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INTERRELATIONSHIPS AMONG THE SPECIES OF THE GENUS *PUNTIUS* (TELEOSTEI, CYPRINIDAE) AS INDICATED BY THE CAUDAL SKELETONS

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Abstract

The studies on the osteology of caudal skeleton and the ray counts showed that the species of Puntius *studied fall into two groups, one containing* 11 *species and the other with one species. The major group with* 11 *species has a primitive caudal skeleton with* 6 *free hypurals and* 16 *or more branched rays, the minor group with one species has an advanced caudal skeleton with* 5 *free hypurals and* 15 *branched rays.*

Key words: Caudal skeleton, Hypurals, Parhypural, Uroneurals, Epurals

1. Introduction

Characters of the caudal skeleton are widely used to demonstrate the phylogenetic relationships among fishes. Gosline (1961) brought about the similarities among the subfamilies of Salmonidae. He also demonstrated that *Kuhlia, Chaetodon, Polydoctylus* with six fin elements are primitive. Gosline (1965) used caudal characters with some other features such as circumorbital bones and suprabranchial organ to study the Phylogeny of Teleostei. According to him, unlike the other features, which are practically undeterminable in fossils, the caudal skeleton can and often been used in such material to excellent advantage. Vladkov (1954) showed that in the taxonomy of chars (Salmonidae) the most important sections of the skeleton is the tail and the head. He brought about the differences among the species of the genus *Salvelinus* and also the differences among the genera, *Salvelinus, Christivomer* and *Salmo* of Salmonidae. In a comparative osteological study of Salmonid Fishes, Norden (1961) showed that there is a variation of size and shape of fin elements of caudal skeletons of species within the genera and between the genera. Retaining of maximum number of independent bones in caudal skeleton of *Scianops gill* (Telesotei: Seiaenidae) was discribed as a primitive character by Topp and Cole (1968). On the other hand reduction of the number of independent bones by fusion and simplification of the caudal skeleton is an evolutionary advanced character. This is evident by the study of *Hippoglossoides platessoides* (Perciform) by Frame, Andrews and Cole (1978). Collette and Chao (1975) used caudal skeleton in the systematics of the *Bonitos* (Sarda) and their relatives (Scombridae: Sardini). The purpose of the present study was to provide a detailed study of caudal skeletons of *Puntius* (Teleostei: Cyprinidae) initially with a view to expand on it to encompass the entire osteology so as to obtain an overview of the family Cyprinidae. When such a broader view of other genera are obtained the generic status of *Puntius* will be easier to understand.

2. Materials and Methods

Five caudal fins with the last few vertebrae from each species of known standard length were digested in 2% potasium hydroxide and stained in Alizarin Red S and was kept in 50% glycerol. Skeletons were examined and studied under the stereomicroscope. Bones were disarticulated whenever needed in 4% KOH solution. These were identified according to Goslin (1961) and drawings whenever needed were made under the stereomicroscope. Following abbreviations were used throughout to label the bones.

List of Bones and abbreviations

EP	—	Epural
Hs	—	Haemal Spine
HYP	—	Hypural
Lepl	—	Unbranched Lepidotriehs
LepII	—	Branched Lepidotrichs
Ns	—	Neural spine
PHYP	—	Parhypural
PU2	—	First Preural Centrum
PU3	—	Second Preural Centrum
TP	—	Transparent Bony Plates
U	—	Urostylar Vertebra
UNI	—	First Uroneural
UN2	—	Second Uroneural)

The species of *Puntius* in this study were initially identified from the descriptions given by Deraniyagala (1958), Deraniyagala (1962), Mendis and Fernando (1962) and Munro (1955).

3. Results

The caudal skeleton of *Puntius* is built on a general plan (Fig. 1) consisting of two pairs of uroneurals (UN 1, UN 2), six unpaired free median hypurals (HYP1-HYP6), one unpaired Parhypural (PHYP) and two epurals (EP1, EP2), all of which are cartilage bones. The last three vertebra the Urostyle (U), the penultimate or the first preural (PU2) and the antipenultimate or the Second preural (PU3) of the axial skeleton are involved in caudal support. The dermal bones are the lepidotrichs which have paired branched or unbranched rays.

