Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 96, No. 2, March 1987, pp. 135-140.

Effect of starvation on food utilization in the freshwater snail *Pila globosa* (Swainson)

M A HANIFFA
Post-Graduate and Research Department of Zoology, St. Xavier's College, Palayamkottai 627 002, India

MS received 20 August 1986; revised 27 January 1987

Abstract. Increase in food supply produced elevated values of several parameters in energy budget of both normal and starved individuals ($P < 0.001$). Starvation accelerated the rates of feeding, absorption and metabolism (3 times) and conversion (1½ times; $P < 0.001$). *Pila globosa* starved for a month lost 79·5 mg dry weight/g live weight and the recovery periods to attain the original body weight were estimated as 66, 72, 88, 32, 28 and 23 days between 8 and 20% rations.

Keywords. *Pila globosa*; starvation; feeding; conversion.

1. Introduction

This paper is in continuation of a series on food utilization in freshwater snails exposed to different rations (Haniffa and Pandian 1974; Vivekanandan *et al* 1974; Haniffa 1982), food combinations (Haniffa *et al* 1984; Haniffa and Sethuramalingam 1985), crowding and water level (Haniffa 1980) and aestivation (Haniffa M A, unpublished results). Starvation is by definition a condition in which the animal's ration is not sufficient to balance its basal demand for energy. Under this condition the reserve food energy within the body is utilized in order to make good the difference between ration and respiratory loss (see Bayne 1973). Studies on the effect of starvation on metabolism of molluscs are well documented (Martin and Goddard 1966; Emerson 1967; Emerson and Duerr 1967; Stickle and Duerr 1970; Uma Devi *et al* 1986), but that on food utilization is meagre (Haniffa and Mullainathan 1982). The present work examines the effects of starvation on mortality, weight loss and food utilization in a freshwater snail *Pila globosa*.

2. Material and methods

Active individuals of *P. globosa* were collected from the pond Idumban (Palni, Tamil Nadu) and acclimated to laboratory conditions. About 150 snails of 12 ± 2 g live weight were recruited after 12 h of exposure to air (Haniffa 1978a) and introduced in groups of 25, into 6 glass aquaria (25 l capacity). Water was changed once in two days and the snails were starved for a period of two months; every week, mortality rates and weight losses were recorded. Fifty snails, starved for a month were divided into 10 groups, each containing 5 individuals and kept in troughs of 5 l capacity. Experimental snails were fed on *Chara fragilis* at chosen feeding levels ranging from

2–20% of their respective live weights. Everyday a control sample of 5 g food plant was dried at 85°C and weighed to measure its water content. Fifteen such starved snails were dried and weighed to determine the initial dry weight. Unconsumed plant was removed daily, dried and weighed to estimate the amount of food consumed. Faecal pellets were collected daily by filtering the water from the entire trough through a fine sieve of 160 μm. This experimental setup was maintained for a period of one month.

The scheme of energy budget followed here is a slightly modified IBP formula (Petrusewicz and Macfadyen 1970).

$$C\text{ (consumption)} = P\text{ (growth)} + R\text{ (metabolism)} + F\text{ (faeces)}.$$

The sacrifice method (Maynard and Loosli 1962) was followed to estimate the initial and final dry weight (inclusive of shell) of the test snails. Following the same procedure energy budget was estimated for normal *P. globosa* and a comparative analysis was made between starved and normal snails.

3. Results and discussion

The data presented in table 1 show the mortality rate and weight loss of one month starved *P. globosa*. Survival was 99·6% for one week-starved individuals and it decreased to 70·6% for the 7 week-starved snails. Total mortality during the tenure increased from 0·4% in the first week to 29·4% in the last week and mean mortality estimated after one month starvation was 10·5%. Following the least mean square method, the slope was calculated as 1·032 ($Y = 1{\cdot}032x + 0{\cdot}072$). Analysis of correlation coefficient confirmed that increase in the period of starvation resulted in heavy mortality ($P < 0{\cdot}01$). As the test individuals were forced to starve, it is possible to suggest that the absence of food energy and the utilization of body reserve during the course of starvation resulted in mortality (Uma Devi *et al* 1986). Weight loss via metabolism (shell and body tissue) amounted to 2·65 mg dry weight for one month

Table 1. Effect of starvation on survival and weight loss of the freshwater snail *P. globosa*.

