

SEX RATIO AND SUSCEPTIBILITY OF THE GOLDEN APPLE SNAIL, *POMACEA CANALICULATA*

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Abstract. Golden apple snails, *Pomacea canaliculata*, were collected at two localities having different ecological environments. In both canal and pond, *P. canaliculata* males were found more than females during the dry season (summer and winter).

In the canal, the male snails were highest in number (86.67%) in May. When rain started, they began decreasing and were lowest at 33.33% in August. Of 575 snails collected, 30.6% were infected by one or more of the three groups of amphistome, distome and echinostome metacercariae. There were two high peaks of infection in April and October, as 60.7% and 68.4%, respectively, during which there were more males than females. The average number of parasites per snail which was highest at 54 was found in the medium-sized males (25 out of 35 males) in October. The number of parasites per snail was significantly correlated with the collected males ($p < 0.01$), but such relationship was not occurred with the females. Of the females, only the large-sized individuals were infected.

In the pond, the female snails were present in much greater numbers than the males during the reproductive time (June-September). The females were highest (94.23%) in August. Only 24 (4.0%) of 605 snails were infected; most of the infected snails were large.

INTRODUCTION

The golden apple snail, *Pomacea canaliculata* (Orbigny), is one of the New World species of the family Ampullariidae (Pilidae). The snails were formerly found only in South America, Central America, the West Indies and the southern USA (Michelson, 1961), but they are now widely distributed in Southeast Asia including Thailand. Because of the ability to greatly increase the population in a short period of time and destroy economic plants, such as rice and aquatic vegetables, *Pomacea* snails are an important pest that governments of some countries (*ie* Philippines, Taiwan and Thailand) are urgently attempting to get rid of.

Regarding the ecology of *Pomacea* snails, few reports have been published. *Pomacea canaliculata* is moderately amphibious, likely to live in the water much more than on the ground. The snails can stay far from the water for a period of time but not too long because they have medium thick shells with chitinous opercula (Keawjam and Upatham, 1990). In comparison, the other genus *Pila*, the native apple snail of Thailand, can survive a prolonged period of estivation during the dry months because they have thick shells and calca-

reous opercula (Keawjam, 1987). Keawjam and Upatham (1990) proposed that *Pomacea* snails may be able to change their sex from male to female, but the change may occur during either the active period or estivation.

Our interest about the ecological life of *Pomacea canaliculata* is whether local environmental conditions can affect the sex ratio of the snails, which sex is more susceptible to parasites and how age and size of the snails are relative to parasitic infection.

MATERIALS AND METHODS

Pomacea canaliculata, the golden apple snails were collected once a month, approximately 50 individuals per station. Two stations were chosen at Kasetsart University, Bangkok. One was a man-made canal, 800 m in length, and the other was a pond, having a surface area of 500 m². These two sampling stations were 1.5 km apart. The canal was under the shade of trees and also covered by water lilies. In contrast, the pond was a large open area, through which sunlight could penetrate.

The snails were randomly collected and brought

to the laboratory. They were anesthetized and then removed without breaking the shell. The foot muscle was cut, weighed, chopped and put into a 50 ml beaker individually, to which sufficient digestive solution (5% pepsin) was added. The mixture of 1g muscle tissue/3 ml pepsin was incubated in an incubator at 37°C for 12 hours, and periodically agitated. Large pieces of tissue were removed using a sieve, while the remaining mixture was transferred to a 40 ml centrifuge tube and left until it sedimented. The sediment was cleaned with dechlorinated water until the liquid became transparent (Poonswad *et al*, 1988). The sediment along with water was added into the channel of Scott's chamber for examination and counting of the parasites within, using a dissecting microscope at 15X magnification.

The snails were dissected to remove their heart and kidney. These two organs were placed between two pieces of glass (0.5 × 5 × 23 cm) and squashed to a thin film. Within this film the parasites were examined. (More details of materials and methods can be seen in Keawjam *et al*, 1993).

To analyze the data, the percentage of female and male snails collected and infected for each month was calculated. The average number of parasites per snail was recorded. Linear regression analysis was used to investigate relationship and predict the number of infected snails from the number of collected snails. Student's *t*-test was used to determine whether the regression was significant.

