Japan. J. Ichthyol.
40(4): 500–503, 1994

魚類学雑誌
40(4): 500–503, 1994

Fossils of *Silurus biwaensis* (Siluridae) from the Ueno Formation, Ancient Lake Biwa, Japan

Midori Kobayakawa[1] and Shigemi Okuyama[2]

[1] Department of Fisheries Faculty of Agriculture Kyushu University, 6–10–1 Hakozaki, Higashi-ku, Fukuoka 812, Japan
[2] 1096–27 Tateoka Shijyukyu-cho, Ueno, Mie 518, Japan.

(Received April 30, 1993; in revised form November 17, 1993; accepted December 25, 1993)

Lake Biwa, one of the world's oldest lakes, has several endemic fish species. Their points of origin and speciation patterns have been studied by Annandale (1922), Tomoda (1984) and Nakajima (1987a, b, 1989). Nakajima (1989) discussed succession in the cyprinid fish fauna of Paleo-Lake Biwa and indicated that the recent fauna of the lake appeared about 10,000 years ago.

Two endemic catfishes occurring in the basin are *Silurus lithophilus* and *S. biwaensis* (Tomoda, 1961). Morphological and ecological studies of these species led Tomoda (1962, 1984) to conclude that both had speciated from *S. asotus* in the lake. Moreover, he inferred that *S. biwaensis* appeared after the modern cyprinid fauna in Lake Biwa had become established. Kobayakawa's (1989) review of *Silurus* and its intergeneric relationships, however, concluded that *S. biwaensis* was more closely related to species of *Silurus* distributed on the Asian mainland.

Despite these views, the origin of *S. biwaensis* is still unclear, although the examination of fossils apparently representative of the species may provide a solution. In this paper fossil catfish specimens are described from the Ueno Formation of the Kobiwako Group, of sediments from Paleo-Lake Biwa, and the origin of *S. biwaensis* discussed.

Locality and Horizon

Catfish fossils were collected from the Ueno Formation at Hata, Oyamada, Ueno city, Mie Prefecture, Japan (34°46′3″N, 136°12′10″E) by Shigemi Okuyama (Fig. 1). The formation is in the lower part of the Kobiwako Group, being distributed in the southern part of the Ueno Basin (Kawabe, 1989). The fossils lay in silt just below the Hattorigawa II Volcanic Ash Layer, coincident with the lower boundary of Mammoth Event (3.15 Million age) according to paleomagnetic measurements (Kawabe, 1989) (Fig. 2).

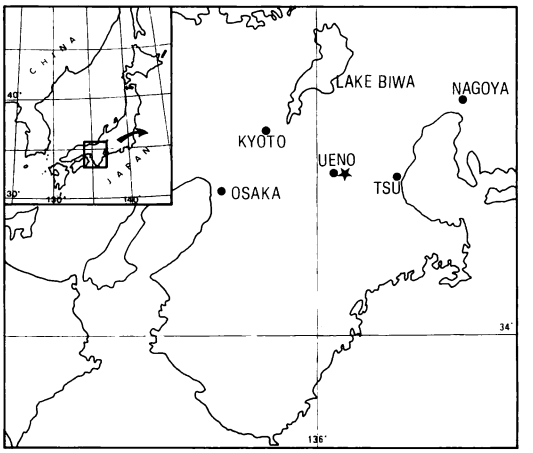

Fig. 1. Locality map. Asterisk indicates collection site of *Silurus biwaensis* fossils.

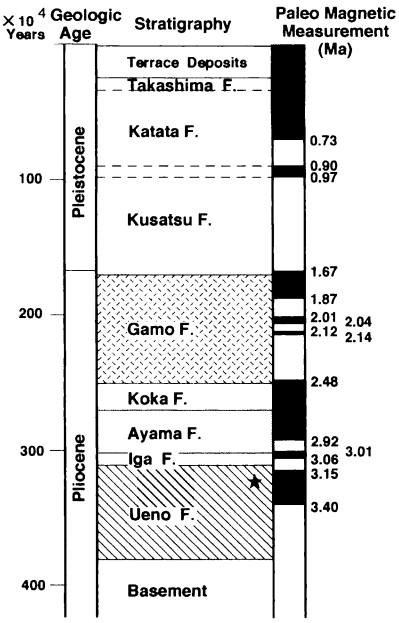

Fig. 2. Stratigraphy of the Kobiwako Group (after Kawabe, 1989). Asterisk indicates horizon applicable to *Silurus biwaensis*.

