

## Comments on the Development of Fin-supports in Fishes

Hiroshi Kohno and Yasuhiko Taki

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The cartilaginous-osteological development of teleostean fishes remained little studied largely because of technical difficulties. With the development of techniques for clearing and staining whole specimens through the works of Taylor (1967, for bone only) and Dingerkus and Uhler (1977, for both cartilage and bone), a great deal of knowledge has been accumulated concerning the cartilaginous-osteological development of fish larvae of various species by many workers, notably by Potthoff (see Table 1). This study is designed to discuss some topics raised through our previous study on the cartilaginous-osteological development of *Pagrus major* larvae (Kohno et al., 1983). This study concurrently reviews works of many researchers listed in Table 1. Supplemental observations were made in 24 species. Fin-supports of all fins except for the ventral are dealt with in this study.

Terminologies generally follow Starks (1930), Eaton (1945) and Monod (1968).

**Material examined.** *Engraulis japonica* (Houttuyn) (18 specimens; 17.00~40.70 mm in SL). *Oncorhynchus keta* (Walbaum) (27; 21.90~68.90). *Rhodeus ocellatus ocellatus* (Kner) (24; 5.50~39.60). *Synodontidae* sp. (5; 14.25~38.15). *Poecilia reticulata* Peters (21; 5.75~14.70). *Atherion elymus* Jordan et Starks (28; 10.30~16.40). *Seriola quinqueradiata* Temminck et Schlegel (5; 13.95~25.85). *Trachurus japonicus* (Temminck et Schlegel) (5; 11.95~29.15). *Tilapia nilotica* (Linnaeus) (33; 6.45~19.75). *Coryphaena hippurus* Linnaeus (5; 12.80~77.35). *Leiognathus rivuratus* (Temminck et Schlegel) (33; 9.60~21.90). *Pempheris japonica* Döderlein (5; 10.35~35.70). *Pempheris xanthoptera* Tominaga (31; 6.45~22.40). *Lateolabrax japonicus* (Cuvier) (10; 21.60~36.25). *Terapon jarbua* (Forsskål) (10; 7.15~11.20). *Rexea prometheoides* (Bleeker) (1; 117.55). *Auxis* sp. (24; 3.55~9.05). *Euthynnus affinis* (Cantor) (8; 3.60~7.05). *Katsuwonus pelamis* (Linnaeus)

(21; 3.80~16.45). *Scomber japonicus* Houttuyn (48; 3.60~15.90) (cf., Kohno et al., in press). *Trichiurus lepturus* Linnaeus (5; 24.35~195.40 mm in TL). *Mugilogobius abei* (Jordan et Snyder) (12; 2.00~15.50). *Hexagrammos otakii* Jordan et Starks (19; 8.70~17.20). *Stephanolepis cirrhifer* (Temminck et Schlegel) (4; 4.45~17.80).

**Dorsal and anal fin-supports.** The structures of the dorsal and anal fin-supports were minutely studied by Bridge (1896) and Eaton (1945). Lindsey (1955) reviewed meristic relations in the dorsal and anal fins of teleosts. Anterior dorsal fin-supports and predorsal bones were examined by Smith and Baily (1961) and Kendall (1976) in relation to its phylogenetic significance within the percoids.

The distal and proximal radials were observed as originating from an elongate cartilaginous

Table 1. Selected literature on the cartilaginous-osteological development of fin-supports, shown in chronological order with family names dealt with.

Year	Author	Family
1974	Houde et al.	Clupeidae
1975	Potthoff	Scombridae
1976	Houde and Potthoff	Sparidae
1977	Futch	Bothidae
	Hensley	Bothidae
	Mook	Sparidae
1979a	Leiby	Ophichthidae
b	Leiby	Ophichthidae
1980	Fritzsche and Johnson	Percichthyidae
	Matarese et al.	Gadidae
	Potthoff	Coryphaenidae
	Potthoff et al.	Scombro-labracidae
	Powell and Gordy	Sciaenidae
	Richardson et al.	Pleuronectidae
1981	Leiby	Ophichthidae
1982	Markle	Gadidae
	Matarese and Marliave	Cottidae
	Matsuoka	Sparidae
	Potthoff and Kelley	Xiphiidae
	Tucker	Bothidae
1983	Dunn	Review
	Kohno et al.	Sparidae
In press	Kohno et al.	Scombridae

pterygiophore during ontogeny in such genera as *Thunnus* (Potthoff, 1975), *Coryphaena* (Potthoff, 1980), *Scombrolabrax* (Potthoff et al., 1980) and *Xiphias* (Potthoff and Kelley, 1982). However, in our observations on *Pagrus major*, the distal radial was first seen in a 6.40 mm NL specimen, in which the radial is rather widely separated from the proximal radial (Kohno et al., 1983, figs. 2, 3). As development goes on, these two radials come in close contact. This suggests that both radials have their own cartilaginous center and they are connected by a connective tissue.

