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Consumption, Absorption and Conversion of Food in the Larvivorous Fish, *Macropodus cupanus* (Cuv. & Val.) [Pisces: Anabantidae]

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The assessment of the parameters of growth energetics with respect to food quality, fish size and breeding season reveals that, in terms of unit body weight, the relationship between size and overall feeding rate, expressed as g cal/g/day, is inverse. However, consumption, per individual, in terms of g cal/day is directly related to fish size. The conversion rate per gram body weight and the conversion efficiency per unit fish weight per unit time exhibit an inverse relation to size. Data on absorption efficiency do not reveal consistent and significant differences between the various size groups. Considering the influence of breeding season on nutritive efficiency, a decline is noted in consumption, feeding rate, conversion rate and conversion efficiency during the pre-breeding season as compared to the post-breeding season. Data on the effect of feeding different types of food to the fish indicates that food quality also radically affects growth energetics.

Key Words: Larvivorous fish, *Macropodus cupanus*, **Consumption, Absorption, Conversion**

Introduction

The importance of larvivorous fishes, the premier biological control agents of mosquito larvae, lies in the fact that existing, chiefly chemical methods of mosquito control have proved inadequate (Wigglesworth 1976), prompting enquiry into other control techniques, including biological methods. However, indiscriminate releases of exotic larvivorous such as *Gambusia affinis* (Baird & Girad) and *Poecilia reticulata* Peters have sometimes resulted in the alteration/eradication of valuable faunal components of the ecosystem (Myers 1965, Bay 1973 and Menon 1977). This has been responsible for the renewed interest in India in the bio-control potential of indigenous larvicidal fishes such as *Macropodus cupanus* (Cuv. & Val.) (=*Polyacanthus cupanus*)

An essential pre-requisite for assessing biocontrol potential is data on conversion efficiency, which allows reasonably accurate estimates of food consumption in nature (Carline & Hall 1973), provides an insight into the nutritional contribution of prey species, including mosquito larvae, towards sustained growth of the predator (Reddy & Katre 1979), and is a suitable and sensitive parameter to measure metabolism, in addition to growth energetics. However, such studies on tropical fishes are limited and those on larvivorous fishes such as *M. cupanus* are almost totally lacking apart from the work of Ponniah and Pandian (1977) and Ponniah (1978). Therefore, the assessment of feeding rate, absorption and conversion efficiency has been investigated in different sizes of the fish as a function of two factors not hitherto dealt with—breeding season and different types of food.

Materials and methods

Specimens of *M. cupanus* collected during the post-breeding season (October) from the environs of Trivandrum (Kerala, South India) were sorted out on the basis of live weight into large (A–1.1 ± 0.1 g), medium (B–0.35 ± 0.05 g) and small-sized (C–0.07 ± 0.01 g) groups and acclimated to well water at a temperature of 28 ± 2°C, *p*H of 7.1 ± 0.3 and oxygen at near air saturation, in glass aquaria. Size groups were chosen rather than age/year groups, as accurate determination of the latter is difficult in *M. cupanus*, as in other tropical fishes, by conventional techniques (Weatherley & Rogers 1978). All three groups were again subdivided into three groups of 15 specimens each; groups A_1, B_1, and C_1 were trained to feed on fourth instar *Culex* larvae (reared in the laboratory), groups A_2, B_2 and C_2 on *Tubifex* species, an aquarium food and groups A_3, B_3 and C_3 on algae (*Oedogonium* species), a food item occurring in the diet of the fish in the natural habitat (Jacob 1981).