RESULTS

Dry months in Thailand are usually between early November and late April. In both canal and pond *Pomacea canaliculata* males were found more than females (Fig 1) during this dry season. In the canal, the male snails were 54.90% in March, 80.36% in April and highest in number (86.67%) in May. During June, rain started, and the male snails began decreasing, reaching the lowest in number, at 33.33%, in August. Between June and September was the time for *P. canaliculata* mating and reproduction. We saw several clusters of eggs attached to objects above water level in July. The eggs increased in number with the highest number of females (66.67%) in August, and in September many clusters were still found

and also young snails were hatching out of the eggs. They were all males. From September and December, the females were decreasing while the males increase.

In the pond, the number of *Pomacea canaliculata* males was greater than the females during the dry months. The females started to increase in number in May (34.88%) and June (40.38%) and then were highest (94.23%) in August. During the wet season (July-October), the females were present in much greater numbers than the males.

The percentage of infected snails collected from the canal was compared with that from pond. Parasites found in the *Pomacea canaliculata* snails were amphistome, distome and echinostome metacercariae. Of 575 snails collected from the canal, 176 individuals (30.6%) were infected by one or more of these three groups of parasites, whereas of 605 snails collected from the pond, only 24 individuals (4.0%) were infected. In the pond, May was the only month in which the snails had a high percentage of infection (30.2%) (Fig 2), when the female : male ratio was 4 : 9. All these females and 8 of 9 males were large sized (shell length > 30 mm). Due to low parasitic infection, in general, of the snails in the pond, the pond data was disregarded.

In the canal, there were two high peaks of infection in April and October, as 60.7 and 68.4%,

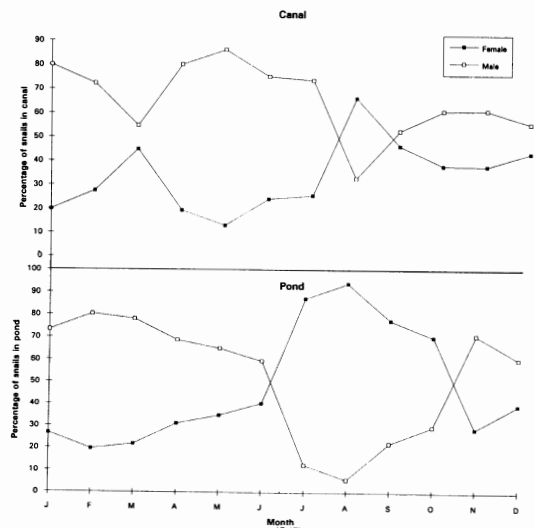


Fig 1—Comparison of percentage of female and male *Pomacea canaliculata* from two different localities according to time of the year.

