Studies on the Sinistral Flounders Found in the Waters around Japan

—Taxonomy, anatomy and Phylogeny—*

By

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Contents

I. Introduction

The sinistral flounders and the related flatfishes are widely distributed throughout the waters in the tropical and the temperate zones, inhabiting the sand-muddy bottom between shallow inshore waters and rather deep waters far from the coast.

Since TEMMINCK and SCHLEGEL (1843) first described in "Fauna Japonica" four species of this group obtained from Japan, taxonomic studies of Japanese sinistral flounders have been made by various authorities. JORDAN and STARKS (1906), making the first actual revision of this group found in the sea around Japan, described in "A review of the flounders and soles of Japan" 11 species which are referred to one family and five genera. Subsequently, several authors (FRANZ, 1910; HUBBS, 1915; TANAKA, 1915, 1918; KAMOHARA, 1936) added many new genera and species of this group to the ichthyofauna of Japan. In 1938, OKADA and MATSUBARA gave in their "Key to the fishes and fish-like animals of Japan" a useful analytical key to the 36 species in 17 genera hitherto recorded from Japan, Korea and Formosa. Since the well-known monograph which deals in some detail with the flatfishes all over the world was published by NORMAN (1934), his system has been for a long time followed by many Japanese investigators who are interested in the classification of fishes. Afterward, HUBBS (1945) revised the classification of this group, on the basis of some important characters. Taking the opinions of both NORMAN and HUBBS into consideration, MATSUBARA (1955) revised the system of classification of Japanese sinistral flounders and referred them into 43 species in 18 genera, eight subfamilies, two families and two suborders. There remain, however, some doubtful points in the classification of this group, since those studies were based mainly on external characters.

On the other hand, the phylogenetic relationships of the flatfishes have already been treated by many ichthyologists such as REGAN (1910), KYLE (1921), NORMAN (1934), CHABANAUD (1934-1937), HUBBS (1945), and MATSUBARA (1963). In spite of the contributions of these investigators, the phylogenetic relationships among this group have not been satisfactorily understood, because of poor osteological studies of the flatfishes and because of the special emphasis each author placed on a few limited characters.

The phylogenetic relationships of this group can not be established until the morphology of all known species of Heterosomata of the world has been investigated.

The present work of classifying sinistral flounders and related flatfishes is intended to reveal the interrelationships of the genera of the sinistral flounders and the related flatfishes which have been collected around Japan, through the comparative study particularly with respect to their cranium, orbital bones, gill-rakers, branchial apparatus, urohyal, vertebrae, caudal rays and caudal skeleton.

On the basis of these characters and of the important external and internal characters which have already been investigated by others, the author proposes the following list of species, which are arranged in conformity with the new scheme. In the list, asterisks mark families, subfamilies, genera and species which will be newly erected.

Suborder Psettodina

Family Psettodidae
Genus *Psettodes*
Psettodes erumei (BLOCH and SCHNEIDER)
Suborder Pleuronectina
Family Citharidae
Subfamily Brachypleurinae
Genus *Lepidoblepharon*
Lepidoblepharon ophthalmolepis WEBER
Subfamily Citharinae
Genus *Citharoides*
Citharoides macrolepidotus HUBBS
Family Paralichthyidae*
Genus *Paralichthys*
Paralichthys olivaceus (TEMMINCK and SCHLEGEL)
Genus *Pseudorhombus*
Pseudorhombus dupliciocellatus REGAN
Pseudorhombus oligodon (BLEEKER)
*Pseudorhombus oculocirris**
Pseudorhombus pentophthalmus GÜNTHER
Pseudorhombus arsius (HAMILTON)
Pseudorhombus cinnamoneus (TEMMINCK and SCHLEGEL)
Pseudorhombus levisquamis (OSHIMA)
Genus *Tarphops*
Tarphops oligolepis (BLEEKER)
*Tarphops elegans**
Family Bothidae
Subfamily Taeniopsettinae*
Genus *Taeniopsetta*
Taeniopsetta ocellata (GÜNTHER)
Subfamily Bothinae
Genus *Parabothus*
Parabothus coarctatus (GILBERT)
Parabothus kiensis (TANAKA)
Genus *Tosarhombus**
*Tosarhombus octoculatus**
Genus *Crossorhombus*
Crossorhombus kobensis (JORDAN and STARKS)
Crossorhombus kanekonis (TANAKA)
Genus *Engyprosopon*
Engyprosopon grandisquama (TEMMINCK and SCHLEGEL)
Engyprosopon multisquama AMAOKA
Engyprosopon xystrias HUBBS
Engyprosopon macroptera AMAOKA

*Engyprosopon longipelvis**

Genus *Bothus*

Bothus myriaster (Temminck and Schlegel)

Bothus mancus (Broussonet)

Bothus pantherinus (Rüppell)

Genus *Asterorhombus*

Asterorhombus intermedius (Bleeker)

Genus *Psettina*

Psettina iijimae (Jordan and Starks)

Psettina gigantea Amaoka

Psettina tosana Amaoka

Genus *Arnoglossus*

Arnoglossus tenuis Günther

Arnoglossus polyspilus Günther

Arnoglossus japonicus Hubbs

*Arnoglossus oxyrhynchus**

Arnoglossus orientalis Kamohara ?

