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CULTIVATION OF THE GIANT AFRICAN SNAIL, *ACHATINA FULICA*

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Abstract

Effects of various types of food on growth, the systematic cultivation, and the food analysis of snail meat of Achatina fulica, *the giant African snail, were studied. Growth was found to be best in the snails fed with a combination of food such as lettuce leaves, chicken feed and synthetic snail food. The life-cycle, growth characteristics and reproductive activity of* A. fulica *were studied in the laboratory culture. Sexual maturity was reached as early as 5 months of age. Egg clutches contain 80-100 eggs and the incubation period was 7-10 days. Food analysis study revealed high protein, fat, Ca and vitamin contents in snail meat of* A. fulica.

Introduction

One of the most important problems in the developing countries, including Thailand, is the need for new sources of high-protein food for local people. Land snails in Thailand and other developing countries could be considered to be another source of high-protein food.

Land snails are plentiful in Thailand. One of the common edible species of land snails is *Achatina fulica,* the giant African snail. Due to its dark-coloured flesh, this species of land snails has not been popular diet among Thai people. However, it has been very popular in other countries, such as Taiwan, China, European and Western countries and has become most popular as export items in the form of frozen meat or canned meat. There are a number of companies which export snail meat. These exporting factories have depended entirely on the collection of snails from the fields during the rainy season, when they are plentiful. At present, Thailand has not yet developed systematic cultivation and farming of these snails.

The heavy collection of *A. fulica* may deplete the natural population in the future; thus, proper cultivation and farming is essential. In addition, it has been known that *A. fulica* is an intermediate host of a nematode parasite, *Angiostrongylus cantonensis,* the rat lung worm, which can cause eosinophilic meningoencephalitis and brain damage in man.[1] The consumption of field-collected snails could lead to the infection of this nematode if snails are eaten raw or under-cooked. However, the canned snails will be free from viable parasites since they will have been boiled and passed through the hot steam, which kills

the parasite larvae during the canning processes. Moreover, the parasite larvae will be harmless if the snails are cooked properly. Hence, the systematic cultivation and farming of *A. fulica* snails would help solve the problem of parasites and the disappearance of snails in nature in the future. Furthermore, the cultivated snails would be free of the nematode parasites since they would be raised from the egg stage to maturity without being exposed to any rats or other animals or their faeces, which carry the parasites.

The giant African snails have high economic value as one of the high-income earning export items. With increasing demand on the international market, the cultivation and processing of snails could be one of the major profit-making enterprise for Thailand as well as other developing countries. At present, we are reporting on (1) the effects of various types of food on the growth of *A. fulica,* (2) the systematic cultivation of *A. fulica* and (3) the food analysis for snail meat of *A. fulica.*

Materials and Methods

The giant African snails, *Achatina fulica* were collected from different localities around Bangkok, and from the southern provinces of Thailand. Voucher specimens (MUFSTH 00-0111) have been deposited in the Museum of Malacology, Mahidol University, Bangkok.

Effects of various types of food on growth of *A. fulica*

The following types of food were used to feed the snails (1) sweet potatoes (2) lettuce leaves (3) cucumbers (4) "Gold Coin" rat feed (5) chicken feed and (6) synthetic snail food [1 kg inorganic $CaCO_3$ powder, 100 mg essential amino acids (arginine, phenylalanine, isoleucine, methionine, tryptophan, valine, threonine, leucine, lysine, histidine), 10 mg vitamin B complex (vitamins B_1, B_2, B_6, nicotinamide, calcium pantothenate), 0.5 kg cornstarch and 1000 ml distilled water].

Fifteen experiments were conducted in order to test the effects of various types of food on growth of the snails in terms of growth in shell length and weight increase. Various types of food mentioned above were given either singly or in combination as follows: Experiments 1-5 consist of a single type of food (sweet potatoes, lettuce leaves, cucumbers, rat feed, chicken feed). Experiments 6-10 consist of a single type of food (as in experiments 1-5) plus the synthetic snail food. Experiments 11-15 consist of combinations of 3-4 types of food: 11, sweet potatoes, lettuce leaves and cucumbers; 12, sweet potatoes, lettuce leaves, cucumbers and synthetic snail food; 13, sweet potatoes, lettuce leaves, cucumbers and rat feed; 14, sweet potatoes, lettuce leaves, cucumbers and chicken feed; 15, sweet potatoes, lettuce leaves, cucumbers, rat feed and chicken feed.

Ten small, round plastic containers, of 11 cm in diameter, 6 cm in height, were used to maintain the snails for each type of food experiment. One snail was put into each container. Altogether, the total of 150 snails were used in fifteen types of food experiments. The snails used were 2.5 months old or approximately 2.3-2.6 cm in shell length.

For each type of experiment, the snails were given various types of food daily. The shell length of the snails was measured and the snails were weighed once every ten days.

Systematic cultivation of *A. fulica*

Breeding culture and environmental conditions. Cement tanks with the diameter of 80 cm and the height of 30 cm were used for breeding culture. These tanks were provided with damp, ground coconut husks as a substratum. The substratum had to be approximately 3-4 cm in thickness, which was enough for snails to embed themselves when laying eggs.

The cement tanks were provided with wire lids which had been covered with dark-coloured plastic sheet to keep the tanks dark at all times. The lids would prevent the snails from escaping from the containers. In addition, since the snails were nocturnal feeders, provision of constant darkness would help the snails to feed continuously, hence, more rapid growth and reproduction.

