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***Research article***

# MORPHOLOGY OF BUCCOPHARYNGEAL CAVITY OF TWO SPECIES OF GENUS *HYPOPHTHALMICTHYS*

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**ABSTRACT:** Morphological and morphometric data of the buccal cavity, pharyngeal bone and dentition of two species of Hypophthalmicthys (i.e. *H. molitrix* and *H. nobilis*) were collected. The structure of the bucccopharyngeal cavity (BC) of *Hypophthalmicthys* spp. follows a typical pattern of teleost fish. BC in bighead carp is comparatively bigger than that of silver carp measuring 29.01% and 28.12% of standard body length. Mouth gape measures 21.7% of head length in bighead carp and 31.06% of head length in silver carp. In both the species ventral surface of the lateral projection of pharyngeal bone bears pits and openings however, their position differs. This can be a high weight taxonomic character for the identification of the two species. Both species exhibit small teeth bearing area with Dl/Pl ratio <0.5. Pharyngeal bone bears a single row of teeth (0,4-4,0) with their masticating surface steeply inclined towards dorso-mesially.

**Key words**: Morphology; Buccopharyngeal cavity; Hypophthalmicthys sp.

## INTRODUCTION

Morphology of fish feeding apparatus is strongly correlated with feeding strategy and environmental conditions (Svardson, 1979), which may be instrumental to our understanding of resource utilization, ecological community structure and ultimately the process of speciation (Van Valen, 1965; Grant, 1986). However, data on relationship between morphological constraints and exploitation of trophic resources in fishes are rarely gathered (Wainwright, 1987, 1988). Literatures pertaining to the morpho-anatomical structures of the buccopharyngeal cavity in freshwater teleosts are fragmentary and many authors (Vanajakshi, 1938; Kapoor, 1958; Khanna, 1961, 1962; Pasha and Kamal, 1964 a, b, c; Saxena and Bakhshi, 1964; Lal, *et al*., 1964; Chitray, 1965; Sehgal, 1966; Moitra and Bhowmik, 1967; Lal, 1968; Sehgal and Salaria, 1970; Moitra and Sinha, 1971; Sinha, 1986; Sinha and Moitra, 1975, 1976, 1978; Kapoor, *et al*.,1975) while studying the alimentary canal, briefly described the morphology and structural organization of the mouth of different fish species. One such example is *Hypophthalmichthys*, a genus of cyprinidae consisting of three species (*H. nobilis,* Bighead Carp; *H. molitrix*, Silver Carp and *H. harmandi*, Largescale Silver Carp) native to fresh waters of eastern Asia. However, in Indian subcontinent *H. harmandi* is not reported so far. So, the present study deals with buccopharyngeal cavity of two species i.e. *H.* molitrix and *H. nobilis* as it has been poorly described in literature. Buccopharyngeal cavity of *Hypophthalmichthys* has the modifications for filter feeding (Bitterlich, 1985; Lu *et al*., 2002).

## MATERIAL AND METHODS

The samples of *Hypophthalmicthys nobilis* and *H. molitrix* ranging from 327- 350mm and 54.67- 267.0 mm respectively were collected from different parts of Haryana during the year 2011- 2013. The specimen were fixed in 10% formalin and brought to the laboratory for different measurements. Subdivision of buccal cavity, whereby the "anterior pharynx" is the region of the gill arches and palatal organ (PO) and the "posterior pharynx" is the region occupied by the chewing pad (CP) (Sibbing *et al*., 1986). The pharyngeal bones (PB) along with teeth and mucous membrane were taken out to facilitate the observation of morphology, for this the bone was air dried and then dehydrated in ethanol followed by degreasing in acetone. The definition of the traits on pharyngeal bone (PB) was adopted from Chu (1935) and those on pharyngeal teeth from Zeng and Liu (2011). All the measurements were made to the nearest 0.01 mm with digital calipers to represent the general shape and size. The number of teeth per bone were counted and photographed with Olympus sigma alpha digital camera.