The anteriormost anal pterygiophore is originated from two cartilaginous pieces in *Thunnus* (Potthoff, 1975), *Morone americana* (Fritzsche and Johnson, 1980) and *Scombrolabrax* (Potthoff et al., 1980). We observed the same condition in *Tilapia nilotica* and *Auxis* sp. As to the anteriormost dorsal pterygiophore, however, Smith and Baily (1961) mentioned that it is not possible for the pterygiophore to originate from the fusion of two elements, and Potthoff (1975) found no evidence of this fusion during the ontogeny of *Thunnus*. Whereas, from observation of two parallel struts of bony tissues in the first dorsal pterygiophore, Kendall (1976) indicated the possible origin of the pterygiophore from a fusion of two elements. Fritzsche and Johnson (1980) directly observed the first dorsal pterygiophore originated from two elements in *Morone americana*, but it was not detected in the related species, *M. saxatilis*. They may have failed in observing it in the latter species, because, as mentioned by themselves, the elements remain separated for only a very short time.

In our observations of *Pagrus major*, in which the first dorsal pterygiophore supports two spines by secondary (non-serial) association, the pterygiophore of initial stages consists of two struts connected by thin cartilage stained palely, indicating its derivation from two cartilaginous pieces (Kohno et al., 1983, fig. 2). On *Scomber*, in which the first dorsal pterygiophore supports one spine by secondary association, Kramer (1960) mentioned that the pterygiophore is derived from two elements. However, in *S. japonicus* we could observe neither separated cartilaginous nor a two-strut condition as in *P. major* (cf., Kohno et al., in press, fig. 1). Thus our observations seem to support Kendall's (1976) opinion

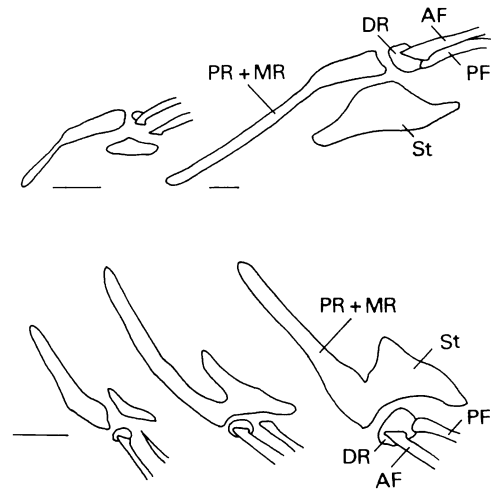


Fig. 1. Development of the last dorsal fin elements in *Tilapia nilotica* (top) and the last anal fin elements in *Pempheris japonica* (bottom). Larval sizes in SL are, starting from the left, 9.50 and 19.75 for top, and 10.35, 14.55 and 35.70 for bottom. All elements excepting the last double fin-ray are cartilage. AF, anterior fin-ray of last double fin-ray; DR, distal radial; MR, middle radial; PF, posterior fin-ray of last double fin-ray; PR, proximal radial; St, stay. Scale bars: 0.1 mm.

that the pterygiophore supporting two spines by secondary association might have originated from two pieces of cartilage.

