

Sexual Dimorphism in the Polypterid Fishes, *Polypterus senegalus* and *Calamoichthys calabaricus*

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Sexual dimorphism in polypterid fishes was first described by Boulenger (1907), but no further studies have been made since then. According to Boulenger (1907), the sexes of polypterid fishes are distinguished externally by the form of the anal fin; the male anal fin has thick anterior rays and an enlarged scaly fold at its base, the anterior endoskeletal supports of the fin being fused into a single triradiate bone, whereas the female anal fin has normal rays and a shorter base, the endoskeletal supports not being fused as in the male. In this study, more detailed observations were made on sexual

dimorphism in polypterids. Sex associated morphological differences were found in the caudal skeleton and fine structure of the scales, in addition to the anal fin and its supports.

Materials and Methods

Six adult males (SL; 183.9–280.0 mm, mean 197.5 mm) and six adult females (SL; 153.7–181.1 mm, mean 168.7 mm) of *Polypterus senegalus* Cuvier, imported from western Tanzania, and 10 adult males (SL; 210.4–300.0 mm, mean 248.5 mm) and 10 adult females (SL; 180.5–288.3 mm, mean 233.2 mm) of *Calamoichthys calabaricus* Smith, imported from Nigeria, were used for the study.

Following the method of Dingerkus and Uhler (1977), the caudal skeletons were stained for bone with alizarine red S, for cartilage with alcian blue 8 GX, and then cleared with enzyme solution.

For scanning electron microscopy, scales of *P. senegalus* and *C. calabaricus* were treated with 5% KOH and cleared with supersonic cleaner for 10

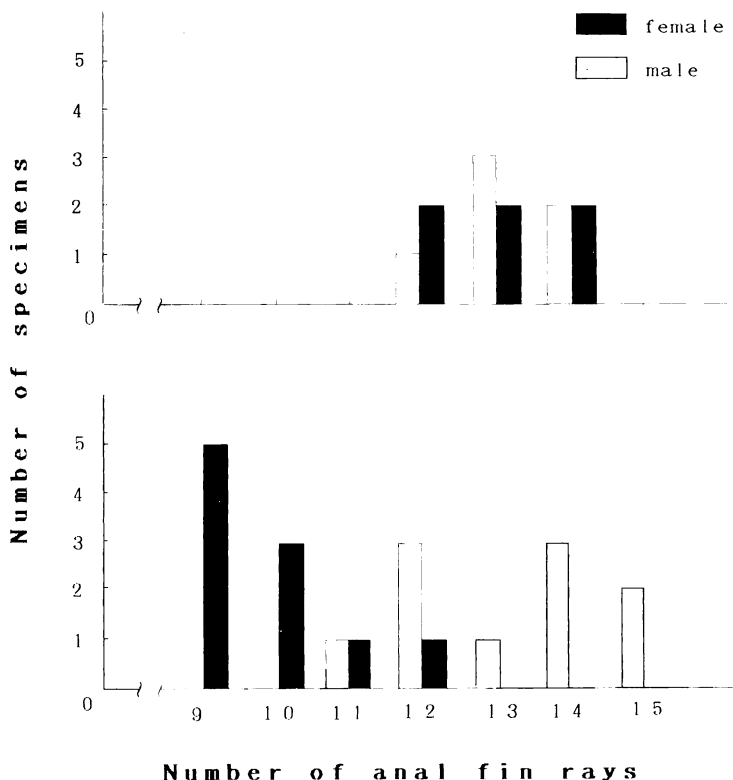


Fig. 1. Number of anal fin rays in the polypterids, *Polypterus senegalus* (above) and *Calamoichthys calabaricus* (below).

