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# Size related feeding patterns and electivity indices of silver barb (*Barbodes gonionotus* Bleeker) from a pond, Bangladesh

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**Abstract**
The feeding patterns with respect to quality and quantity of food of silver barb, *Barbodes gonionotus* varied with their size and development. The results indicated that the fish in the size group I (7-25 mm TL) were fairly omnivore with particular liking for rotifera, green and blue-green algae while the size group II (25.1-44 mm TL) and III (44.1-55 mm TL) were omnivore with higher tendency of feeding on debris, aquatic plants, green algae, blue-green algae and rotifera. However, the fish of the size group IV (55.1-80 mm TL) were found to be herbivore with feeding preference for aquatic plants, green and blue-green algae. In all the size groups, debris was the most dominant food item. Feeding preference of the fish showed clear ontogenetic shift. The electivity indices revealed that the fish weie selective feeder.

**Key words:** Food, Feeding, Electivity index, *Barbodes gonionotus*

## Introduction

There exists enormous aquaculture potential of silver barb, *B. gonionotus* as an appropriate species for the seasonal as well as perennial fish ponds. It was introduce to Bangladesh from Thailand in 1977 and by now it has become a popular fish in our country (FRI 1992). But the performance of this species in our closed water condition have not yet been evaluated. The most important aspects of biology of any fish is the study of its food and feeding habits which is a prerequisite for its culture operation. A knowledge of food and feeding habits would thus help in the species selection for polyculture by ensuring maximum survival through utilization of all available potential food in the water bodies with minimum competition.

Dietary overlap is affected by food availability, competition, and the size of the fish, among other factors. Though fish may broaden their dietary breadth when food resources are scarce, food items may remain sufficiently partitioned for competition to be avoided (Keast 1977, Keast and Fox 1990). Intrspecific niche overlap decreases with ontogenetic shifts in diet, i.e. differences in habitat utilization by young and adults and increasing disparity in size (Pen *et al.* 1993, Esteves and Galetti 1995). The present experiment was carried out to know the feeding habit and the variations in quality and quantity of food taken by different sizes of *B. gonionotus*.

## Materials and methods

The *B. gonionotus* for the present study was collected from April to June '96 by a small seine net from a rainfed artificial pond. Samplings were done fortnightly at 9.00 to 10.00 am and a total of 60 fish measuring 7-80 mm in total length (TL) were collected. Immediately after collection, the fish were killed by suffocation and preserved in 10% buffered formalin to prevent further digestion of food and brought to the laboratory and dissected out the gut and put on a labeled vial for further studies. For the study, the total length of fish in millimeter were measured and grouped into four groups according to their size. All fishes were divided into four size groups and was designated as - group I (7-25 mm TL), young; group II (25.1-44 mm TL), juvenile; group III (44.1-55 mm TL), pre-adult and group IV (55.1-80 mm TL), adult.

### *Gut content analysis*

The stomach of individual fish was dissected out immediately after sampling and the index of fullness of the stomach was visually recorded irrespective of the size of the stomach or the fish and assigned a score of; 0 for empty, 1.0 for one-fourth, 2.0 for half, 3.0 for three-fourth and 4.0 for full. Then the volume of stomach contents was also assessed visually on an obsolete scale and points were allotted to each stomach according to the volume of its contents (Hynes 1950). The stomach with largest volume was allotted 100 points, and each of the stomach as examined was then rated in one of the following point categories 0, 3, 6, 12, 25, 50 and 100 points according to volume of the food present. The categories were based on inspection and estimation, but a set of stomachs of all categories were made from extra stomach and was used in relating absolute volumes to assign point values. Stomach with intermediate quantities of food were allotted to the point categories which they closely approach. Then it was diluted with distilled water to 4 ml. One ml sub-sample from 4 ml sample was transferred by a pipette to a Sedgwick-Rafter cell. By using a binocular microscope (Swift, M-4000D), all organisms were counted and each food item was identified to the nearest taxonomic group. Organisms of each taxonomic group were then summed together and points were assigned to the different categories of food according to their respective volume partitioning the total points allotted to the fish. Bellinger (1992), Rosalind (1978) and Needham and Needham (1962) were consulted for identification of the different food items.