Usually one additional radial, the vestigial radial element of Bridge (1896) or stay of Weitzman (1962), is present posterior to the last dorsal and anal pterygiophores. The gempylids have two stays (Potthoff et al., 1980; present obs.) and *Coryphaena* has no stay (Potthoff, 1980; present obs.). On the origin of the stay, Potthoff (1975, 1980), Potthoff et al. (1980) and Potthoff and Kelley (1982) mentioned that it originated from the last cartilaginous proximal (-middle) radial and is not a vestige of fin-support. Our observations on *Pagrus major*, *Scomber japonicus*, *Oncorhynchus keta*, synodontid sp., *Tilapia nilotica* and two species of *Pempheris*, however, suggest that the stay is originally different from the last pterygiophore. In early stages, the two rays of the last double fin-ray are widely separated, the anterior ray attaches to the last pterygiophore and the

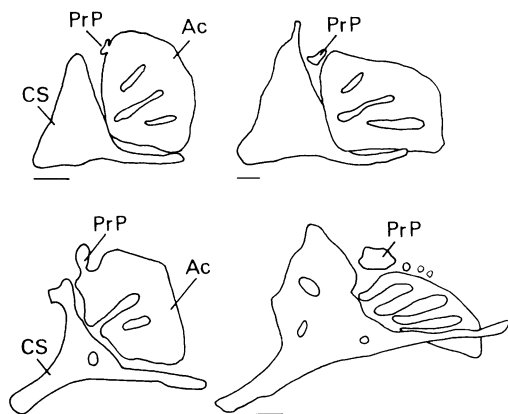


Fig. 2. Development of the primary shoulder girdle in *Engraulis japonica* (top) and *Oncorhynchus keta* (bottom). Larval sizes in SL are 25.85 (left) and 30.40 (right) for top, and 22.30 and 29.70 for bottom. All elements are cartilage. Ac, actinost (blade-like cartilage); CS, coraco-scapular cartilage; PrP, propterygium. Scale bars: 0.2 mm.

posterior one is situated close to the stay (Fig. 1). With growth the proximal (-middle) radial and stay fuse together, and the posterior ray moves forward, thus forming a double fin-ray on the last pterygiophore (Fig. 1). From this the stay is considered to be a vestige of a fin-support. This view agrees with the opinions of Bridge (1896) and Potthoff (1974) in the respect that the stay is a reduced proximal radial.

**Pectoral girdle.** The cartilaginous-osteological development of the pectoral skeleton was studied by Swinnerton (1905) for *Salmo salar* and *Gasterosteus aculeatus*. Starks (1930) described the primary shoulder girdle of a large number of fish in detail.

The coracoid and scapula originated from a cartilaginous plate, or the coraco-scapular cartilage, through ossification in each part. Saksena and Richards (1975) reported the appearance of an unstained Y-shaped coracoid, which was judged by Potthoff (1980) as a coraco-scapular cartilage. Our observations on all species support Potthoff's (1980) judgement. The actinosts (=proximal radials) are derived from a blade-like cartilage. Both the coraco-scapular and blade-like cartilages remain as they are in adult *Dallia* (Starks, 1930) and adult sundasarangids (Roberts, 1981). The pro-

pterygium (Jessen, 1973) is derived from the blade-like cartilage in *Engraulis japonica* and *Oncorhynchus keta* (Fig. 2). The possibility was suggested by Starks (1930) that the pectoral condyle supporting the uppermost fin-ray may be an ankylosed actinost. Potthoff and Kelley (1982), on the other hand, mentioned that the condyle originated from the upper part of the coraco-scapular cartilage, i.e., the scapular cartilage. However, the condyle develops neither from the scapular cartilage nor from the blade-like cartilage in our observations. The condyle may have its own cartilaginous center, and may possibly be homologous with the distal radials (cf., Kohno et al., 1983, fig. 5).

**Caudal complex.** The caudal complex occupies an important position in phylogenetic studies. A great deal of knowledge concerning its structure has accumulated on various groups of fishes, and phylogenetic relationships have been induced from its features (e. g., Hollister, 1936; 1937a, b; Gosline, 1961b; Monod, 1968; Rosen and Patterson, 1969; Rosen, 1973).

The urostyle of primitive fishes is composed of three or more centra which are separated even in adults (e.g., Gosline, 1961a). Though such a separate condition is not seen in all adult higher fishes, their urostyle is considered to have originated from three centra, the preural centrum 1 and ural centra 1 and 2 (Nybelin, 1973; Ahlstrom in Potthoff, 1975). We observed in larval *Pagrus major* a urostyle containing two separate elements, most probably the ural centra 1 and 2 (Kohno et al., 1983, fig. 4C). This agrees with the above view as to the origin of the urostyle of higher fishes. These centra were stained light blue by alcian blue, and hence Kohno et al. (1983) considered them to be cartilage. However, this view is mistaken since the centrum of teleostean fishes develops probably directly from a notochord (Takashima, 1982). Alcian blue is specific for mucopolysaccharides (Dingerkus and Uhler, 1977), and in the above case it may have stained those in the second chorda sheath. According to our observations and Roberts (1981), alcian blue stains uncalcified bone or bone in early stage larvae. Setting aside this misinterpretation, it is interesting from a phylogenetic viewpoint that the separate ural centra 1 and 2 were observed, even though momentarily. Yabumoto (1980) reported the presence of the