## RESULTS AND DISCUSSION

Bighead carp and Silver carp are large cyprinid fishes that closely resemble each other. Both are deep-bodied and spindle-shaped; however, Silver carp is more laterally compressed than Bighead carp. Bighead carp displays a smooth keel between the anal and pelvic fins, while Silver carp exhibits a keel from the throat to the vent. Bighead carp is creamy white on the ventral surface and greyish on the dorsal surface with blotches varying from grey to black on the dorsal and lateral surface. Silver carp is grey-black dorsally, olive to silver-shaded laterally, and silver ventrally. Both species has relatively large head with upturned mouth. The adaptations of fish buccal cavity are quite evident from the size and shape of mouth, structure of the oro-pharynx and dentition which are subjected to variations and modifications in accordance with the feeding habits (Dasgupta, 2000; Khalaf-Allah, 2009). The structure of the bucccopharyngeal cavity (BC) of *Hypophthalmicthys* spp. (Fig. 3 a, b) follows a typical pattern of teleost fish. BC in bighead carp and silver carp measures 29.01% and 28.12% of standard body length (Table–1). Predator mouth-gape sets the upper limit for potential prey items (Dabrowski and Bardega, 1984) and can be used to estimate the efficiency with which fish ingest prey of different sizes (Arts and Evans, 1987; Cunha and Planas, 1999). Mouth gape measures 21.7% of head length in bighead carp and 31.06% of head length in silver carp.

**Table1: Morphometric measurements of Buccopharyngeal cavity of *H. molitrix* and *H. nobilis***

| S.No. | Parameters | *H. molitrix* (Silver carp) | | *H. nobilis* (Bighead carp) | |
|---|---|---|---|---|---|
| | | Mean±SE (in mm) | %age of Standard length | Mean±SE (in mm) | %age of Standard length |
| **1** | **Buccopharyngeal cavity (BC)**<br>**Length**<br>**Width** | <br>24.83±2.2<br>10.04±1.19 | <br>28.12%<br>14.1% | <br>84.355±2.95<br>42.41±2.96 | <br>29.01%<br>13.62% |
| **Parameters** | | Mean±SE (in mm) | %age of Buccopharyngeal cavity | Mean±SE (in mm) | %age of Buccopharyngeal cavity |
| **2** | **Palatal organ (PO)**<br>**Length**<br>**Width** | <br>3.07±1.18<br>2.24±1.03 | <br>54.8%<br>49.8% | <br>46.28±0.74<br>42.41±2.38 | <br>40%<br>41% |
| **3** | **Chewing pad (CP)**<br>**Length**<br>**Width** | <br>3.074±1.18<br>2.24±1.03 | <br>12.3%<br>9.02% | <br>14.66±0.77<br>11.04±0.65 | <br>17.3%<br>13.08% |
| **4** | **Pharyngeal arch (PB)**<br>**Length (PL)**<br>**Width (PW)** | 6.671±3.97<br>1.509±0.66 | 26.86%<br>15.03% | 28.775±0.459<br>7.745±0.898 | 34.11%<br>18.26% |
| **5** | **Dentulous region (DL)** | 2.200±1.12 | 8.8% | 11.125±0.954 | 13.15% |
| **6** | **DL/PL ratio** | 0.32 | ------ | 0.386 | ---- |

Both species have transversely placed mucosal folds on the floor of the cavity which is found to be beset with papillae and the roof of cavity bears comb plates as a result of which 'U' shaped notch and transverse shelf are lacking (Doosey and Bart, 2011). Comb plate and the gill rackers on the gill arch articulate perpendicularly to form a remarkable sieving structure to facilitate filter feeding (Doosey and Bart, 2011). The form and spatial composition of sieving structure is species specific (Zander, 1906) and is closely related to the structure of the branchial sieve (Magnuson and Heitz, 1971; Matthes, 1963). Bighead carp probably uses a combination of feeding methods, including: pump feeding, ram feeding. During pump feeding individuals hang almost vertical to the water surface, employing the bulges of the PO to pin the food items against the gill rakers and then small waste particles, inorganic material, and water are flushed out of the cavity through the operculum (Sibbing, 1986, 1988; Willink, 2002). The PO in Bighead carp is subrectancular in shape being more wide anteriorly and measures about 54.8 % of buccopharyngeal cavity (BC) by length and 49.8% of BC by width. During ram suspension, individuals swim horizontally, holding the mouth open and forcing water through the gills. It is typically zooplanktivorous, but can be very opportunistic, consuming a variety of prey items (Kolar *et al*., 2007). Silver carp also uses pump feeding and can filter smaller particles than Bighead carp (Kolar *et al*., 2007) due to sponge like gillrakers. In general, adults are phytoplanktivorous, but may feed a variety of zooplankton of a comparable size 4 μm (Kolar *et al*., 2007).

Like in Bighead carp, the PO in silver carp is wide posteriorly but looks somewhat ovoid in shape and measures 40% of BC by length. Width of PO in silver carp measures 41% of length of BC. The gill rakers of silver carp are long, thin, fused, porous, and sponge-like, and are specifically adapted to filter phytoplankton (Fig. 2a). In contrast, the gill rakers of bighead carp are not fused and appear more like combs (Fig. 2b). They are adapted for general use, including filtration of some phytoplankton and zooplankton (Zhou *et al*., 2011).

