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Hard anatomy and morphometry of hill stream fish [*Channa punctatus* (Bloch.)]

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Abstract

***Channa punctatus* is a genus of the Channidae family of snakehead fish. The study on the cranial osteology showed that the bones of the skull were firmly articulated. The skull was well ossified, compact and had massive structure. The ethmoid was a bowl shaped bone, lachrymal was oval, quite prominent and suborbitals were three in number. Sphenotic was present along the ventral border of the frontal and had no attachment with the parietal. Epiotic lamellae were large. Each exoccipital enclosed a single foramen magnum. Dentary and premaxilla bear teeth. *En*dopterygoid had attachment with the quadrate. *Angular* provided attachment to the maxilla. The statistical data in respect to 14 morphometric characters exhibited a linear relationship among all the morphometric characters except body weight.**

Key words: Osteology, morphometry, hill stream, vertebra, systematic.

Introduction

The study of osteology helps in understanding the impressive and rapid adaptive variation in bone-forms among different species (Dhanze 1980). This also helps in understanding the important taxonomic characters either at the species, family, or higher levels. The osteology has proved of immense importance in fish systematic because the pattern of the bone in the animals is most conservative and is not much influenced by environment. So it is being regarded as the most reliable tool in the hand of a taxonomist and has being used in tracing out the interrelationship between and within the group (Shukla and Verma 1973). Keeping all these points in view, the present study was carried out to understand the osteological structure of *Channa punctatus*.

Materials and Methods

The specimens were collected from sub-tributaries of Mole and Neugal (tributaries of river Beas) at different reaches during October 2011 to December 2012. The sampling site i.e. Tanda (Latitude: 32.088083, Longitude: 76.537204) was selected on the Mole stream, Bhatuu (Latitude: 32.084184, Longitude: 76.493876) and Nagni (Latitude: 31.979104, Longitude: 76.46705) on Neugal stream. In the present study 40 number of fish species i.e. *C. punctatus* ranging from 50.9±2.5 to 176.2±3.2 in TL, 38.5±1.9 to148.03±3.1 in SL and 1.59±2.01 to 53±2.02 in BW were subjected for detail analysis. The TL and BW of the fishes to the nearest millimetres (0.1mm) and grams (0.1g) respectively were recorded and preserved in 10 % formalin for morphometric study and in 2% KOH solution for osteological preparation. The regression method has been employed for constant a and b. The different body parameters accessed for relative growth patterns were standard length (SL), head length (HL), head width (HW), body depth (BD), body weight (BW), dorsal fin length (DFL), pectoral fin length (PFL), ventral fin length (VFL), mouth width (MW),

snout length (LS), eye diameter (ED), Pre dorsal length (PDL), Post dorsal length (PstDL), Pre pectoral length (PPL), Post pectoral length (PstPL), Pre anal length(PAL) and post anal length (PstAL). The test of significance for correlation 'r' was employed. A total number of 40 specimens were divided into 4 groups based upon the SL to determine vertebral count and position of different fins.

Results and Discussion

Olfactory Region

Ethmoid (ETH) (Fig. i): It was a bowl shaped bone situated between olfactory capsules and formed the anterior most part of the cranium. It was notched anteriorly and articulated laterally with nasal and lateral ethmoid, posteriorly with frontal and ventrally with vomer.

Lateral ethmoid (LETH) (Fig. i): The paired lateral ethmoid situated on either sides of the ethmoid with which they articulated suturally. Each bone was composed of narrow ends with broad centre and appeared like elliptical shape. Anteriorly it was articulated with nasal, posteriorly with frontal and ventrally with orbital bones.

Nasals (N) (Fig. i): Nasals were the paired quadrangular bones, located on either side of ethmoid. It was surrounded by lachrymal anteriorly and lateral ethmoid posteriorly.

Vomer (VO) (Fig. ii): It was found to be a small, median, unpaired 'T' shaped bone situated on the mid ventral surface of ethmoid. The lateral extension was articulated with the antero-ventral surface of the lateral ethmoid while the posterior long and tapering shaft with the parasphenoid.

Orbital Region

Orbitosphenoid (ORPS) (Fig. ii): It was an elongated bone having broad posterior end, sandwiched between the frontal and parasphenoid. Anteriorly it was articulated with lateral ethmoid and mesially with ethmoid. It took part in the formation of the optic foramina on either side.