preural centrum 1 and ural centrum 1 in *Leio-nathus* larvae, but these centra appear to be the urostyle and relic of the notochord, respectively. Leiby (1981) described separate ural centra in the ophichthid *Bascanichthys bascanium*, though all other ophichthids possess a fused ural centrum (Leiby, 1979a, b, 1981). An urostyle with two-separated parts was described without any comment in *Archosargus* larvae by Mook (1977).

No cartilaginous fusion of the caudal complex takes place in lower fishes, such as the clupeids (Houde et al., 1974) and engraulids (present obs.). During development, bony fusion is seen centering on the uroneurals in lower fishes (Hollister, 1936; Gosline, 1961a).

In hypurals, cartilaginous and bony fusions occur in various ways. Our observations show that cartilaginous fusion at proximal ends takes place between hypurals 1 and 2 in *Oncorhynchus keta* (Fig. 3A) and between the parhypural and hypural 1 in *Rhodeus ocellatus ocellatus* (Fig. 3B). However, cartilaginous fusion takes place more commonly in such a manner in which the proximal ends of the parhypural and hypurals 1 and 2 are fused to form a cartilaginous bar lying ventral to the urostyle (cf., Kohno et al., 1983, fig. 4). With growth, the ossification of these elements goes on, and the cartilaginous bar is lost. In addition to the above-mentioned typical cartilaginous fusion, the distal ends of the hypurals 1 and 2 are fused in *Atherion elymus* (Fig. 3C). In the ophichthids, on the other hand, the hypurals 1 and 2, which are fused at both the proximal and distal ends, are not fused with the parhypural but with the hypural 3 at the proximal end (Leiby, 1979a, b 1981). The cartilaginous hypurals 1 and 2 form a cartilaginous plate from early stages in the cottids, and the cartilaginous parhypural comes to fuse with the plate at both the proximal and distal ends with growth (Matarese and Marliave, 1982). In *Mugilogobius abei* the hypural plate 1+2 shows the same condition as that of the cottids, but no fusion takes place between the plate and parhypural (Fig. 3D). In the bothids (Futch, 1977; Hensley, 1977; Tucker, 1982) and the pleuronectids (Richardson et al., 1980) the hypurals 1 and 2 and the hypurals 3 and 4 are not separated, but they form the hypural plates 1+2 and 3+4 respectively, at their incipient stages. Similarly, the hypural plates 1+2 and 3+4+5 are formed

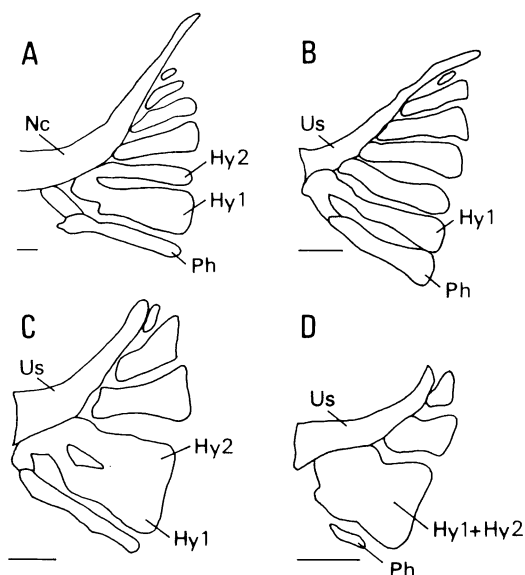


Fig. 3. Fusion of cartilaginous parhypural and hypurals in *Oncorhynchus keta* (A, 25.10 mm SL), *Rhodeus ocellatus ocellatus* (B, 5.80), *Atherion elymus* (C, 10.45) and *Mugilogobius abei* (D, 4.00). Some caudal complex elements are figured. All elements excepting notochord, or urostyle, are cartilage. Hy 1~2, hypurals 1~2; NC, notochord; Ph, parhypural; Us, urostyle. Scale bars: 0.2 mm for A, 0.1 mm for others.