GOLDEN APPLE SNAIL SEX RATIO

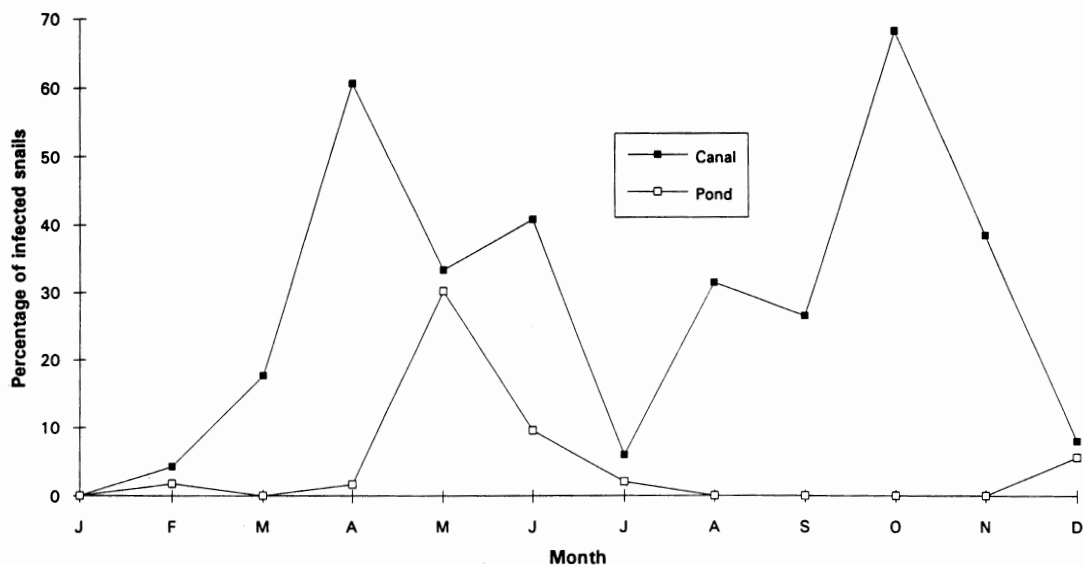


Fig 2—Comparison of percentage of infected *Pomacea canaliculata* from two different localities according to time of the year.

respectively (Fig 2), during which there were more males than females (Table 1). Three females : 31 males in April and 14 females : 25 males in October were infected. Also, the average number of parasites per individual found in the medium-sized male snails (shell length : 10-30 mm) in October was highest at 54. During the reproductive time (June-September), the infected males were generally large-sized. Of the female snails, only the large-sized individuals were infected, and the average number of parasites per individual was highest at 12 in April. Fig 3 shows comparison of average number of parasites in females and males of *Pomacea canaliculata* in the canal. There were no infected females during four dry months (December-March). In August, during which the females made up the greatest percentage of the population (66.67%) (Table 1), the number of infected females and also the average number of parasites were not highest. The number of infected females was 12, and the average number of parasites was two. Of the males, the number of infected individuals as well as the average number of parasites were highest in October. Twenty-five out of 35 males were infected and 54 parasites per individual were found (Table 1, Fig 3). The relationship between number of collected male snails and number of infected males was investigated. A linear regression reflected an increase of the infected males *P. canaliculata*

(Fig 4). By Student's *t*-test the regression was significant ($p < 0.01$).

DISCUSSION

Pomacea canaliculata (Orbigny) has separate sexes. Consecutive hermaphroditism can occur in this snail as reported by Keawjam and Upatham (1990), first being male and then changing to female. From dissecting all young snails collected in September, all of them were males, which supported the previous work. This phenomenon may be one of the mechanisms to maintain the population, males and females are always in the same area. The population is large as the female snails in an area are much more common than the males during the reproductive time (June-September). The females started to increase at this period of time and were highest as 94.23% in August in the pond. Each adult female also lays a great number of eggs (800-1,000 eggs) per clutch (Keawjam and Upatham, 1990). Comparing the proportion of the females and males in the pond and canal, the difference between the two sexes of the snails in the pond was more pronounced than that in the canal. It seems that local environmental conditions affect animals directly in the pond but not those in the canal. The pond experiences low water levels

Table 1

Comparison of female and male *Pomacea canaliculata* regarding number of infected snails and average number of parasites per individual in medium - and large-sized snails in canal.

Month	Total no. collected snails	No. collected females	No. infected females	Avg no. parasites of female		No. collected males	No. infected males	Avg no. parasites of male	
				med-sized	large-sized			med-sized	large-sized
January	15	3 (*20.00)	0	0	0	12 (*80.00)	0	0	0
February	47	13 (27.66)	0	0	0	34 (72.34)	2	1 (2)**	0
March	51	23 (45.10)	0	0	0	28 (54.90)	9	4 (7)	5 (2)
April	56	11 (19.64)	3	0	12 (3)**	45 (80.36)	31	9 (23)	8 (8)
May	45	6 (13.33)	1	0	1 (1)	39 (86.67)	14	7 (12)	4 (2)
June	49	12 (24.49)	3	0	1 (3)	37 (75.51)	17	2 (6)	4 (11)
July	50	13 (26.00)	1	0	3 (1)	37 (74.00)	2	1 (1)	5 (1)
August	54	36 (66.67)	12	0	2 (12)	18 (33.33)	5	1 (1)	2 (4)
September	49	23 (46.94)	7	0	2 (7)	26 (53.06)	6	0	1 (6)
October	57	22 (38.60)	14	0	7 (14)	35 (61.40)	25	54 (14)	9 (11)
November	52	20 (38.46)	8	0	4 (8)	32 (61.54)	12	5 (2)	4 (10)
December	50	22 (44.00)	0	0	0	28 (56.00)	4	0	2 (4)

