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Short Communication

Feeding of some fish larvae as determined by prey characteristics

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Abstract

Fish larvae generally feed on all the cultured organisms, with preference for particular organisms at different growth phases. Preferential selection, however, is determined by several factors, *viz.*, larval age, gape of mouth of larva, prey visibility, prey density and prey digestibility. Of all the food organisms, rotifers form the first food of fish larvae. Among cladocerans, *Alona*, a small species, is the first to make its appearance in larval gut followed by *Ceriodaphnia* and finally by large-sized prey species.

Key words: Feeding, prey size, energy maximizer.

1. Introduction

Rearing the larval stages of fish with appropriate diet is a constraint in aquaculture, because of lack of specific information on the nature of food and its acceptability. In successful aquaculture, supplementary feeding is resorted to with a view to optimize the yield. This is normally achieved by supplying either compounded dry feeds or live wet feeds. Live feeds, generally, are superior to compounded ones, because they are readily ingested[1], digested rapidly[2], do not affect the water quality[3] and have essential growth-promoting factors. Keeping these facts in view, a few cladocerans (*Daphnia, Simocephalus, Moina, Ceriodaphnia* and *Alona*) and *Brachionus* species were cultured in the laboratory and their applicability as food for early fish larvae of various species (*Puntius sophore, Aspidoparia morar, Cyprinus carpio, Gambusia affinis* and *Tor tor*) was studied.

2. Materials and methods

Early fish larval feeding was studied by offering laboratory-cultured zooplankton species in diet culture. Starting with two-day old larvae, 10 individuals were introduced into a trough with 500 ml water containing zooplankton (a mixture of *Brachionus, Daphnia, Simocephalus, Moina, Ceriodaphnia* and *Alona*) at a density of 12/ml. After 45 minutes, the fish were removed from the trough and anaesthetized. They were then fixed in 4% formalin. Larval measurements were made less than 24 h after the catch. Mean length was measured to the nearest 0.1 mm. The upper jaw length (UJL) and the mouth width (MW) were measured to the nearest 0.02 mm. The gape size (GS) was calculated for mouth opened at 90° (after Ponton and Muller[4]) by the following equation:

$$GS\ 90^\circ = UJL \times \sqrt{2}\ .$$

Prey organisms present in the digestive tract of each fish were analysed. Size of the prey in the gut was measured under a microscope with an ocular micrometer, standardized against stage micrometer.

Foraging behaviour was studied by observing one individual fish at a time exposed to zooplankton prey organisms (8/ml) in medium. Observations were made through a magnifying glass and the occurrence of different activities recorded orally using a cassette recorder.

3. Results and discussion

Fish larvae feed on all the cultured organisms with preference for specific organisms at different larval ages (Tables I); preferential selection, however, is determined by various factors, *viz.*, larval age, gape of mouth of larvae, prey visibility and differential prey density.

Table I shows a detailed analysis of prey types in the diets of various fish larvae. In the case of *Tor*, *Aspidoparia* and *Puntius*, *Brachionus* was the first to make its appearance. Among cladocerans, the smallest spcies *Alona* was the earliest (4th day in *Tor*, 8th in *Aspidoparia* and 10th in *Puntius*). The frequency of cladocerans in their diet increased gradually with age. However, *Daphnia*, the largest prey species in the food offered, could be captured at a later stage (13th day–*Tor*, 20th day–*Aspidoparia* and 18th–*Puntius*), but in all the three species, *Daphnia's* contribution to total diet rarely exceeds wt 22%. However, *Gambusia* and *Cyprinus carpio* consume even the largest prey, *Daphnia*, at an early stage (2nd day–*Gambusia* and 6th–*C. carpio*).