Eastman and Underhill, 1973; Iliadou and Anderson, 1998 highlighted the importance of studying forms and relative dimensions of the pharyngeal arch. In bighead carp, length PB averages one third the length of BC and width of PB approximately measures one seventh the width of BC. Whereas, in silver carp its length is one fifth the length of BC and width is one seventh the width of BC. In both the species ventral surface of the lateral projection bears pits and openings (Fig. 5 a, b) which can be a high weight taxonomic character for the identification of the two species. In silver carp, 4 openings on the non-dentulous region and 3 pits on the dentulous region of PB are present. In bighead carp, 4 openings are present in the dentulous region while pitted surface are not seen. A prominent ridge from A1 towards non-dentulous region is thick and solid in silver carp whereas, it is comparatively thin and delicate in bighead carp. They have well developed pharyngeal bone with a single rows of teeth steeply inclined towards dorso-mesial orientation of the masticating surface. On the basis of ratio between dentulous region (DL) and length of pharyngeal bone (PL), Zeng and Liu (2011) classified pharyngeal bone as "small teeth bearing area" (DL/PL<0.5) and "large teeth bearing area" (DL/PL ≥0.5). Thus both species exhibit small teeth bearing area. However, bighead carp has comparatively large dentulous region of about 13.15% of BC than that in silver carp (Table1).

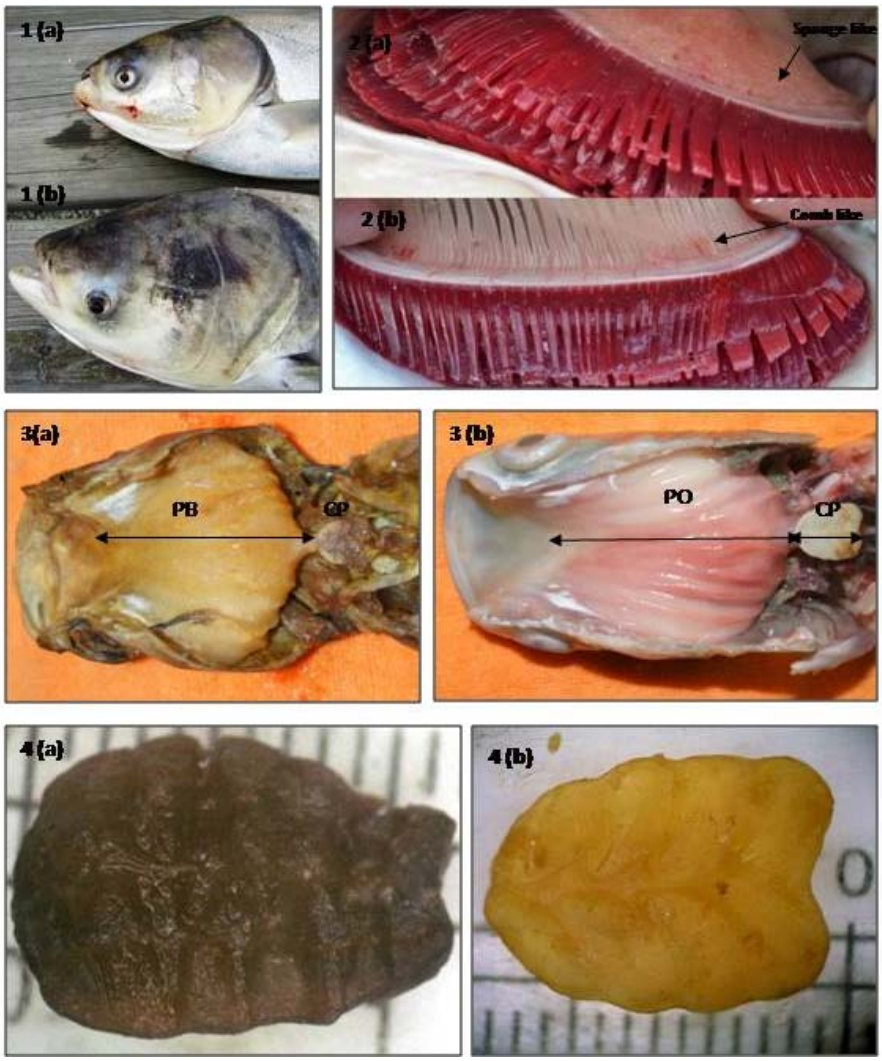


**Figure-1: Head region (a) *H.molitrix* (b) *H.nobilis***
**Figure-2: Gill rakers (a) *H.molitrix* (b) *H.nobilis***
**Figure-3: Buccopharyngeal cavity (a) *H.molitrix* (b) *H.nobilis***
**Figure-4: Chewing pad (a) *H.molitrix* (b) *H.nobilis***