### *Plankton collection, preservation and enumeration*

Water samples were also taken from different areas and depth of the pond to make representative sample of the sampling days and filtered through a fine mesh sealed plankton net. Filtered sample was taken into a plastic bottle and preserved in 5% formalin for further studies. By using a Sedgwick-Rafter cell and a binocular microscope, 1 ml sub-sample was examined for each sample and identification of different food items were done according to Bellinger (1992), Rosalind (1978) and Needham and Needham (1962).

Electivity index (E) was calculated by Ivlev's (1961) classical electivity index (E):

$E = r_{gi} - P_{wi} / r_{gi} + P_{wi}$

where, $r_{gi}$ is the relative content of any food ingredient in the ration expressed as percentage of total ratio, and $P_{wi}$ is the relative proportion of the same item in the environment. The calculated value of E ranged from +1 to -1, where positive values indicate selection and negative values indicate avoidance for certain food items.

## Results and discussion

### *Relationship of size and patterns of feeding based on average index of fullness and average points per fish*

The values of average index of fullness (Table 1) showed little variations in different size groups. Yet comparatively higher value of average index of fullness were recorded in the size group IV, III and II with maximum value (3.9) in the size group IV. The lowest value (2.8) of average index of fullness was recorded in the size group I and this value was closely followed by the value of 3.1 recorded in the size group II. The results clearly indicated that the fish of the larger size groups fed more actively than the smaller ones.

**Table 1.** Relationship of fish size and patterns of feeding of *B. gonionotus* based on average index of fullness and average points per fish

| Items | Group I (7-25 mm ) | Group II (25.1-44 mm ) | Group III (44.1-55 mm) | Group IV (55.1-80 mm ) |
|---|---|---|---|---|
| Number of fish examined (n) | 15 | 15 | 15 | 15 |
| Average length in mm | 16.4 | 30.6 | 47.6 | 62.5 |
| Average index of fullness | 2.8 | 3.1 | 3.7 | 3.9 |
| Number of total points | 262 | 425 | 500 | 612 |
| Average points per fish | 17 | 28 | 34 | 40 |

Total length in mm in parenthesis

The values of average points per fish showed clear variations with the increase in size of fish (Table 1). The highest value (40) of average points per fish was recorded in the size group IV and the lowest value (17) of the same was recorded in the size group I. Values of average points per fish were found to decrease with the decrease in size of fish. From the values of average points per fish, it can be concluded that the amount of food in stomachs increased with the increase in size of fish. This might be due to larger size of stomachs as the fish increased in size. Dewan *et al.* (1977) observed similar size related feeding pattern in *Labeo rohita*.

*Relationship of size and patterns of feeding based on food categories*

***Size group I***: The fish of this size group fed mostly on rotifera, green and blue-green algae, debris, bacillariophyceae and euglenophyceae. In this size group, by percentage of occurrence rotifera (100%), green algae (86.66%), blue-green algae (80%), debris (66.66%), bacillariophyceae (66.66%) and euglenophyceae (60%) were the most dominant food items in this size group (Fig. 1). These were followed by higher aquatic plant (33.33%), cladocera (33.33%) and copepoda (26.66%). By percentage of total points, green algae (24.72%), rotifera (20.78%) and blue-green algae (17.25%) were found to be the most dominant food items and were followed by bacillariophyce (10.50%), debris (10.00%) and higher aquatic plants (4.39%). Next to higher aquatic plants were cladocera (4.00%), euglenophyceae (3.44%), copepoda (1.02%) and others (included dried grass leaves, stem of plants, seeds and unidentified hardy mass, these food items seemed to be of incidental comprising of only, 1%) (Fig. 2).

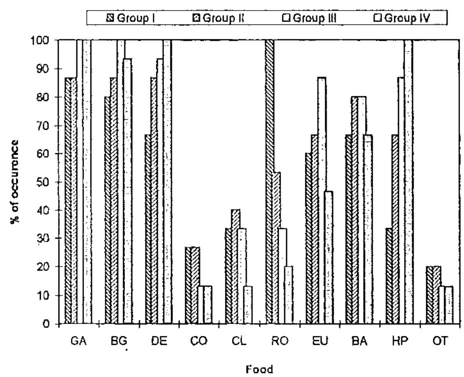


**Fig. 1.** Size related patterns of feeding based on percentage of occurrence with respect to food categories (GA= Green algae, BG= Blue-green algae, DE= Debris, CO= Copepoda, CL= Cladocera, RO= Rotifera, EU= Euglenophyceae, HP= Higher aquatic plants and OT= Others).

