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EFFECTS OF CROWDING ON BREEDING *POMACEA CANALICULATA* (GASTROPODA : AMPULLARIIDAE)*

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ABSTRACT

Two experiments on the survival and growth of *Pomacea canaliculata* (Lamarck, 1801), a potential agent of biological control of aquatic weeds, were performed in order to define a suitable method for life tables under laboratory conditions, avoiding crowding effects. During eleven months after hatching, one hundred snails could be bred in 10 l aquaria, showing no detrimental effects adscribable to squeezing. Cohorts from a pool of egg masses have some advantages upon single-egg-mass ones, both because of a lower mortality rate and a greater growth rate as well.

INTRODUCTION

Several species of the family Ampullariidae were proposed and used as control agents of water weeds, i.e., *Marisa cornuarietis* (L.) in America and Africa (MITCHELL, 1974; NGUMA *et al.*, 1982), *Pila globosa* Swainson in India (THOMAS, 1975) and *Pomacea canaliculata* (Lamarck) in South America (CAZZANIGA, 1981). Experiences in order to mass production were attempted only with *M. cornuarietis* (BUTLER *et al.*, 1969; RICH & ROUSE, 1970). When we started the laboratory breeding of *P. canaliculata* to produce a survivorship schedule, squeezing was seen to cause mortality and lowering of growth.

Crowding is known to produce an important detrimental effect on growth, mortality and fecundity of several freshwater gastropods (FORBES & CRAMPTON, 1942; CHERNIN & MICHELSON, 1957a, b; WRIGHT, 1960; FERGUSON, 1978). This is an item that should be considered when planning the management of snails.

The literature mainly refers to basommatophoran pulmonates, specially schistosome-bearing Planorbidae and Lymnaeidae, the experimental breeding of which being a task.

In this paper, the results of two laboratory experiments of crowded breeding of newly hatched Argentinian apple-snail are presented.

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MATERIAL & METHODS

Two experiments were made to verify the negative effects of crowding. Egg masses of *P canaliculata* were collected at Laguna Alsina (Buenos Aires Province, Argentina), on rushes (*Scirpus californicus*, Cyperaceae).

Eggs of *Pomacea* are easy to handle. They are aereous, reddish pink and they are layed on emerged plants and other objects. Hatching in laboratory requires no care.

The preliminary experiment was intended to reveal the effects of extreme squeezing conditions. The portions supporting egg masses of six rush stems were cut off and each of them put in a 500 cc glass,with 50cc of water to provide them with moisture. They were kept at room temperature (20°C–25°C) until hatching occurred. Another set of four stems was similarly arranged in 10 l aquaria. After hatching, the number of newly born snails and nonviable eggs were recorded. The initial number of snails oscillated between 120 and 478 snails per egg clutch, and the viability was of 80% average. The individual volume at birth was near 0.1 cc and the shell length was 2.5 to 3.2 mm, The snails were maintained in the 500 cc and 10 l glasses respectively*. Water was changed every three days and a customary diet of lettuce was added. During 7 weeks mortality and average length of 20 randomly selected snails from each cohort were measured.

The second experiment was conducted on the differential behavior under three degrees of crowding. One hundred snails from a single egg mass were put in each of three aquaria with 500 cc, 3 l and 10 l, respectively. Another similar set of snails was so arranged, but with 300 snails randomly selected from a pool of three egg masses. Mortality and average length of these snails were also recorded every 4, 7 or 15 days, upto 5 months. The records were then interrumpted and a final record was made at the 11th month, when observations were concluded.

RESULTS

Figure 1 shows the survivorship of extremely crowded snails (6 repetitions) and little crowded ones (4 repetitions). The greater mortality in the former was associated with a smaller growth rate (Fig. 2), leading to significatively different final sizes. No statistical treatment has to be detailed because of the great difference in these data.

Figure 3 shows the survivorship of snails from two origins, either from a same egg mass (A) or from a pool of egg clutches (B), under three different degrees of crowding, throughout eleven months.

Table. 1 gives the results of an homogeneity test (SOKAL & ROHLF, 1969) for 35, 64 and 113 days respectively, for both sets.

On the 35th day set A already showed differential death, but not set B. Set A, with groups of snails born from a single egg mass, maintained the difference throughout the experiment, giving final records (after 330 days) of 85, 35 and 9 survivors in the glasses of 10 l, 3 l and 500 cc respectively.