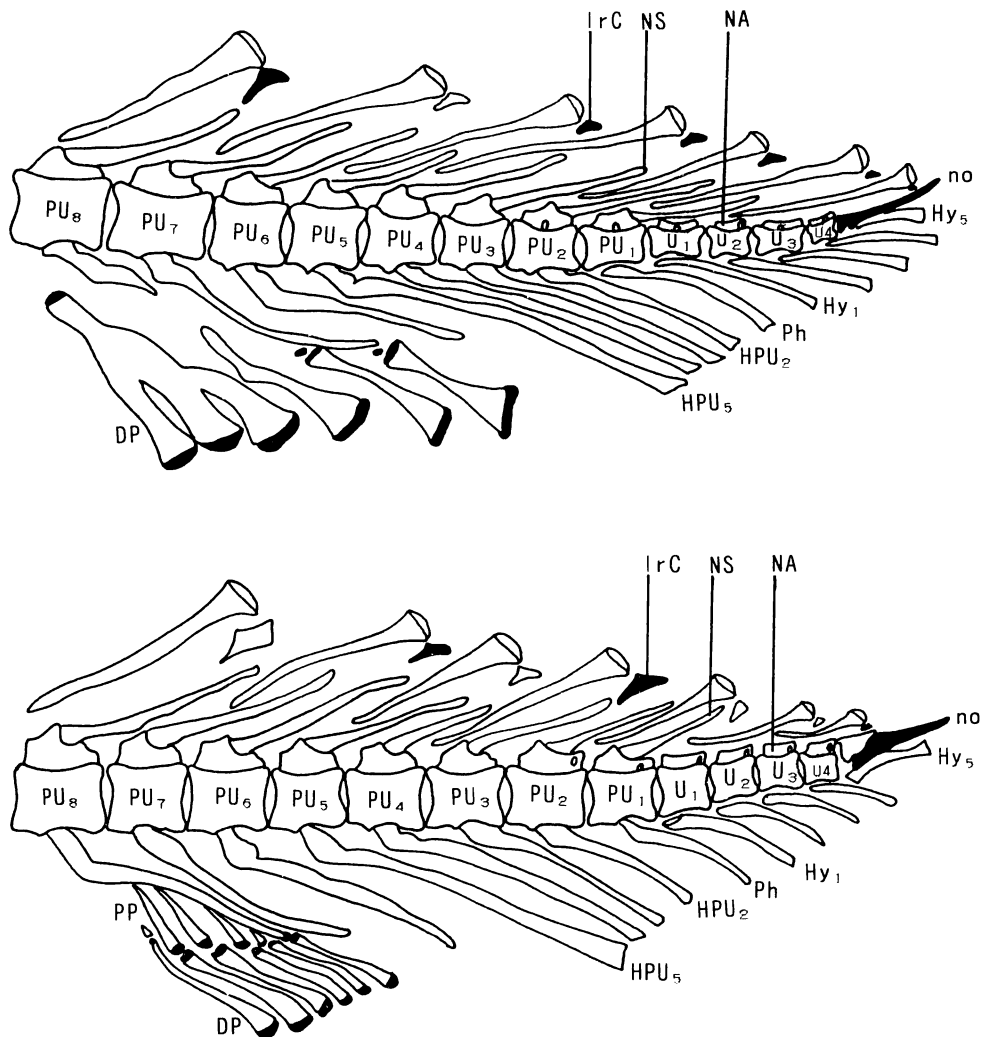


Fig. 2. Endoskeleton of the anal and caudal fins of *Polypterus senegalus*. Above, male; below, female. DP, distal pterygiophore; HPU, haemal spine of preural centrum; Hy, hypural; IrC, interradian cartilage; NA, neural arch; NS, neural spine; no, notochord; Ph, parhypural; PU, preural centrum; PP, proximal pterygiophore; U, ural centrum.

minutes. They were fixed with 2% OsO₄ in phosphate buffer at pH 7.0 for 2 hours, and subsequently dehydrated in ethanol and dried in carbon dioxide gas up to a critical point. The scales were coated with a thin layer of gold and examined with a JEOL JSM-T20 scanning electron microscope.

Results

***Polypterus senegalus*.** The anal fin base was long in males, but short in females. However, the number

of anal fin rays showed no differences between sexes, ranging from 12 to 14 in both (Fig. 1).

In the caudal skeleton, the haemal spine of the preural centrum 8 (PU8) was short and thick in males, but greatly elongate, contacting the proximal ends of the anal fin pterygiophores, in females. The anal endoskeleton comprised a fused triradiate bone and three separate distal pterygiophores (proximal ones absent) in males, and four proximal and six distal pterygiophores in females (Fig. 2).

The body surface was rugged and hard in males,

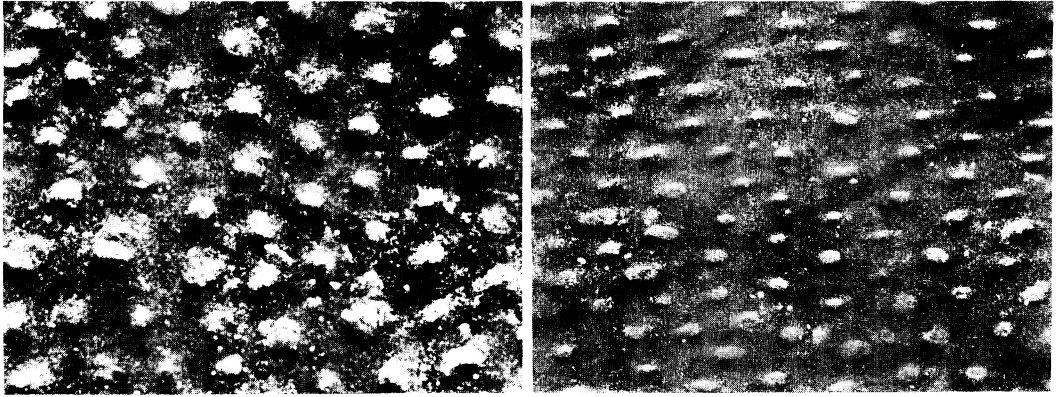


Fig. 3. Scanning electron micrographs of the scales of *Polypterus senegalus*. Right, female; left, male. $\times 1000$.

