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Early Jurassic fish from the Nishinakayama Formation of the Toyora Group, Yamaguchi Prefecture, southwest Japan

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Abstract

A specimen of fossil fish was obtained from the Sakuraguchidani Mudstone Member of the Nishinakayama Formation, the Toyora Group. The fossil-bearing horizon, 23-1, is laminated black mudstone with abundant fossil woods and pyrite granules. On the basis of ammonoid biostratigraphic research, this horizon corresponds to the base of the Harpoceras inouyei Zone, which is correlated to the base of the Exaratum Standard Subzone, middle part of the Lower Toarcian. The present specimen, one of rare occurrences of fish vertebrae, could contribute to tracing the evolutionary history of Early Jurassic fish in the Panthalassa.

Key words: Fish skeleton, Nishinakayama Formation, Toyora Group, Toarcian, Early Jurassic.

Introduction

The Early Jurassic marine macro biota from Japan has been mainly analyzed in the epicontinental sediments of the Toyora and the Kuruma Groups. In the Toyora Group, abundant macro faunas have been recognized as follows: ammonoids, bivalves, gastropods, crinoids, arthropods, and fossil fish (e.g., Matsumoto and Ono, 1947; Hayami, 1958, 1959, 1960a, b, 1961, 1962; Hirano, 1971, 1973a, b; Tanabe et al., 1982; Tanabe, 1991; Nakada and Matsuoka, 2009, 2011; Hunter et al., 2011). Fish skeletons were reported only in the Nishinakayama Formation of the Toyora Group by Tanabe et al. (1982). Two specimens, identified as Leptolepidiformes? gen. et sp. indet., were shown only in the occurrence list (table 2 in Tanabe et al., 1982), but the detailed locality and geological age have not been indicated in the previous study.

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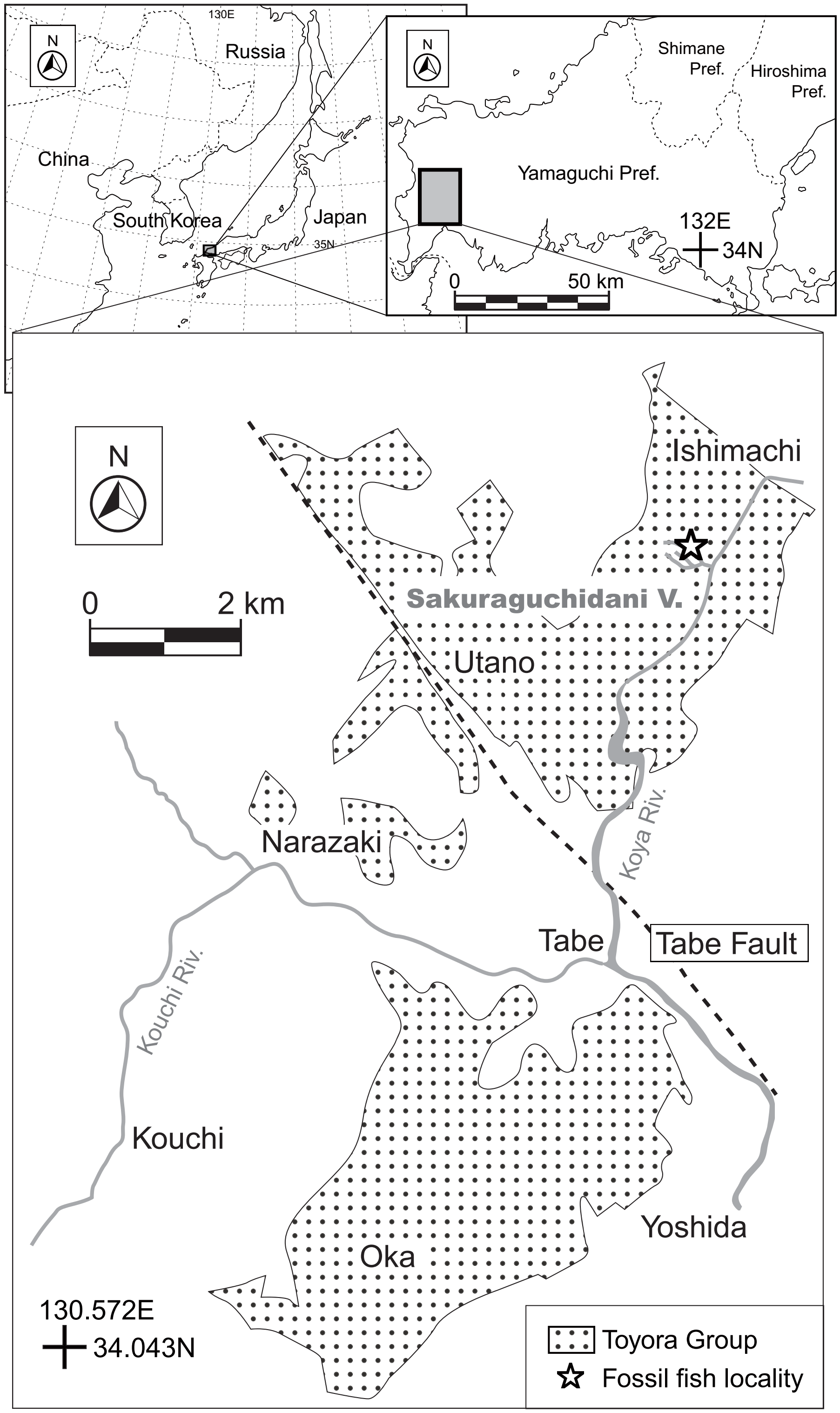