Genus *Japonolaeops**

*Japonolaeops dentatus**

Genus *Laeops*

Laeops nigromaculatus Von Bonde

Laeops kitaharae (Smith and Pope)

Genus *Neolaeops**

Neolaeops microphthalmus (Von Bonde)

Genus *Kamoharaia*

Kamoharaia megastoma (Kamohara)

Genus *Chascanopsetta*

Chascanopsetta lugubris Alcock

Chascanopsetta microstoma Kuronuma ?

II. Materials and methods

The materials examined in the present investigation were obtained from various depths from the inshore to the deep waters around Japan and the adjacent waters, mostly by means of motor-trawlers. Most of the specimens examined have been deposited in the Department of Fisheries, Faculty of Agriculture, Kyoto University. All specimens studied here have been preserved in 10% formalin. As to the measurements of various parts of the body are expressed in accordance with Norman (1934).

The number, body sizes and localities of the specimens used in the comparative osteological study are shown in Table 1.

?, no specimens have come under our examination.

Table 1. Localities and body sizes of specimens used for comparative osteology.

Species	Number of specimens	Standard length (mm)	Localities
Psettodes erumei	2	200.0—221.0	Tonking
Lepidoblepharon ophthalmolepis	3	149.0—210.0	Kochi
Citharoides macrolepidotus	3	147.1—168.2	Kochi
Paralichthys olivaceus	2	151.3—230.4	Kochi, Maizuru
Pseudorhombus dupliciocellatus	1	273.9	Yahatahama
P. oligodon	1	197.2	Kochi
P. arsius	2	158.7—161.3	Kochi
P. pentophthalmus	2	102.0—161.2	Kochi, Owashi
P. oculocirris	2	168.8—179.5	Kochi
P. cinnamoneus	2	141.9—159.8	Kochi, Miya
P. levisquamis	1	125.0	Kochi
Tarphops oligolepis	2	64.5— 66.5	Kochi, Owashi
T. elegans	2	60.9— 65.5	Choshi, Nagasaki
Taeniopsetta ocellata	2	150.5—166.1	Kochi, Nobeoka
Parabothus coarctatus	3	173.5—195.5	Kochi
P. kiensis	2	173.5—184.1	Kochi
Tosarhombus octoculatus	3	126.5—159.2	Kochi, Tanegashima
Crossorhombus kobensis	5	85.5—102.2	Kochi, Owashi
C. kanekonis	3	92.2—108.9	Kochi, Nobeoka
Engyprosopon grandisquama	2	89.0— 97.2	Kochi
E. multisquama	2	114.0—130.6	Kochi, Miya
E. macroptera	1	105.9	Kochi
E. xystrias	2	73.0— 87.1	Tanegashima
E. longipelvis	2	50.9— 61.2	Kochi
Bothus mancus	2	151.8—166.1	Okinawa
B. myriaster	10	104.0—214.5	Kochi, Nobeoka
B. pantherinus	2	87.0—114.8	Amami
Asterorhombus intermedius	2	103.5—122.0	Kochi
Psettina iijimae	2	84.8— 86.0	Kochi, Owashi
P. tosana	2	93.8— 98.6	Kochi, Owashi
P. gigantea	2	105.5—114.5	Kochi
Arnoglossus tenuis	2	68.1— 80.3	Kochi, Nagasaki
A. polyspilus	2	160.6—170.8	Kochi, Owashi
A. japonicus	2	131.9—139.2	Kochi, Owashi
A. oxyrhynchus	2	164.1—188.2	Kochi, Owashi
Japonolaeops dentatus	2	124.1—149.5	Kochi, Miya
Laeops nigromaculatus	2	154.9—159.4	Kochi
L. kitaharae	3	111.9—129.5	Kochi
Neolaeops microphthalmus	2	116.2—179.1	Kochi, Tokushima
Kamoharaia megastoma	2	128.4—147.8	Kochi, Tokushima
Chascanopsetta lugubris	2	152.5—213.8	Kochi

The skeletal parts of the body were examined by means of the binocular microscope after the sample had been cleared and stained by alizarin red, and also by X-ray (soft X-ray).