In Hypophthalmicthyins, teeth represent one of the highest specializations attained by the cyprinid fishes (Chu, 1935). Both have dental formula 0, 4-4, 0 with no replacement teeth. All teeth have the same general appearance with respect to physical characteristics. The grinding surfaces of the pharyngeal teeth of the Bighead carp (Fig. 6a) differ from that of the silver carp (Fig. 6b), which have fine striations that are visible with magnification. Such striations have also been reported by Yokote 1956. In both the species, CP is connected to PO with a stalk. CP is more or less ovoid in shape with uniform pattern (Fig. 4b) in bighead carp. It is wide at posterior side with truncated margins averages 17.3 % of BC in length and mean width is 13.08 % of BC. CP is subrectangular shaped in silver carp with truncated margin and occupies 12.3% of BC in length and 9.02% of BC in width (Fig. 4a). Its free surface is rugose with slight pattern on the free surface and the pharyngeal teeth bite against it. This pad, together with the alternating disposition of the teeth, enabled to masticate the food.

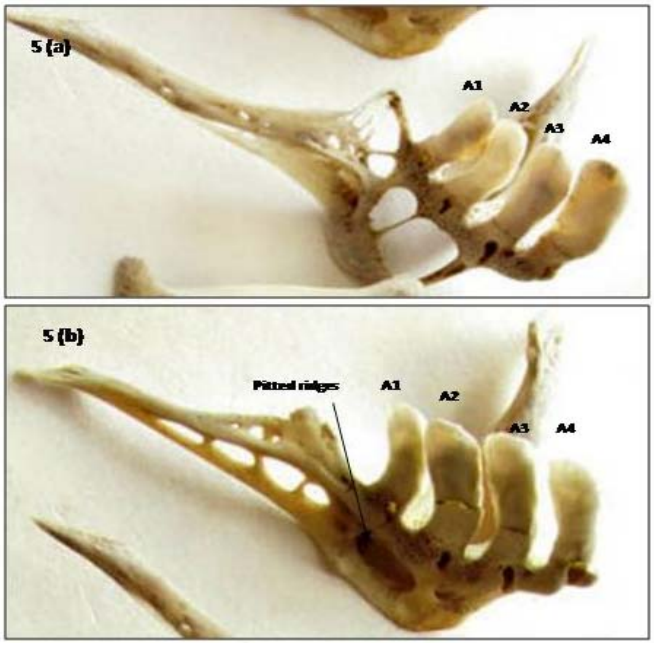


**Figure-5: Pharyngeal arch with teeth (a) *H.nobilis* (b) *H.molitrix***

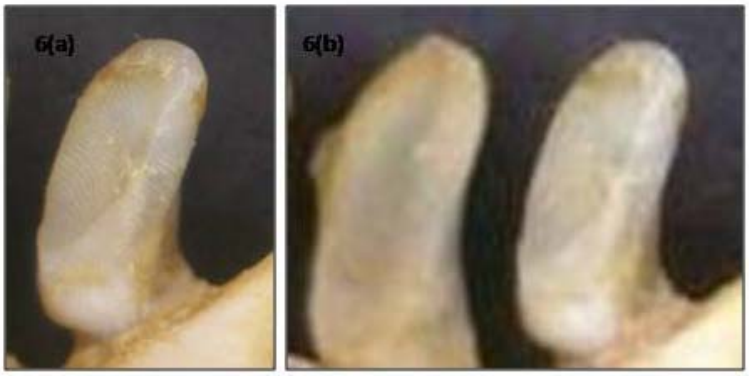


**Figure-6: Pharyngeal teeth (a) (a) *H.nobilis* (b) *H.molitrix***

## CONCLUSION

Morphological novelty is found in the buccopharyngeal cavity of Hypophthalmicthys for filter feeding mechanism. The gill rakers of silver carp are long, thin, fused, porous, and sponge-like, and are specifically adapted to filter phytoplankton. In contrast, the gill rakers of bighead carp are not fused and appear more like combs. They are adapted for filtration of both phytoplankton and zooplankton. In both the species ventral surface of the lateral projection bears pits and openings which can be a high weight taxonomic character for the identification of the two species. Teeth represent one of the highest specializations with dental formula 0, 4-4, and 0.

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