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Caudal Skeleton Ontogeny in the Adrianichthyid Fish, *Oryzias latipes*

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The caudal skeleton of the adrianichthyid fish, *Oryzias latipes*, has already been studied by several authors for the purposes of detailed observations on the bony elements and the classification and understanding of phylogenetic relationships (e.g. Iwamatsu and Hirata, 1980; Rosen and Parenti, 1981; Yabumoto and Uyeno, 1980). The caudal skeleton of *Oryzias latipes* shows a high degree of fusion. However, the ontogenic developmental osteology of this species was not covered in these papers.

The purpose of this study is to describe and comment on the osteological development of the caudal skeleton of *Oryzias latipes*.

Materials and methods

The specimens of *Oryzias latipes* examined in this study were obtained from eggs spawned in aquaria on 15 May, 1990 and hatched at the Laboratory of Ichthyology, Tokyo University of Fisheries. Incubating and rearing temperatue ranged from 19.5° to 26.5°C (mean, 23.9°C). Larvae and juveniles were fed on egg yolk, *Artemia* nauplii, and live *Daphnia*. A total of 165 specimens ranging from 3.8 mm in notochord length (NL) to 13.3 mm in standard length (SL) were sampled, about five specimens each time, at one or two-day intervals starting from hatching and ending on the 30th day after hatching. They were preserved in 5% buffered formalin. Clearing and staining followed Dingerkus and Uhler's (1977) methods. Observations and illustrations were made under a dissecting microscope equipped with a camera lucida.

The terminology of the caudal skeleton followed Fujita (1990).

Results

The caudal complex of *Oryzias latipes* consists of two epurals, an autogenous parhypural, two hypural plates (one upper and one lower, probably corresponding to fused third, fourth and fifth hypurals, and first and second hypurals, respectively), long neural and hemal spines of the second preural centrum, an extra caudal ossicle, an interhemal spine cartilage of the third preural centrum (CIHPU3), and 9 branched caudal rays (4 in the upper and 5 in the lower lobes). The upper hypural plate is autogenous, and the lower plate is fused with the urostyle at the proximal base.

At 4.0 mm NL (Fig. 1A) (immediately after hatching, 12 days after fertilization), one cartilaginous parhypural (PH) and two hypural plates had already formed beneath the posterior portion of the notochord, which had just started flexing. The lower hypural plate consisting of the first and second hypurals (HY1+2) was the largest of these three elements. One caudal ray extended from below the posterior part of the lower hypural plate and another one from the upper hypural plate (HY3+).

At 4.5 mm NL (Fig. 1B), a cartilaginous bud of the hemal arch of the second preural centrum (HAPU2) was recognizable in front of the parhypural and a very small, cartilaginous second epural (EP2) above the notochord. Two caudal rays could be seen at the posterior ends of each of the two hypural plates.

At 4.8 mm NL (Fig. 1C), the notochord flexion was more pronounced, the preural centra (PU3 and anterior ones) with their associated arches had formed and ossified, and the neural arch of the future second preural centrum (NAPU2) had appeared and begun to ossify. The parhypural became free of the notochord and a single caudal ray extended from it. There were three new rays each extending from the upper and lower hypural plates.

At 5.2 mm NL (Fig. 1D), the ossified first preural centrum plus first ural centrum (PU1+U1) and second preural centrum (PU2) had formed, and the lower hypural plate (HY1+2) was fused with PU1+U1. There were four rays in the upper lobe of the caudal fin and five in the lower.

At 5.5 mm SL (Fig. 1E), the second ural centrum (U2) had formed from the notochord, anterior to the upper hypural plate. A small, free, cartilaginous first epural (EP1) formed anterior to the second epural. The middle part of the parhypural and the proximal part of the hypural plates began to ossify. The neural and hemal arches of the preural centra from PU2 anteriorly had fused at the dorsal and ventral medial planes respectively, and the neural and hemal spines were observable.

At 6.4 mm SL (Fig. 1F), all components of the caudal skeleton were larger than at the previous