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IV. Taxonomy

The analytical key has been established to delimit the sinistral flounders (Psettodina and Pleuronectina except for Pleuronectidae) obtained from the seas around Japan; it is based mainly on external characters for convenience sake. The present key, however, has taken account of some important internal characters in order to clarify presumable phylogenetic relationships among known genera, subfamilies, families and suborders. In the key, Paralichthyidae and Bothidae have been elevated from the rank of the subfamily to that of family. The family Bothidae further has been newly arranged in two subfamilies, Taeniopsettinae and Bothinae. The genera *Tosarhombus, Japonolaeops, Neolaeops* and *Asterorhombus* have been newly established, the last two of which have been differentiated from the genus *Arnoglossus*. In the present study, the following six species have been found to possess distinctive features which will enable us to recognize them as new to the science: *Pseudorhombus oculocirris, Tarphops elegans, Engyprosopon longipelvis, Tosarhombus octoculatus, Arnoglossus oxyrhynchus* and *Japonolaeops dentatus*. Not included are *Arnoglossus orientalis* KAMOHARA and *Chascanopsetta microstoma* KURONUMA which have been hitherto reported from Japan, as specimens of these species have not been examined.

1. Key to two suborders of Pleuronectida (except for suborder Soleina)

A[1] Dorsal fin not extending forward on head, anterior several rays spinous; anterior two rays of anal fin spinous. Palatine toothed. Vent and genital papilla on midventral-line of body.... Psettodina

A^2 Dorsal fin extending forward on head at least to above eye, dorsal and anal fin rays without spines. Palatine not toothed. Vent and genital papilla shift from midventral-line of body ..... Pleuronectina

2. Suborder Psettodina

Dorsal fin not extending forward on head, the anterior several rays spinous; anterior two rays of anal fin also spinous. Eyes indiscriminately sinistral or dextral; optic chiasma dimorphic, nerve of migrating eye either dorsal or ventral. Palatine with a single row of teeth (Fig. 2, C, D). Urohyal rectangular in shape, not fishhook-like (Fig. 115, A). Vent and genital papilla opens on midventral-line. Pseudomedial bar, which is placed at dorsal portion of the upper eye between prefrontal and frontal on blind side, is not united with latter one (Fig. 96, A1, A2). One preorbital and four suborbital bones on ocular side (Fig. 109, A); on blind side, however, suborbital bones absent, although one preorbital bone present (Fig. 106, A). Second and third hypobranchial bones with toothed plate; glossohyal very short, with a pair of toothed plates (Fig. 113, A). First haemal spine normal, not expanded (Fig. 118, A1). Vertebrae 10+14=24 or 10+15=25.

3. Family Psettodidae

Dorsal fin starting above posterior end of maxillary, anterior several rays spinous, other rays branched. Anal fin similar in shape to dorsal; anterior two rays spinous, other rays branched. Pectoral fins subequal, upper two rays simple and others branched. Ventral fins short based and nearly symmetrical, supported by pelvic bone placed more posteriorly than cleithrum (Fig. 117, A), one spine and five soft rays. Caudal fin rays 24 in total number and those 15 rays branched. Lateral line well developed on both sides, rising slightly above pectoral fin. Teeth biserial on both jaws with a barbed tip, those of inner row depressible (Fig. 2, A, B). Gill-rakers varied in shape, most of them palmate, with a barbed tip; inner and outer sides of gill-arch armed with many tubercles (Fig. 111, A1, A2); branchiostegal membranes of the two sides widely separated. A supplemental maxillary present. Vomer toothed.

Supraoccipital widely connected with exoccipitals, and epiotics widely separated from each other (Fig. 101, A2); zygapophyses of exoccipitals widely adjoining (Fig. 101, A2); alisphenoid on ocular side large, extending to orbital cavity (Fig. 96, A1); interorbital bone consisting of interorbital process (frontal on blind side) and interorbital bar (frontal on ocular side), the former coming in contact anteriorly with prefrontal on blind side, and the latter being connected anteriorly with prefrontal on ocular side (Fig. 101, A1; Fig. 104, A); opisthotic elliptical, connected with pterotic dorsally, with exoccipital ventrally and posteriorly, but separated from basioccipital by intervention of exoccipital; prootic articulated to pterotic, and its posterior margin connected with opisthotic, exoccipital and basioccipital (Fig. 96, A1, A2).

Lower pharyngeal bone barlike in shape with toothed plate; second, third and fourth

upper pharyngeal bones armed with toothed band; first epibranchial bifurcate; third epibranchial without toothed band (Fig. 113, A).

First neural spine present; platelike neural spines present in first to sixth vertebrae; parapophysial stay present; neural postzygapophyses beneath prezygapophyses present on first to tenth vertebrae; rib and epipleural present, epipleural beginning with first vertebra; opening for notochord very small and in middle of centrum; transverse apophysis absent; epicentrum, epimeral, hypomeral and myorhabdoi absent (Fig. 118, A1-A5). Caudal rays 24 (5+15+4) in total number. Urostyle not fused with hypural; last neural and haemal spines not fused with last centrum; uroneural 1 large; uroneural 2 and epural present; hypural platelike in shape, and six in number (Fig. 127, A).