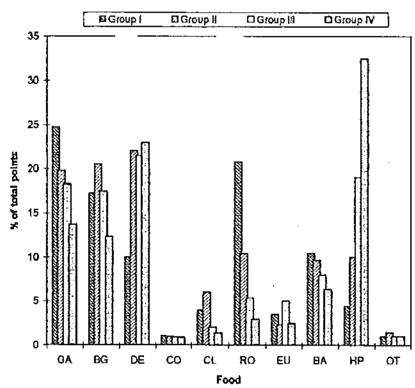


**Fig. 2.** Size related patterns of feeding based on percentage of total points with respect to food categories (GA= Green algae, BG= Blue-green algae, DE= Debris, CO= Copepoda, CL= Cladocera, RO= Rotifera, EU= Euglenophyceae, HP= Higher aquatic plants and OT= Others).

From the above observation, it can be concluded that the fish of this size group fed almost equally on both plant and animal foods and can be considered as fairly omnivore. However, higher aquatic plant was taken by the fish of this size group in a small amount. This was probably due to the fact that the fish of this size group were too small to eat higher aquatic plant. Kamal (1971) observed that rotifera, cladocera, copepoda and insects larvae were the food items of rohu (*L. rohita*) fry.

***Size group II:*** In this group debris was the most dominant and preferred food item both by the percentage of occurrence and percentage of total points (Figs. 1 and 2). By percentage of occurrence, debris (86.66%), green algae (86.66%) and blue-green algae (86.66%) were the dominant food items. They were followed by bacillariophyceae (80%), euglenophyceae (66.66%) and higher aquatic plant (66.66%). Next to higher aquatic plants, rotifera (53.33%), cladocera (40%), copepoda (26.66%) and others were found to occupy the successive positions.

By percentage of total points, debris (22%) was followed by blue-green (20.51%) and green algae (19.73%). Rotifera (10.44%), higher aquatic plants (10%), bacillariophyceae (9.70%) and cladocera (6.04%) were found to occupy the successive positions after the green algae. These were followed by euglenophyceae and copepoda. From the above observation it may be concluded that debris, blue-green and green algae, higher aquatic plants and rotifera were the most preferred food of this size group. This indicated that the fish of this size group were though omnivore yet started to show feeding preferences for plant foods.

***Size group III:*** This group showed a similar feeding pattern as that of the size group II, debris and plant food were the most dominant and preferred food items. Whereas, animal foods were taken in a small amount by this group. By percentage of occurrence, green algae (100%), blue-green algae (100%) and debris (93.33%) were the most dominant food items while by percentage of total points, debris (21.42%), higher aquatic plants (19%), green algae (18.23%) and blue-green algae (17.46%) were the most dominant food items. However, respectively by percentage of occurrence and percentage of total points bacillariophyceae (80%, 8%), rotifera (33.33%, 5.32%) cladocera (33.33%, 2.02%) and euglenophyceae (86.66%, 5%) were important food items (Figs. 1 and 2). Copepoda was taken by this fish incidentally.

A remarkable increase in the proportion of plant foods and decrease in the presence of animal foods in the stomach contents of this size group indicated that the fish of this size group are showing an ontogenetic dietary shift. Kumar *et al.* (1986) noted that *Puntius filamentosus* and *P. amphibius* were omnivore with preferences for filamentous algae and higher aquatic plants.

***Size group IV:*** This group also showed a similar feeding pattern as that of the size group III, and were found to be feeding mostly on higher aquatic plants, debris, green and blue-green algae. By percentage of occurrence, higher aquatic plants (100%), debris (100%) and green algae (100%) occupied the highest position which were followed by blue-green algae (93.33%). Next to blue-green algae were bacillariophyceae (66.66%), euglenophyceae (46.66%) and rotifera (20%). Next to these food groups, copepoda (13.33%), cladocera (13.33%) and others (13.33%) occupied the same position in respect to percentage of occurrence (Fig. 1). However, amongst all food items, higher aquatic plants (32.47%) and debris (22.98%) were the most dominant food by percentage of total points (Fig. 2). Next to debris were green algae (13.77%), blue-green algae (12.37%), bacillariophyceae (6.35%) rotifera (2.95%) euglenophyceae (2.47%), cladocera (1.40%), others (1.03%) and copepoda (0.90%). It appeared that euglenophyceae among the plant foods and copepoda among the animal foods were by far the less important food groups.