Period of starvation (weeks)	Survival (%)	Mortality: Week (%)	Mortality: Total (%)	Weight loss (mg dry/g live snail): Shell	Flesh	Total
1	99·6	0·4	0·4	1·20	3·01	4·21
2	97·8	1·8	2·2	0·74	3·21	2·96
3	93·9	3·9	6·1	0·62	1·70	2·32
4	89·2	4·7	10·8	0·39	0·71	1·10
5	83·3	5·9	16·7	0·33	0·59	0·92
6	76·9	6·4	23·1	0·23	0·54	0·77
7	70·6	6·3	29·4	0·32	0·006	0·33
Correlation coefficient						
	r − 0·987	0·845	0·987	0·899	−0·676	−0·956
	$P<0{\cdot}001$	<0·01	<0·001	<0·001	<0·001	<0·001

$P<0{\cdot}01$, Significant; $P<0{\cdot}001$, Highly significant.

starved *P. globosa* and this accounted for 0·74 mg loss of shell weight/g live snail/day i.e. those snails which survived one month starvation, exhibited 25% decrease in shell weight. Increase in starvation period resulted in a loss of shell weight from 1·2 mg in the first week to 0·32 mg in the 7th week ($P<0.001$). According to Haniffa (1978b), shell weight of *P. globosa* which successfully survived 5 months of aestivation exhibited 5·25% decrease in total shell weight. *P. globosa* is capable of aestivating for a period of 5 years (Hyman 1967) but starvation is not possible beyond 90 days. Hence the weight loss via metabolism during starvation is comparatively more. Working on the mortality rate of *Lymnaea stagnalis*, Jose *et al* (1968) reported that pond snails can survive a starvation period of 6 weeks by utilizing the reserve food energy. Uma Devi *et al* (1986) reported that the tropical intertidal gastropod *Morula granulata* can be subjected to prolonged starvation of 70 days.

Increase in food supply/day enhanced the energy budget of *P. globosa*. Feeding rate of normal *P. globosa* increased from 2·2 mg/g/day at 2% to 18·4 mg/g/day at 20% ration level (figure 1). Corresponding increases in the rates of absorption and metabolism were from 1·7 – 13·7 mg/g/day and 4·2 – 11·4 mg/g/day. The gain in body substance increased from 0·5 mg at 10% to 2·2 mg/g/day at the maximum ration level of 20%. Feeding rates estimated for one month starved *P. globosa* at different ration levels ranged from 5·1 to 53·3 mg/g/day (figure 1). Starvation caused about 2 times increase in food consumption; it might have stimulated the nerve centres controlling the appetite and in response to this the snail consumed more food.

Both normal and starved *P. globosa* showed weight losses at lower rations (2–8%). For feeding rates of 12·1 and 20·9 mg/g/day, a gain in weight of 0·5 and 1·2 mg/g/day was observed in normal and starved snails respectively. Maximum growth rate was

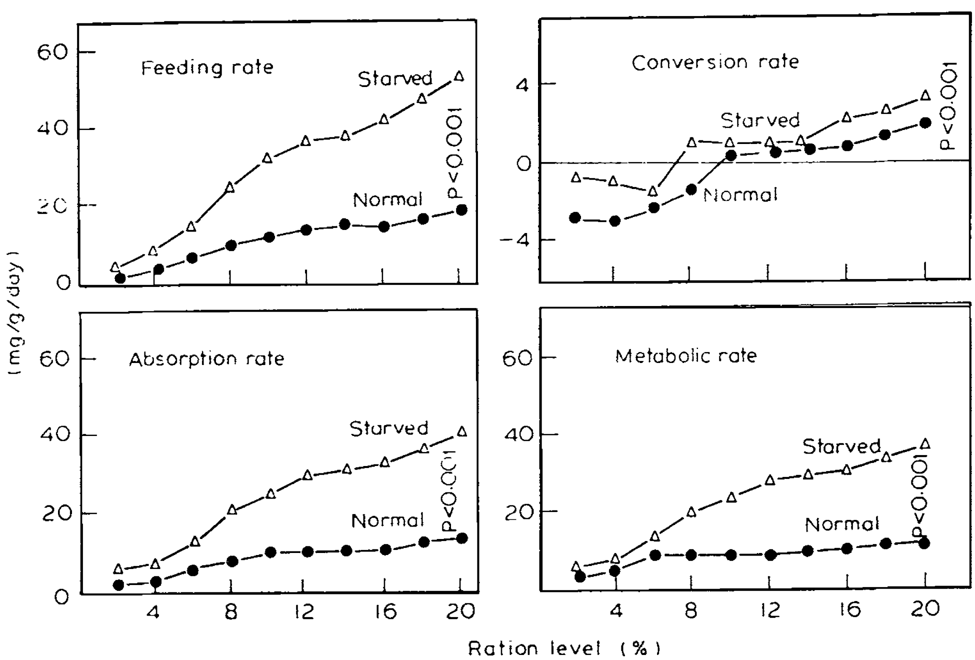

Figure 1. Effects of starvation on the rates of physiological energetics of *P. globosa*.

