

Sardinella miyanoshitaensis, a New Clupeid Fish from the Middle Miocene Tottori Group, Tottori Prefecture, Japan

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Abstract A fossil clupeid fish collected from the Middle Miocene Fuganji Mudstone bed at Miyanoshita, Kokufu-cho, Tottori Prefecture, Japan is described as a new species, *Sardinella miyanoshitaensis*. The new species is very similar in appearance to the extant *Sardinella marquesensis* which is endemic to Marquesas Island in the central Pacific, but is distinguishable in having an endopterygoid tooth plate, a different form of scales and a rather deeper body.

Key words: Fish fossil, Clupeidae, Middle Miocene, Tottori Group, Tottori Prefecture, *Sardinella miyanoshitaensis* sp. nov.

Introduction

As the fourth account in a series describing fossil fishes from the Middle Miocene Fuganji Mudstone bed from the Iwami Formation of the Tottori Group (Uemura *et al.*, 1979; Matsumoto, 1991) at Miyanoshita, Kokufu-cho, Tottori Prefecture, Japan, described here is a new species of the clupeid genus *Sardinella*. This locality, which has yielded numerous specimens that we have examined, is the same locality reported by Uyeno and Suda (1991) for the carangid fish, *Scomberoides maruoi*, Sakamoto and Uyeno (1993) for the paralichthyid fish, *Paralichthys yamanai*, and Yabumoto and Uyeno (1994) for the leiognathid fish, *Leiognathus tottori*.

Specimens of extant genera, *Amblygaster* and *Sardinella*, were compared with the fossil specimens in the process of describing the new species, and are listed in Table 1.

Abbreviations: FAKU (Fisheries Research Station, Kyoto University); FPMN (Fukui Prefectural Museum); NSM, NSMT (National Science Museum, Tokyo); SL (standard length); TKPM (Tokushima Prefectural Museum).

Table 1. The specimens of extant clupeid fishes used for comparison with the fossil specimens.

Species	Catalogue number (no. of specimens)	Standard length (in mm)	Locality
<i>Amblygaster clupeioides</i>	TKPM-5696(2)	130.5–132	Con Son Island, Viet Nam
<i>Amblygaster leiogaster</i>	FAKU 107135(1)	202	East coast of USA
<i>Amblygaster sirm</i>	FAKU S3971(1)	162	Ryukyu Islands, Japan
<i>Sardinella albella</i>	NSMT-P23102(1)	130	Songkhla, Thailand
<i>Sardinella aurita</i>	FAKU 45020(1)	144	Off Guiana, western central Atlantic
<i>Sardinella gibbosa</i>	NSMT-P23097(1)	129	Songkhla, Thailand
<i>Sardinella lemur</i>	FAKU 100414(1)	145	Gulf of Tongking, South China Sea
<i>Sardinella marquesensis</i>	NSMT-P54332(1)	87	Marquesas Island, central S. Pacific
<i>Sardinella zunasi</i>	TKPM-P805(1)	111	Okayama Pref., Japan
<i>Sardinella zunasi</i>	TKPM-P809(1)	97	Tokyo Bay, Japan

Systematic Description

Class Osteichthyes Huxley, 1880
 Order Clupeiformes Bleeker, 1859
 Suborder Clupeioidi, 1859
 Family Clupeidae Cuvier, 1817
 Genus *Sardinella* Valenciennes, 1847

Sardinella miyanoshitaensis sp. nov.

(New Japanese name: Miyanoshita-sappa)

Figs. 1–8

Holotype: FPMN 98047284 (56 mm SL).

Paratypes: FPMN 98047228 (57 mm SL), 98047229 (51.5 mm SL), 98047230 (51.5 mm SL), 98047232 (57.5 mm SL), 98047290 (84 mm SL), 98047291 (62 mm SL). NSM PV-18181a, b (ca. 52 mm SL), 18570a, b (disarticulated bones of the skull and trunk), 18571a, b (disarticulated bones of the skull, trunk and tail), 18575a, b (top of posterior part of the skull and urohyal), 18578a, b (ca. 55 mm SL), 18579a, b (disarticulated bones of the skull), 18580. TRPM 664-060A, B (ca. 21.5 mm SL), 664-080 (23 mm SL), 664-081 (ca. 52 mm SL), 664-094A (72 mm SL), 664-095A (69.5 mm SL), 664-104 (29.5 mm SL).

Other specimens examined: FPMN98047231, 98047233-98047235, 98047237-98047283, 98047237-98047277, 98047283, 98047285, 98047286, 98047289, 98047291-98047296. NSM PV-18296, 18572, 18573, 18574, 18576, 18577, 18581-18630. TRPM 664-036, 664-037, 664-053, 664-054, 664-082, 664-086, 664-102.

Etymology: Both the species name, *miyanoshitaensis*, and the Japanese name, *miyanoshita-sappa*, are derived from the type locality.

