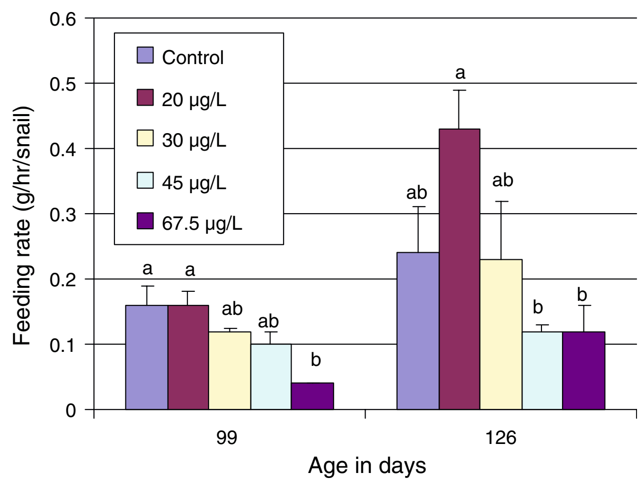

Fig. 1 Feeding rates with age of *Pomacea canaliculata* exposed to varying concentrations of copper starting on their 90th day of age. Results are mean ± SEM (n = 3). Analysis by Repeated Measures ANOVA and post-hoc Tukey HSD test. Within each group, same letter indicates no significant difference at $p < 0.05$

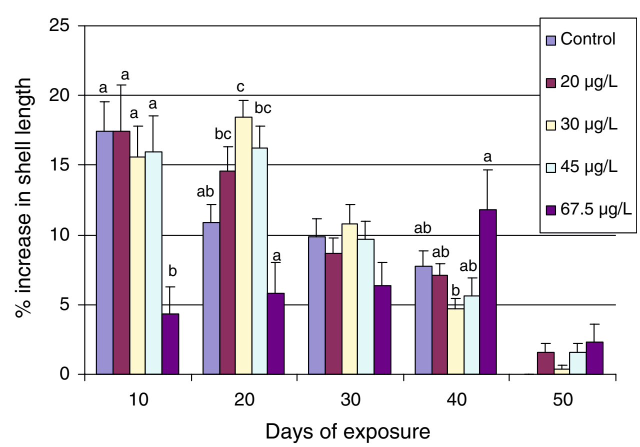

Fig. 2 Percent increase in shell length of *Pomacea canaliculata* with chronic exposure to varying concentrations of copper. Results are mean ± SEM (n = 9). Analysis by Repeated Measures ANOVA and post-hoc Tukey HSD test. Within each group, no letter or same letter indicates no significant difference at $p < 0.05$

was least with the 67.5 μgCu/L concentration, particularly on the first 20 days of exposure. This can be attributed to the low feeding rate of the snails. By day 20, those in the lower concentrations of copper exhibited sustained growth. This result probably demonstrates the importance of copper as a micronutrient. At this time, the shell length obtained from those in 30 μgCu/L was significantly different from those obtained from control snails. Thereafter, growth declined except for the snails exposed to 67.5 μg/L, which by then has increased feeding rate by 200% (at 36 days of exposure). The increased feeding rate (150%) of snails exposed to 20 μg/L occurred without apparent additional growth. This discrepancy between feeding and growth can probably be explained by the snails' redirection of their energy to sexual maturation and copulation. It was observed that some snails had already started to copulate by day 30 and by day 50, all snails were at this state. This result agreed with the finding of Estebenet and Cazzaniga (1992) that *P. canaliculata* exhibit decreased growth rate during the breeding season. All the snails' shell length at the start of the experiments ranged from 19–29 mm and reached 28–45 mm at the peak of the reproduction period.

In a previous study, it was reported that the reproduction of *P. canaliculata* in terms of number of egg masses laid, size of egg mass, number of eggs in an egg mass, incubation period and hatchability can be affected by the kind of food that the animal eats (Lacanilao 1990). In this present study, results showed that the exposure of snails to different copper concentrations had no effect on the reproduction endpoints stated above. The size (area) of egg mass ranged from 135–1,275 mm^2 while number of eggs per egg mass ranged from 30 to 370. Their incubation period was from 9 to 15 days and hatchability was from 7% to 99%. De Lara (1988) observed in her laboratory experiment that the snails had an incubation period of 8–12 days and hatchability of 75%.

In contrast to the present results is the effect of copper to a freshwater pulmonate snail *Radix quadrasi* in which reproduction was affected. De Lara (1991 Ph. D. Dissertation) noted that the total egg production was highest in the control group and as copper concentration increased, egg production decreased.

In another study, *Biomphalaria glabrata* snails were exposed to Pb, Cd and Hg. The metals had affected their size but not reproduction (Abd Allah et al. 1997). This observation is similar to the present findings with copper.

Acknowledgments I thank Dr. Carlos Primo C. David, Dr. Annabelle Herrera, Dr. Nemesio Montaño and Ms. Chat S. Kwan of the University of the Philippines, Diliman, Quezon City, Philippines for their valuable suggestions. Likewise to Rofe Obena, Orlex Yllano, Leonora Nudo, and Mercy Dy for the assistance in the preparation of this manuscript and to Dr. Meda San Juan and Hope Sazon for editing this paper.

References

Abd Allah AT, Wanas MQS, Thompson SN (1997) Effects of heavy metals on survival and growth of *Biomphalaria glabrata* Say (Gastropoda, Pulmonata) and interaction with schistosome infection. J Molluscan Stud 63:79–86

De Lara AV (1988) Life history of golden apple snail (*Pomacea canaliculata*) under laboratory conditions. Terminal Report. University of the Philippines Los Baños Basic Research Program

Engel DW, Sunda WG, Fowler BA (1981) Factors affecting trace metal uptake and toxicity to estuarine organisms. I. Environmental parameters. In: Vernberg FJ et al. (eds) Biological monitoring marine pollutants. Academic Press, New York, pp 127–142

Estebenet AL (1995) Food and feeding in *Pomacea canaliculata* (Gastropoda: Ampullariidae). Veliger 38:277–283

Estebenet AL, Cazzaniga NJ (1992) Growth and demography of *Pomacea canaliculata* (Gastropoda: Ampullaridae) under laboratory conditions. Malacolog Rev 25:1–12

Humphrey CL, Faith DP, Dostine PL (1995) Baseline requirements for assessment of mining impact using biological monitoring. Aust J Ecol 20:150–166

Lacanilao F (1988) Culture problems of the golden apple snail. Nat Appl Sci Bull 40:43–49

Lacanilao F (1990) Reproduction of the golden apple snail (Ampullaridae): egg mass, hatching, and incubation. Philipp J Sci 119:95–105

Mochida O (1988) Nonseedborne rice pests of quarantine importance. In: Rice seed health. International Rice Research Institute, Los Baños, Philippines, pp 117–129

Mochida O (1991) Spread of freshwater Pomacea snails (Pilidae, Mollusca) from Argentina to Asia. Micronesica Suppl 3:51–62

Naylor R (1996) Invasions in agriculture: assessing the cost of the golden apple snail in Asia. Ambio 25:443–448

Saxena RC, de Lara AV, Justo HD Jr (1987) Golden apple snail: a pest of rice. Int Rice Res Newsl 12:24–25