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Comparative studies on the food intake, growth and food conversion of two larvivorous fishes

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Abstract. Food intake, growth and conversion efficiency of two larvivorous fishes have been studied by supplying different proportions of first instar *Culex fatigans* larvae and *Tubifex tubifex* worms. The worms inhibit the preferential feeding on mosquito larvae by *Gambusia affinis* and *Poecilia reticulata*. The reduction is more marked in *G. affinis* than in *P. reticulata*. Growth and conversion efficiency of *P. reticulata* surpassed the values observed for *G. affinis* indicating that the mosquito larvae are better utilised by *P. reticulata* than by *G. affinis*.

Keywords. Larvae; worms; fishes; growth; conversion.

1. Introduction

Since the end of 19th century, the top minnow *Gambusia affinis* has been introduced into many areas of the world to serve as an important predator of both *Anophaline* and *Culicine* mosquitoes (Gerberich and Laird 1965). However, more recently the potentiality of the other poeciliid *Poecilia reticulata* in mosquito control programmes has been indicated (Bay 1972). Several short term studies on the predation of mosquito larvae by adult *G. affinis* and *P. reticulata* have confirmed that they effectively bring about considerable reduction in the larval populations of *Culex fatigans* (Gerberich and Laird 1965; Sasa *et al* 1965; Reddy 1973). Further, in both fishes, females are found to predate more number of larvae than the males (Hess and Tarzell 1942; Yamagishi 1966; Pandian and Reddy 1971). However, short term studies only indicate the immediate response of the fish towards the prey species and do not indicate the fulfilment of nutritional value of each of the prey species towards sustained growth of the predator. The nutritional value of each of the prey species can experimentally be determined through laboratory growth and food conversion studies (Kinne 1971). Laboratory studies were therefore undertaken to determine the food value of the larvae of filarial mosquito *Culex fatigans* and the oligochaete worms *Tubifex tubifex* on the food intake, growth and conversion efficiency of *G. affinis* and *P. reticulata*. Such studies provide an insight into the potentialities of these larvivorous fishes in controlling the populations of mosquito larvae.

2. Materials and methods

Gravid females of *Gambusia affinis* and *Poecilia reticulata* were collected from local freshwater habitats of Bangalore and maintained in the laboratory. Healthy fry obtained from similar sized females of either genera were grouped in tens and used for the feeding experiments. All the feeding experiments were conducted in aquaria (surface area: 503 cm^2) containing 4 litres of freshwater. As light influences the predatory efficiency of these fishes (Reddy *et al* 1977), all the aquaria were illuminated using a cool white fluorescent lamp for 10 hr/day and during this period the water was aerated. The newly born individuals were fed from the first day on an *ad libitum* diet of *Culex fatigans* larvae and/or *Tubifex tubifex* worms in the following combinations: Series 1. 100% larvae; Series 2. 75% larvae and 25% worms; Series 3. 50% larvae and 50% worms; Series 4. 25% larvae and 75% worms and Series 5. 100% worms. Continuous supply of first instar *C. fatigans* larvae were obtained from laboratory cultures and the oligochaete worms were obtained from a local firm. The *ad libitum* feeding was continued for 50 days, after which the fishes were sacrificed to determine the final live and dry weights. Initially a group of newly born fry of each genus was sacrificed to determine the live and dry weights.

3. Results

3.1. *Food intake*

The average daily food intake values of *Gambusia affinis* and *Poecilia reticulata* fed on different proportions of mosquito larvae and/or oligochaete worms are presented in table 1. When larvae alone were offered, the daily intake was higher in *G. affinis* (0·82 mg dry food/fish/day) than in *P. reticulata* (0·66 mg dry food/fish/day). However, in both the fishes as the amount of worm substance offered in the diet was increased, the total food intake/fish also increased reaching a maximum of 2·24 mg dry food/fish/day (*G. affinis*) or 2·91 mg dry food/fish/day (*P. reticulata*) in the series receiving 100% worms. From the table it is also evident that even when surplus quantity of food is offered, the per day consumption of the two fishes was markedly reduced when mosquito larvae alone were offered than when 25 to 100% worms were available. This indicates that the two fishes were unable to elaborate their potential predatory capacity when the prey offered was first instar *C. fatigans* larvae as compared to the *T. tubifex* worms.