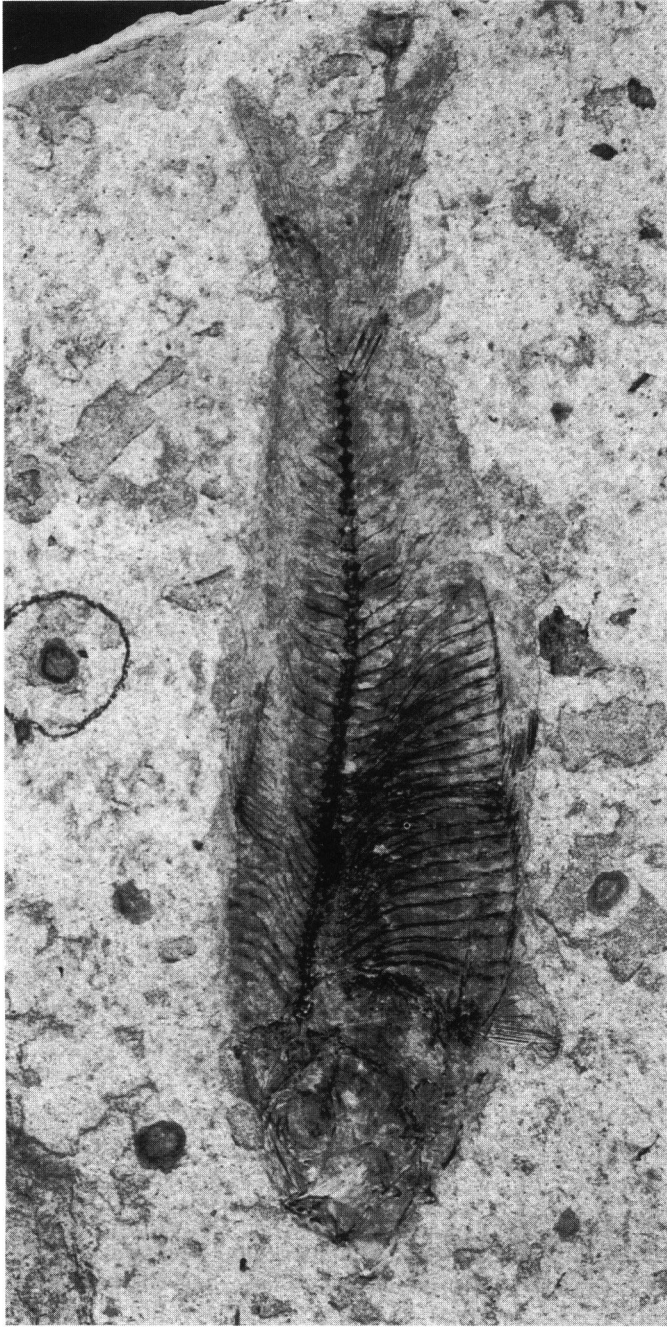


Fig. 1. *Sardinella miyanoshitaensis* sp. nov., holotype, FPMN 98047284 (56 mm SL) from the Middle Miocene bed in Miyanoshita, Kokufu-cho, Tottori Prefecture., Japan.