2·2 mg/g/day in normal snails and it increased to 3·4 mg/g/day for the starved *P. globosa* (figure 1). Haniffa and Mullainathan (1982) have also reported enhancement of conversion rate in the freshwater snail *Viviparus variatus* as a function of starvation.

Vivekanandan *et al* (1974) reported 14·7 gcal/g/day as the minimum energy cost of maintenance of *P. globosa* exposed to starvation and 67·4 gcal/g/day as the maximum energy cost of living for an active *P. globosa* fed *ad libitum* on *Ceratophyllum demersum* at 28°C. Considering the calorific content of *P. globosa* as 3682 ± 444 g cal/g dry weight (Haniffa 1978b), the energy lost through metabolism in one month starved *P. globosa* in the present investigation amounted to 9·8 gcal/g/day. When compared with normal snail, the metabolic level of one month starved *P. globosa* was lowered by 1/7th. The metabolic level of the aestivating snail was lowered by 1/18th of that of the normal snail (Haniffa M A, unpublished results). Similar observations on the capacity of the snail to lower its metabolic level have also been reported in *P. virens* (Meenakshi 1964), *P. ovata* (Visser 1965) and *Morula granulata* (Uma Devi *et al* 1986).

Increase in ration level caused rapid decrease in metabolism in normal snails but the decrease was slow in starved *P. globosa* (table 2). Starved snails also showed higher metabolic cost of 69–79% of consumption or 92–97% of absorption at higher rations (12–20%) than normal snails (62–71% of consumption or 84–93% of absorption). Hence it is possible to suggest that higher metabolic cost may be responsible for poor conversion efficiency in starved snails.

Increase in food supply enhanced the conversion efficiency from 5·6–12·1% in normal and 5·7–8·4% in starved *P. globosa*. Starvation elevated the values of conversion rate though the conversion efficiency actually showed decreases (table 2). Net conversion efficiency in the present investigation ranged from 5·6–13·0 and from 3·0–8·4% for normal and starved snails respectively. Increase in ration level caused a decrease in absorption efficiency from 83–74% and from 93–76% in normal and starved *P. globosa* (table 2) respectively (Vivekanandan *et al* 1974; Haniffa 1982). Absorption efficiency values reported for gastropods range from 73–88% for *P. globosa* (Haniffa 1982), 57–89% for *Littorina littorea* (Grahame 1973), 73–88% for

Table 2. Effect of ration level on efficiencies of absorption and conversion and recovery period to attain original weight by starved *P. globosa*.

Ration level (%)	Absorption efficiency (%)		Conversion efficiency (%)		Total loss of body weight (mg dry/g live snail)	Recovery period (days)
	Normal	Starved	Normal	Starved		
2	83·4	92·7	—	—	79·5	—
4	82·6	84·6	—	—	79·5	—
6	84·4	80·7	—	—	79·5	—
8	80·6	82·6	—	5·7	79·5	66
10	78·8	78·7	—	4·5	79·5	72
12	76·7	81·7	5·6	3·7	79·5	72
14	75·2	79·8	7·4	3·0	79·5	88
16	73·6	78·4	7·7	7·5	79·5	32
18	74·4	77·1	13·0	7·5	79·5	28
20	74·2	75·6	12·1	8·4	79·5	23

Gyraulus convexiusculus (Vivekanandan and Pandian 1976) and 64–80% for *V. variatus* (Haniffa and Mullainathan 1982).

Elevations in the rates of feeding, absorption, metabolism and conversion as a function of ration level in normal and starved *P. globosa* were statistically significant ($P < 0.001$). Starvation accelerated the energy budget of *P. globosa* and Student's t test confirmed that this elevation was statistically significant ($P < 0.001$; figure 1). Regression equations were fitted by the method of least squares and the coefficients were used in analysis of variance (Zar 1974). It was confirmed that feeding and ration level significantly influenced the absorption efficiency ($P < 0.05$ and < 0.01) and conversion ($P < 0.05$) but the difference in metabolic rate (as percentage of consumption or absorption) was not significant ($P > 0.05$) as a function of feeding or ration level (table 1).