4. Genus *Psettodes* BENNETT

Psettodes BENNETT, 1831, 147 (type-species by original designation: *Psettodes belcheri* BENNETT).

Body elliptical, not greatly compressed, tip of isthmus below posterior margin of maxillary; anterior dorsal profile similar in both sexes. Caudal peduncle deep. Head large, 3.2-3.5 in standard length. Eyes sinistral or dextral, separated by a flat space of moderate width; interorbital region similar in both sexes. Rostral, orbital and mandibular spines absent in both sexes. Nostrils two on each side, the anterior one somewhat tubular with a broad flap posteriorly, the posterior one not tubular, without flap. Mouth oblique, large, and almost straight; maxillary extending to well beyond posterior edge of lower eye; lower jaw strongly protruding at symphysis. Teeth biserial on both jaws, those of outer row fixed, but those on inner row depressible; most of them with barbed tip (Fig. 2, A, B). Gill-rakers varied in shape, most of them palmate with a barbed tip; outer and inner sides of gill-arch with many tubercles (Fig. 111, A1, A2). Scales moderate in size and adherent, ctenoid on both sides (Fig. 2, E); snout, tips of both jaws and interorbital not scaled, but a scaled sheath at bases of dorsal and anal fins. Lateral line well developed on both sides of body, with low curve above pectoral fin; supratemporal branch absent.

Dorsal fin starting above hinder part of maxillary; anterior several rays spinous, but others branched. Anal fin starting behind posterior end of base of pectoral fin, anterior two rays spinous, but all others branched. Pectoral fins subequal, upper two rays simple, but all the rays branched. Ventral fins subequal, one spine and five soft rays, the posterior rays branched. Caudal fin double-truncate, inner 15 rays branched, upper five and lower four rays simple. Vent opens on midventral-line of body, in front of origin of anal fin; genital papilla lies immediately behind vent.

Psettodes erumei (BLOCH and SCHNEIDER) "Bozu-garei"

Fig. 1

Pleuronectes erumei BLOCH and SCHNEIDER, 1801, 150.
Hippoglossus erumei. CANTOR, 1850, 1198.

Psettodes erumei. GÜNTHER, 1862, 402. ——BLEEKER, 1866-72, 4, pl. 1, fig. 2. ——DAY, 1875-78, 422, pl. 91, fig. 4. —— JORDAN and SEALE, 1907, 45. —— JORDAN and RICHARDSON, 1909, 201. —— BARNARD, 1925, 383, pl. 17, fig. 1. —— NORMAN, 1926, 221. —— NORMAN, 1927, 8, fig. 1. ——OSHIMA, 1927, 178. ——WEBER and BEAUFORT, 1929, 97, fig. 24. ——MCCULLOCH, 1929, 276. —— WU, 1932, 73. —— FOWLER, 1933, 163. —— WU and WANG, 1933, 298. —— WANG, 1933, 37, fig. 16. —— NORMAN, 1934, 57, fig. 30. —— UMALI, 1936, 80, fig. 42. —— FOWLER, 1936, 495, fig. 239. —— FOWLER, 1937, 216. —— HERRE and MYERS, 1937, 50. —— ROXAS and MARTIN, 1937, 65. —— OKADA and MATSUBARA, 1938, 415. —— HERRE, 1941, 390. —— BLEGVAD, 1944, 197, fig. 21. —— SMITH, 1949, 155, fig. 299. —— HERRE, 1953, 176. —— OGILBY, 1954, 23, fig. 24. —— MUNRO, 1955, 256, pl. 49, 741. —— PUNPOKA, 1964, 13, fig. 1. —— SHIH-CHIEH, 1966, 162, figs. 2-4.

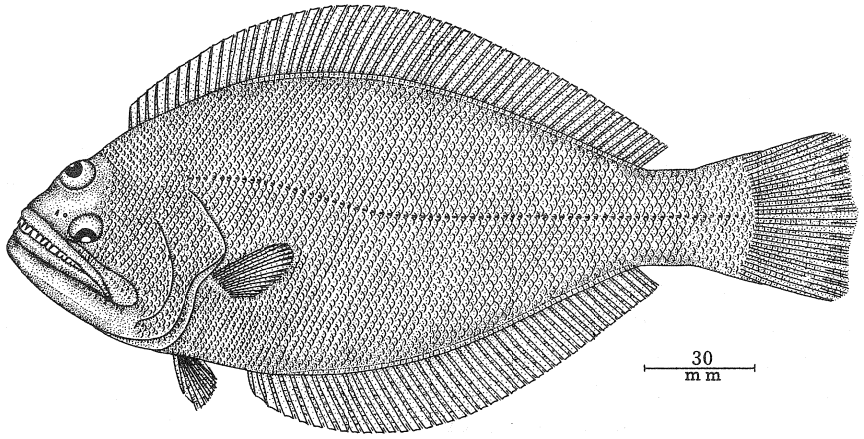

Fig. 1. Lateral view of *Psettodes erumei* (BLOCH and SCHNEIDER): No. S 566, 181.8 mm in standard length.