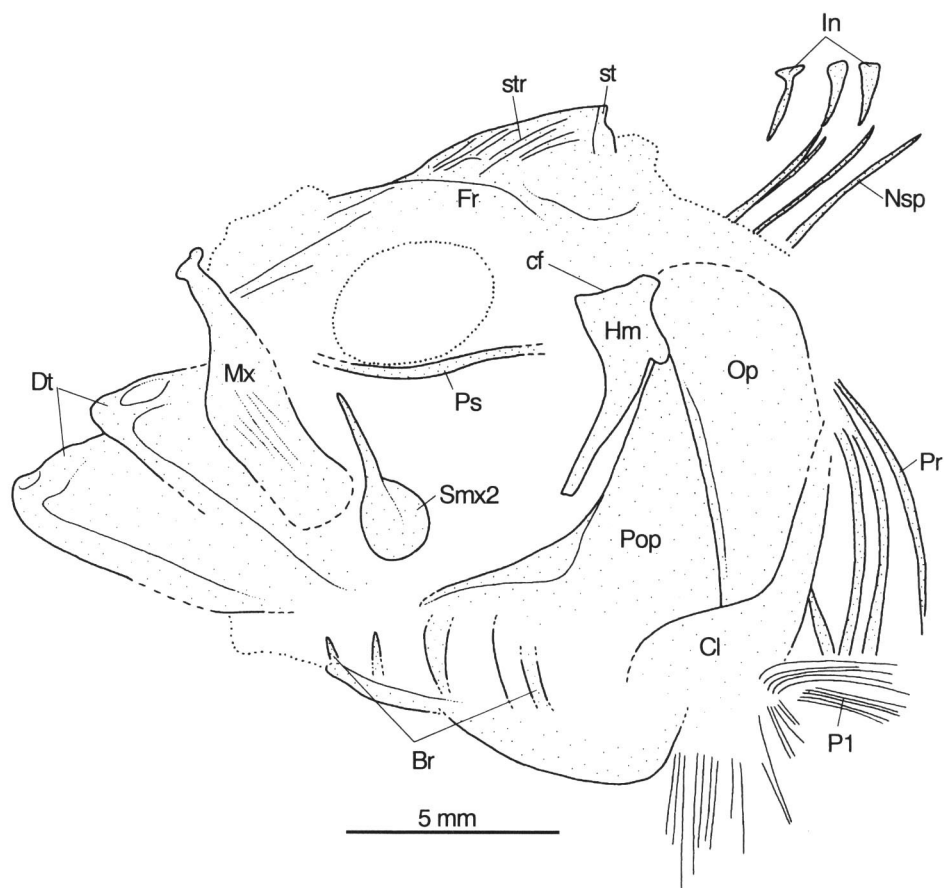


Fig. 2. Head of *Sardinella miyanoshitaensis* sp. nov., holotype, FPMN 98047284. Br: branchiostegal ray, cf: cranial facet of hyomandibular, Cl: cleithrum, Dt: dentary, Fr: frontal, Hm: hyomandibular, In: interneural, Mx: maxillary, Nsp: neural spine, Op: opercle, P1: pectoral fin, Pop: preopercle, Pr: pleural rib, Ps: parasphenoid, Smx2: 2nd supramaxillary, st: groove or tube for supratemporal canal, str: frontoparietal stria.

Diagnosis: Abdominal scutes (both prepelvic and postpelvic scutes) present. Last dorsal fin ray not elongated. Opercle smooth except for a flange along its anterior margin, without radiating striae. Frontoparietal striae on top of the skull more than 7 in number. Second (posterior) supramaxilla paddle shaped, its expanded posterior portion dorso-ventrally symmetrical. Endopterygoid bearing a tooth plate. Vertical striae of scales covering the mid-lateral area of the trunk disjunct at center except for posterior-most stria; no fimbriation or perforations on the hind part of the scale. Body fairly compressed, its depth usually more than 27% of SL.