The cement tanks were kept dark and moist at all times. They were sprayed with water every other day and maintained in a place with outdoor temperatures (25-37° C).

Culturing parent snails. Fifty adult snails (5-6 cm in shell length) were placed in each of twenty cement tanks for breeding. Since the snails are hermaphroditic in nature, there was no need for sex identification and separation. Altogether, 20 breeding tanks with a total of 1000 snails were used for breeding. The snails were fed daily, with lettuce leaves, chicken feed and synthetic snail food as described in the experiment on effects of various types of food on growth of *A. fulica.*

Culturing young snails. Approximately 1-2 weeks after the introduction of adult snails to the breeding cultures, the snails started to lay eggs in a shallow holes in the substratum. The whole batch of eggs (about 80-100 eggs/snail) of these snails was removed from the breeding culture for separate care. The eggs were washed with tap water and placed in a plastic bowl (22 cm in diameter), half-filled with damp ground coconut husks, and covered with a glass plate in order to prevent excess water loss. The bowls were kept moist at all times by spraying with water daily.

After the hatching of eggs, twenty F_1 snails were removed and placed in a plastic bowl of 22 cm in diameter, half-filled with damp ground coconut husks and fed with lettuce leaves and synthetic snail food until they reached the size of 1.5-2 cm, then they were placed in the culture cement tanks.

The preparation of cultures for raising young snails was nearly the same as that described for the culturing of parent snails : cement tanks provided with damp ground coconut husks were used, each with a density of 40-50 young snails. The young snails were fed with lettuce leaves, chicken feed and synthetic snail food daily until sexually mature stage (about 6 cm in size).

Measurement of growth. The shell length of the young snails was measured once every 10 days using a vernier scale. At the same time, the snail weight was recorded.

These measurements provided data necessary for determining the growth rates of *A. fulica.*

Termination of breeding cultures. The fecundity of breeding snails decreased with time. The cultures were terminated when there were unexpected high mortality due to deteriorated and accumulated waste; low production of young; appearance of harmful organisms such as ants and other insects.

Methods of food analysis for snail meat

Canned and fresh snail meat of *A. fulica* were analysed for food value. Samples of snail meat were ground in an electric blender with distilled water until they became a homogeneous paste. The paste was stored in a plastic bottle and kept at – 20° C before analysis.

The samples were analysed for crude protein[2], for crude fat[3], for calcium and iron contents[4], and for vitamin contents such as vitamin A[5,6], vitamin B_1 and vitamin B_2[7].

Results

Effects of various types of food

The results of the effects of various types of food on snail growth, expressed in terms of shell length and weight, are shown in Tables 1 and 2, respectively. Table 1 shows that the maximum growth in shell length of snails was obtained among the snails fed with chicken feed and synthetic snail food. Slightly less growth was manifested among snails fed with sweet potatoes, lettuce leaves, cucumbers and chicken feed; snails fed with rat feed and synthetic snail food; and snails fed with sweet potatoes, lettuce leaves, cucumbers and synthetic snail food. In terms of weight (Table 2), the maximum weight was obtained among snails fed with sweet potatoes, lettuce leaves, cucumbers and synthetic snail food; slightly less among snails fed with sweet potatoes, lettuce leaves, cucumbers and chicken feed; and among snails fed with chicken feed and synthetic snail food. The minimum growth in shell length and weight was obtained among snails fed with sweet potatoes alone, and snails fed with sweet potatoes and synthetic snail food.

Table 1. Effects of various food types on growth in shell length (cm) of snails.

Measurement times (in days)