Materials: Sinistral specimens-No. 26997, 264.0 mm in standard length, Tonking Bay, March 15, 1953. No. S191, 255.7 mm, Tonking Bay, June 4, 1957. Nos. S556, S561, S563-564, S566, 160.9-271.2 mm, Tonking Bay, August 6, 1957. Dextral specimens-No. S258, 295.0 mm, Tonking Bay, June 17, 1957. Nos. S554-555, S558, S562, 178.0-196.5 mm, Tonking Bay, August 6, 1957.

Diagnosis: A sinistral or dextral flounder with dorsal fin not extending forward on head, and anterior rays spinous; upper eye placed on dorsal surface of head.

Description: Dorsal fin rays 52-56; anal fin rays 37-43; pectoral fin rays 14 on ocular side, 14 on blind side; scales on lateral line 65-72; gill-rakers on first arch 18-20; vertebrae including urostyle 10+14=24. Head 3.16-3.47 in standard length; depth 2.08-2.42. Snout 3.5-3.94 in head; upper eye 5.71-8.26; lower eye 6.5-7.76; maxillary 1.35-1.44 on ocular side, 1.35-1.45 on blind side; lower jaw 1.22-1.30 on ocular side, 1.22-1.31 on blind side; depth of caudal peduncle 2.07-2.64; first dorsal fin ray 7.66-16.7; longest dorsal fin ray 2.22-2.75; first anal fin ray 10.1-14.8; longest anal fin ray 2.12-2.74; pectoral fin 1.98-2.32 on ocular side, 1.89-2.19 on blind side; ventral fin 2.76-3.20 on ocular side, 2.51-2.90 on blind side.

Body elliptical, not greatly compressed, highest at middle part of body, its depth less than half its length; dorsal and anal contours evenly arched except for region of upper eye. Caudal peduncle deep, a little less than 1/3 depth of body.

Head large in size, about 2/3 depth of body; the upper profile slightly convex at upper eye. Snout stout and rather large, much longer than eye diameter. Eyes small, subequal to 1/4 to 1/5 length of maxillary, separated by a flat space, its width as long as or a little narrower than eye diameter; the upper placed on dorsal surface of head, and a little in advance of the lower, which is situated above middle of maxillary. Nostrils on ocular side two, very small, and located in front of midline of interorbital space, the anterior more or

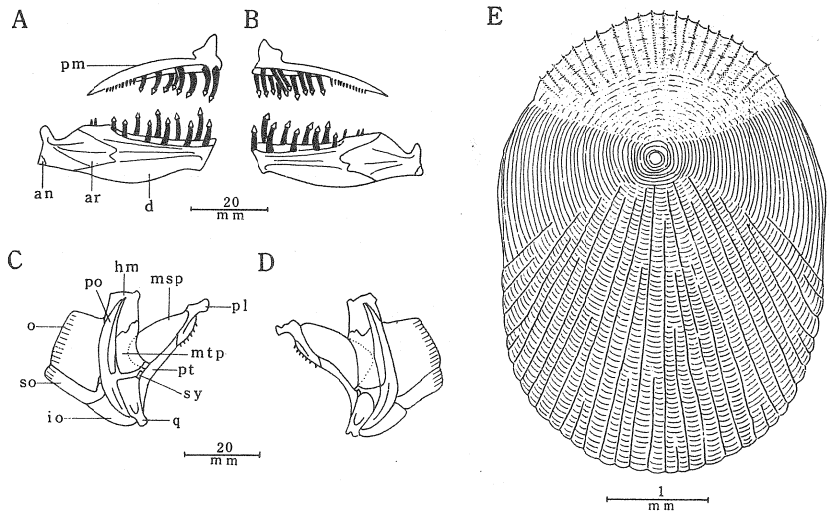

Fig. 2. Lateral view of both jaws (A, on blind side; B, on ocular side), suspensorium and opercular apparatus (C, on blind side; D, on ocular side) and scale (E) in *Psettodes erumei* (BLOCH and SCHNEIDER). pm, premaxillary; d, dentary; ar, articular; an, angular; hm, hyomandibular; mtp, metapterygoid; sy, symplectic; q, quadorate; msp, mesopterygoid; pt, pterygoid; pl, palatine; po, preopercle; o, opercle; so, subopercle; io, interopercle.

less tubular with a triangular flap posteriorly, the posterior not tubular, without flap; those on blind side located between upper eye and tip of snout, the anterior tubular with broad flap posteriorly, the posterior not tubular, without flap.