Parasphenoid (PS) (Fig. ii): It was a median, ventrally, longest dermal bone. It extended from the basioccipital to the vomer. Laterally it was overlapped by lateral ethmoid, articulated anteriorly with ethmoid and laterally with orbitosphenoid. After this point it was flared into two lateral expansions and articulated with alisphenoid mid-laterally and with the anterior end of prootics postero-laterally.

Alisphenoids (AS) (Fig. ii): These were irregularly curved bones, broad at the distal end and tapering proximally. Anteriorly it was articulated with the frontal and sphenotic and dorsally with the lateral expansion of the parasphenoid. Anteriorly they extended upto the orbitosphenoid and articulated with it, posteriorly with the prootics and ventrally with pterotic.

Lachrymal (LA) (Fig. i): It was oval shaped, quite prominent, situated anterior to the nasal. It was first orbital bone, formed anterior wall of the nasal and attached with it posteriorly. Dorsally it articulated with the ethmoid and ventrally with maxilla, premaxilla and palatine.

Suborbitals (SOB) (Fig. iii): These were paired dermal bones, formed the ventral and posterior boundary of the orbits. These were three large, stout and curved elements. The first suborbital articulated anteriorly with the distal end of the lachrymal and third one with the frontal and the sphenotic.

Frontal (FR) (Fig. i): Frontals were long flat bones and was separated by a mid dorsal line with each other. These were somewhat rectangular and anteriorly extended up to the lateral ethmoid. Ventro-laterally, articulated with the suborbital, sphenotic and pterotic bones and formed the dorsal boundary of the orbit. On the posterior side, it was attached to the parietals and supraoccipital and ventrally with the orbitosphenoid, parasphenoid and alisphenoid.

Otic Region

Sphenotic (SPH) (Fig. i): These were irregular bones, had an anterior thin and posterior curved broad end. It was located on the ventral side of frontal, anterior to the pterotic, posterior to the orbital and ventro-laterally bear facet in conjunction with pterotic for the

articulation of hyomandibular condyle.

Pterotic (PTR) (Fig. i): Pterotic was a paired narrow and elongated bone, located between the sphenotic and epiotic and was articulated with frontal and parietal on its dorsal side. It was smaller in size as compared to the sphenotic bone.

Parietals (PR) (Fig i): It was paired, large and square shaped bone. Each bone was articulated with frontal on the anterior side and with epiotic and exoccipital on posterior side, ventrally sutured with the pterotic and dorsally with the supraoccipital.

Prootic (PRO) (Fig. ii): These were large flat oval shaped bones, anteriorly articulated with the alisphenoid and posteriorly with the exoccipital. Each bone met its fellow in the mid ventral line above the parasphenoid and extended up to the junction of the basioccipital.

Epiotic (EP) (Fig. i): It was a paired bone, present on the posterior side of pterotic and parietal. It was almost L-shaped bone and capped the postero-dorsal surface of the cranium. It had a median ridge and lamellae which provided the attachment area to the lateral muscles. Anteriorly it was articulated with the parietal and supraoccipital and dorsally with the exoccipital.

Occipital Region

Supraoccipital (SO) (Fig. i): It was a median pentagonal shaped bone, large in size and formed the roof of cranial cavity. Anteriorly it was articulated with the frontals and laterally with the parietals and posteriorly with the exoccipital which excluded this bone from the foramen magnum.

Exoccipital (EO) (Fig. i): These were almost comma shaped bones, situated dorsally on either side of the foramen magnum. Each exoccipital joined its fellow of the other side along the dorso-median line above the cavum sinus-imparis thereby formed its roof. They were articulated anteriorly with the prootic and supraoccipital, ventrally with epiotic, ventro-mesially with basioccipital and the post-temporal.

Basioccipital (BO) (Fig ii): It was a mid ventral bone and was quite massive in the posterior region and articulated with the exoccipital antero-laterally. Posteriorly it was fused with the ventral half of the first vertebra. Anteriorly the bone was narrow, articulated with the parasphenoid and prootic on lateral side.

Mandibular Region

Premaxillaries (PMX) (Fig. iii): These were dermal thin bones, roughly rectangular and firmly attached to the ventral surface of the ethmoid. Its anterior surface was concave and posterior was convex, bearing sharp villiform teeth on ventral surface, posteriorly attached with the maxilla of the corresponding side.

Maxillaries (MX) (Fig. iii): These were long, slender and slightly curved rod like structure with a broad end which was articulated with the anterior end of palatine and premaxilla. The posterior end was broad hammer shaped and articulated with angular.

