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Food Selection and Electivity Indices of the Thai Barb *Puntius* (=Barbodes) *gonionotus* in Extensively Managed, Rain-fed Ponds in Bangladesh

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Abstract

A food selection and electivity study was carried out on Thai barb *Puntius gonionotus* of 7 to 10 cm standard length. The fish were fed a range of food items, includ-ing phytoplankton, zooplankton, higher plant material and detritus. The samples were found to change their food habit over time. Although there was a marked shift in planktivory from zooplankton, it was clear that plankton size had no effect on choice. Food analysis by points method indicated that, overall, the food habit of the fish shifted from plankton towards detritus and macrophytes over time. Coincidentally, gut length: body length ratio increased while total gut length and gill raker length decreased, paralleling the observed changes in feeding habits.

Introduction

Since its introduction from Thailand in 1977, there has been a dramatic increase in the farming of the Thai barb (Thai sharputi) *Puntius gonionotus* in Bangladesh. The fish has become very popular, grows well in culture with other carp species and is also commercially important in India, Indonesia and Thailand. However, although *P. gonionotus* is an important pond fish, almost no work has been done on food selection, electivity and morphometry of its feeding apparatus. Information on diet is needed to fully assess the likely impacts of the introduction on native fish fauna. Such information can also provide a clearer understanding of food selection and feeding mechanisms, which are essential to ensure maximum utilization of natural food items through polyculture with appropriate carp species. Changes in plankton community because of the feeding habits of this fish may also be important..

Thus, the objectives of the present experiment are to study the food selection, electivity and gill raker morphometrics of *P. gonionotus*.

Materials and Methods

Ponds

Two non-drainable, rain-fed earthen ponds measuring $40m^2$ (8m x 5m) at the Bangladesh Agricultural Campus, Mymensingh, were used for the trials.

Plankton

Ten 1-l samples of water were collected from different areas and depths of each pond at 2- week intervals to make representative samples, which were then filtered through a fine-mesh plankton net. The material collected was carefully washed into plastic jars and made up to a standard volume with water and preserved in 5% buffered formalin. A Sedgwick-Rafter cell (550; Fisons) was used and standard methods (APHA 1985) were followed for counting plankton, which were identified to genus level. Plankton dimensions were measured by light microscopy, using an eyepiece graticule. Approximately 20 phytoplankton cells/colonies and 20 individual zooplankton were examined in each case.

Fish

One hundred fish, ranging from 7.0 to 8.0 cm in standard length, were stocked in each pond as a monoculture.

Samples of 10 fish were taken from each pond at two-week intervals using a cast net. Fish were killed immediately by a blow to the head and measured. The body cavity was carefully opened and gut fullness assessed on a scale of 0 (empty) to 4 (full); total gut length was also recorded. Gut contents from the anterior portion of the gut were carefully washed into a petri dish and analyzed following the method used by Ivlev (1961). Ivlev's (E) was calculated according to:

$$E = r_i - p\ r_i + p_i \quad \text{(Ivlev 1961)},$$

where r_i is the relative content of any ingredient in the ration, expressed as percentage of total ration, and p_i is the relative proportion of the same item in the environment. The resultant value of E ranges from + to -1: a positive value indicating selection for certain food items and a negative value indicating avoidance.

Feeding apparatus

The feeding apparatus (i.e. gill arches) were carefully removed from fish preserved in 10% buffered formalin for morphometric analysis. The following measurements were made using a light microscope: (a) gill arch length (from the base of the anteriormost gill raker to the base of the posteriormost gill raker); (b) the number of gill rakers; (c) gill raker length; and (d) the distance between gill rakers. Six sets of gills were studied from every fortnightly sample of fish. Only the midsection of the second gill arch was used to determine (c) and (d).

Results

Electivity

Electivity indices, the fortnightly changes of various planktonic food organisms and the size of the plankton are given in Table 1. The detrital fragments were excluded from the numerical analysis of the gut contents. The present investigation shows that P. gonionotus appeared to be a selective feeder under the conditions in the experimental ponds.

For all planktonic crustaceans, comprising *Diaptomus*, *Cyclops*, *Daphnia*, *Diaphanosoma* and *Nauplii*, a strong positive selection seemed to occur which decreased during the experiment. In the case of *Diaphanosoma*, a negative selection was observed latterly, although previously it had been positively selected (Table 1).