Mouth oblique and large, not arched, maxillary extending well beyond posterior edge of lower eye; the lower jaw strongly protruding at symphysis. Teeth pointed and curved, gradually becoming smaller and shorter posteriorly; some of them with barbed tips; teeth on both jaws biserial, those of inner row longer and depressible, those of outer row fixed (Fig. 2, A, B). Gill-rakers numerous, varied in shape, most of them palmate with a barbed tip; the outer side of gill-arch armed with small disklike tubercles covered with prickles,

and arranged irregularly on hypobranchial, on ceratobranchial and on epibranchial; the inner side of gill-arch with palmatelike tubercles, arranged in a single regular row extending throughout the entire length of the arch; and many prickles cover lower half of posterior margin of upper limb, and sparsely, the ceratobranchial and the hypobranchial (Fig. 111, A1, A2).

Scales moderate in size and not deciduous, ctenoid on both sides (Fig. 2, E); snout, tips of jaws and interorbital not scaled, but a low scaled sheath at bases of dorsal and anal fins.

Lateral line well developed on both sides of body, rising slightly above pectoral fin; no distinct supratemporal branch.

Dorsal fin starting above hinder part of maxillary, becoming gradually higher toward middle part of body and decreasing in height posteriorly; anterior several rays spinous, but remaining ones branched. Origin of anal fin below and much behind base of pectoral fin, similar in shape to dorsal; anterior two rays spinous, but others branched. Pectoral fins subequal, and not produced; all rays branched except for upper two rays. Ventral fin slightly to rear of vertical through posterior margin of preopercle, nearly symmetrical, one spine and five soft branched rays. Caudal fin double-truncate, inner 15 rays branched, upper five and lower four rays including embedded rays simple.

Vent opens on midline of body, in front of origin of anal fin; genital papilla lies immediately behind vent.

In formalin, general ground color of body brownish, sometimes with four or five broad dark transverse bands; vertical fins dark; blind side of body and paired fins pale brownish.

5. Suborder Pleuronectina

Dorsal fin extending forward on head at least to above eye; dorsal and anal fin rays without spines. Eyes sinistral (Paralichthyidae and Bothidae) or dextral (Pleuronectidae), except in reversed specimens in certain species; optic chiasma monomorphic, nerve of migrating eye dorsal only in nonreversed fish, but basically dimorphic in Citharidae, nerve of migrating eye being dorsal in either normal or reversed fish. Palatine not toothed. Urohyal fishhook-like in shape. Vent and genital papilla shifting from midventral-line of body. Pseudomedial bar united with frontal on blind side (Fig. 104, B-G). Suborbital bones on ocular side lacking, but those on blind side present (Fig. 106, B-F; Figs. 107-108). Hypobranchial and glossohyal bones without toothed plate (Fig. 113, B-L; Fig. 114, A-L). First haemal spine expanded (Fig. 118, B1; Figs. 119-122). Vertebrae never fewer than 10+17=27 (Table 10).

6. Key to families of Pleuronectina (except for family Pleuronectidae)

A[1] Ventral fin with one spine and five soft rays (Fig. 3, B); branchiostegal membranes separated

from each other (Fig. 3, A); caudal fin rays 23 in total number, 15 rays branched; pectoral fin on ocular side shorter and slenderer than that on blind side; opisthotic and exoccipital connected with prootic anteriorly (Fig. 96, B1, B2, C1, C2); urostyle not fused with hypural (Fig. 127, B, C) ..... Citharidae

A^2 Ventral fin without a spine (Fig. 8, B); branchiostegal membranes connected with each other (Fig. 8, A); caudal fin rays 17 or 18 in total number, 9 to 13 rays branched; pectoral fin on ocular side as long as or longer than that on blind side; either opisthotic or exoccipital connected with prootic anteriorly (Fig. 96, D1-F1, D2-F2; Figs. 97-100); urostyle fused with hypural (Fig. 127, D-O; Fig. 128, A-H).

B^1 Ventral and pectoral fin rays branched at least in posterior and inner parts; ventral fins short based, and almost symmetrical, that on ocular side not elongate, the distance between tip of isthmus and origin of ventral fin much greater than length of base of ventral fin (Fig. 8, B); lateral line developed on both sides; exoccipital connected with prootic anteriorly, but opisthotic not connected with latter (Fig. 96, D1-F1, D2-F2); preorbital bone on blind side present; rib and epipleural present; epicentrum, epimeral, hypomeral, myorhabdoi and transverse apophysis absent (Fig. 119, A1-A5, B1-B5); tip of sciatic part of urohyal truncate, cardiac apophysis bifurcate (Fig. 115, D-G) ..... Paralichthyidae