Description: Counts and proportional measurements are shown in Table 2. The

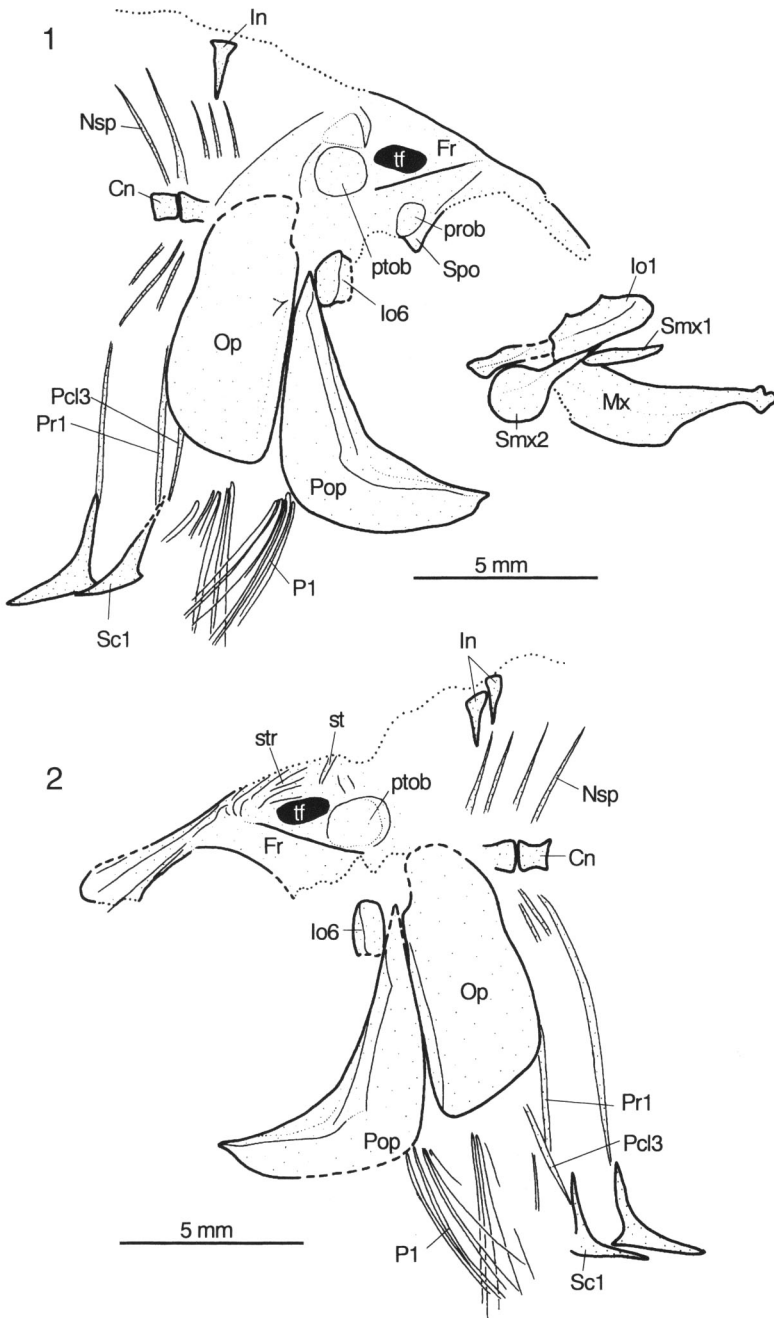


Fig. 3. Head of *Sardinella miyanoshitaensis* sp. nov., paratype, NSM PV-18181. 1, part. 2, counterpart. Cn: centrum, Fr: frontal, In: interneural, lo1: 1st infraorbital, lo6: 6th infraorbital, Mx: maxillary, Nsp: neural spine, Op: opercle, P1: pectoral fin, Pcl3: 3rd postcleithrum, Pop: preopercle, Pr1: 1st pleural rib, prob: prootic bulla, ptob: pterotic bulla, Sc1: 1st prepelvic scute with ascending process; Smx1: 1st supramaxillary, Smx2: 2nd supramaxillary, Spo: sphenotic, st: groove or tube of supratemporal canal, str: frontoparietal stria, tf: temporal foramen.

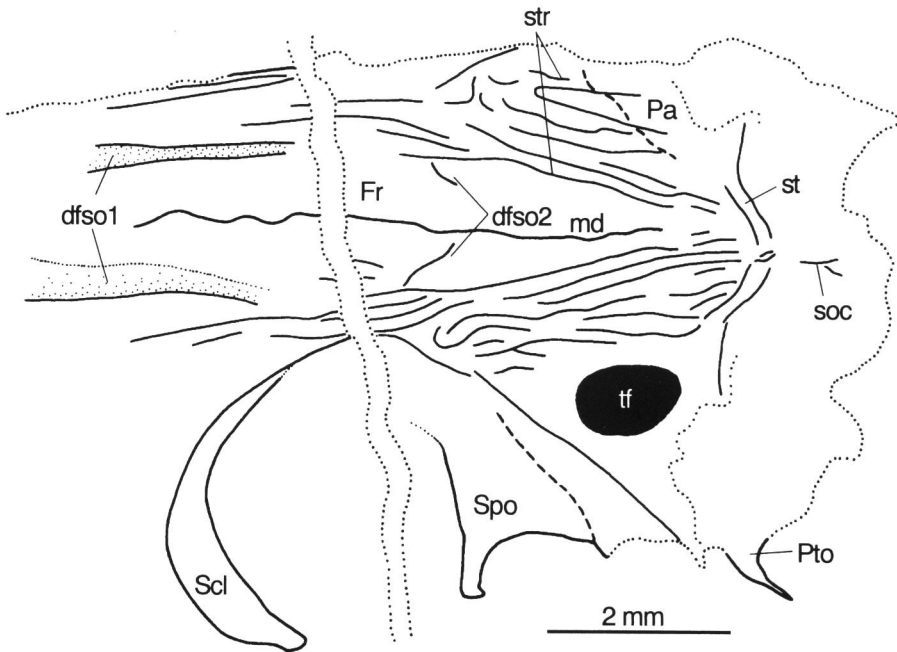


Fig. 4. Top of skull of *Sardinella miyanoshitaensis* sp. nov., paratype, NSM PV 18570. dfo1: 1st dorsal foramen for supraorbital canal, dfo2: 2nd dorsal foramen for supraorbital canal, Fr: frontal, md: median depression, Pa: parietal, Pto: pterotic, Scl: sclerotic, soc: supraoccipital crest, Spo: sphenotic, st: groove or tube for supratemporal canal, str: fronto-parietal stria, tf: temporal foramen.

body is well compressed and moderately deep, 27–33% of standard length (range 26.1–35.7%, $x=30.3$, $SD=2.87$, $n=11$).

Counting the fin rays was difficult in all specimens due to poor preservation. The tip of the pectoral fin does not reach under the dorsal fin. The pelvic fins are inserted midway between the pectoral and anal fins, and are placed under the middle of the dorsal fin base. The tip of the pelvic fin does not reach the anal fin. The dorsal fin originates immediately anterior to the midpoint of the body. The last dorsal fin ray does not elongate filamentously. The anal fin is placed far back on the body. The length of the anal fin base is nearly equal to the dorsal fin base. The caudal fin is forked, and the lower lobe is slightly longer than the upper lobe. The principal rays are most probably 10 in the upper lobe and 9 in the lower lobe.