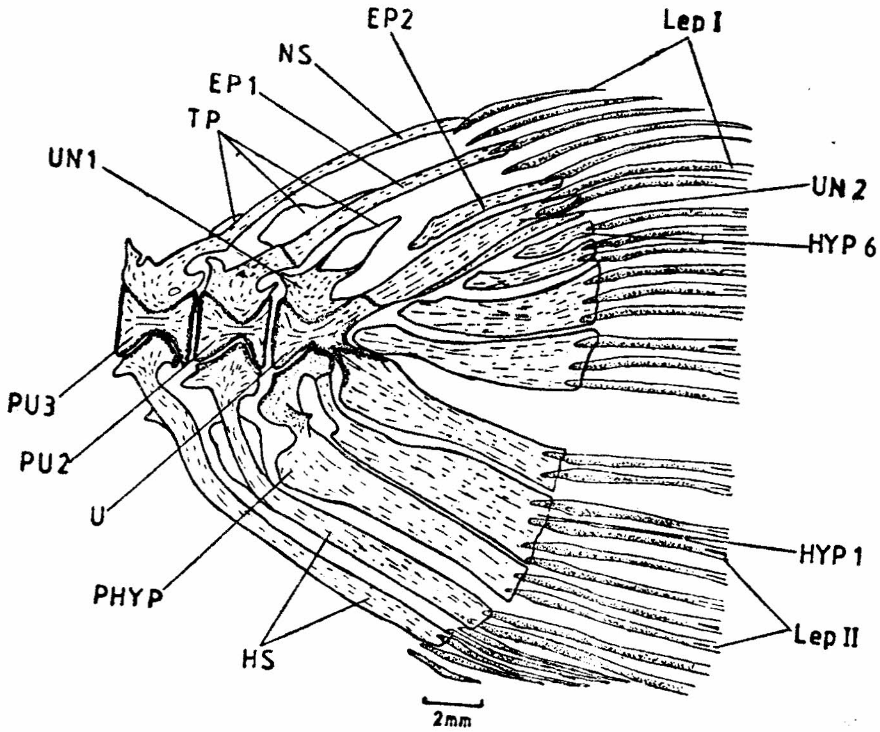

Figure 1. Caudal skeleton of *Puntius sarana*

The haemal spine and the neural spine of the second preural vertebra (PU3) are opposite each other and are somewhat broader than that of other caudal vertebra. They extend backward to the bases of unbranched lepidotrichs. The haemal spine of PU2 is also broad extending backward to articulate with three unbranched lepidotrichs. The neural spine of PU2 is stunted and articulate with the long first epural (EP1). The inflected distal end of urostyle (U) articulate firmly with the second uroneural (UN2) while the dorsal side firmly articulate with the first uroneural (UN1). The ventral side of the urostyle articulate with the parhypural (PHYP) and first two hypurals (HYP1 and HYP2).

3.1 Epurals (EP1 apd EP2, Fig. 1)

There are two rod shaped unpaired epurals (EP1, EP2). The proximal end of EP1 is club shaped and articulate with the stunted neural spine of PU2. Epural 1 is long and look like a neural spine of a caudal vartebra and the distal end of it articulate with one or two unbranched lepidotrichs. The epural 2 is shorter than EP1 and lie dorsal to the UN2. The distal end of EP2 articulates with an unbranched ray. The shape of the proximal end of EP2 is a species specific character (Fig. 2).

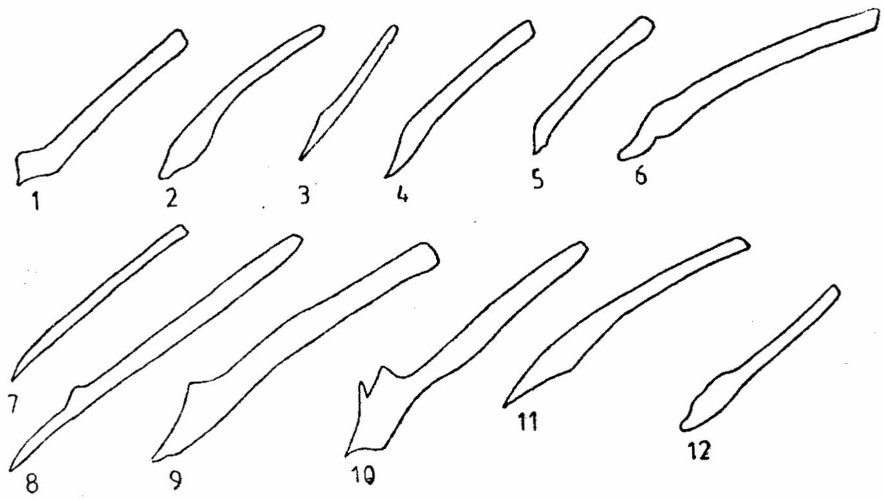

Figure 2. The shape of the second epural of *Puntius* species.