B^2 Ventral and pectoral fin rays simple; ventral fin on blind side short based, that on ocular side slightly or greatly elongate, starting on tip of isthmus or slightly behind it (Fig. 30), in the latter case, the length between tip of isthmus and origin of ventral fin subequal to length of base of ventral fin (Fig. 28, B), second to fourth ray on ocular side sets opposite first on blind side; lateral line on blind side generally absent or feebly developed; opisthotic connected with prootic anteriorly, but exoccipital not connected with latter (Figs. 97-100); preorbital bone on blind side absent (Fig. 107, D-G; Fig. 108); rib and epipleural absent; epicentrum, epimeral, hypomeral, myorhabdoi and transverse apophysis present (Figs. 120-124); tip of sciatic part of urohyal generally pointed, rarely truncate in Taeniopsettinae; cardiac apophysis a ridge or wing (Fig. 115, H-O; Fig. 116) ..... Bothidae

7. Family Citharidae

Dorsal fin rays branched – all or at least those on posterior half. Anal fin similar in shape and structure to dorsal. Pectoral fin on ocular side shorter and slenderer than that on blind side, several inner rays branched; but all rays simple on blind side. Ventral fin short based, supported by pelvic bone placed behind cleithrum (Fig. 117, B), one spine and five soft rays. Caudal fin rays 23 in total number, 15 rays branched. Lateral line well developed on both sides. Eyes sinistral or dextral; optic chiasma basically dimorphic, nerve of migrating eye is consistently dorsal in chiasma, whether in normal or reversed specimen. Teeth all small, pointed, in bands (Fig. 5, C, D; Fig. 6). Gill-rakers well developed, armed with many spinules in bands; many tubercles arranged on outer and inner sides of arch (Fig. 111, B1, B2; Fig. 5, A, B); branchiostegal membranes on both sides separated (Fig. 3, A); vestigial supplemental maxillary present or absent.

Supraoccipital connected with exoccipitals by a narrow patch or at tip, and epiotics separated from each other; zygapophyses of exoccipitals widely adjoining (Fig. 101, B1-C1, B2-C2); alisphenoid on ocular side large or moderate in size, not invariably extending to orbital cavity (Fig. 96, B1-C1); interorbital bone consisting of interorbital process (frontal on blind side) and interorbital bar (frontal on ocular side), each frontal in contact anteriorly with the prefrontal of the same side (Fig. 104, B); opisthotic elliptical, moderate in size,

connected with pterotic dorsally, with exoccipital ventrally and posteriorly, but separated from basioccipital by intervention of exoccipital; prootic articulated with pterotic, its posterior margin connected with opisthotic, exoccipital and basioccipital (Fig. 96, B1-C1, B2-C2).

Suborbital bones on ocular side scaly nodules; prefrontal bone on blind side, five short suborbital bones on blind side (Fig. 106, B, C).

Lower pharyngeal bone rodlike in shape with toothed plate; second, third and fourth upper pharyngeal bones armed with toothed band; first epibranchial bone bifurcate, and third bone with toothed band (Fig. 113, B, C).

Urohyal fishhook-like in shape; tip of sciatic part of urohyal truncate, extending to posterior 1/3 of main part; cardiac apophysis small and simple (Fig. 115, B, C).

First neural spine present; platelike neural spine present in first to fourth vertebrae; parapophysial stay present; neural postzygapophyses beneath prezygapophyses present in eighth to tenth vertebrae; rib and epipleural present, but epicentrum, epimeral, hypomeral and myorhabdoi absent, epipleurals beginning with first vertebra; opening for notochord very small, in middle of centrum; transverse apophysis absent (Fig. 118, B1-B5).

Caudal rays 23 (4+15+4) in total number; urostyle not fused with hypural; last neural spine fused with centrum, but last haemal spine jointed to centrum; hypurals platelike in shape, and six in number; uroneural 1, uroneural 2 and epural present (Fig. 127, B, C).

