
Pleistocene Clupeid and Engraulidid Fishes from the Kokubu Group in Kagoshima Prefecture, Japan.

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Abstract Fish fossils were found in the Pleistocene Kokubu Group in Kagoshima Prefecture, Japan. These are identified as the extant species *Sardinops melanostictus* in the family Clupeidae and *Engraulis japonicus* in the family Engraulididae. Figures of the complete skeletons of those extant species are presented for the comparison with the fossil specimens.

Several specimens of fossil fishes yielded from the Kokubu Group at Aira Town in Kagoshima Prefecture were sent to the author by Mr. Shigeru Takaki of the Kagoshima Prefectural Museum for identification in March, 1987. In September, 1987, I collected two more fossils. Two species, *Sardinops melanostictus* and *Engraulis japonicus*, are recognized among these specimens. The Kokubu Group was first described by Ida, et al. (1950) and studied in detail by Otsuka and Nishiinoue (1980) and Nishiinoue and Otsuka (1982). Otsuka and Nishiinoue (1980) recognized five stratigraphic units: the Kajiki Formation, the Nabekura pyroclastic flow deposits, the Kamo Formation, the Oda pyroclastic flow deposits and the Hayato Formation in ascending order and reported the fossil fishes, *Sardinops melanostictus* from the Hayato Formation at Kuwanomaru, Yoshida Town and an unknown species of the Gobiidae from the Kajiki Formation at Ooyama, Aira Town, without description. I examined their specimens in the National Science Museum and recognized *Engraulis japonicus* and *Sardinops melanostictus*. The fossils of *E. japonicus* and *S. melanostictus* are described here, compared with bones of the extant species. The only fossil records of *S. melanostictus* and *E. japonicus* in Japan are isolated otoliths from the Pleistocene deposits of Boso and Miura Peninsulas (Aoki, 1968). This is the first fossil record of partial and almost complete skeletons of fossil *S. melanostictus* and *E. japonicus* in Japan.

Previously there were only partial osteological descriptions of *S. melanostictus* and *E. japonicus*: craniums and vertebral columns of both species (Hotta, 1961), dorsal and anal fin rays and their pterygiophores (Kinoshita, 1984) and hypobranchial apparatus (Balart, 1985) of *E. japonicus*. Figures of the complete skeletons of *E. japonicus* and *S. melanostictus* are presented here for the first time for comparison with fossils. The names of the bones and anatomical elements are based on Harrington...
(1955), Ridewood (1905), Chapman (1944a, 1944b), Uyeno (1975) and Patterson and Rosen (1977).

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Localities and Horizon

The locality of fish fossils at Ooyama (longitude 130°37'38"E. and latitude 31°45'77"N.) is in Aira Town (Fig. 1). This locality belongs to the Kajiki Formation which is the lowest unit in the Kokubu Group. The locality of fish fossils at Kuwanomaru (130°33'58"E. and 31°44'19"N.) is in Yoshida Town (Fig. 2). This locality belongs to the Hayato Formation which is the uppermost unit in the Kokubu Group. Both towns are located at the northern part of Kagoshima Prefecture, about

Fig. 1 A map showing the locality (X) for the fossil fishes from the Kajiki Formation at Ooyama, Aira Town in Kagoshima Prefecture.
Fig. 2. A map showing the locality (X) for the fossil fishes from the Hayato Formation at Kuwanomaru, Yoshida Town in Kagoshima Prefecture.

20 km north of Kagoshima City. The age of the Kokubu Group is Early Pleistocene (Otsuka and Nishiinoue, 1980).

Class Osteichthyes
Order Clupeiformes
Family Clupeidae
Sardinops melanostictus (Temminck et Schlegel, 1846)

Material: KMNH (Kitakyushu Museum of Natural History) VP100,138, almost complete specimen with lateral side exposed; KMNH VP100,139, almost complete specimen with right side exposed. Both specimens are bent at the center of the body, collected from the Kajiki Formation at Ooyama, Aira Town by the author. ESK (Institute of Earth Sciences, Faculty of Science, Kagoshima University) 6053, scales, collected from the Hayato Formation at Kuwanomaru, Yoshida Town by Dr. Hiroyuki Otsuka.

Description: In the specimen of KMNH VP100,138, there are 19 dorsal fin rays, located near the middle of the body (Plate 1). Three abdominal scutes in front of the pelvic, one under the pelvic and 7 behind the pelvic are observable. The number of vertebrae is 48. Three ridges are present on the opercle. The quadrate, angular, preopercle and hyomandibular are partially preserved and these bones are
Fig. 3. *Sardinops melanostictus*: A, head region of the fossil specimen of KMNH VP100,138; B, head bones of the Recent specimen, KMNH VR100, 094, 92 mm in standard length, collected at Wakamatsu, Kitakyushu, Fukuoka Prefecture, 18 October, 1980. ang, angular; den, dentary; ecp, ectopterygoid; enp, endopterygoid; hyo, hyomandibular; ino, interopercle; max, maxillary; met, metapterygoid; ope, opercle; pal, palatine; prem, premaxillary; preo, preopercle; qua, quadrate; ret, retroarticular; subop, subopercle; supm1, first supramaxillary; supm2, second supramaxillary; sym, symplectic. Cartilage is indicated by hatching.
Fig. 4. Pleistocene *Sardinops melanostictus*: A, middle part of the body, KMNH VP100,138; B, scales, ESK 6053.