1. *P. amphibius* 2. *P. bimaculatus* 3. *P. vittatus* 4. *P. nigrofaciatus*
5. *P. titteya* 6. *P. sarana* 7. *P. melanamphyx sinhala* 8. *P. filamentosus*
9. *P. dorsalis* 10. *P. pleurotaenia* 11. *P. chola* 12. *P. cumingi*

3.2 Uroneurals (UN1 and UN2. Fig 1.)

There are two pairs of uroneurals in all *Punt.us* species studied. The first pair of uroneurals (UN1) is very short and stout and firmly articulate with the dorsal side of the urostyle. Dorsal side of the UN1 articulates with a horn like transparent bony plate which extends backward.

The second pair of uroneurals (UN2) are long and flattened sideways. The proximal end of it firmly articulates with the urostyle while the distal end is free. The free distal end of UN2 articulates with two unbranched lepidotrichs.

3.3 Parhypural (PHYP Fig. 1)

Parhypural is a long and broad unpaired bone which is loosely articulated to the ventral side of the urostyle. Proximally this bone bears a weak dorsolaterally directed spine (Hypurapophyses of Nursall 1963) which provides attachment for the hypochordal longitudinal musculature. Broad distal end of the parhypural articulate with three branched lepidotrichs.

3.4 Hypurals (HYP 1-6, Fig. 1)

There are six hypurals in the *Puntius* species studied. Hypurals are unpaired, laterally compressed broad elements. They form a broad base to articulate with branched lepidotrichs of the caudal fin. The narrow proximal end of the first hypural (HYP1) articulate with the enlarged proximal end of the parhypural which articulate with the urostyle. The second and the third hypurals (HYP2 and HYP3) directly articulate with the posterior end of the urostyle while the fourth fifth, and sixth hypurals (PHY4, PHY5 and PHY6) articulate with the postventral margin of the second uroneurals. The articulation of HYP2 with the urostyle is firm while the articulation of HYP3 with the urostyle is loose. The length and breath of hypurals gradually decrease from HYP1 to HYP6. A number of branched rays articulate with each hypural for eg. three or four branched rays articulate with the HYP1, two branched rays articulate with the HYP2, three branched rays articulate with the HYP3, three or four branched rays articulate with the HYP4 and two branched ray articulate with HYP5.

3.5 Lepidotrichs (Lep-I and Lep-II, Fig. 1)

Lepidotrichs are the paired or unpaired fin rays which articulate with the bones of the caudal skeleton. There are two types of lepidotrichs, branched (LepII) and unbranched (LepI). The branched rays are confined to the middle portion of the caudal fin while the unbranched rays are confined to the dorsal and ventral sides of branched rays. All branched rays are long and articulate with parhypural and hypurals only. On the other hand unbranched rays increase in length from anterior to posterior and articulate with neural spines haemal spines, epurals and uroneurals. The bases of all rays are peg-like without enlarged procurrent spur of Jonson (1975).

Table I. The number of branched and unbranched lepidotrichs of *Puntius*.

Species	Number of Unbranched Lepidotrichs	Number of Branched Lepidotrichs	Total Number of Lepidotrichs
P. filamentosus	14	17	31
P. sarana	14	17	31
P. dorsalis	17	17	34
P. pleurotaenia	17	17	34
P. chola	14	17	31
P. nigrofaciatus	13	17	30
P. amphibius	16	17	33
P. bimaculatus	15	17	32
P. vittatus	16	17	33
P. titteya	19	15	34
P. melanamphyx sinhala	13	17	30
P. cumingi	12	16	28

3.6 Transparent Bony Plates (TP, Fig. 1)

There are transparent bony plates articulated with neural spines, epurals and uroneurals (TP. Fig. 1). These are articulated to neural spine of PU3, EP1 and UN1. The size and shape of these bones vary in specimens obeved.