Among the rotifers, *Lecane*, *Trichocerca*, and *Cephalodella* were eluded and *Keratella* was completely avoided. Brachionus was initially positively selected, although it was later avoided (Table 1).

Among the green algae, fish selected *Mesotraenium*, with increasing positive selection being observed for *Ophiocytium* and *Ulothrix* over time. In this group, some genera were initially eluded but positively selected later. *Scenedesmus* and *Echinosphaerella* were avoided throughout (Table 1).

Blue-green algae (cyanobacteria), other than *Oscillatoria*, which was positively selected, throughout, were initially avoided by fish although they were positively selected later on (Table 1). Fish exhibited positive selection for the diatoms *Navicula* and *Actinella*. Among the phytoflagellates, the fish showed a positive selection for Trachelomonas while the remaining two genera were avoided. Fish showed a positive selection for *Difflugea* (rhizopoda). *Plumatella* (Bryozoa) was initially selected for positively but later avoided by fish.

It is thus concluded that the fish exhibited a dietary shift in planktivory over the course of the experiment, from zooplankton to phytoplankton (Figure 1).

Effect of food size

The results show that plankton dimensions had no effect on selection of food items by the fish. Among the phytoplankton, Ulothrix colonies, which were the largest (mean diameter = 1120 mm), were observed to be always positively selected while *Spirulina*, the second largest phytoplankter (mean diameter = 822 mm), was absent from the gut content of the samples collected during the first fortnight (Table 1). Among this group, the smallest-sized (mean diameter = 32 mm) genus, *Echinosphaerella*, was rarely ingested while *Mesotraenium*, the second smallest (mean diameter = 37 mm), was generally abundant in the diet at all sampling times (Table 1). Among the zooplankton, the largest (mean size = 1560 mm) genus, *Diaptomus*, was positively selected, while

Table 1. Electivity indices with their fortnightly changes and size of various planktonic food organisms of the fresh water fish *P. gonionotus*.

Food item	Size (mm)	Fortnightly changes			
		1st	2nd	3rd	4th
Drustaceans					
Cyclops	602	+0.61	+0.56	+0.54	+0.06
Diaptomus	1560	+1.00	+0.84	+0.46	+0.18
Nauplius	182	+0.21	-	-	-
Daphnia	747	+1.00	+0.56	+0.50	+0.08
Diaphanosoma	950	+1.00	+0.76	+0.50	+0.01
Rotifers					
Brachionus	336	+0.14	-0.50	-1.00	-
Lecane	125	-	-	0.50	-
Trichocerca	208	-0.50	-	-	-
Cephalodella	142	-0.501	-	-	-
Keratella	213	-	-	-1.00	-
Green algae					
Ophiocytium	407	+0.13	+0.50	+1.00	+1.00
Mesotraenium	037	+1.00	+1.00	+1.00	+1.00
Ulotrix	1120	+0.33	+0.50	+0.59	+0.61
Quadrigula	043	-	+0.50	-	-
Pediastrum	073	-	+0.50	+0.29	+0.50
Tetraedron	041	-	+0.50	-0.50	+0.21
Ankistrodesmus	067	-0.82	-0.50	-0.50	+0.10
Scenedesmus	067	-	-	-	-0.50
Echinosphaerella	032	-0.50	-	-	-
Blue green algae					
Oscillatoria	418	+0.05	+0.07	+0.33	+1.00
Nostoc	050	-	+0.12	+1.00	+0.23
Microcystis	212	-0.33	-1.00	+0.13	+0.23
Spirulina	822	-1.00	-0.37	+0.57	+1.00
Chroococus	052	-	-	-0.50	+0.06
Diatoms					
Navicula	046	+0.07	+0.59	+1.00	+1.00
Actinella	231	-	+0.50	-	-
Phytoflagellates					
Trachelomonas	037	+0.50	-	+0.50	-
Euglena	071	-	-	-0.50	-0.53
Phacus	139	-	-0.50	-	-
Rhizopoda					
Difflugea	071	-	+0.67	+0.50	+0.43
Bryozoa					
Plumatella	018	-	-	+0.50	-0.50

