Freshwat. Biol. 1974, Volume 4, pages 275–280

Studies on energy transformation in the freshwater snail *Pila globosa*

1. Influence of feeding rate

E. VIVEKANANDAN, M. A. HANIFFA, T. J. PANDIAN *and* R. RAGHURAMAN *Zoology Department, Madurai University P.G. Centre, Sri Palaniandavar Arts College, Palni, Tamil Nadu, India*

Manuscript accepted 28 July 1973

Summary

The effects of eleven chosen feeding levels ranging from 0 to 198 mg damp dry (plant) *Ceratophyllum*/g live snail/day on the absorption, conversion and metabolism of the snail *Pila globosa* (of 1·9 g body weight) have been studied. Absorption rates increased from 3·0 to 21·0 mg dry food/g live snail/day in snails fed 3·4–28·8 mg dry food/g live snail/day. In these snails, absorption efficiency decreased from 87·5 to 73·0%. Conversion rates increased from 0·3 mg/g/day for snails receiving 23·4 mg/g/day to 2·7 mg/g/day for those fed maximum amounts, and the efficiency (K_2) also increased from 1·9% to 13·0%. When compared to other gastropods, *Pila globosa* appears to be a poor convertor. During 30 days' starvation, the test individuals lost 4·4 mg dry body substance/g/day i.e. the maintenance cost was 14·7 cal/g live snail/day. The SDA increased by four times for those feeding on maximum rations in comparison to those receiving about 5 mg/g/day, i.e. the energy cost for converting food was increased four times.

Introduction

Food intake has been shown to be one of the most important factors which determines the rate and efficiency of conversion (Ricker, 1946). In recent years, effects of feeding rate on conversion efficiency have been studied in a number of fishes by several workers (Gerking, 1955, 1971; Davies, 1963; Pandian, 1967; Pandian & Raghuraman, 1972; Davis, 1968; Brett, Shelbourn & Shoop, 1969; Hari Sethi, 1970). Barring a few workers (Gerking, 1955; Davies, 1963; Pandian, 1967), most of them have not concentrated on absorption. Secondly, these authors have chosen either carnivorous species or predominantly herbivorous omnivorous species, and fed them with animal food. Comparative work on the effects of feeding rates on absorption and conversion on the macrophytic herbivorous molluscs is totally wanting. Working on different species of *Aplysia*, Carefoot (1967, 1970) studied the effect of quality of food on absorption with reference to calorific content and amino acids. The present paper is a preliminary note concerning the effects of feeding rate on absorption and conversion in the freshwater snail *Pila globosa* fed on the aquatic weed *Ceratophyllum*.

Correspondence: Dr T. J. Pandian, Zoology Department, Madurai University P.G. Centre, Sri Palaniandavar Arts College, PALNI, Tamil Nadu, India.

Materials and methods

The snails were collected from Lake Idumban Kulam (Palni) and reared in large aquaria in the laboratory (Haniffa & Pandian, 1974). Eleven groups each containing five individuals of about 2 g were recruited and kept in separate aquaria of 3-l capacity. Experimental individuals were fed for a period of 30 days on *Ceratophyllum* at previously chosen feeding levels ranging from 0 to 198 mg damp dry plant/g live snail/day. Every day a control sample was dried to measure the corresponding water content of the damp dry food plant supplied. Unconsumed plants were removed every day and weighed to estimate the exact amount of food consumed. Appropriate corrections were made for the amount of plant substance produced due to photosynthesis during the experimental period in the test aquaria. Faecal pellets were collected every day by filtering the entire aquaria with minimum disturbance to the test individuals. The 'sacrifice method' (Maynard & Loosli, 1962) was used to measure the initial and final dry weight of the experimental animals.

The test individuals, their faeces and *Ceratophyllum* were dried at 105°C to constant weight in order to present data on absorption and conversion in terms of dry weight. Dry weight of food consumed minus dry weight of faecal pellets defaecated yielded the amount of dry food absorbed; the final dry weight of test individuals (inclusive of shells) minus the respective initial dry weight of test individuals gave the amount of dry food converted.