Although the above is the general plan of caudal skeleton of *Puntius* there are two deviations from it. One is the reduction of the number of hypurals from six to five in *P.titteya* (Fig. 3). The other deviation is the fusion of two centra of PU3 and PU2 of *P. amphibius* (Fig. 4).

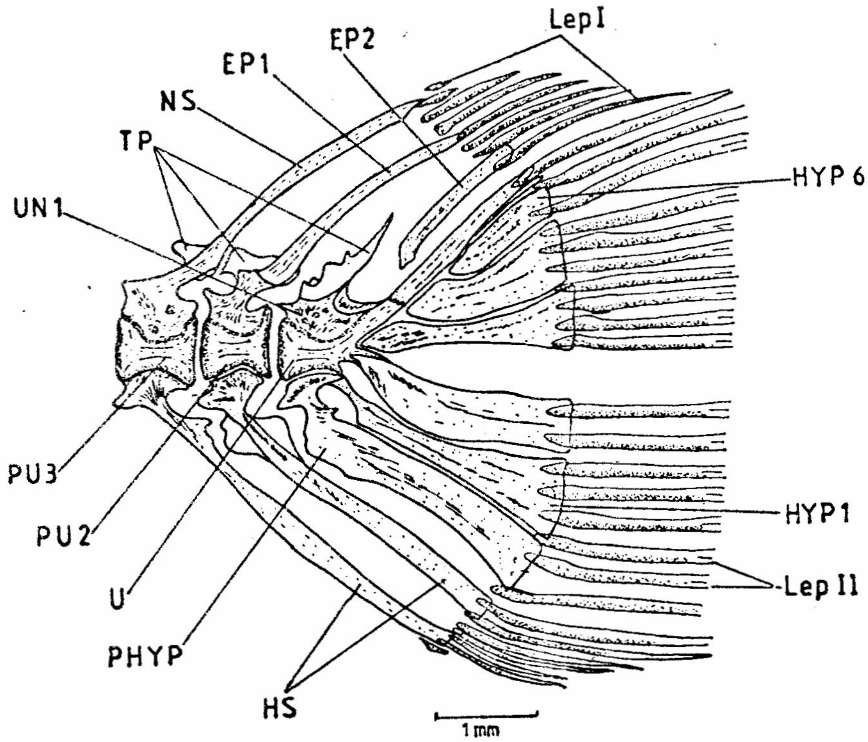

Figure 3. The caudal skeleton of *P. titteya*

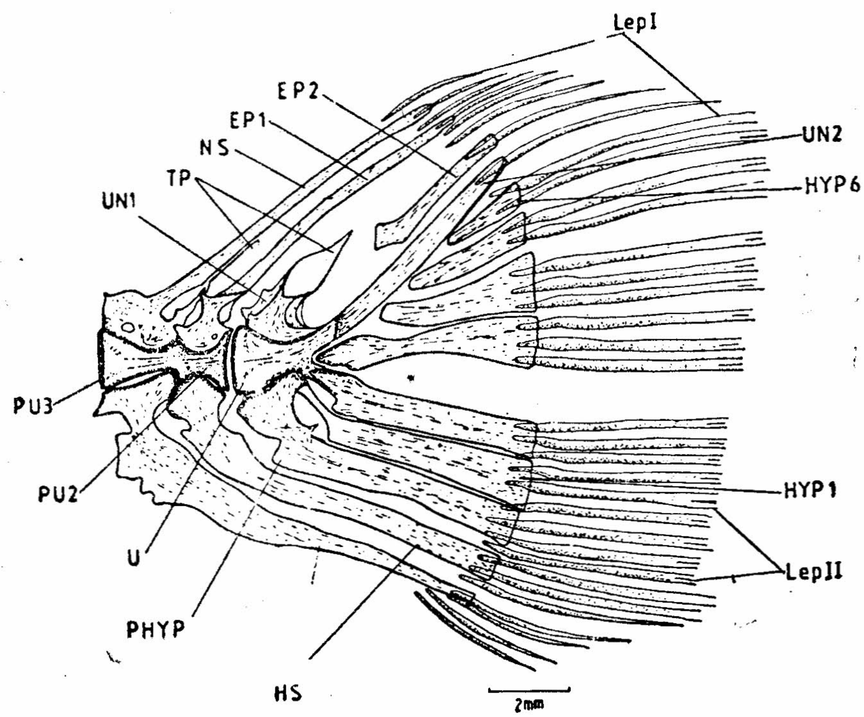

Figure 4. The caudal skeleton of *P. amphibius*

4. Discussion

In primitive fishes such as *Kuhlia, Chaetodon* and *Polydactylus* the caudal skeleton contained six free hypurals. Still more primitive fishes such as *Amia* contained even more, about 15 independent hypurals. These fishes are considered as primitive fishes (Gosline 1961, Norden 1963). On the other hand when the number of free hypurals is smaller than six, such fishes are considered as evolved forms. Accordingly, Scombrids that contained one free triangular caudal plate (Fused hypurals) are considered highly evolved (Collette 1975).