Type of food	Day 10th	Day 20th	Day 30th	Day 40th	Day 50th	Day 60th	Day 70th	Day 80th
1. sweet potatoes	2.36 ± 0.207	2.72 ± 0.148	2.88 ± 0.228	3.52 ± 0.277	3.88 ± 0.217	4.18 ± 0.460	4.16 ± 0.451	4.22 ± 0.421
2. lettuce leaves	2.26 ± 0.134	2.8 ± 0.187	3.34 ± 0.152	3.76 ± 0.182	4.08 ± 0.239	4.38 ± 0.192	4.58 ± 0.217	4.58 ± 0.356
3. cucumbers	2.52 ± 0.286	2.88 ± 0.589	3.52 ± 0.303	3.86 ± 0.288	4.12 ± 0.277	4.36 ± 0.336	4.48 ± 0.286	4.48 ± 0.303
4. rat feed	2.26 ± 0.166	2.8 ± 0.235	3.38 ± 0.249	3.94 ± 0.219	4.08 ± 0.335	4.42 ± 0.402	4.5 ± 0.374	4.45 ± 0.336
5. chicken feed	2.4 ± 0.485	3.06 ± 0.573	3.72 ± 0.550	4.4 ± 0.552	4.9 ± 0.543	5.42 ± 0.466	5.72 ± 0.517	5.92 ± 0.554
6. sweet potatoes + synthetic snail food	2.36 ± 0.270	2.6 ± 0.158	2.98 ± 0.356	3.32 ± 0.602	3.72 ± 0.769	3.92 ± 1.083	4.08 ± 1.134	4.12 ± 1.173
7. lettuce leaves + synthetic snail food	2.4 ± 0.158	2.46 ± 0.152	3.24 ± 0.288	3.88 ± 0.130	4.44 ± 0.230	4.76 ± 0.219	4.94 ± 0.230	5.0 ± 0.187
8. cucumbers + synthetic snail food	2.62 ± 0.259	3.16 ± 0.288	3.78 ± 0.327	4.34 ± 0.472	4.62 ± 0.653	5.06 ± 0.702	5.2 ± 0.837	5.26 ± 0.780
9. rat feed + synthetic snail food	2.5 ± 0.265	3.06 ± 0.522	3.68 ± 0.383	4.44 ± 0.434	5.2 ± 0.406	6.06 ± 0.305	6.44 ± 0.230	6.64 ± 0.230
10. chicken feed + synthetic snail food	2.44 ± 0.089	3.08 ± 0.130	3.84 ± 0.114	4.64 ± 0.182	5.4 ± 0.187	6.18 ± 0.228	6.66 ± 0.230	6.88 ± 0.311
11. sweet potatoes + lettuce leaves + cucumbers	2.42 ± 0.130	3.04 ± 0.152	3.8 ± 0.141	4.44 ± 0.230	4.76 ± 0.336	5.14 ± 0.483	5.3 ± 0.381	5.5 ± 0.548
12. sweet potatoes + lettuce leaves + cucumbers + synthetic snail food	2.4 ± 0.122	3.12 ± 0.335	3.94 ± 0.195	4.74 ± 0.241	5.3 ± 0.283	5.92 ± 0.370	6.38 ± 0.572	6.62 ± 0.626
13. sweet potatoes + lettuce leaves + cucumbers + rat feed	2.48 ± 0.192	3.2 ± 0.187	3.92 ± 0.192	4.36 ± 0.305	4.88 ± 0.249	5.3 ± 0.187	5.4 ± 0.235	5.8 ± 0.255
14. sweet potatoes + lettuce leaves + cucumbers + chicken feed	2.5 ± 0.274	3.24 ± 0.251	4.0 ± 0.367	4.46 ± 0.321	4.96 ± 0.297	5.88 ± 0.476	6.42 ± 0.449	6.68 ± 0.482
15. sweet potatoes + lettuce leaves + cucumbers + rat feed + chicken feed	2.5 ± 0.158	3.22 ± 0.084	4.08 ± 0.259	4.56 ± 0.336	4.98 ± 0.311	5.38 ± 0.217	5.68 ± 0.311	6.02 ± 0.402

Table 2. Effects of various food types on growth in weight (g) of snails

Measurement times (in days).

Type of food	Day 10th	Day 20th	Day 30th	Day 40th	Day 50th	Day 60th	Day 70th	Day 80th
1. sweet potatoes	2.58 ± 0.563	4.14 ± 0.611	5.44 ± 0.890	7.1 ± 1.140	8.7 ± 1.304	9.6 ± 2.702	9.4 ± 3.209	10.0 ± 3.391
2. lettuce leaves	2.5 ± 0.122	3.7 ± 0.758	5.7 ± 0.758	7.8 ± 1.789	9.8 ± 1.483	12.0 ± 1.000	12.0 ± 0.707	13.2 ± 1.095
3. cucumbers	2.48 ± 0.192	4.9 ± 1.710	8.1 ± 2.247	9.2 ± 3.114	11.2 ± 2.588	14.0 ± 2.739	15.6 ± 6.693	15.4 ± 4.037
4. rat feed	2.5 ± 0.447	4.3 ± 0.447	5.8 ± 0.447	9.2 ± 1.304	10.4 ± 3.130	11.6 ± 2.702	11.0 ± 2.739	12.8 ± 2.490
5. chicken feed	2.6 ± 0.071	5.9 ± 3.715	8.9 ± 3.715	12.8 ± 4.438	17.2 ± 4.147	23.4 ± 5.550	23.4 ± 6.148	26.6 ± 8.050
6. sweet potatoes + synthetic snail food	2.4 ± 0.292	3.5 ± 1.118	4.3 ± 1.483	5.4 ± 2.408	8.0 ± 4.183	10.0 ± 5.568	9.8 ± 5.891	11.3 ± 6.797
7. lettuce leaves + synthetic snail food	2.7 ± 0.158	5.4 ± 1.673	10.2 ± 1.924	14.0 ± 3.674	18.6 ± 5.320	20.0 ± 5.385	22.6 ± 6.580	24.2 ± 7.694
8. cucumbers + synthetic snail food	2.6 ± 0.308	5.6 ± 2.608	8.6 ± 2.608	12.4 ± 3.362	15.8 ± 4.324	18.4 ± 5.683	18.6 ± 4.980	21.0 ± 5.244
9. rat feed + synthetic snail food	2.6 ± 0.418	4.8 ± 1.304	6.8 ± 7.155	12.2 ± 4.266	19.0 ± 4.301	28.6 ± 5.030	29.2 ± 4.207	34.0 ± 5.431
10. chicken feed + synthetic snail food	2.5 ± 0.122	5.4 ± 0.822	8.0 ± 1.000	13.8 ± 1.789	20.0 ± 2.449	28.4 ± 4.722	32.0 ± 6.782	36.4 ± 7.603
11. sweet potatoes + lettuce leaves + cucumbers	2.6 ± 0.158	6.6 ± 1.140	9.6 ± 1.140	12.6 ± 1.817	17.2 ± 3.225	20.0 ± 4.950	22.6 ± 4.159	25.4 ± 5.595
12. sweet potatoes + lettuce leaves + cucumbers + synthetic snail food	2.5 ± 0.158	6.0 ± 1.581	10.0 ± 1.581	15.0 ± 1.871	23.0 ± 1.871	27.6 ± 4.722	33.6 ± 6.066	39.8 ± 7.259
13. sweet potatoes + lettuce leaves + cucumbers + rat feed	2.4 ± 0.158	5.8 ± 1.891	9.0 ± 2.121	12.6 ± 2.510	18.0 ± 4.062	21.8 ± 3.701	26.2 ± 3.493	28.2 ± 4.438
14. sweet potatoes + lettuce leaves + cucumbers + chicken feed	2.6 ± 0.158	6.6 ± 1.817	10.8 ± 3.194	13.2 ± 3.493	18.6 ± 5.857	28.2 ± 7.120	36.0 ± 6.819	39.4 ± 5.367
15. sweet potatoes + lettuce leaves + cucumbers + rat feed + chicken feed	2.7 ± 0.158	6.4 ± 2.074	10.0 ± 2.121	14.2 ± 3.701	20.6 ± 4.775	22.8 ± 3.033	26.6 ± 5.030	32.6 ± 5.899