A perusal of literature pertaining to energy balance in fishes reveals several methods in vogue for estimating food consumption and assimilation and conversion efficiency. In the present investigation, the method of Gerald (1976), being the most suitable, was followed with minor modifications in laboratory techniques. Chief among these was that the fish were permitted to feed *ad libitum* (at the feeding level at which they consume the maximum amount voluntarily in a day) as advised by Brett (1971), on live (moving) prey, as recommended by Ponniah (1978), to achieve an approximate simulation of feeding under natural conditions. Further, since food utilisation, conversion rate and conversion efficiency are depth—and temperature—dependent activities (Vivekanandan & Pandian 1977), these parameters were kept constant (depth at 15 cm and temperature at 28 ± 2° C). The phenomenon of slowing down of food-uptake and growth under laboratory conditions (Gerald 1976), being met with only in experiments extending for a long period, did not pose any problem since here the usual period of each experiment was 21 days, as a substantial calorific increase was recorded during that period, except in the small-sized group, where this increase could be recorded within 14 days. Caloric estimation was carried out in a Parr 1412 Semi Micro Bomb Calorimeter, following standard procedures.

To determine the influence of breeding season on nutritive efficiency, an experiment was also conducted during the pre-breeding season. The fish exhibits a prolonged monsoon spawning season from April to September and a shorter one in January and February (Jacob 1981). However, to obtain the requisite number of specimens for experimental purposes, tests were conducted in March and

October (i.e. the pre-spawning and post-spawning period, respectively). The procedure adopted during the pre-spawning period was identical to that described above, except that the medium (D_1) and large (D_2) size groups alone were fed on *Culex* larvae since small-sized specimens were not available in numbers sufficient for experimental purposes at that time of the year.

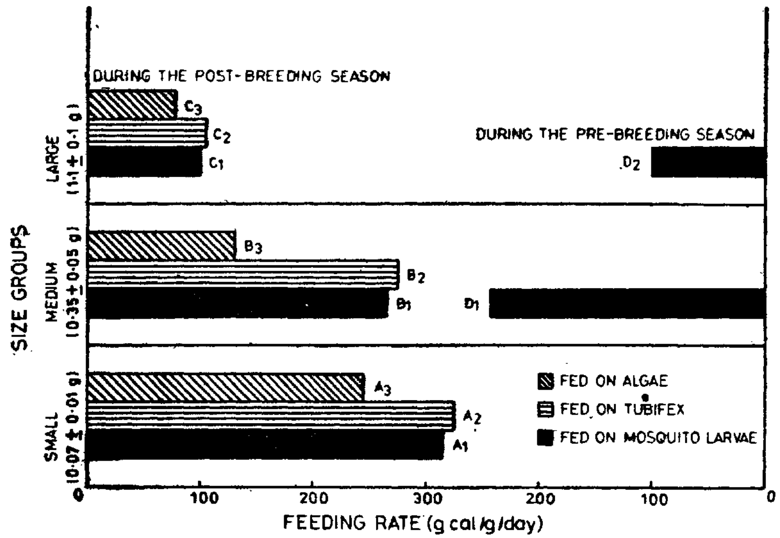

Figure 1 Feeding rate in the various size groups of *M. cupanus* fed on different types of food

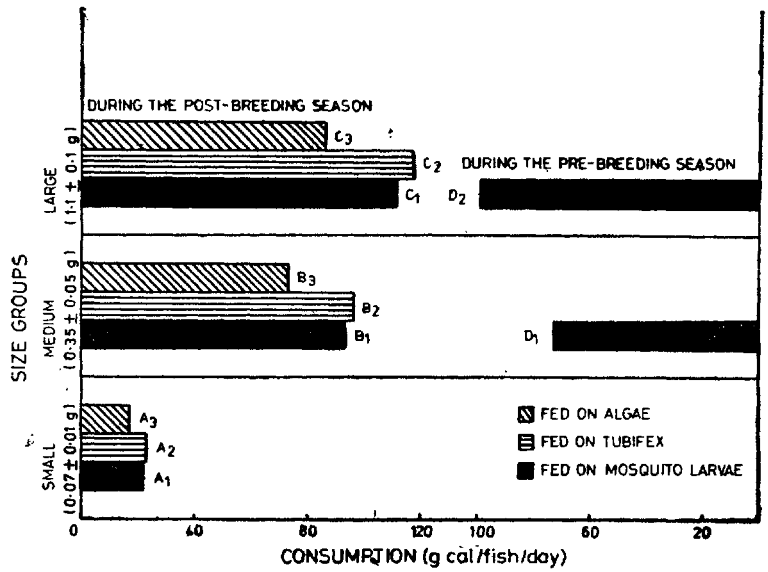

Figure 2 Rate of consumption in the various size groups of *M. cupanus* fed on different types of food