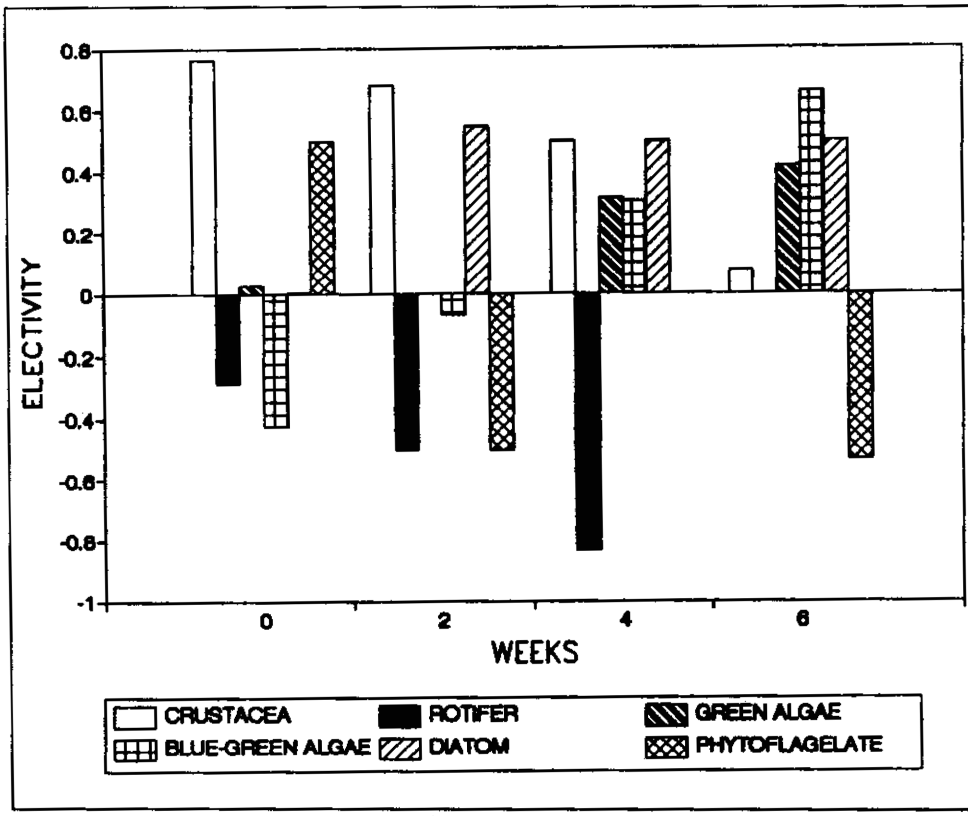

Fig. 1. Changes in electivity indices for the different food items during the experiment.

Diaphanosoma, the second largest (mean size = 950 mm), seemed to be avoided throughout the course of the study (Table 1).

Amount of food eaten

The results of stomach content analysis by points method have been presented in Table 2. For the purposes of the present study, the food items were considered as 4 groups; phytoplankton, zooplankton, higher plant material and detritus. Organic debris was the most dominant food item in terms of total point percentage. The study also indicated an increasing tendency of the fish to ingest detritus and higher plant material over time (Table 2).

Gut length-standard length ratio

The results of the gut length and standard length ratio are presented in Table 3. The results indicate that the ratio of gut length to standard length increased with increasing body length of fish.

Gill raker and inter raker space

The results from the gill raker morphometric study are presented in Table 4 and 5. Gill raker length and inter-raker spaces increased over the period of the study, but at a rate less than the increase in standard length.

Table 2. Composition of diet of *P. gonionotus* based on percentage of total points and its fortnightly changes.

Food categories	Percentage of total points of gut content (in different fortnights)			
	1st	2nd	3rd	4th
Detritus	34.13	61.13	73.15	81.87
Higher plant	02.67	03.02	04.80	07.52
Phytoplankton	29.66	26.16	16.05	09.20
Zooplankton	33.55	09.69	06.00	01.40

Table 3. Relationship between standard length and gut length of *P. gonionotus*.

Fortnight study	Average standard length (mm)	Average gut length (mm)	Standard length
1st	72.3	177.9	1 : 2.5
2nd	75.8	213.9	1 : 2.8
3rd	80.3	288.9	1 : 2.85
4th	87.5	252.4	1 : 2.89

Table 4. Relationship between gill raker length and standard length of *P. gonionotus*.