In this size group proportion of higher aquatic plants was found to increase to a considerable extent, both by the percentage of occurrence and percentage of total points than the other size groups. From the above findings it can be concluded that the fish of this size group were herbivore with likings for higher aquatic plants, green and blue-green algae. Javid (1971) recorded that *P. sophore* was herbivore feeding mostly on algae (chlorophyceae, bacillariophyceae and xanthophyceae).

Although, the fish were found to be omnivore in most of the size groups yet the proportion of plant foods and debris were found to increase significantly in the stomach contents of the size groups II and III. Plant foods were found to be most preferred by the size group IV. This might be due to the change of food and feeding habits of fish with its increasing size. However, in all the size groups, debris was the most important food item of this fish. Rotifera and cladocera were found to be important food items in smaller size groups and less important food items in larger size groups. The amount of different food items, except higher aquatic plant was found to increase with the increase in size of the fish. This might be associated with increased size of the stomach as the fish increased in size. Whereas, the proportion of animal foods decreased with the increase in size of the fish. This fish showed less feeding performance for animal foods as it increased in size. The small size group of *B. gonionotus* had a wider dietary breadth than the large individuals. Large fish increased their specialization on certain food items (on aquatic macrophytes) and narrowed down their niche width with increasing size and competitive ability (Haroon and Pittman 1997, 1998 and 2000).

### *Electivity indices*

Electivity indices of different size groups of fish are shown in Table 2. The present investigation showed that *B. gonionotus* appeared to be a selective feeder. For all planktonic crustaceans (copepoda, cladocera), nauplii and *Daphnia* were positively selected which decrease with the increment of fish sizes. In case of *Cyclops*, *Diaptomus*, *Diaphanosoma*, negative selection was observed in the smallest size group. Although in the later size groups those had been positively selected, except *Diaphanosoma* in size group IV which was negatively selected.

**Table 2.** Electivity indices (E) of four size groups of *Barbodes gonionotus*

| Plankton | Electivity indices of four size groups | | | |
|---|---|---|---|---|
| | Size group I (7 - 25 mm) | Size group II (25.1 - 44 mm) | Size group III (44.1 - 55 mm) | Size group IV (55.1 - 80 mm) |
| **Green algae** | | | | |
| *Ankistrodesmus* | -0.82 | -0.50 | -0.70 | +0.20 |
| *Botryococcus* | - | -0.31 | -0.51 | -0.80 |
| *Chlorella* | +0.91 | +1.00 | +1.00 | +1.00 |
| *Crucigenia* | - | - | +0.20 | +0.50 |
| *Gonatozygon* | -0.50 | -0.40 | +0.20 | +0.81 |
| *Gleocystis* | -0.50 | +0.18 | +0.40 | +0.53 |
| *Oocystis* | - | - | - | +0.50 |
| *Pediastrum* | - | -0.50 | +0.29 | +0.49 |
| *Scenedesmus* | - | - | - | -0.47 |
| *Spirogyra* | - | - | - | -0.10 |
| *Tetraedron* | - | -0.50 | -0.21 | +0.21 |
| *Ulothrix* | -0.33 | +0.10 | +0.59 | +0.61 |
| *Volvox* | - | - | - | -0.21 |
| **Blue-green algae** | | | | |
| *Anabaena* | - | - | - | +0.41 |
| *Aphanocapsa* | - | - | - | +0.79 |
| *Chrococcus* | - | -0.50 | +0.43 | +0.87 |
| *Microcystis* | -0.33 | -1.00 | +0.19 | +0.25 |
| *Merismopedia* | - | - | - | - |
| *Oscillatoria* | +0.03 | +0.07 | +0.33 | +1.00 |
| **Basillariophyceae** | | | | |
| *Fragelaria* | - | - | +0.39 | +0.67 |
| *Navicula* | +0.09 | +0.57 | +1.00 | +1.00 |
| **Euglenophyceae** | | | | |
| *Euglena* | - | - | -0.50 | -0.69 |
| *Phacus* | - | - | - | +0.50 |
| **Copepoda** | | | | |
| *Cyclops* | -0.80 | +0.20 | +0.43 | +0.01 |
| *Diaptomus* | -0.42 | +0.12 | +0.29 | +0.01 |
| Nauplii | +1.00 | +0.84 | +0.46 | +0.18 |
| **Cladocera** | | | | |
| *Daphnia* | +0.61 | +0.56 | +0.40 | +0.08 |
| *Diaphanosoma* | -0.76 | +0.52 | +0.43 | -0.21 |
| **Rotifera** | | | | |
| *Brachionus* | +0.14 | -0.50 | -0.97 | -1.00 |
| *Filinia* | - | -0.45 | -0.29 | -0.10 |
| *Keratella* | +0.40 | +0.20 | -0.70 | -0.98 |
| *Lecane* | -0.60 | -0.40 | -0.20 | -0.39 |
| *Polyarthra* | - | - | -1.00 | - |
| *Trichocera* | -0.17 | -0.29 | -0.46 | -0.78 |