Results

Influence of size

Feeding rate in terms of g cal/g/day (figure 1) declines as size increases; mean feeding rate shows a reduction from 294.93 and 222.35 g cal/g/day in the small and medium-sized groups, respectively, to 95.46 g cal/g/day in the large-sized group. However, consumption in g cal/fish/day is proportional to size of the individual (figure 2), average consumption being 20.64 g cal/fish/day in

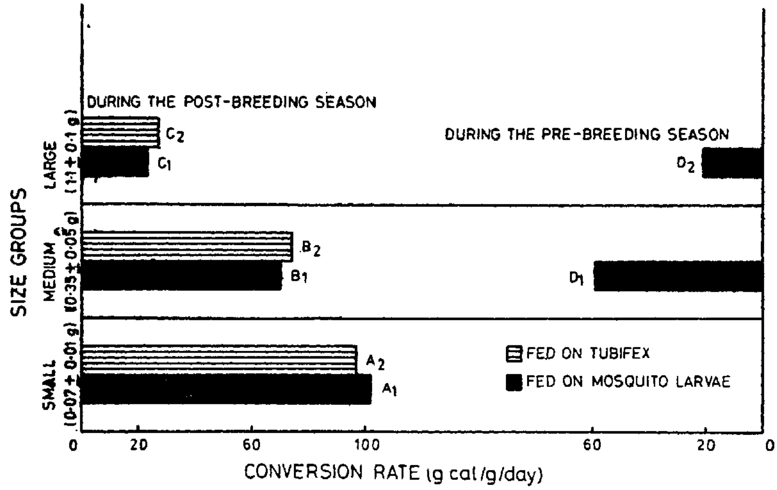

Figure 3 Rate of conversion in the various size groups of *M. cupanus* fed on different types of food

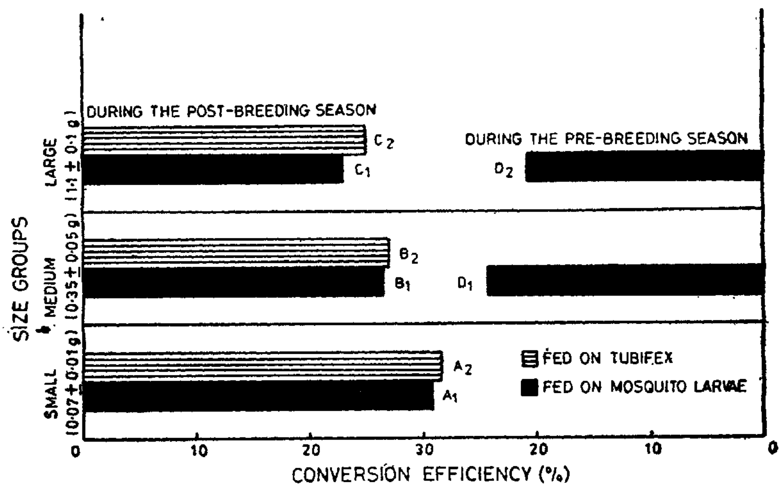

Figure 4 Conversion efficiency in the various size groups of *M. cupanus* fed on different types of food

the small and rising to 87.15 and 105.00 g cal/fish/day in the medium and large-sized groups, respectively.

Data on absorption efficiency do not reveal consistent and significant differences between the various size groups. Mean absorption efficiency in the large-sized group is 90.06%, while in the medium-and small-sized groups it is 88.73 and 90.57%, respectively. Thus, on an average, nearly 90% of the food supplied to the different size groups is assimilated.

Both conversion rate and conversion efficiency data reveal an inverse relationship to size (figures 3 & 4). In small-sized *M. cupanus*, the mean conversion rate and conversion efficiency are 99.83 g cal/g/day and 31.25% respectively. In medium-sized individuals they are 72.14 g cal/g/day and 26.78% respectively, while in large-sized specimens they are 24.91 g cal/g/day and 23.93% respectively.