Salmonid fishes such as *Salmo gairdneri, Oncorhynehus gorbuscha. Salvelinus fontinalis* and *Thymallus arcticus* contained seven free hypurals (Norden 1961). Sciaenids or drum fishes such as *Sciaenops gill* also contain the full number of free hypurals (Topp and Cole 1968). Therefore both, Salmonids and Sciaenids are considered as primitive fishes. The Genus *Paralonchurus* was divided into two subgenera namely *Paralonchurus* and *Polychurus* (Jinadasa and Cole 1978). These researchers have pointed out clear distinction in the caudal and skull skeleton in the two subgenera. Seven species of *Paralonchurus* and monotypic genus *Lonchurus* contain six free hypurals. According to Jinadasa and Cole (1978) they are also primitive fishes. The Sciaenid genera *Ctenosciaena* and *Umbriana* for the same reason are also primitive.

Further, based on Nyblin (1963) and Gosline (1961), fishes with large num ber of hypurals and branched rays are primitive. Based on the above, it is evident that the genus *Puntius* in much more primitive than most of the species referred to above. Further it has primitive features such as wing like bones (TP) that articulate to neural spines, epurals and uroneurals. Further the epural 1 is almost identical to a neural spine and the UN2 is also firmly articulated to the urostyle. Based on these characters it is also evident that the genus *Puntius* is primitive. The procurrent spur of Johnson (which is considered as an advanced character) is also absent altogether in species of *Punctius*. Therefore, in general, the genes Puntius is a primitive genus.

Based on the number of branched rays, it is also evident that the genus *Puntius* is primitive as it contains more than 15 branched rays. All the *Puntius* species except *P. titteya* contains more than 15 branched rays. The reduction of number of branched lepidotrichs of *P. titteya* may be attributed to the loss of one hypural. The *Puntius titteya* which contains 5 free hypurals and 15 branched rays is the most advanced among the *Puntius*. On the other hand all the other species studied. *P. filamentosus. P. sarana. P. dorsalis, P. nigrofaciatus, P. amphibius, P. bimaculatus, P. vittatus* and *P. melanamphyx sinhala* contained 6 free hypurals and more than 15 branched rays are the less evolved.

Based on the osteology and the ray count of caudal skeleton of the species of *Puntius* studied, the following phylogenetic relationship as shown in Fig. 5 is evident. Their taxonomic position could be resolved only after the study of their entire osteology.

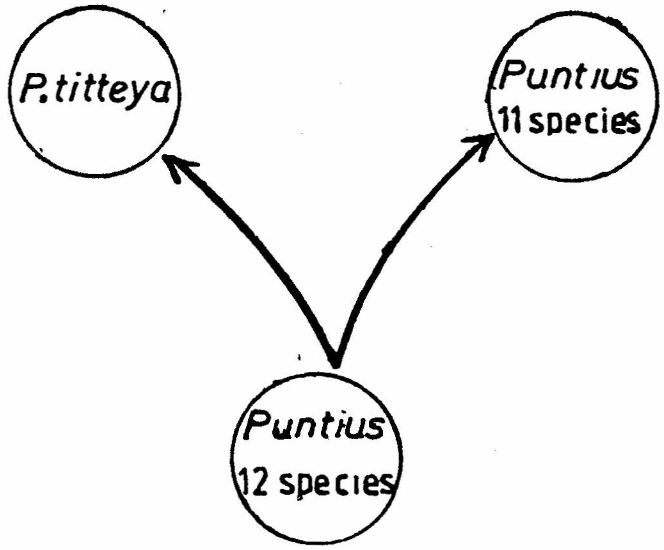

Figure 5. The phylogenetic relationship of 12 *Puntius* species

5. Acknowledgement

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