Results and discussion

The rate and efficiency of nutrient matter absorbed and converted by the snails feeding on different rations are given in Table 1. The absorption rate steadily increased from 3·0 to 21·0 mg dry food/g live snail/day in the snails fed 3·4 to 28·8 (= 161·1 mg damp dry plant/g live snail/day) mg dry food/g live snail/day. Absorption efficiency, the amount absorbed as a percentage of *Ceratophyllum* consumed, progressively decreased from 87·5% to 73·0% (Table 1). Since the test individuals did not accept more than 161 mg damp dry *Ceratophyllum* (28·8 mg dry plant/g live snail/day) under the laboratory conditions, it is very likely that the efficiency does not decrease below 73%.

Table 1. *Pila globosa*: rates and efficiencies of absorption and conversion as function of ration levels. Each value represents the average performance of five individuals fed for 30 days at 28°C

Feeding rate (mg dry plant/ g live snail/day	Absorption rate (mg dry plant/g live snail/day)	Change in weight (mg dry weight/g live snail/day)	Metabolic rate (mg dry weight/g live snail/day)	Absorption efficiency (%)	Conversion efficiency (%) (K_2)
0	0	−4·4	4·4	—	—
3·4	3·0	−2·1	5·1	87·5	—
7·0	6·1	−1·8	7·9	86·0	—
10·6	9·1	−2·1	11·2	85·8	—
14·0	11·1	−2·0	13·1	79·7	—
18·7	13·8	−2·1	15·9	79·4	—
20·6	15·7	+2·4	13·3	76·3	15·0
23·4	17·6	+0·3	17·3	75·3	1·9
25·8	19·1	+1·7	17·4	74·0	9·1
27·4	19·7	+1·4	18·3	72·1	7·3
28·8	21·0	+2·7	18·3	73·0	13·0

The efficiency values available for macrophytic herbivorous animals are 78% for the angelfish *Holocanthus bermudancis* (Menzel, 1959), 69% for the urchins *Strongylocentrotus intermedius* (Fuji, 1967), and 70% for the gastropod *Tegula funebralis* (Paine, 1971). The efficiency values reported by Carefoot (1967, 1970) for different species of *Aplysia* fed several species of sea weeds range from 15 to 84%. Most of the values obtained for *Pila globosa* fall within the values reported for other herbivorous animals and give experimental evidence for the first time that feeding levels do not alter the absorption efficiency; this supports a similar finding of Conover (1966) for the microphytic herbivorous copepod *Calanus hyperboreus*.

The gain in body substance increased from 0·3 mg/g/day for *Pila globosa* receiving 23·4 mg/g/day to 2·7 mg/g/day for those fed maximum rations (Table 1). Conversion efficiency also increased from 2% to 13% (Table 1). The efficiency values reported for gastropods range from 20 to 28% for *Tegula* (Paine, 1971) while those reported by Carefoot (1967, 1970) for different species of *Aplysia* are from 20 to 84%. *Pila globosa* appears to be poor convertor (Fig. 1).

The IBP formula for energy balance is $I = \cancel{A}\ F+U + C + R$, where I is the intake of food, ~~A, the absorption~~ F, faeces, U, urine, C, the conversion and R, the metabolism (Petrusewicz &