The vertebral count ranges from 41 to 43 of which 16 or 17 are caudal vertebrae judged by insertion of the 1st anal pterygiophore. The intermuscular bones are well developed. The epineural and epipleural bones are distributed along the length of vertebral column. Epicentral bones are visible at the anterior portion of the trunk. There are 8 interneural (=predorsal) bones (Fig. 1).

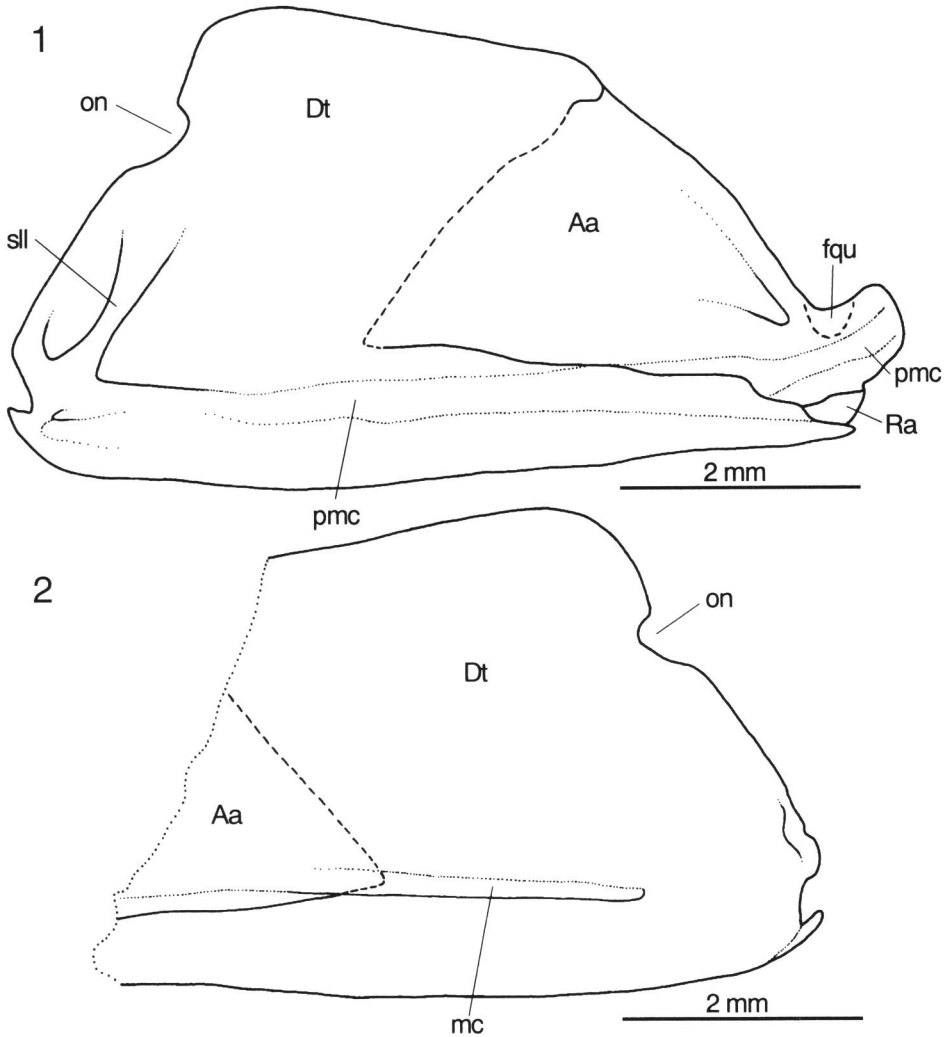


Fig. 5. Lower jaw of *Sardinella miyanoshitaensis* sp. nov., paratype, NSM PV-18570. 1, lateral view. 2, medial view. Aa: angulo-articular, Dt: dentary, fqu: expected medial fossa for quadrate articulation, mc: groove for Meckel's cartilage, on: oral notch, pmc: groove or tube for preoperculo-madibular canal, Ra: retroarticular, sll: strut for lip ligament.