in early stages in the gadids (Matarese et al., 1981; Markle, 1982). Whereas, in the scombrids such cartilaginous fusion comes during early development in the following patterns: the hypurals 1 and 2 are fused into a hypural plate 1+2 with which the proximal end of the parhypural is fused, and the hypurals 3 and 4 are also fused together at a later stage (Potthoff, 1975; present obs.). It is interesting to compare the scombrids with *Coryphaena* (Potthoff, 1980) and *Xiphias* (Potthoff and Kelley, 1982) in which cartilaginous fusion does not occur with the exception of aforementioned typical cartilaginous fusion, but bony fusion takes place in later stages to form a hypural plate as in the scombrids.

Adults of *Coryphaena* have one epural. This epural originates from a bony fusion of two epurals during ontogeny (Potthoff, 1980). Adults of *Trachurus japonicus* possess two epurals, of which the anterior one results from a bony fusion of two epurals in the same way as

in *Coryphaena* (present obs.).

The relation between the specialized neural arch on the preural centrum 2 and the anterior epural in the scombrids shows an interesting case from a phylogenetic viewpoint. Both elements originated from a cartilaginous state, and no cartilaginous fusion occurs. In advanced scombrids, e. g., *Thunnus*, bony fusion occurs in considerably advanced stages (Potthoff, 1975). On the other hand, in adult primitive scombrids, e. g., *Scomber*, the anterior epural is never fused with the specialized neural arch.

Fusion of various parts of the caudal complex observed in the course of ontogeny was discussed by Potthoff (1975, 1980) and Potthoff and Kelley (1982). Gosline (1961b) emphasized the necessity of studies on the ontogenetic fusion of the caudal complex. Important clues for interpretation of higher-level phylogenetic relationships seems to be found in the developmental pattern of the caudal complex.

#### Literature cited

- Bridge, T. W. 1896. The mesial fins of ganoids and teleosts. J. Linn. Soc. London, Zool., 25: 530~602, pls. 21~23.
- Dingerkus, G. and L. D. Uhler. 1977. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. Stain Tech., 52 (4): 229~232.
- Dunn, J. R. 1983. The utility of developmental osteology in taxonomic and systematic studies of teleost larvae: A review. NOAA Technical Report NMFS Circular 450: 1~19.
- Eaton, T. H., Jr. 1945. Skeletal supports of the median fins of fishes. J. Morph., 76 (3): 193~212.
- Fritzsche, R. A. and G. D. Johnson. 1980. Early osteological development of white perch and striped bass with emphasis on identification of their larvae. Trans. Am. Fish. Soc., 109 (4): 387~406.
- Futch, C. R. 1977. Larvae of *Trichopsetta ventralis* (Pisces: Bothidae), with comments on intergeneric relationships within the Bothidae. Bull. Mar. Sci., 27 (4): 740~757.
- Gosline, W. A. 1961a. Some osteological features of modern lower teleostean fishes. Smithson. Misc. Collns., 142 (3): 1~42.
- Gosline, W. A. 1961b. The perciform caudal skeleton. Copeia, 1961 (3): 265~270.
- Hensley, D. A. 1977. Larval development of *Engyophrys senta* (Bothidae), with comments on intermuscular bones in flatfishes. Bull. Mar. Sci., 27 (4): 681~703.
- Hollister, G. 1936. Caudal skeleton of Bermuda shallow water fishes. I. Order Isospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumeriidae, Engraulidae. Zoologica, N. Y., 21 (23): 257~290.
- Hollister, G. 1937a. Caudal skeleton of Bermuda shallow water fishes. II. Order Percomorphi, Suborder Percosces: Atherinidae, Mugilidae, Sphyraenidae. Zoologica, N. Y., 22 (17): 265~279.
- Hollister, G. 1937b. Caudal skeleton of Bermuda shallow water fishes. III. Order Iniomi: Synodontidae. Zoologica, N. Y., 22 (28): 385~399.
- Houde, E. D. and T. Potthoff. 1976. Egg and larval development of the sea bream *Archosargus rhomboidalis* (Linnaeus): Pisces, Sparidae. Bull. Mar. Sci., 26 (4): 506~529.
- Houde, E. D., W. J. Richards, and V. P. Saksena. 1974. Description of eggs and larvae of scaled sardine, *Harengula jaguana*. Fish. Bull. U. S., 72 (4): 1106~1122.
- Jessen, H. L. 1973. Interrelationships of actinopterygians and brachiopterygians: evidence from pectoral anatomy, pp. 227~232. In P. H. Greenwood, R. S. Miles and C. Patterson, eds., Interrelationships of fishes. Academic Press, London, xvi+536 pp.
- Kendall, A. W., Jr. 1976. Predorsal and associated bones in serranid and grammistid fishes. Bull. Mar. Sci., 26 (4): 585~592.
- Kohno, H., Y. Taki, Y. Ogasawara, Y. Shirojo, M. Taketomi and M. Inoue. 1983. Development of swimming and feeding functions in larval *Pagrus major*. Japan. J. Ichthyol., 30 (1): 47~60.
- Kohno, H., M. Shimizu and Y. Nose. (In press). Morphological aspects of the development of swimming and feeding functions in larval *Scomber japonicus*. Bull. Japan. Soc. Fish. Sci.
- Kramer, D. 1960. Development of eggs and larvae of Pacific mackerel and distribution and abundance of larvae 1952~1956. Fish. Bull. Fish Wildl. Serv. U. S., 60 (174): 393~438.
- Leiby, M. M. 1979a. Leptocephalus larvae of the eel family Ophichthidae. I. *Ophichthus gomesi* Castelnau. Bull. Mar. Sci., 29 (3): 329~343.
- Leiby, M. M. 1979b. Morphological development of the eel *Myrophis punctatus* (Ophichthidae) from hatching to metamorphosis, with emphasis on the developing head skeleton. Bull. Mar. Sci., 29 (4): 509~521.
- Leiby, M. M. 1981. Larval morphology of the eel *Bascanichthys bascanium*, *B. scuticaris*, *Ophichthus melanoporus* and *O. ophis* (Ophichthidae), with a discussion of larval identification method. Bull. Mar. Sci., 31 (1): 46~71.
- Lindsey, C. C. 1955. Evolution of meristic rela-