Table 1 also represents the individual amounts of larval/worm substance consumed by *G. affinis*/*P. reticulata* in relation to the availability of different proportions of the prey species. It is clear that the increase observed in the total daily food intake of *G. affinis* as well as of *P. reticulata* is due to the increased consumption of worms. The amount of mosquito larvae consumed decreased correspondingly with the increase in the intake of worm substance. This indicates that when *T. tubifex* is available as another prey along with *C. fatigans* larvae, both the fishes tend to feed preferentially on the worms than on mosquito larvae. Taking the amount fed at 100% mosquito larvae as 100, it is further evident from the table that while the decrease in consumption of larvae was as low as 21% for *G. affinis* (fed 25% larvae and 75% worms), the corresponding decrease for *P. reticulata* was only 35%

Table 1. Daily food intake and individual amounts of larval/worm substance ingested per day by *Gambusia affinis* and *Poecilia reticulata* in relation to the different proportions of the diet. Each value is the mean (± S.D.) of means of three experiments, each with 10 individuals.

Food offered	*Gambusia affinis*			*Poecilia reticulata*		
	Total food intake (mg/fish/day)	*Culex* larvae (mg/fish/day)	*Tubifex* worms (mg/fish/day)	Total food intake (mg/fish/day)	*Culex* larvae (mg/fish/day)	*Tubifex* worms (mg/fish/day)
100% larvae	0·82± 0·050	0·82± 0·050	..	0·66± 0·064	0·66± 0·064	..
75% larvae 25% worms	1·03± 0·165	0·51± 0·111	0·52± 0·012	1·03± 0·098	0·53± 0·060	0·50± 0·178
50% larvae 50% worms	1·48± 0·191	0·42± 0·082	1·06± 0·073	1·75± 0·042	0·38± 0·042	1·37± 0·147
25% larvae 75% worms	1·26± 0·143	0·17± 0·020	1·09± 0·082	1·80± 0·098	0·23± 0·045	1·57± 0·098
100% worms	2·24± 0·072	..	2·24± 0·072	2·81± 0·452	..	2·81± 0·452

indicating that in the presence of another prey species *P. reticulata* feeds better on larvae unlike *G. affinis*.

Table 2 represents the total number of first instar *C. fatigans* larvae predated by *G. affinis* and *P. reticulata* when different proportions of the two prey were offered as food. It is evident that under identical conditions, when larvae alone were offered as food, *G. affinis* consumes more larvae than *P. reticulata*. On the other hand excepting in the series which received 50% larvae and 50% worms, in all other series *P. reticulata* consumed more number of larvae than *G. affinis*. The availability of worms thus inhibits the preferential feeding of *G. affinis* on mosquito larvae more severely than that of *P. reticulata*.

Reddy (1973) and Katre (1973) have reported the caloric value of first instar *C. fatigans* larvae and *T. tubifex* worms respectively. Taking these values, the average daily food intake of the two groups of fishes were recalculated in terms of calories and presented in figure 1. It is clear from the figure that the increase in total calorific intake of the two fishes was enhanced by the increased intake of worm substance. Consequent to the preferential feeding on worms, both the fishes procured more and more energy from worm substance than through larval substance. Further it is interesting to note that when the two prey species were offered in equal amounts (50 : 50) out of the daily total intake in calories, the caloric intake due to worm substance was more than the ratio of food offered confirming the preferential

Table 2. Number of first instar *Culex fatigans* larvae predated/fish/day by *Gambusia affinis* and *Poecilia reticulata* in relation to the proportions of the diet offered. Each value is the mean (±S.D.) of means of three experiments, each with 10 individuals.