Set B arising from a pool of egg masses, displayed a different behavior. The final record (77, 66 and 22 survivors, respectively) were greater than the equivalent results in the set A. The benefits of a greater genetic pool were also shown by the little dissimilarity in the 3 l and 10 l experiences.

On the 64th and 113th days there was a small advantage in the survivorship of the

*It is to be noticed that a couple or individual adult snails, of 50 mm length and 30 cc body volume, are able to survive in the little glasses (500 cc) for several months.

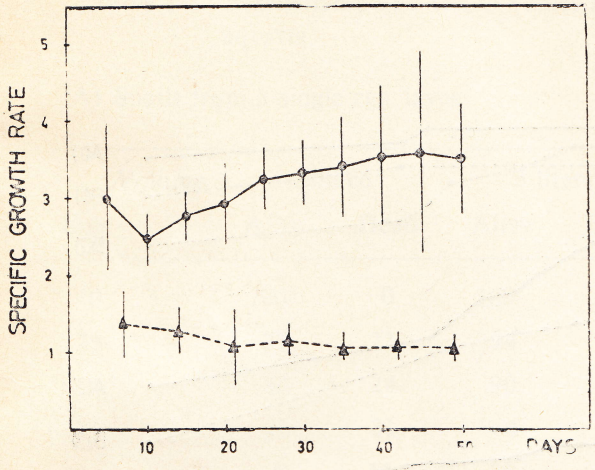


Fig. 1. Survivorsip curve from newly hatched *Pomacea canaliculata* in 10 1 aquaria (full line : 4 repetitions) and 500 cc glasses (dotted line : 6 repetitions). Vertical lines : standard deviations.

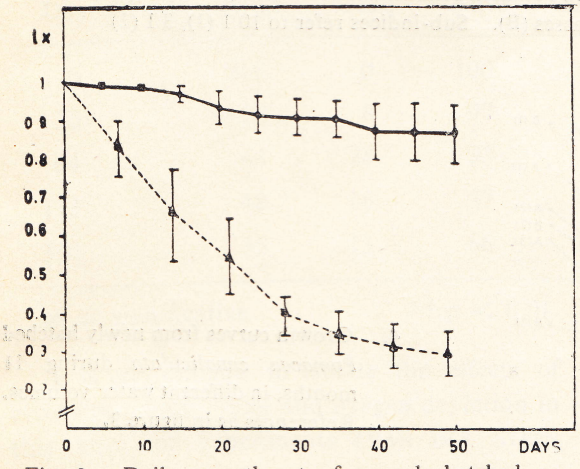


Fig. 2, Daily growth rate for newly hatched *Pomacea canaliculata* in 10 1 aquaria (full line : 4 repetitions) and 500 cc glasses (dotted line : 6 repetitions). Vertical lines: standard deviations.

3 1 snails although they were more crowded than those in the 10 1 aquaria. Notwithstanding, on the 11th month there were more survivors in the latter.

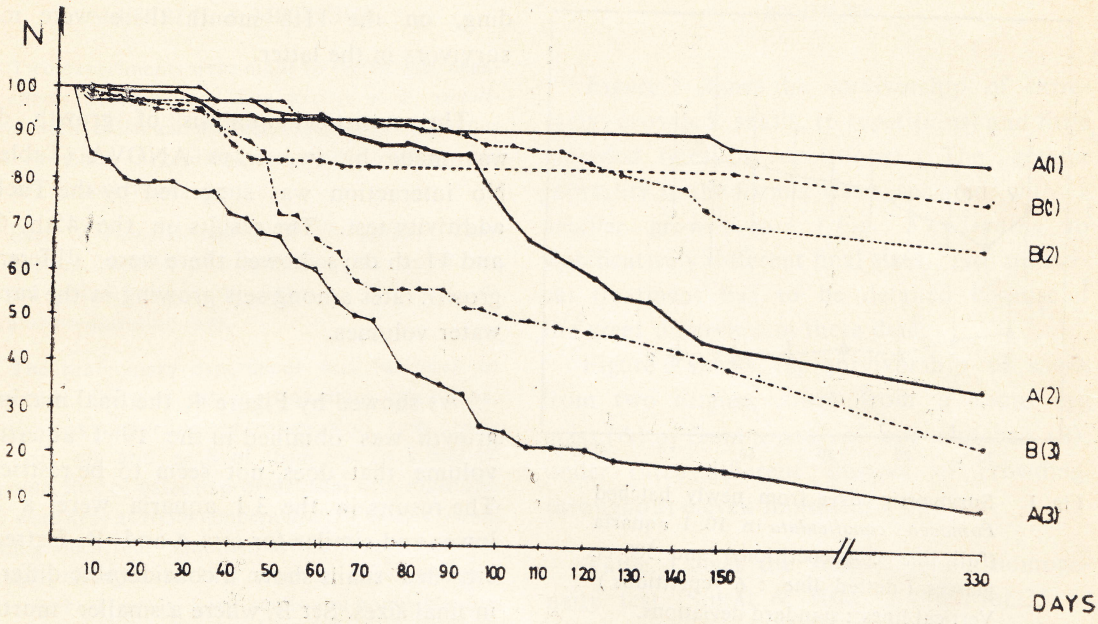
The statistical analysis of growth data was made by two ways ANOVA (Table 2). No interaction was suggested by the Tucky's additivity test. The results on the 45th, 64th and 11.th days showed there were differential growth rates among sets growing in the various water volumes.