The larvae exhibited considerable individual variability in their feeding behaviour. In experiments conducted to measure certain foraging parameters and prey selectivity, variability was very high. In some experiments, up to 15% of the larvae did not ingest a single prey item while the rest showed normal feeding rates. This was a common observation with all the fish species except *Gambusia* and *C.carpio*. Although the reasons are not clearly understood, the observed high individual variability in fish larvae can be attributed to differences in individual developmental rates related to behaviour[5,6]. Ansari and Qadri[5] observed that individual larvae differ widely in their foraging behaviour, feeding attempts, capture successes and prey preferences. In the present study, apart from individual differences in feeding activity, *Gambusia* and *C. carpio* exhibited violent movements and proved to be voracious feeders.

Table I

Feeding behaviour/preferences of various fish larvae at early ages: larval characteristics in relation to prey species selected

a) *Brachionus* sp., b) *Alona* sp., c) *Ceriodaphnia* sp., d) *Moina* sp., e) *Simocephalus* sp , f) *Daphnia* sp.

Age of fish (days post-hatching)	*Average body length of larvae (mm)*	*Size of gape of larvae (mm)*	*Average size of prey organisms ingested (mm)*						*Relative percentage of each prey species*					
			a	*b*	*c*	*d*	*e*	*f*	*a*	*b*	*c*	*d*	*e*	*f*
Cyprinus carpio														
3	5·80–6·00	0·39	·16	·22	·30	·40	·39	–	22	30	26	14	8	–
4	6·00–7·00	0·40	·16	·23	·34	·45	·47	–	20	25	30	15	10	–
5	7·00–7·50	0·44	·18	·22	·40	·47	·49	–	8	10	40	32	10	–
6	8·20–8·50	0·50	·18	·25	·47	·52	·53	·57	–	12	35	35	12	6
8	9·40–10·00	0·62	·19	·26	·49	·58	·60	·60	4	10	16	45	15	10
Gambusia affinis														
2	10·00	·47	·17	·25	·38	·43	·48	·49	22	18	20	18	18	4
3	10·60	·69	·18	·29	·47	·65	·62	·68	7	20	26	20	18	9
4	11·00	·80	·18	·28	·49	·69	·84	·94	10	9	30	28	13	10
5	11·90	·89	·17	·28	·48	·73	·88	·90	4	5	12	32	20	27
Tor tor														
4	4·5	·15	·18	·21	–	–	–	–	90	10	–	–	–	–
6	4·6	·22	·19	·24	–	–	–	–	85	15	–	–	–	–
7	4·7	·36	·20	·27	·42	·42	–	–	23	28	42	7	–	–
10	5·8	·42	·20	·29	·45	·40	–	–	7	18	35	40	–	–
12	6·3	·62	·20	·30	·48	·60	–	–	6	13	30	39	7	5
13	6·6	·66	·19	·31	·47	·72	·68	·68	–	11	30	42	8	9
20	10·9	·82	·20	·33	·50	·81	·85	·85	4	4	10	45	15	22
Puntius sophore														
4	4·20–4·50	0·08	–	–	–	–	–	–	–	–	–	–	–	–
6	4·80–5·00	0·10	–	–	–	–	–	–	–	–	–	–	–	–
8	5·20–5·30	0·16	·16	–	–	–	–	–	100	–	–	–	–	–
10	6·10–6·20	0·19	·18	·20	–	–	–	–	80	20	–	–	–	–
12	7·00–7·10	0·36	·16	·21	·28	·40	–	–	65	20	12	3	–	–
14	8·00–8·05	0·39	·20	·24	·30	·45	–	–	30	30	30	10	–	–
16	8·50–9·00	0·46	·20	·24	·38	·48	·50	–	30	20	32	12	6	–
18	9·00–9·50	0·52	·18	·30	·45	·54	·58	·58	18	25	22	20	8	7
20	9·80–10·00	0·58	·20	·32	·46	·54	·59	·62	8	18	30	25	11	8
Aspidoparia morar														
4	4·10–4·30	0·10	–	–	–	–	–	–	–	–	–	–	–	–
5	4·10–4·40	0·10	–	–	–	–	–	–	–	–	–	–	–	–
6	4·20–4·40	0·14	–	–	–	–	–	–	–	–	–	–	–	–
8	4·80–5·00	0·18	·18	·21	–	–	–	–	70	30	–	–	–	–
10	5·90–6·00	0·24	·19	·24	·24	–	–	–	60	20	20	–	–	–
12	6·00–6·50	0·35	·19	·25	·36	·40	–	–	10	35	25	30	–	–
14	7·20–7·50	0·38	·20	·24	·40	·42	–	–	6	60	30	4	–	–
16	7·50–8·00	0·45	·20	·26	·48	·48	·50	–	4	30	50	10	6	–
18	8·50–9·00	0·48	–	·26	·50	·51	·52	–	–	15	30	40	15	–
20	10·00–10·50	0·56	–	·24	·48	·54	·58	·56	–	5	40	40	10	5

