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Environmental restraints on the food conversion of cyprinid forage fishes : Influence of availability of food on *Rasbora daniconius* (Hamilton)

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Abstract. The effects of food availability on the bioenergetics and the body composition of the cyprinid *Rasbora daniconius* (Ham.) have been described. During the 15-day experimental period, fish in the weight range of 475 to 1660 mg were fed daily on *Tubifex tubifex* for different durations. The food intake increased from 7·96 ± 2·323 mg dry/fish/day for fish exposed to food for 2 hr to 11·57 ± 0·757 mg dry/fish/day for fish fed *ad libitum* diet. For the same series of fish, the feeding rate also increased. Growth of fish expressed as mg gain in dry weight/fish/day increased with increases in food intake. However, the food conversion efficiency was highly variable in relation to the daily food intake or feeding rate.

Keywords. Food availability; *Rasbora daniconius*; starvation; conversion; body composition.

1. Introduction

The importance of availability of food as a growth regulating factor in fishes has been stressed by Pandian and Raghuraman (1972) and Katre and Reddy (1978). While there are reports on the influence of availability of food on the growth of catfishes (Andrews and Page 1975), salmonids (Le Brasseur 1969; Elliot 1975a, b), cichlids (Hari Sethi 1970; Pandian and Raghuraman 1972) and cyprinodontids (Katre and Reddy 1978; Krishnamurthy 1978), similar studies are wanting in cyprinids. The present paper details the influence of the availability of food on the food conversion and body composition of the common cyprinid forage fish *Rasbora daniconius*.

2. Material and methods

Rasbora daniconius were collected from a local freshwater tank, operating a drag net. The fish were acclimated in the laboratory for a week. Healthy individuals in the weight range of 475 to 1660 mg were selected for the study. Experimental fish were grouped into seven series each with six fish reared individually in glass

aquaria containing 500 ml of freshwater. Fish were fed daily on surplus amounts of the oligochaete worm *Tubifex tubifex*. Each series of fish was exposed to different durations of prey presence per day (0, 2, 4, 6, 8 and 12 hr/day or *ad libitum*). After a 15-day experimental period, the average daily food intake, growth and conversion efficiency ($K_1 = \%$) of the fish were determined following the method of Katre and Reddy (1978). Chemical analyses of the fish were made on material dried to constant weight. Ash was determined following the method of Paine (1964). Organic matter was determined as the difference between the dry weight and the ash weight.

3. Results and discussion

Table 1 presents the influence of availability of food on the daily consumption growth and gross conversion efficiency of *Rasbora daniconius*. The food intake (mg dry/fish/day) increased from $7{\cdot}96 \pm 2{\cdot}323$ for fish exposed to food for 2 hr/day to $11{\cdot}57 \pm 0{\cdot}757$ for fish fed *ad libitum* diet. Marked differences in food intake were not observed between groups fed 2 hr/day and 4 hr/day or between 6 hr/day and 8 hr/day or between 12 hr/day and 24 hr/day. The cumulative average values of food intake for the above three series were 7·69, 9·13 and 11·52 mg dry/fish/day respectively. From this it appears that the food intake of fish per hour depended upon the prior starvation period. While fish fed after 21 hr of starvation (average starvation period of fish fed 2 or 4 hr/day) consumed 2·56 mg dry food/fish/hr, $(7{\cdot}96 + 7{\cdot}42)/(2 + 4)$ those fed after 17 hr $(9{\cdot}00 + 9{\cdot}26)/(6 + 9)$ and 6 hr $(11{\cdot}46 + 11{\cdot}57)/(12 + 24)$ of starvation consumed 1·31 and 0·64 mg dry food/fish/hr respectively. This suggests that in *R. daniconius* food consumption and amount of food per meal are influenced by the prior starvation period. Simi-

Table 1. *Rasbora daniconius*: Influence of food availability on the daily food intake, growth and conversion efficiency. Each value represents the mean of six individuals ($\pm$ = SD).

Food availability (hr/day)	Food intake* (mg dry/fish/day)	Feeding rate (mg dry/g fish/day)	Growth (mg dry/fish/day)	Conversion efficiency ($K_1 = \%$)
0	..	..	$-2{\cdot}972 \pm 0{\cdot}237$	..
2	*a* $7{\cdot}96 \pm 2{\cdot}323$	12·00	$+0{\cdot}921 \pm 0{\cdot}046$	$11{\cdot}80 \pm 6{\cdot}205$
4	*b* $7{\cdot}42 \pm 1{\cdot}026$	13·09	$0{\cdot}942 \pm 0{\cdot}056$	$13{\cdot}21 \pm 6{\cdot}205$
6	*c* $9{\cdot}00 \pm 1{\cdot}003$	15·20	$1{\cdot}620 \pm 0{\cdot}398$	$18{\cdot}13 \pm 4{\cdot}579$
8	*d* $9{\cdot}26 \pm 1{\cdot}318$	15·33	$1{\cdot}759 \pm 0{\cdot}812$	$19{\cdot}44 \pm 10{\cdot}535$
12	*e* $11{\cdot}46 \pm 1{\cdot}581$	19·22	$2{\cdot}776 \pm 1{\cdot}343$	$23{\cdot}44 \pm 9{\cdot}609$
24	*f* $11{\cdot}57 \pm 0{\cdot}757$	21·72	$2{\cdot}108 \pm 0{\cdot}384$	$18{\cdot}23 \pm 3{\cdot}348$
(*ad libitum*)				