The top of the neurocranium is visible in some specimens (Fig. 4). In the posterior region, consisting of the paired frontals and parietals, there is a pair of wedge shaped area bearing 7–10 (mode=8) short striae called the fronto-parietal striae (Figs. 2, 3). The posterior margin of the wedge is bordered by the supratemporal canal. There are supraorbital canals preceding the wedge. The posttemporal foramen is visible, but the pre-epiotic fossa behind the posttemporal foramen is obscured. The

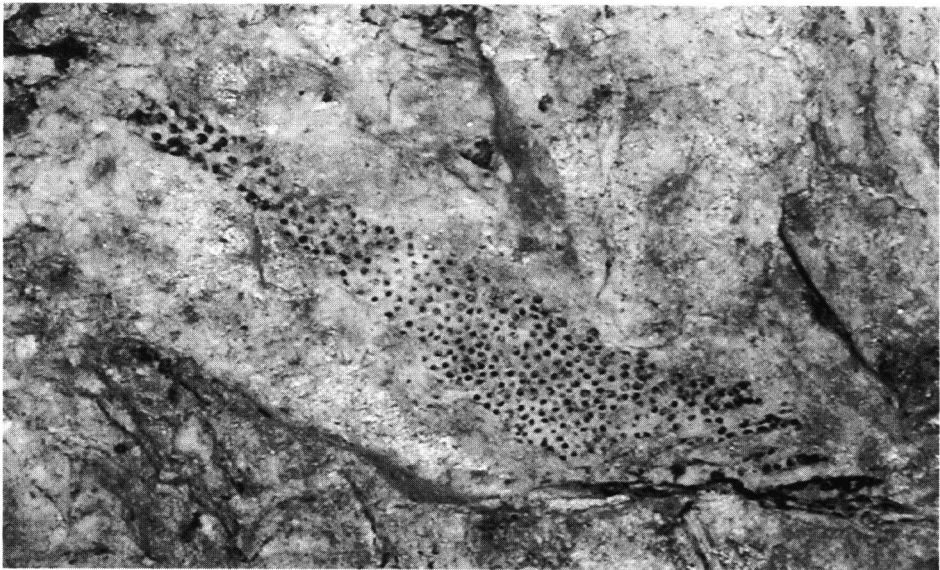


Fig. 6. Endopterygoid tooth plate of *Sardinella miyanoshitaensis* sp. nov., paratype, NSM PV-18580.

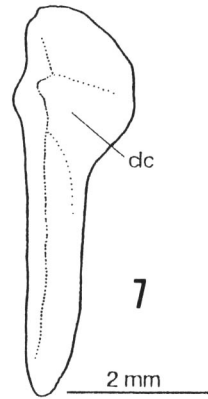
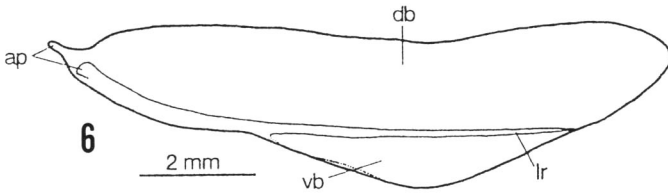
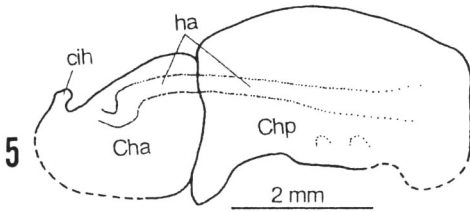
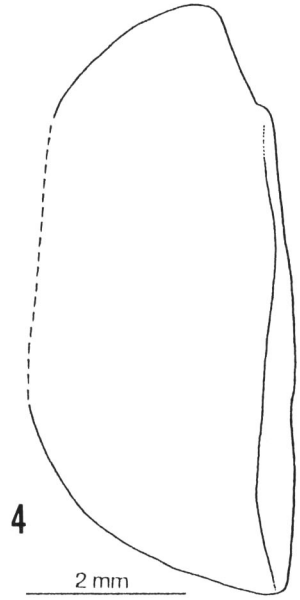
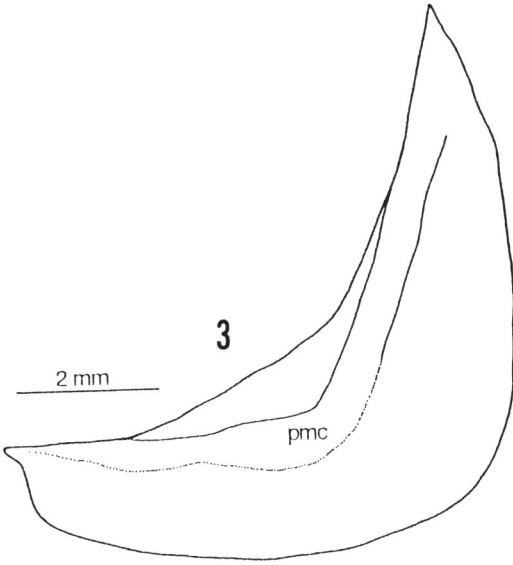
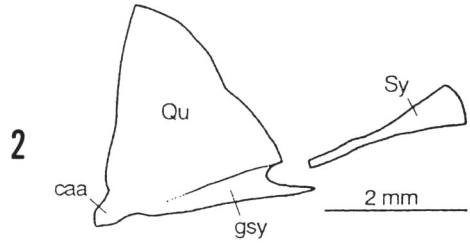
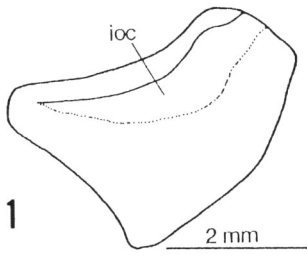
pterotic and prootic bullae associated with the otophysic connection are present (Fig. 3).