As the larvae grow, the gape increased proportionately making it possible for them to capture increasingly larger prey. The gape at 45° angle mouth opening is probably used frequently while the gape at 90° represents the maximum that the larva is capable of. Generally, the gape size of *Gambusia* was more followed by Carp, *Tor, Aspidoparia* and *Puntius*, respectively (Table I). The mean prey size ingested, when offered a wide size range of food organisms, was determined by gape size. In all the cases, correlation between gape and mean prey size in diet was high ($r \geq \cdot 88$).

An investigation of selective preferential behaviour involving different prey species and sizes carried out with larvae at different ages releaved: (i) At the age when small-sized organisms (*Brachionus* and *Alona*) can be successfully captured, the larvae showed a strong preference for the rotifers, (ii) initially, the preference for rotifers was stronger than for *Ceriodaphnia* in *Puntius* and *Aspidoparia*, (iii) among four different sizes (Cladocerans), the intermediate-sized prey *Moina* was preferred to *Simocephalus* and *Daphnia* or even *Ceriodaphnia*. Mills *et al*[7] suggested that intermediate-sized prey is more efficiently digested by the fish than the largest prey.

Unlike the 'size-limited' predators, fish, during larval stages, are generally considered to be 'gape-limited' predators which prefer the largest size of prey they can capture and ingest. Small fry of *Aspidoparia* were found to attack large-sized prey organisms (*Moina, Simocephalus* and *Daphnia*) at early stage (4–6 days post-hatching), but were unsuccessful in capturing them. As a result, the larvae restricted their attacks to small prey organisms (*Brachionus, Alona* and *Ceriodaphnia*) which they could easily consume. This gape-limited feeding activity is a well-documented generalization[4,8]. However, gape size–prey size correlation could be misleading sometimes. In majority of the studies, only one dimension (length) of the prey was taken, without considering smaller dimension (width). When a fish strikes the prey, there is an equal probability of the prey being positioned length or widthwise. In such cases, gape limitation alone is unable to explain for the maximum prey size ingested. Under such conditions there are considerable chances of fish ingesting the prey widthwise thus enabling the larvae to capture prey that may seem larger than the gape of fish larva. Consider, for instance, the fact that the gape of 20-day old *Tor* is not wide enough to engulf adult *Daphnia* or *Simocephalus* (·85 mm), but that larva is capable of capturing it, with a gape at 45° angle, if the prey were positioned widthwise (·45 mm). Further, a point worth considering in this regard is that not only the gape increases with the age of fish; experience with different preys, visibility factor, capture success, etc., are also functions of age[9].

Visibility of prey to predator is another factor that determines prey selection. One such factor in prey investigation is stage of brood maturity which because of its opacity makes the organisms prominent feeding targets as compared to non-ovigerous individuals. This explains the reason for *Moina* (with brood) being the preferred food item over *Daphnia* or *Simocephalus* (without brood) although the prey size of all the types fall in a close range. Besides visibility, the presence of brood is an indication of prey being superior in terms of energy[10,11] and/or nutrients[12]. This has also been discussed by Mellors[13] who attributed the preference exhibited by *Salmo* for ephippial *Daphnia* over non-ephippial ones, not only because of the ease with which ephippial daphnids can be detected by these visual feeders, but also because of superiority of ephippial daphnids in terms of energy.

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