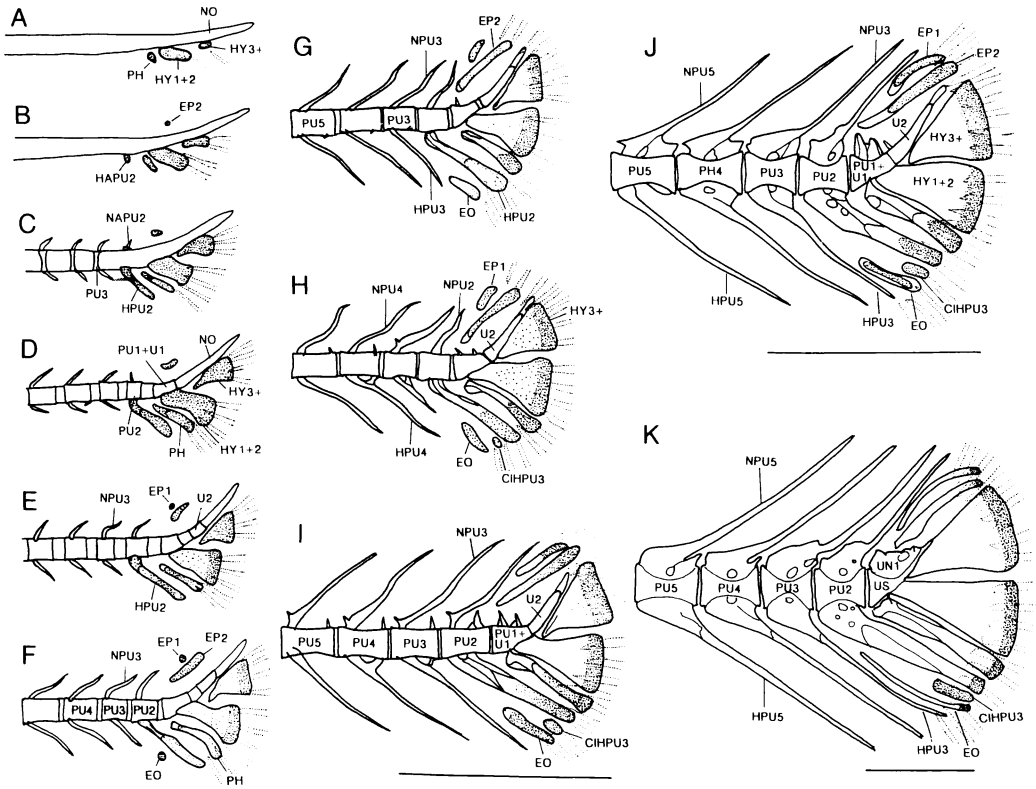

Fig. 1. Development of the caudal skeleton of *Oryzias latipes*. A: 4.0 mm NL. B: 4.5 mm NL. C: 4.8 mm NL. D: 5.2 mm NL. E: 5.5 mm SL. F: 6.4 mm SL. G: 7.2 mm SL. H: 7.9 mm SL. I: 9.0 mm SL. J: 10.2 mm SL. K: 26.0 mm SL (adult specimen). CIHPU3, interhemal spine cartilage of PU3; EO, extra caudal ossicle; EP, epural; HY1+2, hypural 1 plus hypural 2; HY3+, hypural 3 plus hypurals of upper lobe; HAPU, hemal arch of preural centrum; HPU, hemal spine of preural centrum; NAPU, neural arch of preural centrum; NPU, neural spine of preural centrum; NO, notochord; PH, parhypural; PU, preural centrum; U, ural centrum; US, urostyle. Dense dots indicate cartilage. Sparse dots indicate intermediate condition between cartilage and bone. Non-dots areas except notochord indicate bone. Scale bar indicates 0.5 mm.

stage, and the ossified area increased in each element. An extra caudal ossicle (EO) appeared as a small free cartilage in front of the hemal spine of the second preural centrum. The full component of caudal bony elements were present at this stage.

At 7.2 mm SL (Fig. 1G), the two epurals and the extra caudal ossicle began to ossify. An ossified neural arch of PU1+U1 had appeared at the anterodorsal region of the compound centrum, and the second ural centrum became larger. There were eight rays in the upper, and nine in the lower lobes of the caudal fin.

At 7.9 mm SL (Fig. 1H), an ossified second neural arch of PU1+U1 had formed posterior to the first one, and the second ural centrum (U2) had completely attached to the compound centrum (PU1+U1). An interhemal spine cartilage of the third preural centrum (CIHPU3) made its initial appearance between the extra caudal ossicle and the hemal spine of the second preural centrum. There were eight rays in the upper lobe of the caudal fin and nine in the lower.

At 9.0 mm SL (Fig. 1I), all elements of the caudal complex had ossified almost completly. Nine rays in the upper and 10 in the lower lobes of the caudal fin were present.

At 10.2 mm SL (Fig. 1J), a neural arch of the second ural centrum (U2) was formed at the ante-

rodorsal region of the centrum. The two neural arches of the compound centrum (PU1+U1) became larger and fused to each other. The full complement of 20 caudal rays (9 rays in the upper, and 11 in the lower lobes) was reached.

In an adult specimen (Fig. 1K) of 26 mm SL, the second ural centrum and PU1+U1 were completly fused together to form the urostyle (US). The fused neural arch of PU1+U1 and the neural arch of the second ural centrum were also united to form the large uroneural.