Cultivation

The results of the cultivation of *Achatina fulica* are shown in Figures 1-10. Figure 1 shows the adult snails collected from the field. They were about 6-7 cm in size. Figure 2 shows these snails in the cement tank or breeding cultures provided with damp ground coconut husks. Green vegetables, chicken feed and synthetic snail food were provided as food for the snails. These cement tanks were covered and maintained at the outdoor temperatures of 25-37° C (Fig. 3).

After the snails had laid eggs, the eggs were collected and maintained in plastic bowls of 22 cm in diameter, containing damp ground coconut husks and covered with glass plates to prevent snails from escaping and water loss (Fig. 4). The young snails were cultured in the plastic bowls until they reached the size of 2-2.5 cm, then they were put back in the cement tanks until sexually mature stage.

Life cycle

The whole life cycle of the snails, *A.fulica* lasted about 5-5.5 months; egg stage 7-10 days, juvenile to sexually mature stage 5 months. The eggs were laid in a shallow hole in the substratum. They were laid singly but in groups of 80-100 produced by one snail at one oviposition. The eggs were pale yellow in colour and oval in shape with the average diameter of 0.3-0.5 cm (Fig. 5).

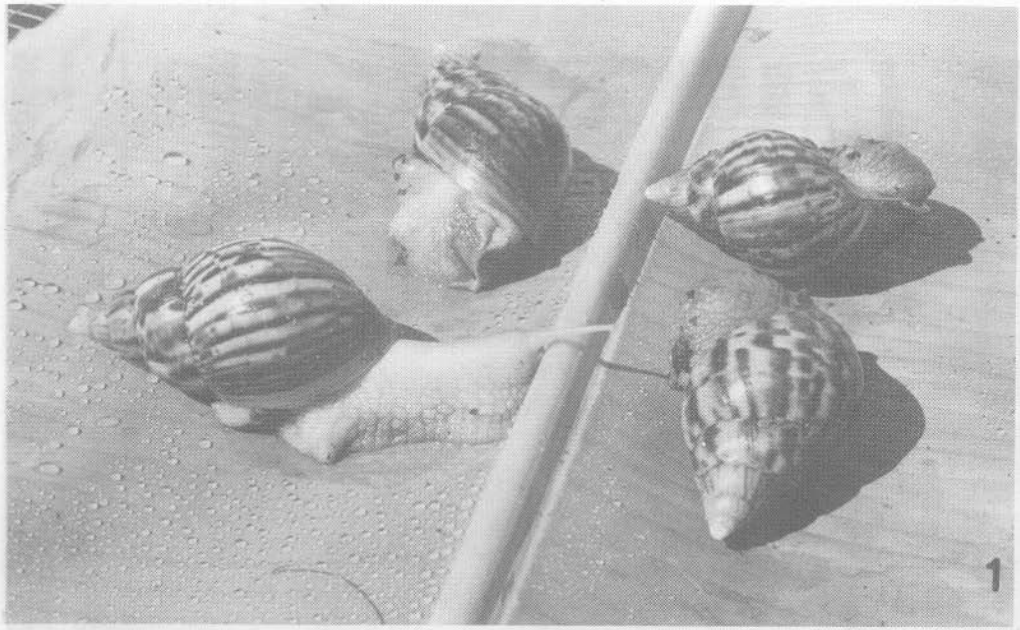

Figure 1 The adult snails of *Achatina fulica* collected from the field.