All the above values have been recorded in the post-breeding season; those in the pre-breeding season are given below. At both times, however, the effect of size described above holds good.

Influence of breeding season

A definite though not drastic decline is recorded in nutritive efficiency during the pre-breeding season when compared to the post-breeding one (figures 1–4). Consumption and feeding rate are, on an average, 75.41 g cal/fish(day and 227.14 g cal/g/day, respectively during the post-breeding season and 90.85 g cal/fish/day and 171.25 g cal/g/day, during the pre-breeding season. Absorption efficiency does not vary greatly with season, being 92.53% and 90.89% during the post- and pre-breeding seasons, respectively. The mean conversion rate and conversion efficiency are both greater during the post-breeding season, being 63.54 g cal/g/day and 26.76% as against 39.90 g cal/g/day and 22.58%, respectively.

Influence of different types of food

The highest mean rate of consumption (78.59 g cal/fish/day) is seen in *M. cupanus* fed on *Tubifex* of a calorific value of 4346 cal/g dry weight; the fish fed on *Culex* larvae of a calorific value of 4548 cal/g dry weight come a close second with an average consumption of 75.41 g cal/fish/day. Specimens fed on algae with a calorie value of 3909 cal/g dry weight exhibit a drop, average consumption being 58.90 g cal/fish/day. In the mean feeding rate also the same pattern was discernible: *M. cupanus* subsisted on 234.68 g cal/g/day of *Tubifex* and 227.14 g cal/g/day of *Culex* larvae, but only on 150.91 g cal/g/day of algae. The average absorption efficiency values, too, were lower in specimens fed on algae (81.83%) than in those fed on *Tubifex* (95.01%) and mosquito larvae (92.53%). The conversion rate and conversion efficiency of fish fed on *Tubifex* (27.38% and 67.70 g cal/g/day on an average) were higher than in those consuming *Culex* larvae (26.76% and 63.54 g cal/g/day); in those fed on *Oedogonium* no gain in weight was noted.

Discussion

Consumption

That the food consumed per individual increases with fish mass has been shown by Kinne (1960), Pandian (1967a,b, 1970), Brett (1971), Gerking (1971), Nimii and Beamish (1974), Gerald (1976), Ponniah (1978) and Webb (1978). However, overall group feeding rate showed that the smallest fish consumed the maximum amount of food considered as percent body weight per day. This greater capacity could be a reflection of growth rate, which is fastest during the earliest life stages and falls later with advancing age and/or increasing body weight (Pandian 1970). These patterns are corroborated by those in other larvicidal fishes such as *G. affinis*, where food consumption, taken as a function of dry body weight, decreases from 78% body weight in the 4 mg fish to 18% in a 41 mg individual. The results obtained here compare well with those of Ponniah and Pandian (1977) and Ponniah (1978). There the maximum feeding rate of the 0.5 g *M. cupanus* is 174.2 g cal/g/day, that of the 0.285, 0.515 and 1.296 g groups averaged 281.8, 210.3 and 105.1 g cal/g/day.

Considering the influence of breeding on consumption, although the general trend of feeding with respect to food type and fish size group does not change drastically with breeding season, there is a slight rise in the post-breeding period, due to the increased energy input essential at this time to make up weight loss due to spawning and reproductive activities. Again, a certain amount of growth potential is sacrificed for the building up of gonad reserves (Sarojini 1957).

Food quality has the greatest potential effect on growth efficiency (Paloheimo & Dickie 1966 and Pandian 1970). The results recorded here that the highest consumption was noted in fish fed on *Tubifex* (although those fed on *Culex* larvae came a close second) are supported by Reddy and Katre (1979) working on other larvicidal fishes such as *G. affinis* and *P. reticulata*. This may be because soft food organisms such as *Tubifex* are digested more rapidly than heavily chitinised forms (Nikolsky 1963), thus leading to a greater intake of the former than the latter.