Food offered	*Gambusia affinis*	*Poecilia reticulata*
100% larvae	941·56± 57·154	751·77±73·462
75% larvae	585·54±127·462	608·46±68·846
50% larvae	482·23± 94·154	436·31±48·231
25% larvae	195·15± 23·000	264·08±51·692

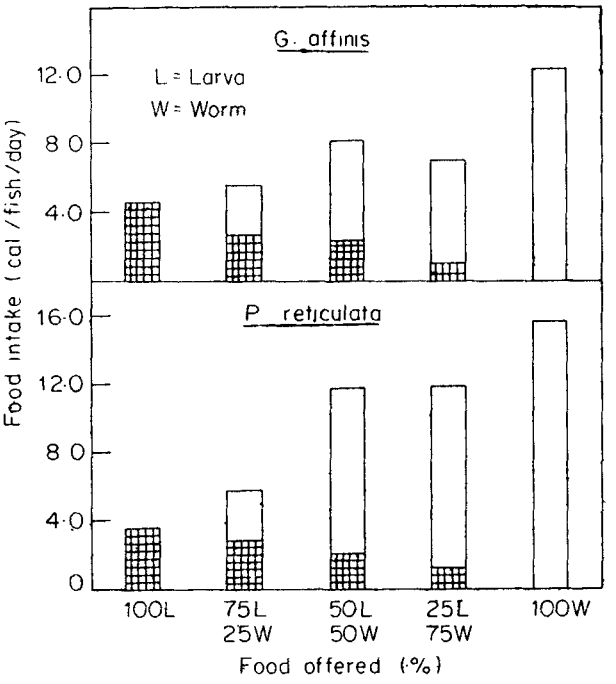

Figure 1. Amount of first instar *Culex fatigans* larvae (#, Cal/fish/day) and *Tubifex tubifex* worms (□, Cal/fish/day) consumed by *G. affinis and P. reticulata.*

feeding of both these fishes on the oligochaete worms as compared to mosquito larvae.

3.2. *Growth*

The initial live weight ranges of fry of *G. affinis* and *P. reticulata* were similar (3·5 ± 0·61 mg). Both the juveniles fed on mosquito larvae exhibited a poor growth (0·10 mg dry substance gained/fish/day; figure 2). The growth in either juveniles steadily increased with increase in worm substance in the diet. Thus the

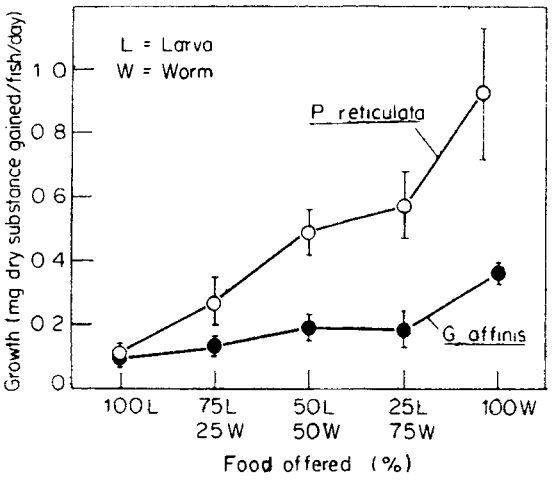

Figure 2. Growth (mg dry substance gained/fish/day) of *G. affinis* and *P. reticulata* fed on different proportions of larvae and/or worms.

highest growth was exhibited by fishes reared on 100% *T. tubifex* (*G. affinis*: 0·36 mg/fish/day; *P. reticulata*: 0·96 mg/fish/day). However, it is interesting to note that in all the series *P. reticulata* surpassed the growth of *G. affinis* (figure 2).

3.3. *Conversion efficiency*

The conversion efficiency (K_1) of the two fishes was calculated following the procedure of Katre and Reddy (1977). From the values represented in figure 3 it is seen that juveniles of *G. affinis* reared on mosquito larvae displayed the lowest conversion efficiency (12·20%) while the highest efficiency (16·14%) was observed in the series receiving 100% worms. In comparision to this, juveniles of *P. reticulata* exhibited a higher conversion efficiency not only in the series receiving 100% larvae (15·15%) but also in all the other series and the highest value (31·67%) was displayed by individuals receiving 100% worm substance.