The upper jaw of each side consists of a premaxillary, a maxillary and two supramaxillary (Figs. 2, 3). The premaxillary and maxillary teeth are very minute or originally absent. The first supramaxillary is a small needle like bone. The second supramaxillary is a paddle shaped bone, and its posterior expanded portion is dorso-ventrally symmetrical.

The lower jaw is trapezoidal in shape and consists of a pair of dentaries, angulo-articulars and retroarticulars (Fig. 5). Its posterior end extends to midway under the orbit (Figs 1, 2). The oral margin of the dentary is steep and the teeth are very minute or originally absent.

Only the first, third and sixth infraorbital bones are recognizable, and all bear the infraorbital canal (Figs. 3, 7-1). The first infraorbital bone has two small dorsal pro-

Fig. 7. *Sardinella miyanoshitaensis* sp. nov., paratype, NSM PV-18571. 1, third infraorbital, lateral view. ioc: infraorbital canal. 2, quadrate (Qu) and symplectic (Sy), medial view. caa: condyle for angulo-articular articulation, gsy: groove for symplectic articulation. 3, preopercle, lateral view. pmc: groove or tube of preoperculo-mandibular canal. 4, opercle, lateral view. 5, ceratohyals, lateral view. Cha: anterior ceratohyal, Chp: posterior ceratohyal, cih: condyle for interhyal articulation, ha: groove or tube for hyal artery. 6, urohyal. ap: anterior processes for ligamentous attachments to ventral hypohyal, db: dorsal blade, lr: lateral ridge, vb: ventral blade. 7, Supracleithrum, lateral view. clc: groove or tube for cephalic lateralis canal.



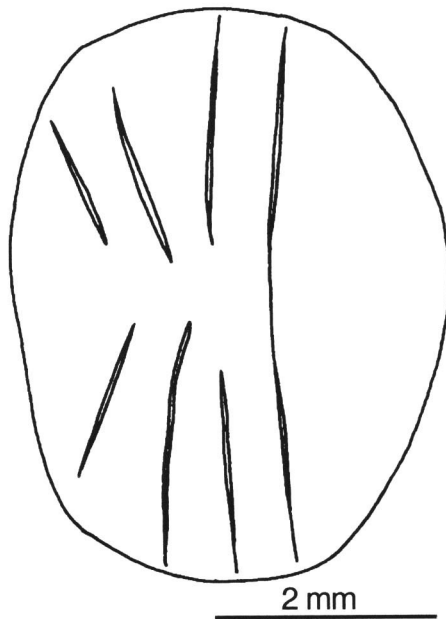


Fig. 8. A scale of *Sardinella miyanoshitaensis* sp. nov., FPMN 98047277, lateral view.

jections.

In the suspensorium, the endopterygoid, hyomandibular, quadrate and symplectic are present. On the endopterygoid of NSM PV-18580, a prominent tooth plate (Fig. 6) was recognized. Each tooth is minute but distinct, aggregating densely to form the tooth plate. The cranial facet of the hyomandibular is nearly flat: the anterior condyle for the sphenotic articulation and posterior condyle for the pterotic articulation are continuous, not separated (Fig. 2). The quadrate is a triangular bone (Fig. 7-2).

Only the preopercle and opercle are clearly observed among four opercular bones (Figs. 1, 2, 7-3, 7-4). The opercle does not bear radial striae on its lateral side, except at a rim along its anterior margin (Fig. 7-4).

In the hyoid apparatus, the anterior and posterior ceratohyals and urohyal are well preserved (Figs. 7-5, 7-6). The urohyal is rather oval in shape and consists of four portions: two pairs of anterior processes for ligamentous attachment to the ventral hypohyal, dorsal and ventral blade and lateral ridge. The dorsal anterior process is more prominent than the ventral.

Only the supracleithrum is clearly observable among the shoulder girdle bones (Fig. 7-7). The supracleithrum is a paddle-like bone bearing the cephalic lateralis canal.

Many scutes are present along the ventral margin of the trunk. Of these, only scutes bearing a pair of well developed ascending processes are countable (Table 2).

Table 2. Counts and measurements of *Sardinella miyanoshitaensis* sp. nov.