Fig. 5. Caudal bones of a Pleistocene *Sardinops melanostictus*, KMNH VP100,139. hyu, hypural; mcfr, middle caudal fin rays; parh, parhypural bone.
similar to those of the extant species (Fig. 3). Some scales are preserved, which have several grooves from the ventral and dorsal margin. These grooves are not continuous in the middle part of the scales (Fig. 4). Two middle caudal fin rays extend over the hypurals.

In the specimen of KMNH VP100,139, the number of dorsal rays is 17. The number of vertebrae is 47. The posterioventral corner of the ceratohyal is extended posterioventrally. The epihyal is large and the length is about three quarters of the ceratohyal. Two middle caudal rays extend over the hypurals. A short ridge is present at the anterior part of the first hypural (Fig. 5).

In the specimen of ESK 6053, thirteen scales are preserved on a mudstone. The posterior parts are missing in some scales. Five or six grooves extend from the ventral and dorsal margin to the middle of the scales and only the most posterior groove is continuous (Plate 1 and Fig. 4).

Family Englaulididae

*Engraulis japonicus* (Houttuyn, 1872)

*Material:* KM(Kagoshima Prefectural Museum)-F-87-1, almost complete specimen with left side exposed, but a part of the dorsal fin, opercular bones and suspensorium are missing, collected from the Kajiki Formation at Ooyama, Aira Town. ESK 6054, anterior part of the body, with ventral side exposed, collected from the Hayato Formation at Kuwanomaru, Yoshida Town by Dr. Hiroyuki Otsuka.

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**Fig. 6.** Head region of a Pleistocene *Engraulis japonicus*, KM-F-87-1. bra, branchiostegal; chy, ceratohyal; cle, cleithrum; cra, coracoid; eth, ethmoid; gra, gill raker; hyph, hypohyal; prev, prevomer; P₁, pectoral fin.
Description: In the specimen of KM-F-87-1, the mesethmoid bone projects beyond the prevomer. The ceratohyal is long with many short branchiostegal rays (Fig. 6). The dorsal fin is situated near the middle of the body. The anal base is long with 14 fin rays. A part of the gill arch, long gill rakers, shoulder girdle and pectoral fins are observable. These are similar to those of the extant species (Figs. 6, 15, 16 and Plate 2). In the specimen of ESK 6054, the maxillaries and dentary are long and bear small teeth. The preopercle is narrow. The suspensorium incline toward the rear (Fig. 7). The preserved body length is 50.9 mm. Thirteen dorsal rays, pterygiophores, and 31 vertebrae are observable. The abdominal scute is absent. The dorsal fin is situated near the middle of the body.
Fig. 8. Scales of an extant *Sardinops melanostictus*, KMNH VR100, 095, 158 mm in standard length, collected from Kokura, Kitakyushu, 10 April, 1988. Roman numerals indicate the rows of scales and Arabic numerals are numbered from top downword.
Fig. 9. Cranium of an extant *Sardinops melanostictus*, KMNH VR100 096, 159 mm in standard length, collected at Kokura, Kitakyushu, 10 April, 1988. A, dorsal view; B, lateral view; C, ventral view. bao, basioccipital; bsp, basisphenoid; epi, epiotic; eth, ethmoid; exo, exoccipital; fro, frontal; inca, intercalar; ors, orbitosphenoid; pari, parasphenoid; pari, parietal; pref, prefrontal; prev, prevomer; pro, prootic; pte, pterosphenoid; pto, pterotic; supo, supraoccipital; sph, autosphenotic. Cartilage is indicated by hatching.
Fig. 10. Extant *Sardinops melanostictus*, KMNH VR100, 096. A, upper jaw; B, lower jaw; C, shoulder girdle; D, ventral view of the shoulder girdle. act, actinost; ang, angular; cle, cleithrum; cra, coracoid; den, dentary; max, maxillary; mes, mesocoracoid; poc lo, lower postcleithrum; poc up, upper postcleithrum; pot, posttemporal; prem, premaxillary; ret, retroarticular; scap, scapula; supc, supracleithrum; supm1, first supramaxillary; supm2, second supramaxillary.
Fig. 11. Extant *Sardinops melanostictus*, KMNH VR100, 096  A, hyoid arch;  B, urohyal;  
C, gill arches.  bab, basibranchial;  bah, basihyal;  bra, branchiostegal;  cbr, ceratobranchial;  chy, ceratohyal;  eph, epibranchial;  epb, epibranchial;  eph, epihyal;  gha, groove for hyoidean artery;  hyp, hypobranchial;  hyph lo, lower hypohyal;  hyph up, upper hypohyal;  inh, interhyal;  pha lo, lower pharyngeal;  pha up, upper pharyngeal, suprp, suprapharyngobranchial.  
Cartilage is indicated by hatching.
Fig. 12. Extant *Sardinops melanostictus*, KMNH VR100, 096  A, dorsal fin; B, anal fin; C, pelvic girdle; D, caudal skeleton. bap, basipterygium; epu, epural; hes, haemal spine; hpap, hypurapophysis; hyu, hypural; lep, lepidotrichia; nes, neural spine; parh, parhypural bone; preu, preural centrum; ptr dis, distal pterygiophore; ptr med, median pterygiophore; ptr pro, proximal pterygiophore; urn, uroneural bone; v ura, ural centrum. Cartilage is indicated by hatching.
Fig. 13. Extant <i>Sardinops melanostictus</i>, KMNH VR100, 907, 156 mm in standard length, collected at Kokuura, Kitakyushu, 10 April, 1988.
Fig. 14. Cranium of an extant *Engraulis japonicus*, KMNH VR100, 098, 59 mm in standard length, collected at Kaie, Kaimon, Kagoshima Prefecture, 28 October, 1987. A, dorsal view; B, lateral view; C, ventral view. supt, supratemporal. Other abbreviations see Fig. 9.
Fig. 15. Extant *Engraulis japonicus*, KMNH VR100, 098 A, suspensorium and opercular bones; B, upper jaw; C lower jaw; D, shoulder girdle; E, ventral view of the shoulder girdle. Abbreviations see Figs. 3 and 10.

