Bull. Fish. Sci. Hokkaido Univ.
66(2), 59-61, 2016.
DOI 10.14943/bull.fish.66.2.59

Anatomical Features of the Pelvic Girdle in the Family Ateleopodidae (Pisces : Ateleopodiformes)

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(Received 22 January 2016, Accepted 1 March 2016)

Abstract

The osteology and myology of the pelvic girdle in a deep sea ateleopodiform fish, *Ateleopus japonicus*, were studied. The pelvic girdle is characterized by four unique features : (1) a pelvis that consists of a cartilaginous plate with a pair of large openings, (2) a pelvic fin that is thread-like owing to a greatly elongated first fin ray and subsequent rays that are concealed under the skin, (3) a greater number of muscles inserted on the first pelvic ray than in other teleosts, and (4) a pelvis that supports fin rays laterally, allowing muscles to insert on the first pelvic ray both anteriorly and posteriorly. The latter three characteristics suggest that the pelvic fin of *A. japonicus* is highly flexible and mobile. As demonstrated in other fishes with thread-like pelvic fins, this fin may not function in swimming, but may function in other actions such as searching for prey or signaling.

Key words : Ateleopodiformes, *Ateleopus japonicus*, Morphology, Pelvic girdle

Introduction

The family Ateleopodidae is widely distributed in temperate and tropical seas. Its anatomy is characterized by several factors : a reduced caudal fin continuous with a long anal fin ; pelvic fins (in adults) positioned at the throat and consisting of a single fin ray ; a dorsal fin with 3-13 rays ; a largely cartilaginous skeleton ; a bulbous snout ; and 7 branchiostegal rays (Nelson, 2006). Researchers have documented the osteology and myology of this family in detail (e.g. Rosen, 1973 ; Fujita, 1990 ; Olney et al., 1993 ; Springer and Johnson, 2004 ; Sasaki et al., 2006). However, the anatomical features of the pelvic girdle, one of the key characteristics of this family, have not been described in detail. Here, I describe the unique musculoskeletal structure of the pelvic girdle of *Ateleopus japonicus* Breeker, 1853.

Materials and Methods

Specimen was dissected after staining with Alizarin Red-S and Alcian Blue. Skeletal and muscular systems of pelvic girdle were observed under a binocular microscope with a camera lucida. Terminology on skeletal and muscular systems followed Stiassny and Moore (1992) and Winterbottom (1974), respectively. In this study, a single specimen of *Ateleopus japonicus* (HUMZ 181760, 468 mm TL) was examined as a representative of Ateleopodidae.

Description

Osteology (Fig. 1)

The pelvic girdle is narrowly separated from the pectoral girdle. The pelvis is mostly cartilaginous, and is fused on both sides. A pair of large openings is located on the central part of the pelvis through which a bundle of neural axons passes, while the edges of the pelvis form a plate-like protrusion. Owing to thin and weakly developed posterior processes, the boundaries of the connective tissue are indistinguishable. The lateral part of the pelvis contains weakly ossified ridges. Four fin rays are supported by the anterolateral part of the pelvis. The first ray is considerably elongated (12.0% of TL) and consists of a series of 63 bony articles, the most proximal of which contain a row of four lateral processes. The other rays are degenerated, unsegmented, and concealed by skin.

Myology (Fig. 2)

Although the extensor proprius is absent, the number of muscles in the pelvic girdle is greater than that in other teleosts. Of the eight total muscles that insert on the first ray, four unnamed muscles insert here only, whereas the other four also insert on the other rays. This differs from other teleosts,

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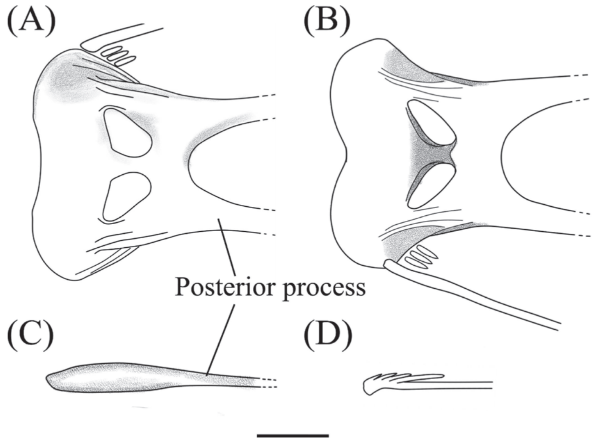

Fig. 1. Dorsal (A) , ventral (B) and lateral (C) views of the pelvic girdle and ventral view (D) of proximal part of first fin ray in *Ateleopus japonicus*. Posterior portions of posterior processes are unclear. Scale indicates 5 mm.