Among the rotifera, *Lecane, Filinia* and *Trichocera* were avoided and *Polyarthra* was completely avoided. *Brachionus, Keratella* were positively selected in smaller size groups, although with the increment of fish size they were avoided. Among the green algae, all groups selected *Chlorella* and an increasing positive selection was observed for *Ankistrodesmus, Gonatozygon, Gleocystis, Oocystis, Pediastrum* and *Ulothrix* by the larger size groups. In this planktonic group some genera were eluded by the smaller size groups but they were positively selected by the larger sizes. *Spirogyra, Scenedesmus* and *Volvox* were avoided by all sizes. Among the blue-greens *Oscillatoria* was positively selected by all size groups. *Anabaena, Aphanocapsa, Chrococcus, Microcystis* were avoided by the smaller size groups. But they were positively selected by the larger sizes. All sizes exhibited positive selection to *Navicula*. Among the euglenophyceae, *Phacus* was selected only by at the size group IV while *Euglena* was avoided by all groups. Fish thus exhibited a ontogenic dietary shift in planktivory with the increase in their sizes from zooplankton to phytoplankton. Haroon and Pittman (1997) reported that large silver barb consumed macrophytes as well as microcystis, anabaena, spirogyra and cladocera and crustaceans (in the pond) or mollusks (in the rice field). Overall electivity was negative for microalgae. Zooplankton were avoided by large fish in the rice field. They also reported that improved fish yields may be achieved by stocking small *P. gonionotus* where available feed resources include important amounts of zooplankton, and by allowing aquatic macrophytes and weeds to grow in the rice field or pond after stocking, such that the growing fish can feed increasingly on these.

In the present study *B. gonionotus* showed pronounced elctivities for different food items and elctivity varied with the fish sizes. Selective feeding is expected when the energy gained by feeding on preferred food items exceeds the energy that has been lost during selection (Al-Akel *et al.* 1987). Wankowsky (1979) and Bartell (1982) reported that fishes expend more energy in selection of larger prey in order to gain more energy. In the present investigation *B. gonionotus* during early stage preferentially selected zooplankton (Table 2) to earn maximum energy to fulfill routine metabolic requirements and growth. The energy content of aquatic algae is very poor and carps cannot obtain sufficient energy to grow when only phytoplankton is available as food item, because phytoplankton are reported to be poorly digested and conversion efficiencies are low (Hamada *et al.* 1983, Bitterlich 1985).

A gradual increasing selection for phytoplankton and a decreasing selection for zooplankton with increment of fish size indicated changes in food habit towards herbivory. Cremer and Smitherman (1980) reported that fishes feeding on plant material generally have greater gut lengths than those feeding on animal matter. Table 3 confirms an increase in gut length relative to its standard length among the *B. gonionotus* supporting the observation that this species becomes increasingly herbivorous with the increase in size.

**Table 3.** Relationship between standard length and gut length of four different size groups of *B. gonionotus*

| Different size groups | Average standard length (mm) | Average gut length (mm) | Gut length: Standard length |
|---|---|---|---|
| 7 - 25 mm TL, I | 16.4 | 41.00 | 1: 2.5 |
| 25.1 - 44 mm TL, II | 30.6 | 85.68 | 1 : 2.8 |
| 44.1 - 55 mm TL, III | 47.6 | 135.66 | 1 : 2.8 |
| 55.1 -80 mm TL, IV | 62.5 | 181.25 | 1 : 2.9 |

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