4. Discussion

The foregoing results reveal the potentiality of the two Cyprinodontid fishes in reducing the larval populations of the filarial mosquito *Culex fatigans*. When mosquito larvae alone form the food of larvivorous fishes, the larvae must supply all the necessary amino acids, vitamins, etc., in sufficient quantities to promote growth and reproduction of the fishes (Reddy and Pandian 1972). However, the stomach content analysis in *G. affinis* and *P. reticulata* has indicated that the two fishes not only feed on mosquito larvae but also on worms, crustaceans and a'gae (Idem 1948; Menon and Chacko 1955). The present study indicates that the preference to feed on mosquito larvae by either fishes is reduced by the presence of the oligochaete worm. The reduction appears to be more marked in *G. affinis* than in *P. reticulata*. Windell (1967) has indicated that in fish, the food intake is

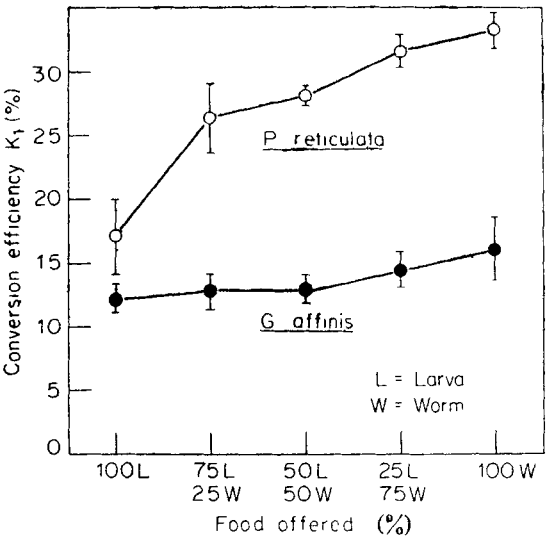

Figure 3. Conversion efficiency (%) of *G. affinis* and *P. reticulata* fed on different proportions of larvae and/or worms.

dependent on the gastric evacuation. Further, the soft food organisms such as worms and dipteran larvae are found to be digested more rapidly than the heavily chitinised forms (Nikolsky 1963). In *G. affinis* the digestion rate is found to be reduced by 50% (4·39 mg/hr; Reddy and Katre 1976) when fed on *C. fatigans* larvae than on *T. tubifex* worms (9·20 mg/hr; Katre 1975). In literature, oligochaete worms have been reported to be highly nutritive (Galinat 1960) and easily digested by fish (Mann 1935). Hence, the lower intake of *C. fatigans* larvae by the two fishes may be due to slower gut evacuation and poorer digestibility. The high intake of worm substance (2·84 mg/fish/day) observed in *P. reticulata* is comparable to the value reported by Krishnamurthy (1978; 2·96 mg/fish/day) for the same fish. However, the value obtained for *G. affinis* (2·24 mg/fish/day) appears to be considerably low to the one reported by Katre and Reddy (1979; 7·1 mg/fish/day).

When mosquito larvae alone were offered, in terms of number although *G. affinis* predated more, its preference to feed on larvae is reduced when larvae are supplemented with *T. tubifex*. However, in the presence of another prey, *P. reticulata* is still able to feed preferentially on mosquito larvae. A similar preferential predation on *C. fatigans* larvae by the guppy in the presence of daphnids has been reported by Yamagishi (1966). This euryphagus feeding habit of the fish is more useful in mosquito control programmes because in natural habitats (*e.g.*, rice fields etc.) mosquito larvae usually emerge along with zooplankton and other organisms and in such situations *P. reticulata* would be more effective in reduing the larval populations than *G. affinis*.

Growth also is found to be markedly influenced by the quality of food offered. In both the fishes, larvae alone failed to promote growth, while in combination with *T. tubifex*, *P. reticulata* surpassed the growth rate of *G. affinis*. MacArthur (1960) has indicated that growth tends to be restricted when the energy expended in catch-

ing the prey exceeds the energy value of the prey. The worms were seen to remain clustered on the floor of the aquarium while larvae were found to be highly motile. Hence, both the fishes would incur considerable energy loss for catching the larvae than for feeding on worms. For instance, Pandian and Ponniah (1976) have reported that in the paradise fish *Macropodus cupanus* the energy cost of predating actively escaping larvae is about 15% more for fish than when fed on freshly dead immobile larvae.

The conversion efficiency values observed for the two fishes also indicate that *P. reticulata* is able to utilise the larval substance better than *G. affinis*. Thus it may be surmised that, in the presence of another prey *P. reticulata* brings about a better reduction of the larval populations of *C. fatigans* than *G. affinis*.

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