Absorption

Measurements of assimilation efficiencies have shown that over 90% of the food consumed is absorbed into the body (Job 1960, Gerking 1971, Pandian 1967a, b, Beamish 1972, Nimii & Beamish 1974, Gerald 1976, Vivekanandan 1976 and Pandian & Ponniah 1977). Further, as found by the above workers, absorption efficiencies vary little with change in fish size. Nevertheless, as reported by Pandian (1967b), type of food supplied alters assimilation efficiencies; in *M. cupanus* fed on algae the energy values of the faecal content are higher than in individuals fed on *Tubifex* and *Culex* larvae.

Conversion

That conversion rate, per gram body weight, decreases with increasing body weight has been established by earlier workers, cited above. Ponniah (1978) attributes this to a corresponding change in digestion rate with weight. However, the findings of Jacob and Nair (1981) that provided food sufficient to satiate the fish is supplied, digestion rate does not alter with change in fish weight, does not support this theory. Therefore, the explanation of Gerald (1976) that this pattern could be due to a decrease in feeding rate of the larger fish appears more plausible.

Comparing these studies with those of Ponniah (1978) on *M. cupanus* fed on mosquito larvae, there the maximum conversion rate for a 0.06 g specimen at 32°C is 173 g cal/g/day, while for a 1.3 g individual it is 47 g cal/g/day. Thus in both studies, weight displays a clear negative effect on conversion rate. However, by restricting rations, Ponniah and Pandian (1977) obtained conversion rate values of 4.1 g cal fish substance/g live fish/day in the group fed 42 g cal/g/day to 38 g cal/g/day in the 0.5 g fish fed on maximum rations.

The effect of breeding season and feeding different types of food is similar to that discussed under feeding rates.

Considering conversion efficiency, the conclusion arrived at, that conversion efficiency per unit fish weight per unit time decreases with increasing body weight, is supported by Paloheimo and Dickie (1966), Pandian (1970), Gerald (1976), Ponniah and Pandian (1977) and Ponniah (1970). The results could be due to the smaller fish requiring comparatively less energy for maintenance and utilising a greater % for growth than larger fish (Gerald 1976), or might be due to the reduced feeding rate (Pandian 1970), although Paloheimo and Dickie (1966) concluded that body weight affects feeding, but is not a determining factor for conversion efficiency.

Comparing these values with those of Ponniah and Pandian (1977), there conversion efficiency increased from 11% in the group receiving 42 g cal/g/day to 31% in those fed on a ration of 84 g cal/g/day, and thereafter decreased to 22% in those receiving maximum ration. The higher values obtained in the present investigation may be due to unrestricted feeding; Kinne (1960) and Rajamani and Job (1976) confirm that *ad libitum* feeding can only show an asymptotic maximum of conversion efficiency and not a gross decrease as described by Pandian and Raghuraman (1972).

The quality of food available, rather than breeding season affects conversion efficiency here, as in other larvivorous fishes such as *G.affinis* and *P. reticulata*. Reddy and Katre (1979), on feeding different prey to the above fishes, recorded the highest conversion efficiency values from individuals fed on *Tubifex*, rather than mosquito larvae. Obviously, the fishes procure more energy from worm rather than from larval substance. This could be because the efficiency of utilisation of metabolizable nutrients depends on how closely their proportions correspond to that which could be effectively utilized for the metabolic processes (Reddy 1973). Also, the deposition of body substance tends to be restricted when energy is expended in capturing prey (MacArthur 1960); of necessity the fish incur more energy loss when capturing motile larvae than when preying on comparatively inert *Tubifex*. This is supported by Ponniah and Pandian (1977) who state that the energy cost of preying on active larvae is about 15% more than for fish fed on freshly killed immobile larvae. However, considering feeding under natural conditions, the fish prefer to feed on dipteran larvae (25.8% of the total yearly food consumed, on an average) and algae (16.4% on an average) rather than on oligochaetes. This could however be due to their paucity in the habitats from which the fish were collected (Jacob 1981).

Thus, a knowledge of the interaction of energy supply, metabolism and growth leads to a better understanding of the potential of this natural biocontrol agent.

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