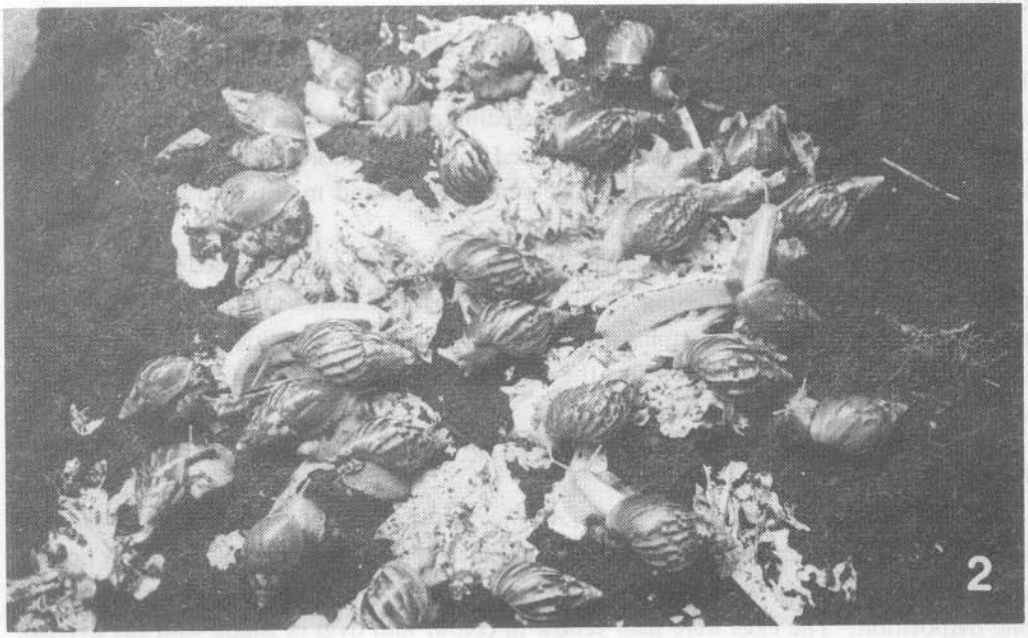

Figure 2 The adult snails of *Achatina fulica* in breeding culture.

Figure 3 Cement tanks used for breeding culture of snails, *Achatina fulica*.

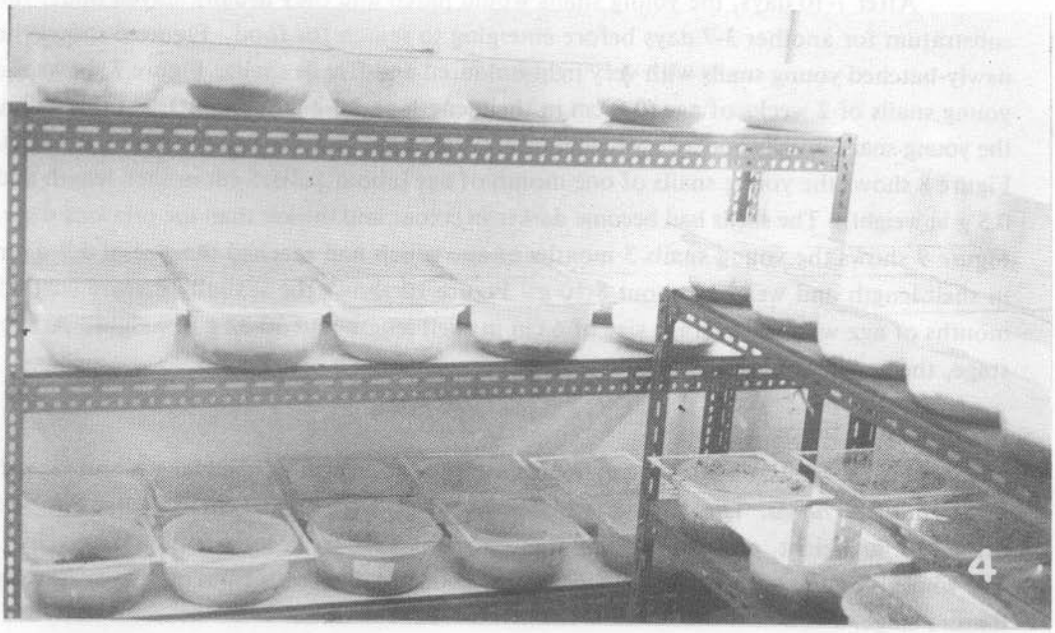

Figure 4 Plastic bowls used for maintaining eggs and young snails.

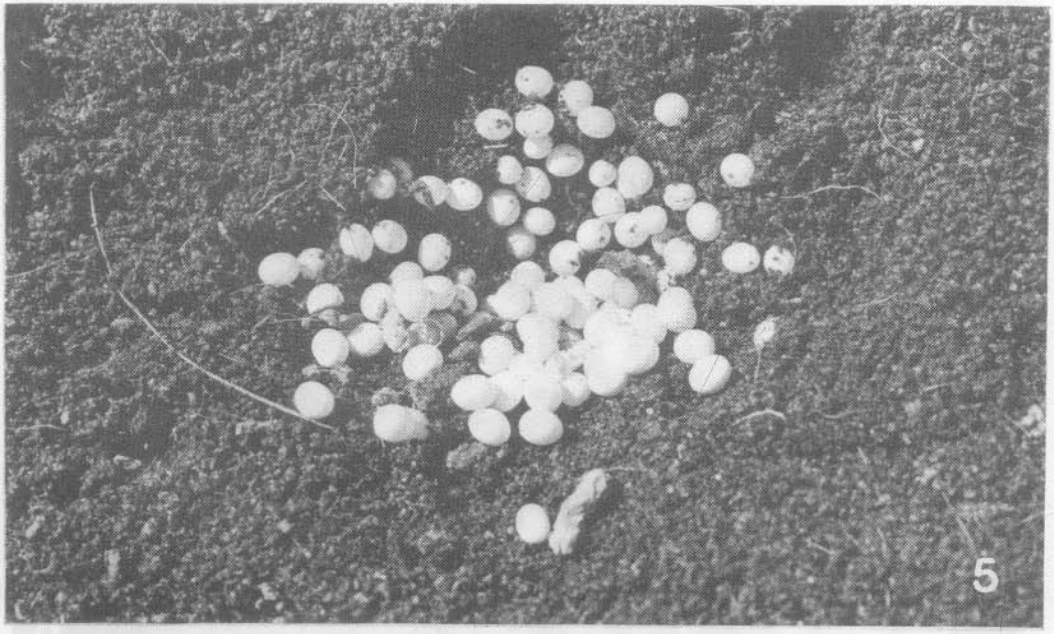

Figure 5 The eggs of the snails, *Achatina fulica*.