Remarks

In *Oryzias latipes*, the two hypural plates, (upper and lower) appear as single elements from the time of hatching. The author considers the upper one to represent normally fused hypurals 3, 4, and 5, whereas the lower one corresponds to fused hypurals 1 and 2. In many advanced teleosts, the urostyle is formed from the very beginning as a single element directly by itself (Potthoff, 1975; Potthoff et al., 1980; Potthoff and Kelley, 1982). However, in *O. latipes*, the second ural centrum is clearly recognizable during the development of the urostyle, indicating that the urostyle is formed by fusion of at least two elements, PU1+U1 and U2. The uroneural (UN1), formed from the fusion of the two neural arches of PU1+U1 and the neural arch of U2, fused with the dorsal part of the urostyle (US). The extra caudal ossicle (EO) is a characteristic feature of the genera *Oryzias* and *Xenopoecilus*, i.e. *O. latipes* (see Rosen, 1964; Iwamatsu and Hirata, 1980; Yabumoto and Uyeno, 1984; Fujita, 1990), *O. celebensis* (see Iwamatsu and Hirata, 1980), *O. javanicus* (see Iwamatsu and Hirata, 1980), *X. poptae* and *X. sarasinorum* (see Rosen, 1964). The extra caudal osscle might be a familial synapomorphy if it is also found in fishes of the genera *Adrianichthys* and *Horaichthys* of the Adrianichthyidae. In the present study, the element from which this extra caudal ossicle differentiated could not be determined.

The interhemal spine cartilage of the third preural centrum (CIHPU3) was the last cartilaginous element of the caudal components formed.

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Literature cited

Dingerkus, G. and L. D. Uhler. 1977. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. Stain Technol., 52(4): 229–232.

Fujita, K. 1990. The caudal skeleton of teleostean fishes. Tokai Univ. Press, 897 pp., 523 figs., 2 plates.

Iwamatsu, T. and K. Hirata. 1980. Comparative morphology of three species of the genus *Oryzias*. Bull. Aichi Univ. Educat., Natural Science, 29: 103–120.

Parenti, L. R. 1981. A phylogenetic and biogeographic analysis of Cyprinodontiform fishes (Teleostei, Atherinomorpha). Bull. Amer. Mus. Nat. Hist., 168, Art. 4: 335–557.

Potthoff, T. 1975. Development and structure of the caudal complex, the vertebral column, and the pterygiophores in the blackfin tuna, (*Thunnus atlanticus*, Pisces, Scombridae). Bull. Mar. Sci., 25(2): 205–231.

Potthoff, T. and S. Kelley. 1982. Development of the vertebral column, fins and fin supports, branchiostegal rays, and squamation in the swordfish, *Xiphias gladius*. Fish. Bull., 80(2): 161–186.

Potthoff, T., W. J. Richards and S. Ueyanagi. 1980. Development of *Scombrolabrax heterolepis* (Pisces, Scombrolabracidae) and comments of familial relationships. Bull. Mar. Sci., 30(2): 329–357.

Rosen, D. E. 1964. The relationships and taxonomic position of the halfbeaks, killifishes, silversides, and their relatives. Bull. Amer. Mus. Nat. Hist., 127(5): 217–268, pls. 14–15.

Yabumoto, Y. and T. Uyeno. 1980. Osteology of the rice fish, *Oryzias latipes*. Bull. Kitakyushu Mus. Nat. Hist., 5: 143–161.

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メダカの尾部骨格の発達

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1990年5月15日に受精したメダカ (*Oryzias latipes*) の卵を孵化させ，その孵化仔魚を30日間飼育し，定期的に仔稚魚をホルマリン固定し，軟骨・硬骨二重染色法で尾部骨格の発達を調べた．

一般的に尾部棒状骨は尾鰭椎前第1椎体と尾鰭椎とが癒合して形成されると言われているが，スズキ目魚類では多くの場合，尾部棒状骨は直接形成され両者の癒合による形成の証拠は明かではない．メダカの場合，その発達過程において尾鰭椎前第1椎体＋第1尾鰭椎 (PU1+U1) と第2尾鰭椎 (U2) が明瞭に現われ，成長に伴って両者は癒合し，尾部棒状骨が形成されることが明らかとなった．尾神経骨はその発生過程では，多くの魚種に見られるような独立した要素として出現せず，尾部棒状骨が形成される前の二つの椎体 (PU1+U1, U2) の神経弓門が癒合して形成された．*Oryzias*, *Xenopoecilus* 両属に共通して認められる補尾骨の由来は明らかでない．

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