*P values: Highly insignificant. $a = b$: 1·0632. $c = d$: 07·850. $e = f$: 0·3139.

lar increases in food intake/hr with increases in starvation period have been reported for the mosquito fish *Gambusia affinis* (Katre and Reddy 1978).

Fish are considered ' satiated ' when they would no longer accept any food, after a period of active feeding, even in the presence of excess food (Brett 1971). Time taken by fish to attain satiation, i.e., the period of time elapsing from the start of active feeding to voluntary cessation is denoted as the ' satiation time ' in fishes (Brett 1971; Niimi and Beamish 1974). In the present study the satiation time for *R. daniconius* has not been recorded. However, the small difference in the food intake between groups fed for 2 hr/day and 4 hr/day indicates that an amount of dry worm substance equivalent to 7·96 ± 2·323 mg represents the full capacity/meal of the fish. Considering the daily food intake of 7·96 mg for fish receiving a food supply for only 2 hr/day as a unit, if the increase in food intake to food exposure time was proportional, the fish should have consumed 12 times that amount (95·52 mg), when the feeding schedule was *ad libitum* (24 hr/day). Figure 1 represents the expected and obtained values of food intake of *R. daniconius* with reference to the prey exposure time. From this it is evident that the experimental values deviate considerably from the expected values. For example, a value of 11·57 ± 0·757 mg for the *ad libitum* feeding is considerably low to the calculated value of 95·52 mg. This indicates that *R. daniconius* feeds intermittently and the amount of food per meal is neither always constant nor proportional to the period of exposure to food. A similar relationship between the availability of food per day and the daily food intake has been reported for Juvenile chum salmon, *Oncorhynchus keta* (Le Brasseur 1969), *Gambusia affinis* (Katre and Reddy 1978) and *Poecilia reticulata* (Krishnamurthy 1978). The larger deviations between the estimated and experimental values of food intake obtained presently (figure 1), as compared to those reported for *G. affinis* or *P. reticulata* may be due to the different feeding habits of the fishes. While *G. affinis* and *P. reticulata* are known to be basically larvivorous, feeding on live prey (Gerberich and Laird 1965), *R. daniconius* is more or less a herbivore with some omnivorous feeding habit (personal observation).

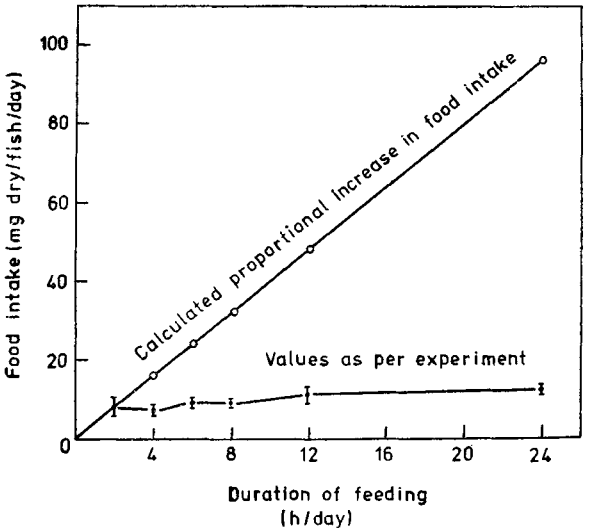

Figure 1. Calculated and experimental food intake of *Rasbora daniconius*.

The calculated feeding rate expressed as mg dry food/g fish/day of *Rasbora daniconius* increased with increases in duration of feeding and fish fed on an *ad libitum* diet exhibited a maximum value of 21·72 (table 1). The present average value of feeding rate was 16·09 mg dry/g fish/day for a fish weighing on an average 674 mg. The present value is significantly higher as compared to a value of 9·306 mg dry food/g fish/day reported for the same species fed on chopped pieces of earthworm (data recalculated from Raghuraman 1973). This indicates that *R. daniconius* feeds on *Tubifex* worms better than on earthworms. This may be due to the smaller size of the prey offered as well as its quality (Galinat 1960) and easy digestibility by the fish (Mann 1960).