After 7-10 days, the young snails would hatch and they usually stayed under the substratum for another 3-7 days before emerging to search for food. Figure 6 shows the newly-hatched young snails with very light-coloured and fragile shells. Figure 7 shows the young snails of 2 weeks of age (0.8 cm in shell length and 0.2 g in weight). At this stage, the young snails usually had a very high mortality rate until they reached the size of 1.5-2 cm. Figure 8 shows the young snails of one month of age (about 1.2-1.5 cm in shell length and 0.5 g in weight). The shells had become darker in colour and thicker than the previous stage. Figure 9 shows the young snails 3 months of age which had reached the size of 3.7-4 cm in shell length and weighed about 8-10 g. Figure 10 shows the sexually mature snails 5 months of age with the average size of 6 cm in shell length and 30-32 g in weight. At this stage, the snails would start producing eggs.

Growth of A. fulica

Figure 11 shows the progressive appearance in growth of shell length and growth in weight of *A. fulica*. The newly-hatched young snails were 0.5-0.7 cm in shell length and 0.1-0.15 g in weight, and the sexually mature snails were 6 cm long and 32 g in weight. The whole life cycle of the snails, *A.fulica* lasted about 5-5.5 months from the egg to sexually matur. stage.

For raising large numbers of *A. fulica,* 10 containers with a total of 400 snails were cultured. A total of 1643 eggs were obtained from these cultures. The number of young snails hatched was 1253 (76.28 %). The number of young snails collected after 2 months (2 cm in size) was 970 (59.04 %). The number of mature snails collected was 500 (30.43 %).

Figure 6 The newly-hatched snails (7-10 days).

Figure 7 The two-week-old young snails of *Achatina fulica*.

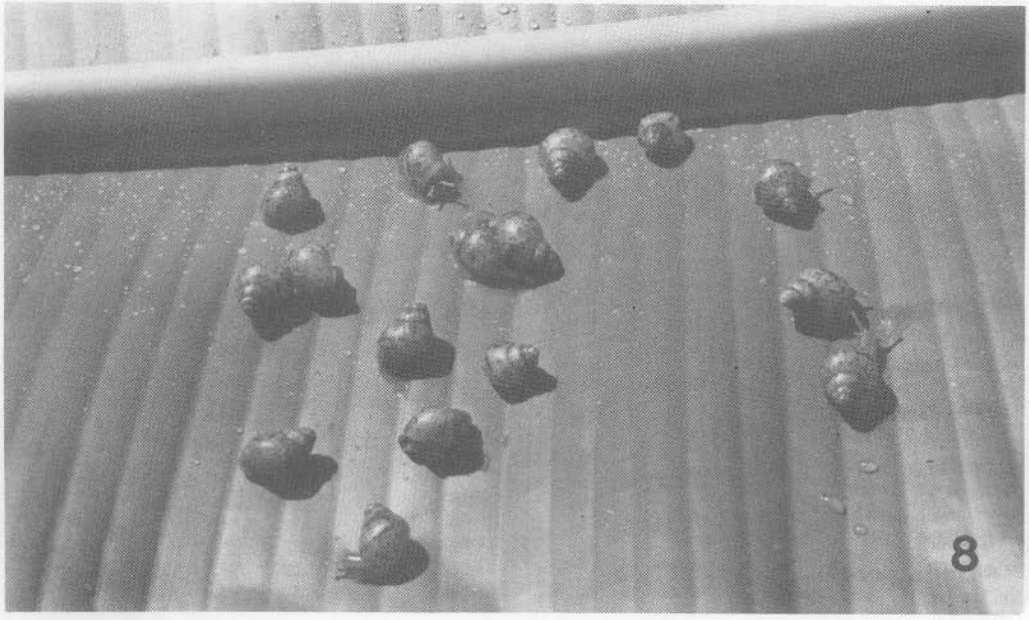

Figure 8 The young snails one month of age.