- tions in the dorsal and anal fins of teleost fishes. Trans. Royal Soc. Can., 49 (Ser. 3): 35~49.
- Markle, D. F. 1982. Identification of larval and juvenile Canadian Atlantic gadoids with comments on the systematics of gadid subfamilies. Can. J. Zool., 60: 3420~3438.
- Matarese, A. C. and J. B. Marliave. 1982. Larval development of laboratory-reared rosy lip sculpin, *Ascelichthys rhodorus* (Cottidae). Fish. Bull. U. S., 80 (2): 345~355.
- Matarese, A. C., S. L. Richardson, and J. R. Dunn. 1981. Larval development of Pacific tomcod, *Microgadus proximus*, in the northeast Pacific Ocean with comparative notes on larvae of walleye pollock, *Theragra chalcogramma*, and Pacific cod, *Gadus macrocephalus* (Gadidae). Fish. Bull. U. S., 78 (4): 923~940.
- Matsuoka, M. 1982. Development of vertebral column and caudal skeleton of the red sea bream, *Pagrus major*. Japan. J. Ichthyol., 29 (3): 285~294.
- Monod, T. 1968. Le complexe urophore des poissons téléostéens. Mém. Inst. Fr. Afr. Noire, (81): 1~705.
- Mook, D. 1977. Larval and osteological development of the sheepshead, *Archosargus probatocephalus* (Pisces: Sparidae). Copeia, 1977 (1): 124~133.
- Nybelin, O. 1973. Comments on the caudal skeleton of actinopterygians, pp. 369~372, pl. 1. In P. H. Greenwood, R. S. Miles and C. Patterson, eds., Interrelationships of fishes. Academic Press, London, xvi+536 pp.
- Potthoff, T. 1974. Osteological development and variation in young tunas, genus *Thunnus* (Pisces, Scombridae), from the Atlantic Ocean. Fish. Bull. U. S., 72 (2): 563~588.
- 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. 1980. Development and structure of fins and fin supports in dolphin fishes *Coryphaena hippurus* and *Coryphaena equiselis* (Coryphaenidae). Fish. Bull. U. S., 78 (2): 277~312.
- 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. U. S., 80 (2): 161~186.
- Potthoff, T., W. J. Richards and S. Ueyanagi. 1980. Development of *Scombrolabrax heterolepis* (Pisces, Scombrolabracidae) and comments on familial relationships. Bull. Mar. Sci., 30 (2): 329~357.
- Powell, A. B. and H. R. Gordy. 1980. Egg and larval development of the spot, *Leiostomus xanthurus* (Sciaenidae). Fish. Bull. U. S., 78 (3): 701~714.
- Richardson, S. L., J. R. Dunn and N. A. Naplin. 1980. Eggs and larvae of butter sole, *Isopsetta isolepis* (Pleuronectidae), off Oregon and Washington. Fish. Bull. U. S., 78 (2): 401~417.