Palatine (P) (Fig. iii): The palatine was an elongated bone, wide in the middle and narrow at the both ends. It was articulated with the maxilla on the anterior side, posteriorly with the angular and quadrate. On the postero-dorsal side it was articulated with the ectopterygoid.

Endopterygoid (ENPT) (Fig. iii): It was a thin, rhomboidal bone, situated dorsal to the ectopterygoid. It was located posterior to the preorbitals and posteriorly adjoined the quadrate and metapterygoid.

Ectopterygoid (ECPT) (Fig. iii): The ectopterygoid was a small triangular bone, embedded on the dorsal surface of the palatine. It was articulated with quadrate posteriorly and dorsally with endopterygoid.

Metapterygoid (MPT) (Fig. iii): It was a large irregular bone. Anteriorly it had an elongated structure for the articulation with the endopterygoid. Postero-ventrally it was attached with the symplectic, ventrally with quadrate and posteriorly as well dorsally with the hyomandibular.

Quadrate (Q) (Fig. iii): It was a large, wedge shaped bone which was situated anterior to the preopercular and ventral to the hyomandibular. The lower angle of each bone was thick and had articular facet for the angular. Dorsally it was articulated with metapterygoid and symplectic, posteriorly with the preopercular and the interopercular.

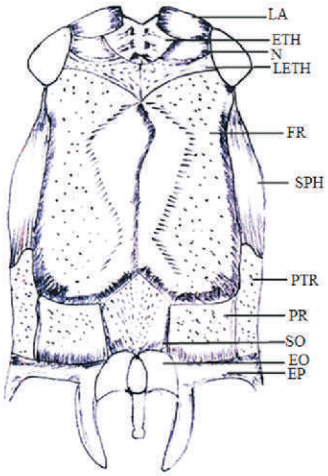

Fig. i. Dorsal view of cranium

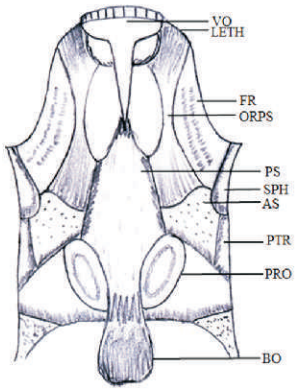

Fig. ii. Ventral view of cranium

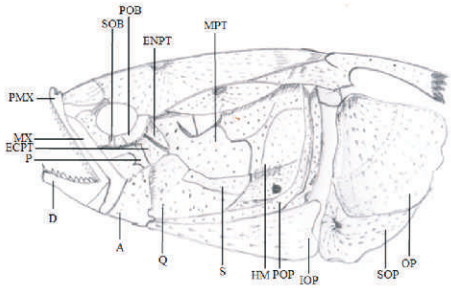

Fig. iii. Lateral view of cranium

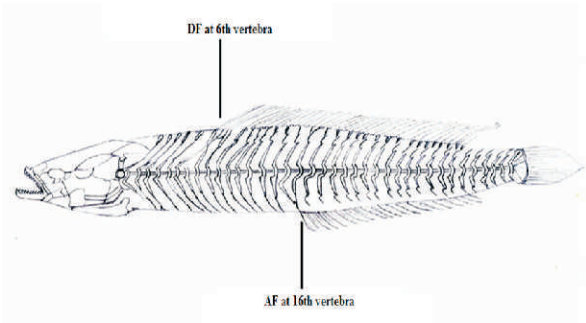

Fig. iv. Vertebral column and positions of fins

Symplectic(S) (Fig. iii): Symplectic was a small paired bone with broad posterior end. Anteriorly as well as ventrally it was attached with quadrate, posteriorly preopercular and dorsally metapterygoid.

Angular (A) (Fig. iii): These were dermal bones, somewhat triangular shaped and anteriorly articulated with dentary. Posteriorly it was attached with the interopercular, preopercular and quadrate and dorsally with palatine and ectopterygoid.

Dentary (D) (Fig. iii): Each bone was hammer shaped and slightly curved mesially to meet its fellow by means of ligament at the symphysis. Villiform teeth were present on its antero-dorsal aspect and articulated with the angular at its posterior end.

Preopercular (POP) (Fig. iii): These were thin crescent shaped bones, placed posterior to the hyomandibular, symplectic and quadrate, dorsal to interopercular and anterior to opercular. Each preopercular had a thick postero convex edge. Its ventral end was attached firmly with the angular while dorsal end apposed over the posterior groove of the hyomandibular.