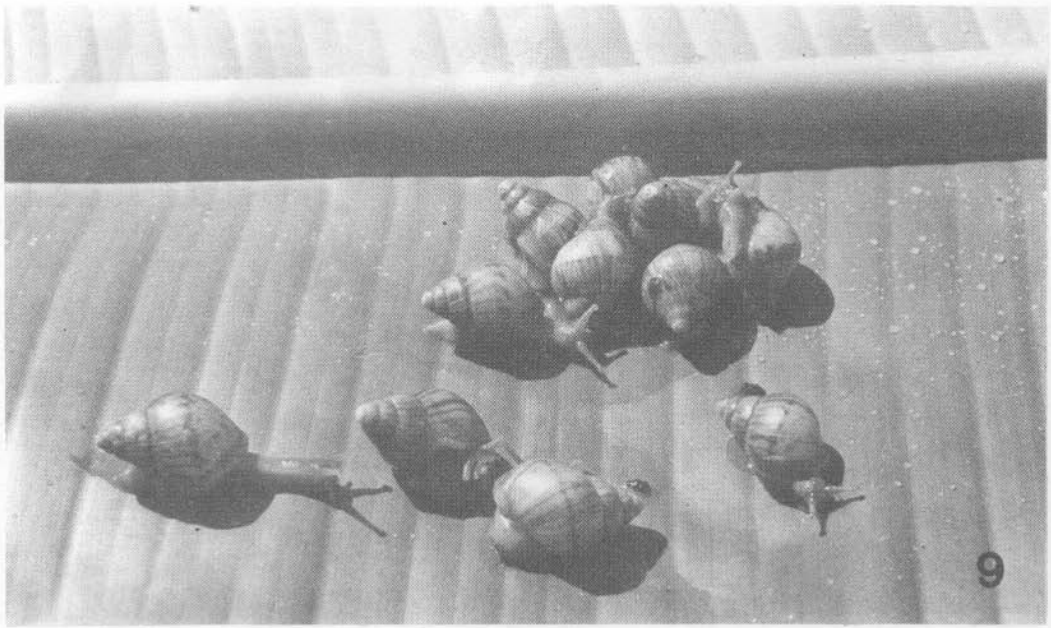

Figure 9 The snails, *Achatina fulica,* three months of age.

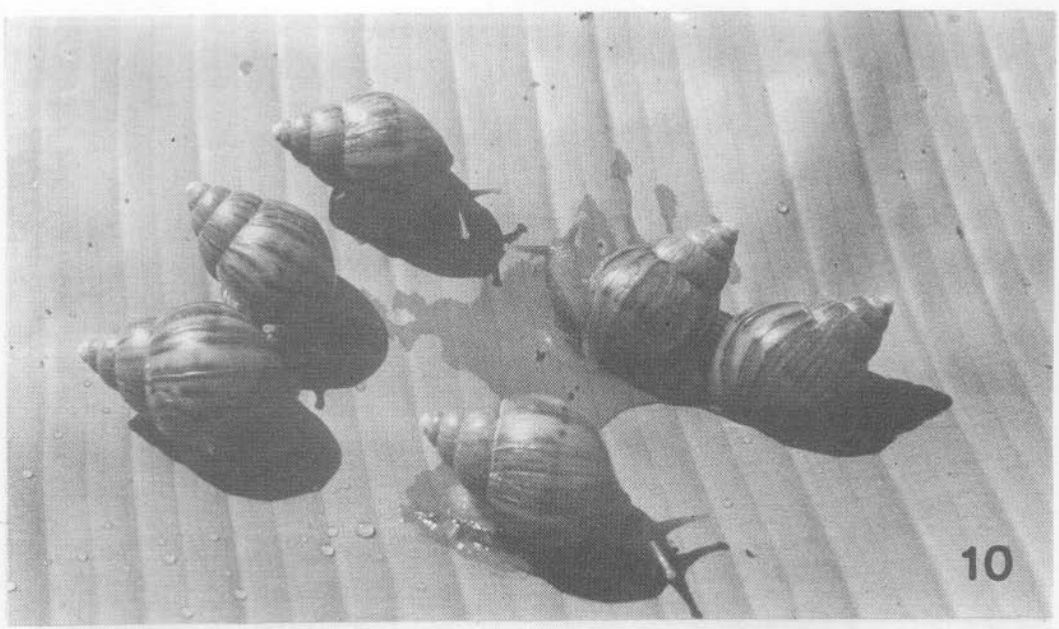

Figure 10 The snails five months of age.