Fig. 1. Locality map of fossil fish from the Nishinakayama Formation of the Toyora Group.

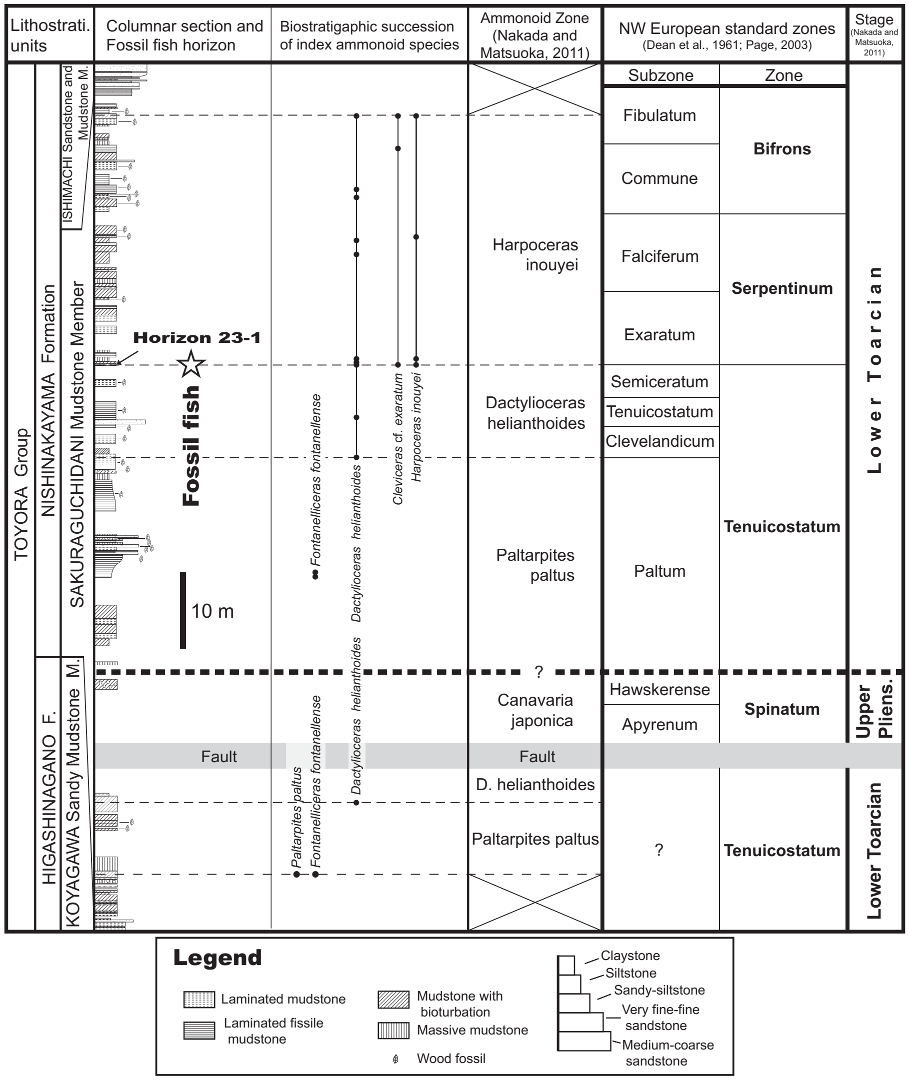

Fig. 2. Columnar section of the Northern Valley of the Sakuraguchidani Valley with a horizon which yielded fish skeleton, biostratigraphic successions of the zonal index ammonoid species, ammonoid biostratigraphic framework of the Sakuraguchidani Mudstone Member established by Nakada and Matsuoka (2011), and the northwest European standard zonation (Dean et al., 1961; Page, 2003).