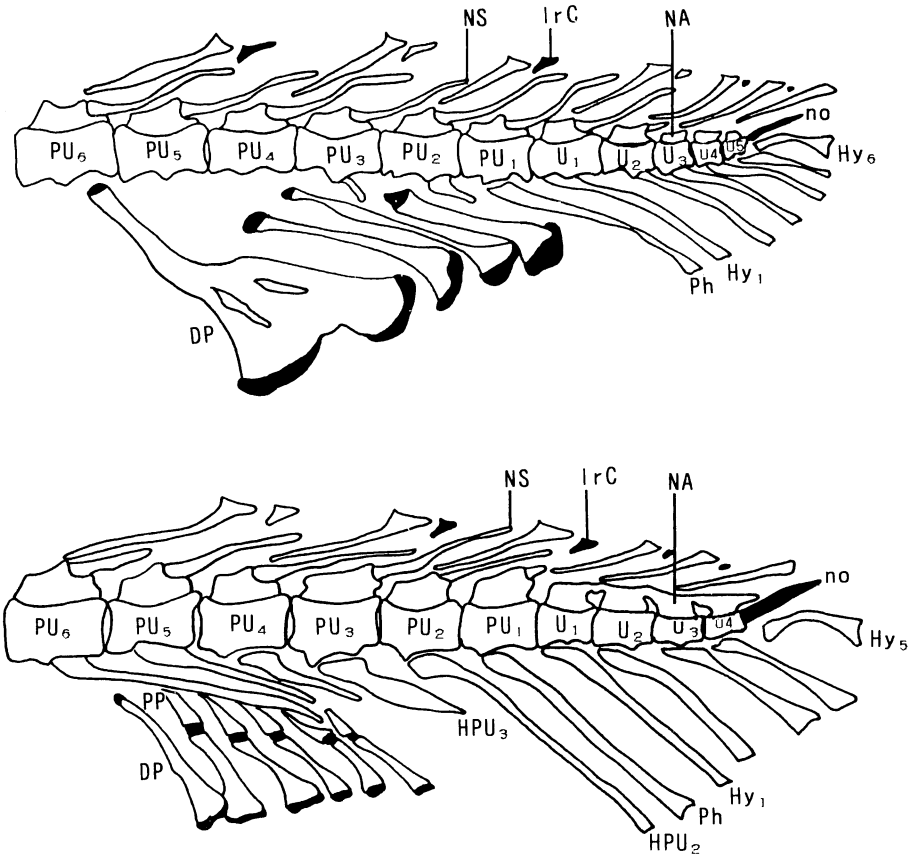


Fig. 4. Endoskeleton of the anal and caudal fins of *Calamoichthys calabaricus*. Above, male; below, female. Legend as Fig. 2.

but smooth and soft in females. This difference was due to the fine structure of the scales. Many small tubercles, 'superficial denticles' (Goodrich, 1907),

occurred on the surface of the scales, such being stouter and higher in males than in females (Fig. 3).

Calamoichthys calabaricus. The anal fin was

long in males, and short in females, as in *P. senegalus*. Anal rays numbered 11 to 15 in the former and 9 to 12 in the latter (Fig. 1).

In the male caudal skeleton, haemal spines of PU4 to PU6 were absent and that of PU3 was vestigial. The pterygiophores comprised a fused flabellum and three separate distal pterygiophores. Proximal pterygiophores were lacking. The proximal end of the fused pterygiophore flabellum was elongate, coming close to PU6.

In the females, the haemal spine of PU6 was elongate, coming close to the anal pterygiophores. The latter varied in number, with 5 or 6 proximal pterygiophores and 6 distal pterygiophores. Specimens having a fused neural arch of the ural centrum (U1-U4) were often observed (Fig. 4).

As in *P. senegalus*, body surface was rugged and hard in males and smooth and soft in females.

Discussion

The observations made in this study indicated that the broad-based, thick anal fin of the male is a derivation from a short-based, thin anal fin, as seen in females, through fusion and enlargement of the skeletal elements.

Regarding the skeletal structure of the anal fin, *Calamoichthys* is more specialized than *Polypterus*, having both a higher degree of fusion of pterygiophores and loss of haemal spines. This is consistent with the specialized external morphological features of *Calamoichthys*, such as the elongation of the body and loss of the pelvic fins.

The sexual dimorphism of the anal fin is relevant to behavioral differences in this family. It has been observed in aquaria that eggs laid by the female are scooped up by the male, probably for insemination, using the anal fin (T. Igarashi, pers. comm.). Even during non-breeding periods, adult males often bend their anal fin into a cup-like shape.

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ポリプテルス科魚類, *Polypterus senegalus* と *Calamoichthys calabaricus* の性的二型

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ポリプテルス科魚類, *Polypterus senegalus* と *Calamoichthys calabaricus* の2種において、臀鰭の形態、臀鰭周辺の骨格形態および鱗の表面構造に性的二型がみられた。両種とも臀鰭の形態は雄が幅広く、雌は細長い。臀鰭の軟条数は *P. senegalus* では雌雄間では差異はみられなかったが、*C. calabaricus* では雄が11-15軟条、雌が9-12軟条と差がみられた。臀鰭周辺の骨格形態では両種ともに雄の臀鰭の近担鰭骨の消失がみられるなど雌の骨格が雄よりも起源的な形態を示すことが観察された。また、鱗の表面構造については両種とも表面の突起が雄では大きく、雌では小さいことが観察された。

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