Description of the fossils

Specimens examined: Skull, LBM (Lake Biwa Museum) 93-2524, 93-2525, 2 specimens; cleithrum,

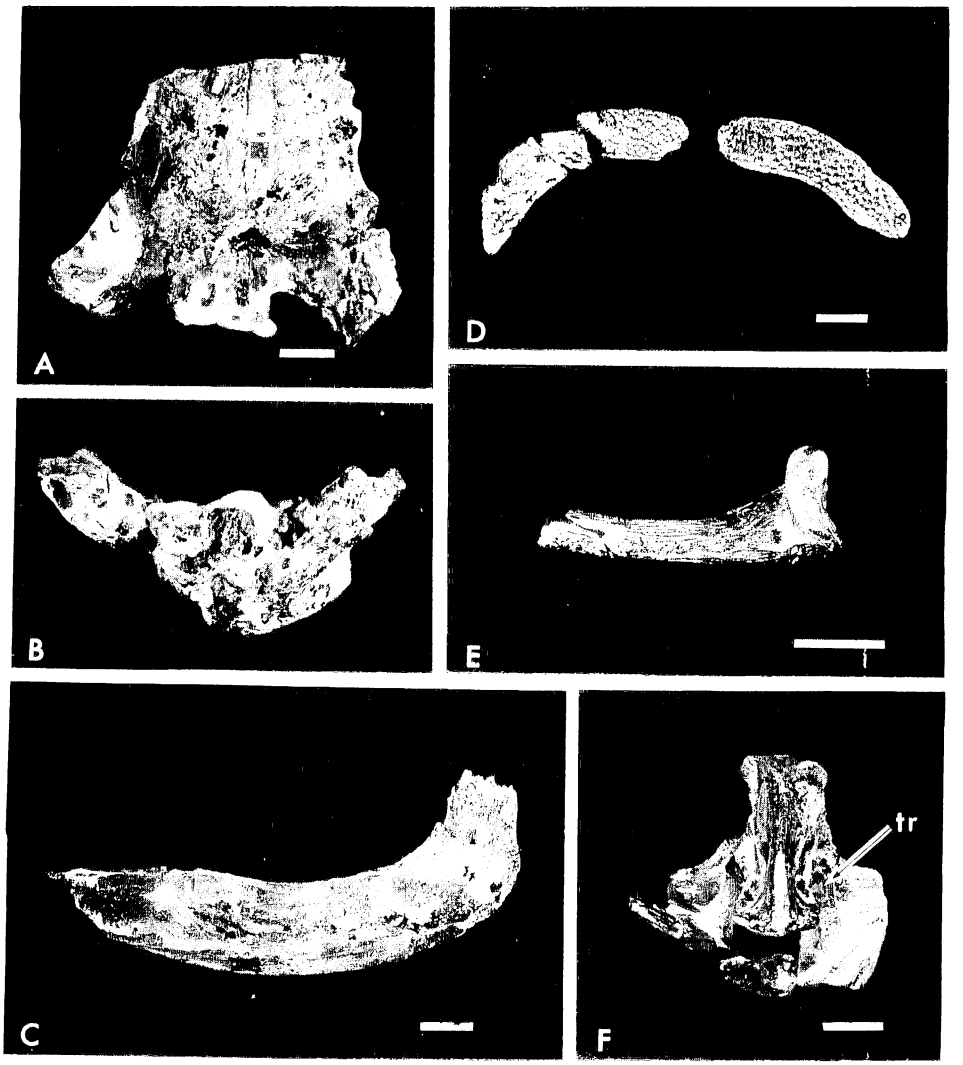

Fig. 3. *Silurus biwaensis* fossils from the Ueno Formation. A) Dorsal view of posterior half of skull (LBM 93-2524); B) posterior view of same specimen; C) left cleithrum, LBM 93-2526; D) premaxillary tooth plate, LBM 93-2529; E) right pectoral spine, showing many small granules on its anterior surface, LBM 93-2531; F) fused vertebrae with tripus (tr) of Weberian apparatus, LBM 93-2539. Scale bars indicate 1 cm.