**Remarks**

In the extant species of *Sardinops melanostictus* and *Engraulis japonicus*, the first ribs are attached to the third vertebra. The number of the dorsal pterygiophores is two fewer than that of dorsal fin rays. This information is useful in determining the numbers of vertebrae and dorsal fin rays in fossil specimens.

The following characters indicate that the fossil specimens are members of the teleostean fish order Clupeiformes; 1) the dorsal fin is situated near the middle of the
The age of the deposits from which the fossil specimens are yielded is Early Pleistocene (Otsuka and Nishiinoue, 1980). Twenty-one species in 3 families of the order Clupeiformes have been recorded in Japan (Masuda et al. 1988). Characteristic and meristic features of the fossil specimens agree well with those of Sardinops melanostictus and Engraulis japonicus.

The specimens of KMNH VP100,138, KMNH VP100,139 and ESK 6053 are
Fig. 17. Extant *Engraulis japonicus*, KMNH VR100, 098. A, dorsal fin; B, anal fin; C, pelvic girdle; D, caudal skeleton. Abbreviations see Figs. 5 and 12.

identified as *Sardinops melanostictus*, on the basis of following characters: 1) the abdominal scutes are present (KMNH VP100,138); 2) three ridges are present on the opercle (KMNH VP100,138); 3) the grooves on each scale are curved and extend from the dorsal and ventral margin to the middle, and are not continuous at the middle (KMNH VP100,138 and ESK 6053); 4) the numbers of vertebrae (47 and 48)
Fig. 18. Extant Engraulis japonicus, KMNH VR100, 098.
and dorsal rays (17 and 19) are in the range of those of the extant species (KMNH VP100,138 and 100,139); 5) the posterovertral corner of the ceratohyal is extended posterovertrally and the length of the epihyal is about three quarters of the ceratohyal (KMNH VP100,139).

The diagnostic characters of engraulidid fish are the oblique (posterior) inclination of the suspensorium and the projected mesethmoid bone beyond the vomer supporting a paired rostral organ (NELSON, 1984b; GRANDE and NELSON, 1985). The specimens of KM-F-87-1 and ESK 6054 are identified as *Engraulis japonicus*, on the basis of the following characters: 1) abdominal scute is absent; 2) the ceratohyal is long and stout with many short branchiostegal rays (KM-F-87-1); 3) the mesethmoid bone projects beyond the vomer (KM-F-87-1); 4) the long maxillary and dentary bear small teeth (ESK 6054); 5) the narrow preopercle and the obliquely inclined suspensorium (ESK 6054); 6) the number of dorsal rays (15) is in the range of the extant species *E. japonicus* (NELSON, 1984a). Both species are now distributed in the waters of Kagoshima Prefecture.

**Literature Cited**


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Explanation of Plates 1–2.
Explanation of Plate 1.

The fossil specimens of *Sardinops melanostictus* from Kagoshima Prefecture:

A.  KMNH VP100,138, from Ooyama, Aira Town.
B.  KMNH VP100,139, from Ooyama, Aira Town.
C.  ESK 6053 from Kuwanomaru, Yoshida Town.

Scale bars indicate 10 mm.
Explanation of Plate 2.

The fossil specimens of *Engraulis japonicus* from Kagoshima Prefecture.

A. KM-F-87-1, from Ooyama, Aira Town.
B. head region, KM-F-87-1.
C. ESK 6054, from Kuwanomaru, Yoshida Town.

Scales of A and C indicate 10 mm. Scale of B indicates 5 mm.