As showed by Figure 4, the final maximum growth was obtained in the 10 1 aquaria, a volume that does not seem to be restrictive. The results in the 3 1 aquaria were a little lower and similar for sets A and B. Extremely crowded snails show a considerable difference in final sizes. Set B, where a smaller mortality was recorded, grew less too, while one-egg-mass snails (set A), less crowded by a greater number of deaths increased their sizes faster, approaching the shell length of those in the 3 1 aquaria.

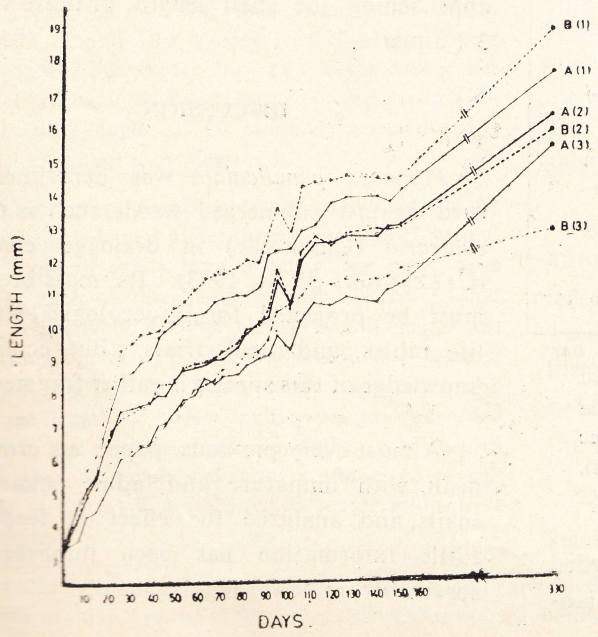
DISCUSSION

Pomacea canaliculata was experimentally used against submerged weeds, such as *Chara contraria* (Characeae) in drainage channels (CAZZANIGA, 1981, 1983). Its mass breeding must be projected for autoecological studies, life tables and field trials. But ecological knowledge of this species is rather fragmentary.

Almost every previous paper on crowding dealt with immature and adult pulmonated snails, and analyzed the effect on fecundity. Little information has been published on survival from newly hatched snails.



3. Survivorship curve from newly hatched *Pomacea canaliculata* from a single egg mass (A) and from a pool of three egg masses (B). Sub-indices refer to 10 1 (1), 3 1 (2) and 500 cc (3) aquaria, respectively.



4. Growth curves from newly hatched *Pomacea canaliculata* during 11 months, in different water volumes. References as in figure 3.

Table 1 : Survivorship and test G values for populations bred in 500 cc, 3 l and 10 l aquaria.

(A) Snails from a single egg layer

Volume	500 cc		3 liters		10 liters		Homogeneity test
Day	Alive	Dead	Alive	Dead	Alive	Dead	G value
0	100	0	100	0	100	0	—
35	77	23	94	6	97	3	2[illegible].48**
64	53	24	90	4	93	4	34.04**
113	22	31	64	26	91	2	65.96**
330	9	13	35	29	85	6	—

(B) Snails from a pool of egg masses

Volume	500 cc		3 liters		10 liters		Homogeneity test
Day	Alive	Dead	Alive	Dead	Alive	Dead	G value
0	100	0	100	0	100	0	—
35	92	8	97	3	92	8	3.16 ns
64	64	28	93	4	84	8	29.22**
113	48	16	87	6	83	1	24.26**
330	35	13	66	21	77	6	—

ns no significative ** $p < 0.01$

It is very difficult to isolate the effects of crowding, food rates and oxygen depletion in this kind of experiments (VAN DER STEEN 1977), but it is also true that guidelines on this phenomenon are needed for an efficient mass-breeding of snails.