LBM 93-2526–93-2528, 3 specimens; premaxillary tooth plate, LBM 93-2529, 1 specimen; pectoral spine, LBM 93-2530–93-2538, 9 specimens; fused vertebrae, 93-2539, 1specimen.

The fossils were isolated elements, there being no complete body found. Nevertheless, they appeared to represent the same species, as duplicated elements had the same characteristics. In addition, they were found in a restricted area, both vertically and horizontally.

The fossils consisted of a part of the posterior half of the skull, cleithrum, fused vertebrae with Weberian apparatus, premaxillary tooth plate and pectoral spines.

Skull (Fig. 3A, B).—The lateral edge of the pterotic was bent upwards as is found in living *Silurus biwaensis*. Viewed ventrally the right and left wings of the parasphenoid formed a relatively acute angle compared with living congeners, a condition similar to that found in living *S. biwaensis*.

Cleithrum (Fig. 3C).—The horizontal and vertical section formed an angle a little larger than 90°, a condition also observed in *S. biwaensis*, *S. soldatovi* and *S. meridionalis*, all being species that have a greater relative head length compared with other congeners (Kobayakawa, 1989).

Premaxillary tooth plate (Fig. 3D).—There were many small pits remaining following loss of the teeth were not so crowded as in living *S. asotus* and *S. lithophilus*, but were instead similar to that condition found in *S. biwaensis*.

Pectoral spine (Fig. 3E).—Many small granules were located on the anterior surface. In some specimens, slight serrations also occurred on the posterior surface.

Fused vertebrae (Fig. 3 F).—The tripus of the Weberian apparatus was observed on both sides of the fused vertebrae, but it was difficult to identify *Silurus* species solely from the morphology of the Weberian ossicles.

The characteristics of the cleithra, pterotics, maxillary tooth plate and pectoral spines were all similar to those of living *S. biwaensis*, being good diagnostic characters for the species.

Discussion

Paleo-Lake Biwa moved from the Ueno Basin area to the present location during the past 4 million years (Kawabe, 1989; Kobiwako Research Group, 1977, 1981). Tomoda (1962) presumed the present habitat of *Silurus biwaensis* in Lake Biwa to be open water. However, the habitat suggested by the fossils seems to be different, as Paleo-Lake Biwa in the Ueno Basin area was shallow and marshy along its shoreline (Kawabe, 1989). Because of the morphological similarity of the fossils to living *S. biwaensis*, the former are considered to represent that species as are two other fossil specimens (LBM 93-2540, 93-2541) from the same locality, reported previously (Kobayakawa and Okuyama, 1984). As the Ueno Formation is situated in the lowermost part of the Kobiwako Group, *S. biwaensis* was present during the earliest stage in the history of Lake Biwa.

Nakajima (1989) stated that the modern endemic cyprinid fauna of Lake Biwa became established about 10,000 years ago, with only a few cyprinid species from Paleo-Lake Biwa having survived. He inferred that the endemic fauna developed as a result of the lake deepening at that time. Since fossils of *S. biwaensis* were found in the Ueno Formation, the lowermost part of the Kobiwako Group, and living *S. biwaensis* is apparently closely related to species occurring on the Asian mainland, *S. biwaensis* appears to be a relict from a period when the Japanese Islands were part of the East Asian mainland. It is believed that *S. biwaensis* survived, despite changes in both the cyprinid fauna and lake condition, because of continual availability of food, principally cyprinid fishes (Tomoda, 1962). Therefore, not all species endemic to Lake Biwa appeared after the formation of the present lake, since at least one species, *S. biwaensis* has survived as a Paleo-Lake Biwa relict.