- Roberts, T. R. 1981. Sundasalangidae, a new family of minute freshwater salmoniform fishes from southeast Asia. Proc. Calif. Acad. Sci., 42 (9): 295~302.
- Rosen, D. E. 1973. Interrelationships of higher euteleostean fishes, pp. 397~513. In P. H. Greenwood, R. S. Miles and C. Patterson, eds., Interrelationships of fishes. Academic Press, London, xvi+536 pp.
- Rosen, D. E. and C. Patterson. 1969. The structure and relationships of the paracanthopterygian fishes. Bull. Am. Mus. Nat. Hist., 141 (Art. 3): 357~474.
- Saksena, V. P. and W. J. Richards. 1975. Description of eggs and larvae of laboratory-reared white grunt, *Haemulon plumieri* (Lacépède) (Pisces, Pomadasyidae). Bull. Mar. Sci., 25 (4): 523~536.
- Smith, C. L. and R. M. Baily. 1961. Evolution of the dorsal-fin supports of percoid fishes. Pap. Michigan Acad. Sci. Arts and Letters, 46: 345~363, pl. 1.
- Starks, E. C. 1930. The primary shoulder girdle of the bony fishes. Stanf. Univ. Publ., 6: 147~239.
- Swinnerton, H. H. 1905. A contribution to the morphology and development of the pectoral skeleton of teleosteans. Q. J. Microsc. Sci., 49 (Pt 2): 363~382, pl. 23.
- Takashima, F. 1982. Skeleton, pp. 16~20. In T. Hibiya, ed., An atlas of fish histology: normal and pathological features. Kodansha Scientific Books, Kodansha, Tokyo, xi+147 pp.
- Taylor, W. R. 1967. An enzyme method of clearing and staining small vertebrates. Proc. U. S. Natn. Mus., 122 (3596): 1~17.
- Tucker, J. W., Jr. 1982. Larval development of *Citharichthys cornutus*, *C. gymnorhinus*, *C. spilopterus*, and *Etropus crossotus* (Bothidae), with notes on larval occurrence. Fish. Bull. U. S., 80 (1): 35~73.
- Weitzman, S. H. 1962. The osteology of *Brycon meeki*, a generalized characid fish, with an osteological definition of the family. Stanf. Ichthyol. Bull., 8 (1): 1~77.
- Yabumoto, Y. 1980. Caudal skeleton in three genera of leiognathid fishes. Bull. Kitakyushu Mus. Nat. Hist., 2: 33~39.

(HK: Department of Fisheries, Faculty of Agriculture, University of Tokyo, 1-1, Yayoi 1, Bunkyo-ku, Tokyo 113, Japan; YT: Tokyo University of Fisheries, 5-7, Kohnan-4, Minato-ku, Tokyo 108, Japan)

#### 魚類の鱭支持骨の形成過程

河野 博・多紀保彦

マダイの研究途上で生じた鱭支持骨の形成過程に関する問題について、他の 24 種の仔稚魚の観察を補足して考察した。

その結果、以下のことが示唆された：背・臀鱭の近

担鱭骨と遠担鱭骨は別々の軟骨から生じる；最前部の近担鱭骨は、2本の棘と2次的に関節している場合には、2つの近担鱭骨から由来する；stay は担鱭骨のこん跡である；烏口骨と肩甲骨は単一の軟骨から発達する；輻射骨は1枚の軟骨板から分化する；特化した魚類の尾部棒状骨は2個の尾鱭椎と1個の尾鱭椎前椎体からなる；尾骨のゆ合は魚種によって、そのパターンが異なる。

(河野：113 東京都文京区弥生 1-1-1 東京大学農学部；多紀：108 東京都港区港南 4-5-7 東京水産大学)