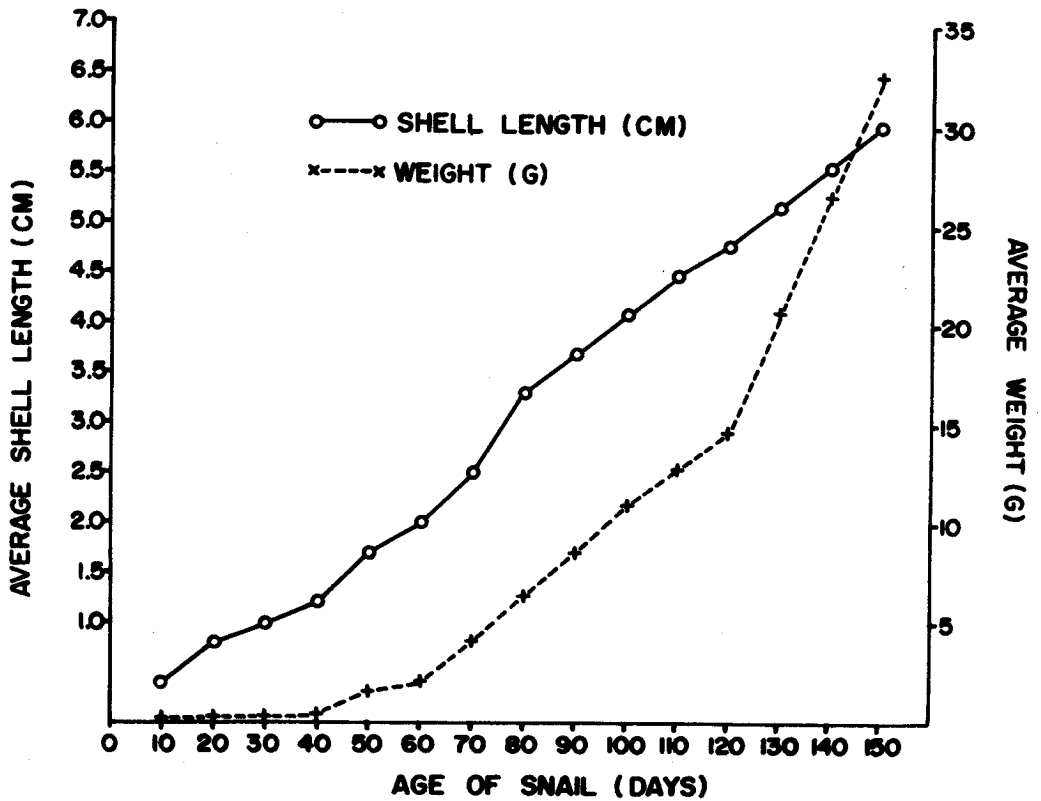

Figure 11 The growth curve of *Achatina fulica*.

Food analysis

Table 3 shows the result on food analysis of snail meat, *A. fulica* as compared to other species of mollusks. It is apparent that, among the most popular edible mollusks, *A. fulica* has the highest protein, fat and Ca contents. In addition, it contains vitamins B_1, B_2 and A at high levels when compared to the other mollusks.

Table 3. Results on food analysis of *Achatina fulica* as compared to other mollusks

Snail species	Food value: Crude protein (g)*	Crude fat (g)	Ca (mg)	Fe (mg)	Vitamins: B_1 (mg)	Vitamins: B_2 (mg)	Vitamins: A (I.U.)
Achatina fulica (giant African snail)	15.4	1.02	118.31	1.37	0.08	0.22	17.36
Arca granulosa (ark shell)	12.2	0.8	89	5.2	0.11	0.18	200
Mytilus smaragdinus (sea mussel)	9.1	0.8	7.5	6.7	0	0.33	–
Paphia undulata (baby clam)	9.0	0.4	94	5.7	0	0.16	–

* per 100 g wet weight

Discussion

Breeding culture and environmental conditions

This study demonstrates the systematic cultivation for maintaining a large scale culture of *Achatina fulica* under their native environmental conditions. It also shows the life cycle, growth rate and the food analysis of the snails. Previous accounts of the life cycle and reproduction of *A. fulica* are scattered throughout the malacological literature.[8-10] The study done by Pawson and Chase[10] has provided the most complete account of development from egg to sexually reproductive adult and description of optimal conditions for laboratory culture. However, their study demonstrated the cultivation of *A. fulica* under laboratory conditions at a location far distant from the snail's native home, Canada.

The cultivation methods for *A. fulica* done in Thailand is quite similar to those of Pawson and Chase[10]. They had maintained their snails in glass vivaria (30 × 40 × 90 cm) with a sand/crushed oyster shell substratum. In the present report, the snails were maintained in round cement tanks, 90 cm in diameter, with ground coconut husks. This type of cement tank can be found anywhere in Thailand. In addition, ground coconut husks are easy to obtain from plant shops and are very inexpensive. Pawson and Chase[10] maintained the snail culture in a small isolated room with the temperature ranging from 20-24°C. For our study, we maintained the snail cultures outdoors, with temperatures ranging from 25-37°C. The snails were observed to lay eggs mostly during the rainy season.

The incubation period in our study ranged from 7-10 days with the clutch size of 80-100, while that of Pawson and Chase[10] ranged from 1-25 days with a mean of 14 days and with the clutch size of 100-200. Other studies had reported the incubation period to be 1-10 days, with the mean of 5.37 days and with a clutch size of 177.3[11], 1-7 days with a clutch size of 97[12], 7 days with a clutch size of 213,[13] and 1-7 days with a clutch size of 50-200[14]. The combined data indicates that the incubation period is commonly variable in *A. fulica*. This species is ovoviparous, i.e. eggs may be retained in the uterus until hatching. The variable occurrence of ovoviviparity in *A. fulica* may be due to the retention of eggs in the uterus if conditions are not favourable, and probably respond negatively to certain environmental conditions such as lack of moisture[15].

After emerging from its egg, a snail remained under the substratum for another 3-7 days before emerging to search for food. It was observed in this study, as well as those done by Pawson and Chase,[10] that the snails reached sexual maturity in 5 months. The age of the snails at sexual maturity varied among the other studies, i.e., 6 months,[11] 5 months,[16] 7 months.[17] The 5 months period is the youngest age yet reported. It is apparent that the onset of sexual maturity, like the incubation time, also has a variable occurrence, which may be due to differences in the living conditions or to inherent variability in the reproductive process of snails[10].

It was observed that the most critical period of rearing young snails was during the first two months after hatching, the period of which they appeared to have a high mortality rate. It may be due to the usage of plastic bowls and glass covers in rearing young snails. Plastic bowls and glass covers may prevent air circulation, promote excessive humidity and substrate moisture, and elevate the temperature in the culture, which may lead to a high mortality rate. Further studies need to be made to observe the survival rate of rearing young snails in wooden containers covered with gauze or fairly porous cloth.

Food analysis

As it is apparent from the results in Table 3 that *A. fulica* is very high in protein, fat and Ca as compared to other edible mollusks such as ark shell, mussels and clams. *A. fulica* has a lower Fe content when compared to the three species of marine bivalves. On the average, it contains a fair amount of vitamins B_1, B_2 and A. Hence, as far as food value is concerned, *A. fulica* could be considered as another interesting high-protein food in addition to the popular edible marine bivalves.

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