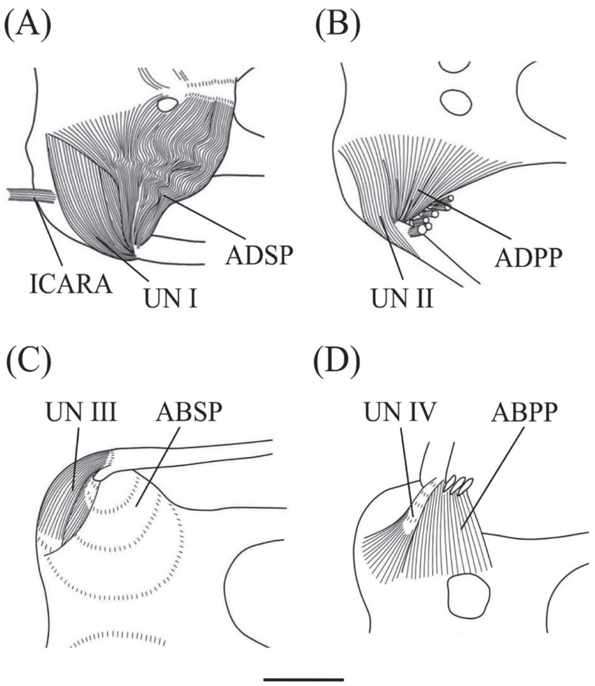

Fig. 2. Dorsal (A and B) and ventral (C and D) views of muscles of pelvic girdle in *Ateleopus japonicus.* B and D ; after removal of ICARA, ADSP and UN I, and ABSP and UN III, respectively. ADSP, adductor superficialis pelvics ; ADPP, adductor profundus pelvics ; ABSP, abductor superficialis pelvics ; ABPP, abductor profundus pelvics ; ICARA, infracarinalis anterior ; UN I–IV, unnamed muscles I–IV. Scale indicates 5 mm.

in which two of the six muscles that insert on the first fin ray (the arrector dorsalis pelvicus and arrector ventralis pelvicus) insert only on this ray. From here on, I will refer to the four unidentified muscles as unnamed muscle (UN) I–IV. All of the muscle elements, except for the infracarinalis anterior (ICARA), were sheet-like and weakly developed.

The infracarinalis medius is considerably thin. The ICARA arises from the ventral surface of the cleithrum and inserts on the anterodorsal part of the pelvis. The adductor superficialis pelvicus (ADSP) originates from the dorsal surface of the pelvis and inserts on the dorsal surface of the base of each fin ray. UN I originates from the anterior part of the pelvis and inserts on the base of the first ray, and its origin is partly concealed by the ADSP. The adductor profundus pelvicus (ADPP) also arises from the dorsal surface of the pelvis and inserts on the base of each ray. A major part of the ADPP is covered by both the ADSP and UN I. UN II, which is covered by UN I, originates from the anterodorsal part of the pelvis and inserts on the lateral surface of the base of the first ray. The abductor superficialis pelvicus (ABSP) arises from the ventral surface of the pelvis and inserts on the inner surface of all rays. UN III, whose origin is partially concealed by the ABSP, originates from the anteroventral part of the pelvis and inserts onto the ventral surface of the first ray. The abductor profundus pelvicus (ABPP) is covered by the ABSP and originates from the ventral surface of the pelvis, inserting on the inner surface of all rays. UN IV, which is largely concealed by the ABSP and UN III, arises from the anteroventral part of the pelvis and has a tendinous insertion on the ventral face of the first ray.

Discussion

In this specimen, the first pelvic ray is elongated, while the others are concealed under the skin. Such reduction in the pelvic fin has been widely reported in adults of ateleopodids (e.g., Olney et al., 1993 ; Nelson, 2006 ; Kaga et al., 2015). One hypothesis for this reduction is that the pelvic fin in adults is used for functions other than swimming. The mobility of the first ray is greatly enhanced by the following unique characteristics of the pelvic girdle : (1) Eight muscles insert onto the first ray in *A. japonicus*, whereas only six muscles insert in typical teleosts (see Winterbottom, 1974). (2) The pelvis supports fin rays laterally, allowing muscles to insert on the first ray both anteriorly and posteriorly. In other teleosts, the fin is located posterior to the pelvis ; thus, muscles attach to the pelvic rays anteriorly only (see Winterbottom, 1974).

Elongated fins are thought to act as sensory organs (Fox, 1999). One study on a gadid, *Muraenolepis microps* (see Eastman and Lannoo, 2001) and another on an ophidiid, *Ophidion rochei* (see Codina et al., 2012) reported free nerve endings and taste buds on their elongated pelvic fins, indicating that these fishes receive tactile and taste stimuli using these fins. This functional specification is associated with a highly modified pelvic girdle that enhances mobility of the pelvic fin in the ophidiid (Codina et al., 2012). Some gadids also show unique morphologies of the pelvis (Endo, 2002,

p. 92). Elongated fins are also thought to be used in signaling (Herring, 2007), which sometimes requires higher mobility of the fins (Amaoka et al., 1994).

Since ateleopodid behavior has rarely been observed, the function of the pelvic fin remains unknown. However, the structure of the pelvic fin of *A. japonicus* suggests that it is highly mobile, and thus, less likely to be used for swimming and more likely to be used in other functions such as searching for prey or signaling.

Acknowledgments

I thank the following for their support of this study : Mamoru Yabe, Hisashi Imamura, Toshio Kawai and other members of the field of systematic ichthyology, Hokkaido University.

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