Figure 2 indicates the relationship between the duration of feeding and growth. *R. daniconius* exhibited a loss of 2·97 ± 0·237 mg dry/fish/day on starvation during the experimental period. Growth (mg dry/fish/day) of fish increased with increases in the duration of feeding upto the feeding schedule of 12 hr/day, beyond which a decrease in the growth was observed (table 1). The values of daily growth also indicated considerable deviations from the calculated linear increases with increase in food supply (see also Le Brasseur 1969; Katre and Reddy 1978; Krishnamurthy 1978).

The mean values of conversion efficiency ($K_1 = \%$) of *R. daniconius* increased with increases in food supply (2 hr/day: 11·80 ± 6·205%; *ad libitum*: 18·23 ± 3·348%). The maximum value of 23·44 ± 9·609% was obtained for fish receiving food supply for 12 hr/day. The average value of conversion efficiency obtained in the present study was 17·38%. A slightly lower value of 16·36% has been indicated for the same species fed on earthworm (data recalculated from Raghuraman 1973). The better efficiency obtained presently may be attributed to the higher feeding rate as well as better utilisation of the *Tubifex tubifex* worms. After exami-

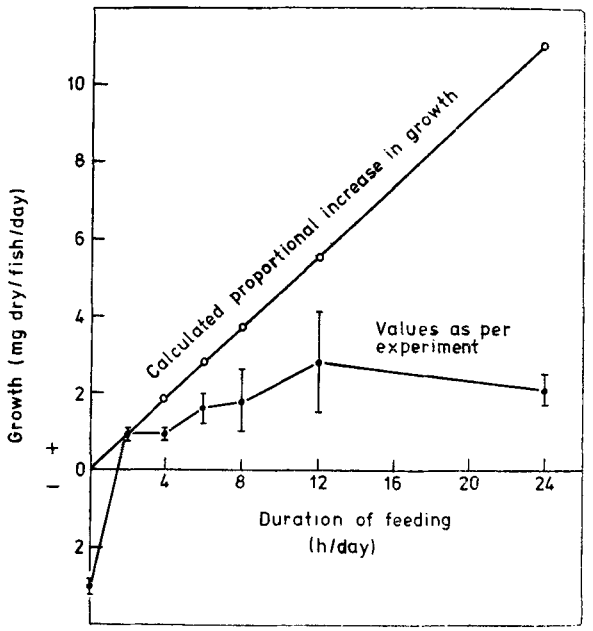

Figure 2. Calculated and experimental values of growth in *Rasbora daniconius*.

ning the literature on food intake and growth of fishes, Paloheimo and Dickie (1965) concluded that gross conversion efficiency decreases from a maximum value at low feeding levels. However, the large deviations from the mean values of conversion efficiency obtained presently do not permit further discussion on this aspect.

Table 2 presents the body composition of control and experimental fish. As compared to the controls, fish that were starved during the period of experiment exhibited a considerable increase in the ash content. Similar effect of starvation on the ash content have been reported for *Tilapia mossambica* (Pandian and Raghuraman 1972) and *Lepomis macrochirus* (Savitz 1971). However, no significant variations in ash content were observed between the controls and those receiving food for different durations per day. Experimental fish on starvation exhibited a considerable decrease in their organic matter indicating the definite utilisation of organic reserves for maintenance. Fish fed for different durations during the study did not exhibit any significant change in their organic components. This indicates that *R. daniconius* is able to obtain the necessary organic components for their maintenance even on a minimum feeding schedule of 2 hr/day. The water content of fish fed on different feeding schedules did not indicate any marked variations from the values obtained for controls. In contrast to this, increases in water content on starvation have been reported for *Salvelinus fontinalis* (Phillips *et al* 1960) and *Tilapia mossambica* (Pandian and Raghuraman 1972). The increase in water content is usually attributed to the increased fat metabolism during starvation (see also Beamish *et al* 1975). The present observations indicate that in *R. daniconius*, at least during a short experimental period of 15 days, reserve fat may not be utilised for purposes of maintenance during starvation. However, extensive experimentation is needed to determine the actual source of nutrient depletion during starvation of *R. daniconius*.

Table 2. *Rasbora daniconius* : Body composition of control and experimental fish. Each value represents the mean of six estimates.

Biochemical constituents determined	Initial fish (control)	Experimental fish: Duration of feeding (hr/day)						
		0	2	4	6	8	12	24
Dry matter (%)	24·68	24·64	25·45	24·57	25·61	24·49	27·17	26·07
Water (%)	75·32	75·36	74·55	75·43	74·39	75·51	72·83	73·93
Ash (% of dry matter)	14·52	20·12	15·88	17·65	15·01	16·92	13·58	14·69
Organic matter* (% of dry matter)	85·48	79·88	84·12	82·35	84·99	83·08	86·42	85·31

* Calculated data

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