This paper reports a specimen of fish obtained from the Nishinakayama Formation of the Toyora Group in Yamaguchi Prefecture, southwest Japan. The aims of this study are to show the locality of fish and to give a detailed age on the basis of ammonoid biostratigraphy.

Geological and biostratigraphical settings

The Toyora Group exposes in the western part of Yamaguchi Prefecture, southwest

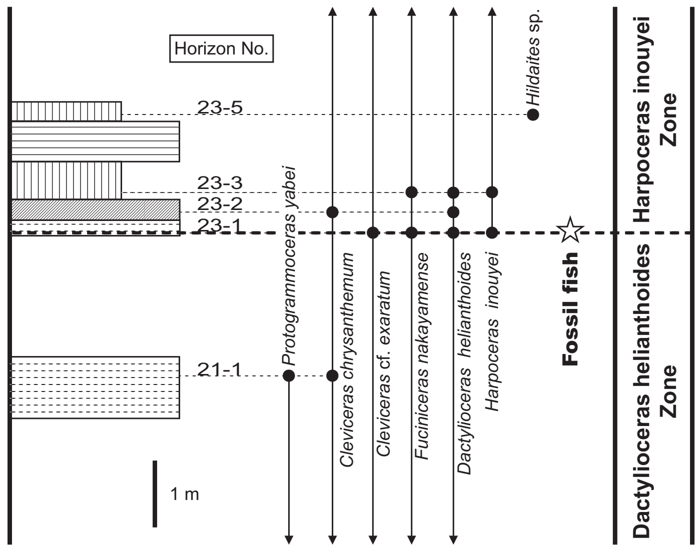

Fig. 3. Columnar section and biostratigraphic succession of ammonoids around horizon 23-1. The legend of the columnar section is as in Fig. 2.

Japan. This group is Lower to Middle Jurassic epicontinental sediments. Matsumoto and Ono (1947) divided the Toyora Group into three formations, the Higashinagano, Nishinakayama, and Utano Formations in ascending order. Each formation was subdivided into several members by Matsumoto and Ono (1947), Hirano (1971), Tanabe (1991), and Nakada and Matsuoka (2011).

In this study, the lithostratigraphic framework follows that of Nakada and Matsuoka (2011), who revised the lithostratigraphic denominations of the members proposed by Hirano (1971). The Higashinagano Formation is subdivided into four members, the Chuzankei Conglomerate Member (basal conglomerates), the Higashinakayama Sandstone Member (massive arkose sandstones), the Kido Sandstone Member (bedded sandstones), and the Koyagawa Sandy Mudstone Member in ascending order. The Nishinakayama Formation is composed of the Sakuraguchidani Mudstone Member and the Ishimachi Sandstone and Mudstone Member (black mudstone with thin sandstone beds) in ascending order. The Utano Formation was subdivided into the Eragawa Sandy Mudstone Member (laminated sandy siltstone), the Andadani Sandstone and Mudstone Member (mudstone with many sandstone intercalations), the Kodani Sandy Mudstone Member (massive siltstone), and the Kamiokaeda Sandstone and Mudstone Member (rhythmically alternating beds of sandstone and mudstone).

The Sakuraguchidani Mudstone Member yields abundant Early Jurassic ammonoid fossils (Matsumoto and Ono, 1947; Hirano, 1971, 1973a, b; Tanabe et al., 1982; Tanabe, 1991; Nakada and Matsuoka, 2009, 2011). The ammonoid biostratigraphy of the member has been analyzed in the Sakuraguchidani Valley by Hirano (1973b), Tanabe (1991), and Nakada and Matsuoka (2009, 2011). Nakada and Matsuoka (2011) established four ammonoid zones, the Canavaria japonica, Paltarpites paltus, Dactylioceras helianthoides, and Harpoceras inouyei Zones in ascending order and correlated the Pliensbachian/