Fortnight study	Average standard length (mm)	Average gill length (mm)	Gill raker length: Standard length
1st	72.3	414.1	1 : 5.73
2nd	75.8	425.0	1 : 5.61
3rd	80.3	427.2	1 : 5.32
4th	87.5	464.7	1 : 5.31

Table 5. Relationship between inter raker space and standard length of *P. gonionotus*.

Fortnight study	Average standard length (mm)	Average inter length (mm)	Inter raker space:Standard length
1st	72.3	370.7	1 : 5.51
2nd	75.8	372.4	1 : 4.92
3rd	80.3	379.3	1 : 4.73
4th	87.5	412.4	1 : 4.71

Discussion

The present study indicates that *P. gonionotus* showed pronounced electivities for different food items and that electivity varied over time. Selective feeding can be expected from fishes when the energy gained by feeding on preferred food items exceeds the energy that had been lost during selection

(Al-Akel *et al.* 1987). Many authors (Mustafa 1976; Wankowsky 1979; Bartell 1982) have reported that fishes expend more energy in selecting prey of large size in order to gain more energy. However, this view has been disputed by Mills *et al.* (1984). In the present investigation Thai barb preferentially selected zooplankton (Table 1) to earn maximum energy to fulfil routine metabolic requirements and growth during the early stages.

Selective feeding of carp fry and fingerlings on zooplankton has also been reported by Khan and Siddiqui (1993), Jaffri and Mustafa (1977) and Jhingran and Pullin (1990). The present study shows a tendency of Thai barb not to ingest some genera of zooplankton, either because they are distasteful or because they are inaccessible to the fish by virtue of their behavior. This is supported by Al-Akel *et al.* (1987) in their work with *Aphanius dispar*.

A gradually increasing selection for phytoplankton and a decreasing selection for zooplankton with increment of growth (Fig. 1) and the presence of similar type of food items in the water body during the experiment (Table 6) indicate changes over time in food habit among Thai barb towards herbivory. Nikolosky (1963) and Cremer and Smitherman (1980) reported that fishes feeding on plant material generally have greater gut lengths than those feeding on animal matter. Table 3 shows an increase in gut length relative to body size over time among Thai barb, supporting the observation that the species becomes increasingly herbivorous with size. Increased gut length helps the retention of food particles in the gut, aiding digestion (Mustafa 1976; Al-Akel *et al.* 1987).

The branchial mesh size of Thai barb is 370-412 mm (Table-5). Nevertheless, fish were able to ingest algae as small as *Mesotraenium* (mean diameter = 37mm), suggesting that some mechanism of particle retention other than passive branchial sieving is involved. Rahmatullah (1992) showed that passive branchial sieving is not the only mechanism of particle retention in filter among *Labeo rohita*, *Catla catla* and *Hypophthalmichthys molitrix* and that small particles could be ingested by the fish by mucus entrapment. Studies of filter feeding in tilapias also show that particles are entrapped among the gill apparatus in a mucus film (Greenwood 1953; Drenner *et al.* 1987; Northcott and Beveridge 1988; Beveridge *et al.* 1988a, b). Tilapia mucus is highly negatively charged and it has been suggested that it may facilitate flocculation and, hence, entrapment of very small particles such as bacteria (Northcott and Beveridge 1988; Beveridge *et al.* 1989; Rahmatullah and Beveridge 1993). Moreover, a recent paper by Sanderson *et al.* (1991) suggests that mucus-assisted entrapment of particles on the roof of the oral cavity may be important in some suspension-feeding cyprinids. In the present study, genera such as *Scenedesmus* (69 mm) and *Echinosphaerella* (32 mm) were eluded by the fish (Table 1). This may be because the fish has the ability to determine suitable or non-suitable food items. Beveridge *et al.* (1993) have reported the abilities of filter feeding carps to distinguish between toxic and non-toxic strains of the cyanobacterium *Microcystis aeruginosa*.

From Table 2, it is clear that the fish is mainly a detritus feeder: small particles may be ingested with detritus, or the detritus may help the fish to retain small particles by blocking the branchial sieve during feeding. The increase in gill raker length and inter-raker space with decreasing mode in relation to increases in standard length (Table 4 and 5) indicates that the food and feeding habit of Thai barb changes over time. This conclusion is supported by the figures presented in Table 1.

Very little work on the biology and ecology of the Thai barb *P. gonionotus* has been done and much more study is needed, especially in the field of feeding behavior and feeding mechanisms.

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