Some of the earlier reports on the crowding effects almost lacked a true statistical treatment, and their results were only tentative (CRABB, 1929; CHERNIN *et al.* 1956; CHERNIN & MICHELSON, 1957 a, b; BRENES *et al.*, 1958; JOBIN & MICHELSON, 1967). There seemed to be a paradoxical difference in the growth results when either the same number of snails were maintained in different volumes or a different number were kept in the same volume of liquid (CHERNIN & MICHELSON, 1957a, b). WRIGHT (1960) interpreted this difference by supposing the existence of an organic, readily oxidizable, substance causing growth inhibi-

Table 2 : Individual growth in populations bred in 500 cc, 3 l and 10 l aquaria. Two ways ANOVA.

46th day

Source	SS	df	MS	F
Water volumes (V)	7.889	2	3.944	35.09*
Origin of the snails (0)	0.005	1	0.005	0.049
V x O	0.225	2	0.112	

64th day

Source	SS	df	MS	F
Water volumes (V)	7.499	2	3.749	20.76*
Origin of the snails (0)	0.160	1	0.160	0.88
V x O	0.361	2	0.181	

113th day

Source	SS	df	MS	F
Water volumes (V)	7.166	2	3.583	23.06*
Origin of the snails (0)	0.716	1	0.716	4.61
V x O	0.311	2	0.155	

*$p < 0.05$

tion. However, the effect of this 'pheromone', identified by BERRIE & VISSER(1963)in another species, is not easily distinguishable from the consequence of oxygen depletion and the fouling of water (JOBIN & MICHELSON, 1967), and it is also probable that crowded snails actually produce substances which increase the growth rate (THOMAS, 1982), but are counterbalanced by fouling.

Other causes of stunting growth could be the number of touches among individuals within the aquarium and the competition for food (CHERNIN & MICHELSON, 1957 a). JOBIN & MICHELSON (1967) explained the apparent Chernin-Michelson's paradox by an increase in food availability in the most crowded aquaria, leading to a greater growth, although the food was always provided *ad libitum*.

Our results of the present investigation are in disagreement with those of CHERNIN & MICHELSON (1957 b) since our most crowded snails were also those of less growth, although they were provided with lettuce in excess.

Other authors tried to establish the importance of food competition, oxygen concentration and density effects within the so-called

"crowding effects" (VAN DER STEEN *et al.*, 1973; MOOIJ-VOGELAAR *et. al* , 1975; JANSEN & VAN DER STEEN, 1975).

CRABB (1929) and FORBES & CRAMPTON (1942) reported that crowding in *Lymnaea* had no definite effects on growth, but recovery was possible within a certain age range. Our results with *P. canaliculata* show that 500 cc snails grew faster as mortality increased, leading to think that recovery is possible during early periods of life.

No pheromone seems to be involved (THOMAS, 1982), and the other proposed mechanisms do not seem to be universal in freshwater snails. *Bulinus truncatus* and *Tarebia granifera*, for example, do not suffer from the effect of density in the laboratory (NAJARIAN, 1960; FERGUSON, 1978).

In the present investigation, it was not attempted to analyze the causes of crowding effects on *Pomacea canaliculata*; what was attempted was simply to obtain the practical results in the laboratory breeding of a potentially useful species. In order to define a standard method for life tables and other laboratory studies on this species, we conclude that :

(1) The effects of crowding on survivorship, whatever their causes be, have an early appearance on newly hatched *Pomacea canaliculata* and they must be taken into account to avoid some bias.

(2) The cohorts arising from pools of egg masses have advantages over the lots hatched from a single mass.

(3) One hundred snails can be bred in 10 l aquaria for almost a year, with normal growth and high survivorship.

(4) If necessary, 3 l aquaria can be used for some months without marked detrimental results.

(5) During the first few months, the effects of crowding on growth seems to be reversible.

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