Acknowledgements

This research work was carried out at Arulmigu Palaniandavar Arts College, Palni. Grateful acknowledgements are due to Council of Scientific and Industrial Research and University Grants Commission, New Delhi for financial assistance.

References

Bayne B 1973 Aspects of the metabolism of *Mytilus edulis* during starvation; *Neth. J. Sea Res.* **7** 399–410

Emerson D N 1967 Carbohydrate oriented metabolism of *Planorbis corneus* (Mollusca, Planorbidae) during starvation; *Comp. Biochem. Physiol.* **22** 571–579

Emerson D N and Duerr F 1967 Some physiological effects of starvation in the intertidal prosobranch *Littorina planaxis* (Philippi 1847); *Comp. Biochem. Physiol.* **20** 45–53

Grahame S D 1973 Assimilation efficiency of *Littorina littorea* (L); *J. Anim. Ecol.* **42** 383–389

Haniffa M A and Pandian T J 1974 Effects of body weight on feeding rate and radula size in the freshwater snail *Pila globosa*; *Veliger* **16** 415–418

Haniffa M A 1978a Secondary productivity and energy flow in a tropical pond; *Hydrobiologia* **59** 49–65

Haniffa M A 1978b Energy loss in an aestivating population of the tropical snail *Pila globosa*; *Hydrobiologia* **61** 169–182

Haniffa M A 1980 Influence of crowding and water level on food utilization in the freshwater snail *Pila globosa* (Swainson); *Indian J. Exp. Biol.* **18** 71–73

Haniffa M A 1982 Effects of feeding level and body weight on food utilization of the freshwater snail *Pila globosa*; *Hydrobiologia* **97** 141–149

Haniffa M A and Mullainathan P 1982 Studies on energy transformation in the freshwater snail, *Viviparus variatus*: Influence of feeding and starvation; *Int. J. Ecol. Environ. Sci.* **8** 187–194

Haniffa M A, Amaladoss A J, Murugesan A G and Isai Arasu L 1984 Influence of plant and animal food on food utilization of a herbivorous snail *Pila globosa* (Swainson); *Indian J. Exp. Biol.* **22** 482–483

Haniffa M A and Sethuramalingam T A S 1985 Food utilization and mineral absorption efficiency in the freshwater snail *Pila globosa*; *Indian J. Com. Anim. Physiol.* **3** 56–64

Hyman L H 1967 *The Invertebrates* (New York: McGraw Hill) Vol. VI Part I

Jose J, Boer M A and Cornelisse C J 1968 *Physiology and ecology of molluscs* (New York: Academic Press)

Martin A and Goddard C 1966 Carbohydrate metabolism; in *Physiology of Mollusca* (eds) K M Wilbur and C M Yonge (New York: Academic Press) pp 275–308

Maynard A L and Loosli K J 1962 *Animal Nutrition* (New York: McGraw Hill)

Meenakshi V R 1964 Aestivation in *Pila*; *Comp. Biochem. Physiol.* **11** 365–368

Petrusewicz K and Macfadyen A 1970 *Productivity of terrestrial animals. Principles and Methods* (Oxford: Blackwell Scientific Publications)

Stickle W B and Duerr F G 1970 Effects of starvation on the respiration and major nutrient stores of *Thais lamellosa*; *Comp. Biochem. Physiol.* **33** 689–695

Uma Devi V, Prabhakara Rao Y and Prasada Rao D G V 1986 Starvation as a stress factor influencing tł metabolism of a tropical intertidal gastropod *Morula granulata* (Duclos); *Proc. Indian Acad. Sci.* (*Anin Sci.*) **95** 539–547

Visser S A 1965 A study of the metabolism during aestivation of the amphibious snail *Pila ovata*; *We: Afri. J. Biol. Appl. Chem.* **8** 41–47

Vivekanandan E, Haniffa M A, Pandian T J and Raghuraman R 1974 Studies on energy transformatio in the freshwater snail *Pila globosa*. 1. Influence of feeding rate; *Freshwater Biol.* **4** 275–280

Vivekanandan E and Pandian T J 1976 Food utilization and mineral absorption efficiency in the sn *Gyraulus Convexiusculus*; *J. Madurai Univ.* **5** 66 – 72