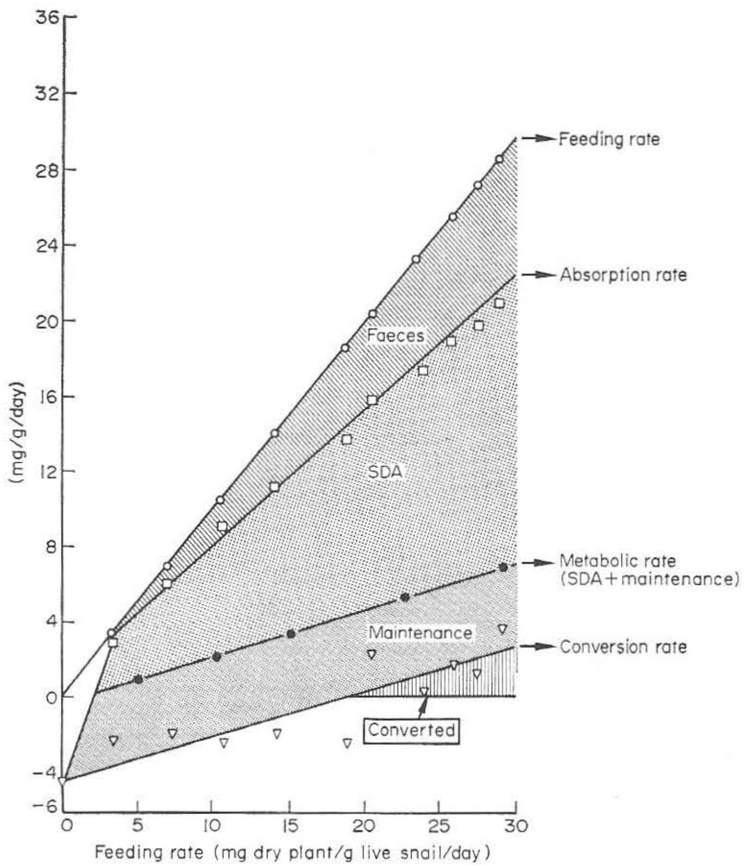

Fig. 1. *Pila globosa*: effect of feeding rates on growth (conversion), metabolism (maintenance + Specific Dynamic Action) and output of faeces in young snails fed *Ceratophyllum* for 30 days at 28°C.

MacFadyen, 1970). Since *I*, *A* and *C* are estimated for *Pila globosa*, *R* has been calculated and given in mg dry substance oxidized/g live snail/day (Table 1; Fig. 1). Starved *Pila* lost 4·4 mg body substance/g/day, which represents the minimum energy cost of maintenance (Brody, 1968). Data on maintenance requirement of snails are totally wanting but those available for fish range from 2·1 mg/g/day for the herbivorous fish *Tilapia mossambica* (Pandian & Raghuraman, 1972) to 6·2 mg/g/day for the carnivorous fish *Poecilia reticulata* (Davis, 1968). Since 42% of the present animal weight represents the shell, which is known to contain only about 1·1% organic matter (Vinogradov, 1953), the shell may not have lost significant energy during starvation. Therefore, the matter lost by *Pila globosa* due to starvation may be entirely from the oxidation of soft tissue, which is known to contain 3682 ± 441 cal/g dry weight (Pandian *et al.*, 1974). Hence, the energy cost of maintenance of *Pila globosa* is ($4{\cdot}4$ mg $\times$ 3682 cal/g$=$) 14·7 cal/g/day. Taking the expenditure of 4·8 cal energy as equivalent to 1 ml of oxygen uptake (Engelmann, 1966), the minimum oxygen uptake of *P. globosa* can be calculated to be 0·13 ml O_2/g/h, which compares well with the values reported for other snails, e.g. *Helicella* (Kienle & Ludwig, 1956).

Having estimated the minimum maintenance energy cost for *Pila globosa*, the level of Specific Dynamic Action (SDA), an extra heat increment incidental to the nutritive process in total, and including the energy cost of excretion of the end products (Brody, 1968), at each ration level has been calculated and is represented in Fig. 1. The SDA is found to be increased nearly four times at the maximum level of feeding in comparison to that at about 5 mg/g/day ration level, i.e. the energy cost for converting food has increased four times (see Fig. 1).

Acknowledgment

We are grateful to Professor K. Arunachalam for offering facilities for this research.