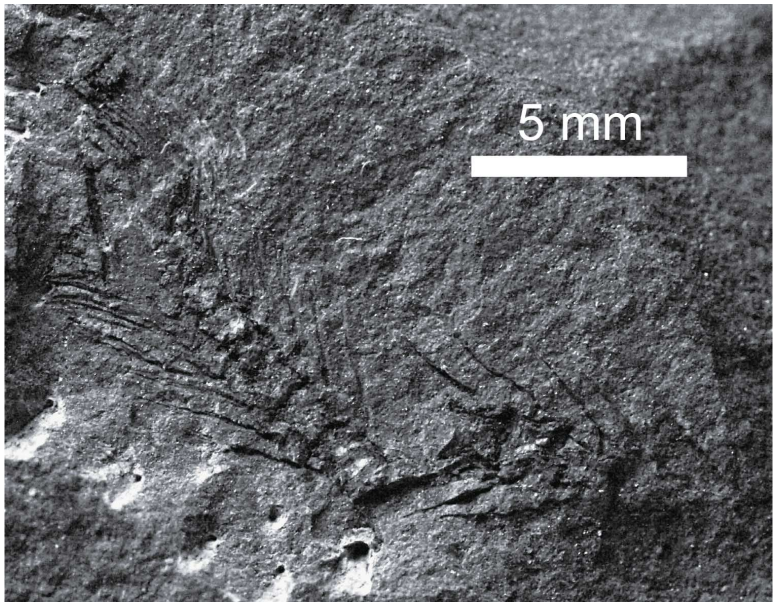

Fig. 4. Fish skeleton from the Sakuraguchidani Mudstone Member. This specimen is stored in the Department of Geology, Faculty of Science, Niigata University.

Toarcian (P/T) boundary to the base of the P. paltus Zone.

The black mudstone of the Sakuraguchidani Member is characterized by having parallel lamination, lacking benthic faunas, and containing huge amounts of organic carbon (Tanabe et al., 1982; Tanabe, 1991; Izumi et al., 2012). Tanabe (1991) suggested that the influence of Oceanic Anoxic Event (OAE) in the Sakuraguchidani Mudstone Member on the basis of these sedimentological and paleontological evidence. Thereafter, Izumi et al. (2012) suggested a development of marine anoxia in earliest Toarcian based on a negative carbon isotope excursion.

Occurrence of fish skeleton and its significance

Fish skeleton, NU-MV0001 (Fig. 4), was obtained from horizon 23-1 exposed along the North Valley of the Sakuraguchidani Valley (Figs. 1–3). This specimen is stored in the Department of Geology, Faculty of Science, Niigata University. Horizon 23-1 is characterized by black mudstone with parallel lamination, pyrite granules, ammonoid fossils, and fragments of fossil wood. This horizon corresponds lithostratigraphically to the middle part of the Sakuraguchidani Mudstone Member in the Nishinakayama Formation (Fig. 2).

The fish skeleton obtained in this study is 15 mm in total length and is composed of successive endoskeletal elements including 12 vertebrae, ribs and a caudal fin (Fig. 4). The caudal fin is characteristic in homocercal. The successive vertebrae are separated into two parts before the fossilization. A small ammonite specimen identified as *Fuciniceras nakayamense* juv. (Matsumoto) co-occurs with the present specimen in the same mudstone block.

The mudstone of horizon 23-1 yields the following abundant and diversified ammonoids: *Cleviceras* sp. cf. *C. exaratum* (Young & Bird), *Harpoceras inouyei* (Yokoyama), *Fuciniceras nakayamense* (Matsumoto), and *Dactylioceras helianthoides* (Yokoyama) (Fig. 3). According to the ammonoid zonal scheme of the Sakuraguchidani Mudstone Member and their international correlation in Nakada and Matsuoka (2011), this horizon corresponds to the base of the H. inouyei Zone on the basis of the first occurrence of the index species, which is comparable to the base of the Exaratum Standard Subzone of the Serpentinum Standard Zone (middle part of the Lower Toarcian) established in the northwest European province (Fig. 2).

In Japan, Early Jurassic fish remains have been reported from several geologic units including the Toyora Group, the Kuruma Group, the Iwamuro Formation, and the Shizugawa Group (Tanabe et al., 1982; Ooe and Chiba, 1988; Goto et al., 1991; Takakuwa and Gunma Fossil Club, 2011). However, most of them are teeth or scales. Early Jurassic fish skeletons were obtained only from the Toyora Group (Tanabe et al., 1982) and the Kuruma Group (a fish skull; Ooe and Chiba, 1988). This new occurrence of fish is important in reconstructing the Early Jurassic marine ecosystem in the western Panthalassa. In addition, the Jurassic period is a crucial time-interval for the evolution of marine fish, because the first radiation of most modern fish groups took place in this period (López-Arbarello et al., 2008). The present specimen could contribute to tracing the evolutionary history of Early Jurassic fish in the Panthalassa.

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