Subopercular (SOP) (Fig. iii): It was an irregular bone, present ventral to the opercular and anteriorly attached with the interopercular.

Interopercular (IOP) (Fig. iii): These were roughly triangular bones with convex ventral edge and concave dorsal edge. Anteriorly each bone was attached with angular, posteriorly with subopercular and dorsally with the preopercular.

Vertebral count and positions of different fins (Fig. iv): It was observed that there is no variation in number of vertebrae in different size groups but some variations were noticed regarding position of fins. Total vertebral counts were found to be 35 in all the specimens irrespective of length and weight. Vishwanath and Kumari (2009) reported the similar findings. In 1st class the dorsal fin was found to be attached with 6th vertebra and anal fin with 16th vertebra. In category II, III and IV classes the dorsal fin was found to be attached with 7th vertebra and anal fin with 17th vertebra as such it might be concluded that in bigger fish (beyond 82.76 mm TL) the position of fins shifted towards posterior (Table 1.1).

Relative growth of different body lengths in relation to SL: HW, HL and BD showed linear relation except BW. The maximum value of 'r' was of HL (0.97) and minimum was of BD (0.78). Table 1.2 showed that unit increase in SL enhanced 0.225, 0.293, 0.183 and 0.530 in HW, HL, BD and BW respectively. The linear relationship of various morphometric characters was reported by Rizkalla (1994) and Pandey et al. (1995). Further, it was noted that all the body parameters had higher values of 'r'. The HL exhibited positive and significant relationship whereas BW negative and significant.

The analysis of PDL, PstDL, PPL, PstPL, PAL and PstAL in respect of SL indicated high 'r'. Table 1.2 denoted that unit increase in SL enhanced the 0.844, 0.746, 0.647 and 0.550 in PstPL, PstDL, PstAL and PAL respectively. Further, PPL indicated positive and significant relationship.

Relative growth of different fin lengths in relation to SL: The various parameters were analyzed which pointed out that VFL, DFL and PFL had a linear relationship with respect of SL. The value of 'r' was found to be higher ($r > 0.88$). Same trend was observed in the values of R^2. Table 1.2 signified that unit increase in SL enhanced 0.064, 0.173 and 0.107 times in VFL, DFL and PFL respectively where as VFL denoted positive and significant relationship.

Relative growth of different body lengths in relation to HL: HW, MW, LS and ED showed a linear relationship. Further, the value of 'r' was found to be high in HW (0.96), MW (0.95) and LS (0.91) where as ED showed comparatively less value (0.80). Similar findings were noticed by Saikia (2012). The enhancement in HW, MW, LS and ED was 0.738, 0.483, 0.273 and 0.115 respectively with unit increase in HL, though all the parameters had negative and significant relationship but ED indicated positive and significant relationship.

Table 1.1 Vertebral count and positions of different fins

Sr. No.	Class Range	No. of samples	SL	Vertebral count	Position of dorsal fin	Position of anal fin
1	37-67	3	38.5-66.49	35	6th	16th
2	67-97	14	73.06-95.95	35	7th	17th
3	97-127	20	99.14-117.59	35	7th	17th
4	127-157	3	129.28-148.03	35	7th	17th

Table 1.2 Relative growth of morphological characters in relation to standard length

x	y	a	b	r	R^2	t-test
SL	HW	-1.605	0.225	0.945	0.894	-1.251
SL	HL	2.764	0.293	0.973	0.946	2.384*
SL	BD	- 2.011	0.183	0.883	0.780	-1.252
SL	BW	-33.144	0.530	0.905	0.819	-8.047*
SL	PDL	2.730	0.334	0.961	0.924	1.675
SL	PstDL	9.521	0.746	0.901	0.812	1.603
SL	PPL	3.058	0.308	0.976	0.952	2.692*
SL	PstPL	4.191	0.844	0.961	0.923	1.046
SL	PAL	1.379	0.550	0.981	0.963	0.783
SL	PstAL	2.200	0.647	0.965	0.933	0.767
SL	VFL	1.285	0.064	0.886	0.785	2.295*
SL	PFL	0.756	0.173	0.896	0.804	0.535
SL	DFL	1.558	0.107	0.899	0.808	1.804
In relation to head length						
HL	HW	-2.675	0.738	0.961	0.925	-2.410*
HL	MW	-3.283	0.483	0.952	0.907	-4.008*
HL	LS	-1.629	0.273	0.931	0.834	-2.519*
HL	ED	1.710	0.115	0.809	0.654	3.843*

* Significant at 5% level of significance

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