* Percentage

** Number of the snails which were infected

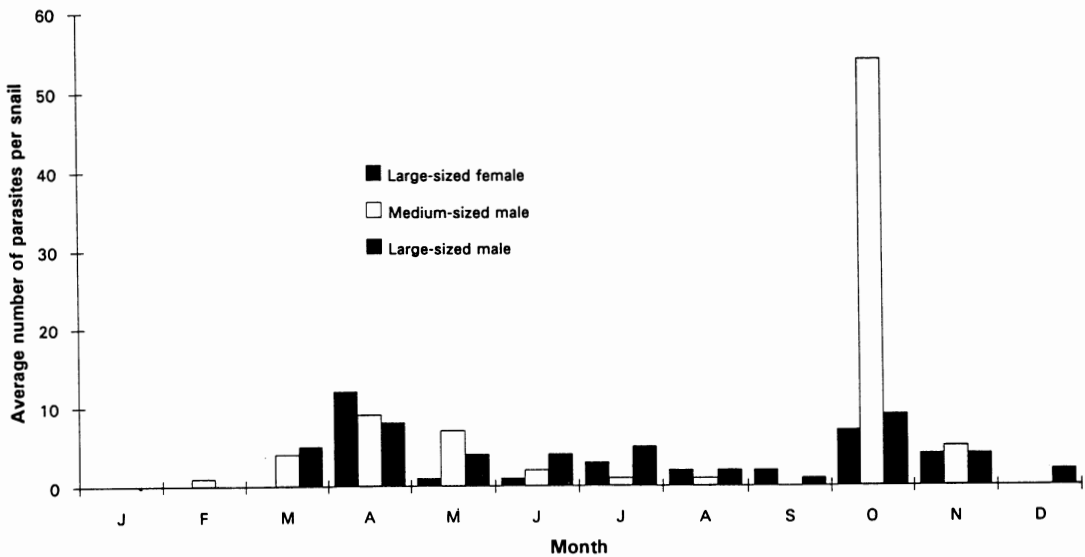


Fig 3—Comparison of average number of parasites infemale and male *Pomacea canaliculata* in canal according to time of the year.

GOLDEN APPLE SNAIL SEX RATIO

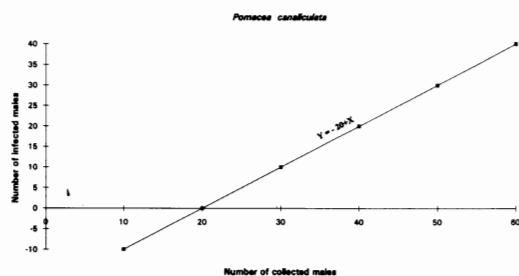


Fig 4—Regression analysis of data in Table 1.

and heat in summer and is flooded in rainy season, but the canal always receives effluent from office building and is shaded by a row of large trees (Keawjam *et al*, 1993).

Regarding the percentage of infected snails of the pond compared to those of the canal, low parasitic infection of the snails in the pond is probably due to physical and ecological factors such as periodical destruction of weeds and penetration of sunlight into the pond water. When the snails were collected in May which was the time when the snails were leaving from estivation they showed the highest percentage of infection (30.2%). Almost all snails were large which means they were more than one year old. These snails must be strong since they can withstand parasitism, heat and drought in the pond.

In the canal, a high percentage of infection occurred in two months, April and October, during which they were more males than females. Only the large-sized female snails were infected. There was no correlation between the number of females collected and infected. On the contrary, the number of infected male snails was significantly correlated with the collected male snails ($p < 0.01$). In October which is the hatching time of the snails, 71% (25 out of 35 males) of the collected males were infected and the average number of parasites per individual was highest at 54. The young snails

might not be as able to resist parasitism as the old ones. Some of them would die later, as not too many of the males were infected. It is, therefore, concluded that both male and female *Pomacea canaliculata* are susceptible to the parasites, but the males especially young males are more susceptible.

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