	Holotype 56.0 mm SL	Paratypes and other specimens ca. 21.5–69.5 mm SL (n=13)
Vertebrae (precaudal+caudal)	41 (26+15)	42–43 (25–26+16–17) (n=6)
Interneural bones	8	8 (n=4)
Abdominal scutes with ascending process (prepelvic+postpelvic)	23 (11+12)	22 (10–12+10–12) (n=6)
Fronto-parietal striae % of SL	7<	7–10 (n=2)
Body depth	30	26–36 (n=10)
Head length	29	25–30 (n=6)
Prepectoral length	28	24–32 (n=6)
Prepelvic length	52	50–57 (n=6)
Predorsal length	44	44–48 (n=6)
Preal anal length	77	74–81 (n=6)
Pectoral to pelvic	26	26–30 (n=6)
Pelvic to anal	—	26–29 (n=4)
Caudal peduncle length	—	11–18 (n=3)
Caudal peduncle depth	12	9–13 (n=6)

The ascending process articulates with a tip of the pleural rib (Figs. 1, 2, 3). The first one shows a well developed ascending process which also articulates with the rib-like third postcleithrum in addition to the first pleural rib. Five or more scutes without ascending processes are present preceding first prepelvic scute which has ascending processes. In addition, one scute without an ascending process must also be present between the pelvic fin insertions. A series of dorsal scutes are absent.

The scattered scales around the body are clearly visible (Fig. 1). Although the profile and ornamentation of the scales are variable with the position, only those scales near the mid-lateral region of the trunk were selected. In typical scales, the length is somewhat shorter than its depth (ca. 70–90% of depth), its lateral surface bears 3–5 vertical striae (Fig. 8). Of the striae, anterior 2–4 striae are discontinuous at the center, and the posteriormost is continuous. The scale bears neither perforation nor fimbriation on its hind part.

Discussion

From the characters described above, it is evident that the present species is a member of the family Clupeidae *sensu* Whitehead (1985), of the suborder Clupeioidi, the order Clupeiformes. It has the following characters: 1) articulation of the lower jaw under the orbit, 2) a series of scutes present along the abdominal margin, 3) well developed canine teeth absent from the dentary, and 4) base of anal fin nearly

equal in length to that of the dorsal fin.

Whitehead (1985) recognized five subfamilies: Dussumieriinae, Clupeinae, Pelonulinae, Alosinae and Dorosomatinae. The following combination of characters indicates that the present fossil species is a member of the Clupeinae: 1) both prepelvic and postpelvic scutes present, 2) two supramaxillaries present and 3) lower jaw trapezoidal in shape and with a steep oral margin.

Among 16 genera recognized by Whitehead (1985) in the subfamily Clupeinae, *Amblygaster* and *Sardinella* resemble the present species in: 1) both pterotic and prootic bullae present, 2) lateral side of opercle without radiating striae, 3) frontoparietal striae on top of skull, 7 or greater, 4) last dorsal fin ray short, 5) posterior expanded portion of the second supramaxillary dorso-ventrally symmetrical.

We examined all three species of *Amblygaster*: *A. clupeioides*, *A. leiogaster* and *A. sirm*, recognized by Whitehead (1985), and found thereby that the cross-section of the abdomen of *Amblygaster* is rather rounded and never markedly compressed. In the present fossil species, the abdomen is well compressed, indicated by absence of the depressed condition of the abdominal scutes. Therefore, the fossil species is assigned to belong to the genus *Sardinella*.

The genus *Sardinella* includes 21 extant species in two subgenera, *Sardinella* and *Clupeonia* (see Whitehead, 1985). Of these species, 5 species belong to the subgenus *Sardinella*. Every member of the subgenus *Sardinella* have slender bodies, and their abdomen is rather rounded. Consequently, the present species is judged to belong to the subgenus *Clupeonia*.

The extant 16 species of the subgenus *Clupeonia* are chiefly distinguishable from their gillraker counts and the morphology of the scales in themid-lateral area of the trunk (Whitehead, 1985). Counting gillrakers is impossible in fossil specimens, therefore we used the morphology of the scale.

The scales of the present fossil species have the following features: 1) vertical striae except posterior most one not meeting at center, and 2) neither perforations nor fimbriations on the hind part. Species which have these features are *S. jussieui* and *S. marquesensis*. The scale of *S. jussieui*, however, bears weak horizontal striae on the hind part (Whitehead, 1985: 102), whereas the present fossil species has no horizontal striae. The scales of *S. marquesensis* are very similar to those of the fossil species.

The present fossil species is distinguishable from *S. marquesensis* by having rather deeper body (usually 27–33% of SL vs. 25–30% in *S. marquesensis*) and having an endopterygoid tooth plate. The endopterygoid of *S. marquesensis* bears sparse minute teeth, which do not form a tooth plate.

Sardinella marquesensis is endemic to Marquesus Island in the Central Pacific, far from any continent (recently introduced into Hawaii Islands: Tinker, 1978). Members of the genus *Sardinella* are generally found near the continents, so the distribution of *S. marquesensis* is unusual.

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