References

Brett J.R., Shelbourn J.E. & Shoop C.T. (1969) Growth rate and body composition of fingerling sockeye salmon, *Oncorhynchus nerka*, in relation to temperature and ration size. *J. Fish. Res. Bd Canada*, **26**, 2363–2394.

Brody S. (1968) *Bioenergetics and Growth.* Hafner Publishing Company, New York.

Carefoot T.H. (1967) Growth and nutrition of *Aplysia punctata* feeding on a variety of marine algae. *J. mar. biol. Ass. U.K.* **47**, 565–590.

Carefoot T.H. (1970) A comparison of absorption and utilization of food energy in two species of tropical *Aplysia*. *J. exp. mar. Biol. Ecol.* **5**, 47–62.

Conover R.J. (1966) Assimilation of organic matter by zooplankton. *Limnol. Oceanogr.* **11**, 338–345.

Davies P.M.C. (1963) Food input and energy extraction efficiency in *Carassius auratus*. *Nature, Lond.* **198**, 707.

Davis C.C. (1968) Quantitative feeding and weight changes in *Poecilia reticulata*. *Trans. Am. Fish. Soc.* **97**, 22–27.

Engelmann F. (1966) Energetics, terrestrial field studies and animal productivity. *Adv. ecol. Res.* **3**, 73–115.

Fuji A. (1967) Ecological studies on the growth and food consumption of Japanese common sea urchin *Strongylocentrotus intermedius* (A. Agassiz). *Mem. Fac. Fish. Hokkaido Univ.* **15**, 83–160.

Gerking S.D. (1955) Influence of rate of feeding on body composition and protein metabolism of bluegill sunfish. *Physiol. Zool.* **28**, 267–282.

Gerking S.D. (1971) Influence of rate of feeding and body weight on protein metabolism of bluegill sunfish. *Physiol. Zool.* **44**, 9–19.

Haniffa M.A. & Pandian T.J. (1974) Effects of body weight on feeding rate and radula size in the freshwater snail *Pila globosa*. *The Veliger* (in press).

HARI SETHI S. (1970) *Temperature and bioenergetics of* Cichlasoma bimaculatum. Ph.D. thesis, Oregon University.

KIENLE, W. A. & LUDWIG W. (1956) Metabolism and body size in land snails. *Z. vergl. Physiol.* **39**, 103–118.

MAYNARD A.L. & LOOSLI K.J. (1962) *Animal Nutrition.* McGraw-Hill, New York.

MENZEL D.W. (1959) Utilization of algae for growth by angelfish. *J. Cons. perm. int. Explor. Mer.* **24**, 308–313.

PAINE R.T. (1971) Energy flow in a natural population of the herbivorous gastropod *Tegula funebralis*. *Limnol. Oceanogr.* **16**, 86–98.

PANDIAN T.J. (1967) Intake, digestion, absorption and conversion of food in the fishes *Megalops cyprinoides* and *Ophiocephalus striatus. Mar. Biol.* **1**, 16–32.

PANDIAN T.J. & RAGHURAMAN R. (1972) Effects of feeding rate on conversion efficiency and chemical composition of the fish *Tilapia mossambica. Mar. Biol.* **12**, 129–136.

PANDIAN T.J., RAGHURAMAN R., HANIFFA M.A. & VIVEKANANDAN E. (1974) Studies on energy transformation in the freshwater snail *Pila globosa.* 2. Influence of feeding rate and body size (under preparation).

PETRUSEWICZ K. & MACFADYEN A. (1970) *Productivity of Terrestrial Animals.* IBP Hand Book No. 13. Blackwell Scientific Publications, Oxford and Edinburgh.

RICKER W.E. (1946) Production and utilization of fish populations. *Ecol. Monogr.* **16**, 373–391.

VINOGRADOV A.P. (1953) The elementary chemical composition of marine organisms. *Mem. Sears Found. Mar. Res.* **2**, 647.