Acknowledgments

We would like to express our thanks to Dr. T. Nakajima and Dr. T. Kawabe for their helpful advice. We also thank Dr. T. J. Donaldson for his critical reading of the manuscript.

Literature Cited

Annandale, N. 1922. The macroscopic fauna of Lake Biwa. Annot. Zool. Japan, 10: 127–153.

Kawabe, T. 1989. Stratigraphy of the lower part of the Kobiwako Group around the Ueno basin, Kinki district, Japan. J. Geosci., Osaka City Univ., 32: 39–90.

Kobayakawa, M. 1989. Systematic revision of the catfish genus *Silurus*, with description of a new species from Thailand and Burma. Japan. J. Ichthyol., 36: 155–186.

Kobayakawa, M. and S. Okuyama. 1984. Pliocene *Silurus* from Iga-Aburahi Formation, Kobiwako Group, Central Japan. Bull. Mizunami Fossil Mus., (11): 107–110. (In Japanese.)

Kobiwako Research Group. 1977. The Kobiwako Group in the western part of Minakuchi Hills, Shiga Prefecture, Japan. Monog. Assoc. Geol. Collab. (Chidanken Senpou), (25): 79–100. (In Japanese.)

Kobiwako Research Group. 1981. The Kobiwako Group in the Seta-Ishibe area, southern part of Shiga Prefecture, Japan. Earth Science (Chikyu Kagaku), 35: 26–40. (In Japanese.)

Nakajima, T. 1987a. The history of fish fauna in Lake Biwa (1). Life in Japan (Nihon no Seibutsu), 1: 31–39. (In Japanese.)

Nakajima, T. 1987b. The history of fish fauna in Lake Biwa (2). Life in Japan (Nihon no Seibutsu), 1: 15–17. (In Japanese.)

Nakajima, T. 1989. The formation of ichthyofauna and the speciation in Lake Biwa. Pages 216–229 *in* N. Mizuno and A. Goto, eds. Freshwater fishes of Japan. An account of their distribution, variation, and speciation.

Tokai Univ. Press, Tokyo. (In Japanese.)
Tomoda, Y. 1961. Two new catfishes of the genus *Parasilurus* found in Lake Biwa-ko. Mem. Coll. Sci. Univ. Kyoto, B, 28: 347–354.
Tomoda, Y. 1962. Studies of the fishes of Lake Biwa-ko–I. Morphological study of the three species of catfishes of the genus *Parasilurus* from Lake Biwa-ko, with reference to their life. Japan. J. Ichthyol., 8: 126–146. (In Japanese.)
Tomoda, Y. 1984. Fauna and flora of the Lake Biwa–An approach to the recent geohistory of the Lake Biwa. Bull. Japan. Sea Res. Inst. Kanazawa Univ., 16: 59–91.

古琵琶湖の堆積物から採集されたビワコオオナマズの化石

小早川みどり・奥山茂美

三重県上野市大山田村畑でナマズ属魚類の頭骨の一部，擬鎖骨，前上顎骨の歯板，胸鰭の棘などの化石が採集された．それらは採集層準と採集地域が極めて限られており，体の同一部位においては同じ特徴を示し，現生する琵琶湖水系特産のビワコオオナマズの特徴と一致することから同一種のものとみなされ，ビワコオオナマズの化石と同定された．産出層準が古琵琶湖の堆積物の最下層部であることから，ビワコオオナマズは，現存する琵琶湖特産のコイ科魚類の多くと異なり，琵琶湖の歴史の初期に形態的に分化を遂げており，現在まで生き残った遺存種であることが示唆された．

(小早川：〒812 福岡市東区箱崎 6-10-1 九州大学農学部水産第 2 教室；奥山：〒518 三重県上野市四十九町立岡 1096-27)