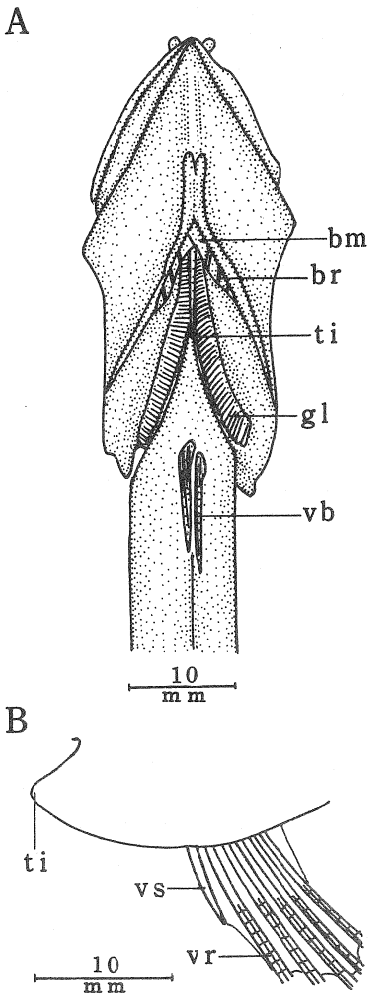

Fig. 3. Ventral view of head with jaws and anterior part of trunk slightly stretched (A) and lateral view of ventral fin on ocular side (B) in *Citharoides macrolepidotus* HUBBS. bm, branchiostegal membranes; br, branchiostegal ray; ti, tip of isthmus; gl, gill; vb, ventral fin on blind side; vs, spine of ventral fin; vr, ray of ventral fin.

8. Key to subfamilies and genera of Citharidae

A[1] Brachypleurinae: Eyes and color on dextral side; dorsal and anal rays branched on posterior half; at least posterior ventral soft rays branched; no spots in axils of dorsal and anal fins; nerve of left eye dorsal in chiasma ..... *Lepidoblepharon*

A[2] Citharinae: Eyes and color on sinistral side; all dorsal and anal rays and all ventral soft rays branched; a pair of conspicuous spots at bases of last rays of dorsal and anal fins; nerve of right eye dorsal in chiasma ..... *Citharoides*

9. Subfamily Brachypleurinae

Eyes and color on dextral side; nerve of left eye dorsal in chiasma. Dorsal and anal rays branched on posterior half; at least posterior ventral soft rays branched. No spots in axils of dorsal and anal fins. Alisphenoid large, extending to orbital cavity; supraoccipital connected with exoccipitals by a narrow patch, and epiotics widely separated from each other (Fig. 101, C1-C2).

10. Genus *Lepidoblepharon* WEBER

Lepidoblepharon WEBER, 1913, 421 (type-species by original designation: *Lepidoblepharon ophthalmolepis* WEBER).

Body elliptical, tip of isthmus below space between posterior margin of lower eye and preopercle; anterior dorsal profile similar in both sexes. Caudal peduncle medium in depth. Head large, 3.0-3.3 in standard length. Eyes dextral, separated by a narrow ridge; interorbital region similar in both sexes. Nostrils two on ocular side, anterior tubular with a flap, posterior large elliptical, opening without flap; nostrils two on blind side, anterior tubular with a flap, posterior not tubular, covered with a membrane. Mouth large, maxillary extending to below middle part of lower eye; lower jaw strongly protruding at symphysis. Teeth all small, pointed, in bands (Fig. 5, C, D). Gill-rakers rather long, armed with many spinules in bands; inner and outer sides of gill-arch provided with many wartlike and disklike tubercles (Fig. 5, A, B). Scales large in size and deciduous, finely ctenoid on ocular side (Fig. 5, E) and cycloid on blind side; snout, both jaws, interorbital and eyeballs scaled. Lateral line well developed on both sides, strongly curved above pectoral fin; a supratemporal branch of lateral line absent.

Dorsal fin originating on blind side and above anterior margin of upper eye; first ray shortest, height longest ray near posterior end; rays on posterior half branched. Anal fin similar in shape and structure to dorsal. Pectoral fins well developed on both sides, but that on blind side longer and stouter than that on ocular side, inner rays on ocular side branched, but other rays simple; all the rays on blind side simple. Ventral fins short based, subequal in size, one spine and five soft rays, at least posterior rays branched. Caudal fin rounded, inner 15 rays branched, but upper four and lower four rays simple. Vent and genital papilla open on ocular side.

Lepidoblepharon ophthalmolepis WEBER "Uroko-garei"

Fig. 4

Lepidoblepharon ophthalmolepis WEBER, 1913, 422, pl. 6, fig. 7. ——WEBER and BEAUFORT, 1929, 143, fig. 36. ——NORMAN, 1934, 401, fig. 290. ——KAMOHARA, 1936, 21. ——KAMOHARA, 1938, 60. ——OKADA and MATSUBARA, 1938, 433. ——KURONUMA, 1940, 53. ——KURONUMA, 1940, 214. ——HUBBS, 1945, 34. ——KAMOHARA, 1950, 245. ——MATSUBARA, 1955, 1250. ——KAMOHARA, 1958, 61. ——KAMOHARA, 1964, 81.

Materials: Nos. 6128, 6171, 6186-6188, 103.2-133.2 mm in standard length, Heta, Shizuoka Pref., December 7, 1938. Nos. 19662-19663, 128.4-132.8 mm, Nobeoka, Miyazaki Pref., December 10, 1952. Nos. 33407-33416, 117.0-161.4 mm, Mimase, Kochi Pref., December 15, 1959. Nos. 33831-33836, 168.0-257.0 mm, Mimase, January 20, 1960.

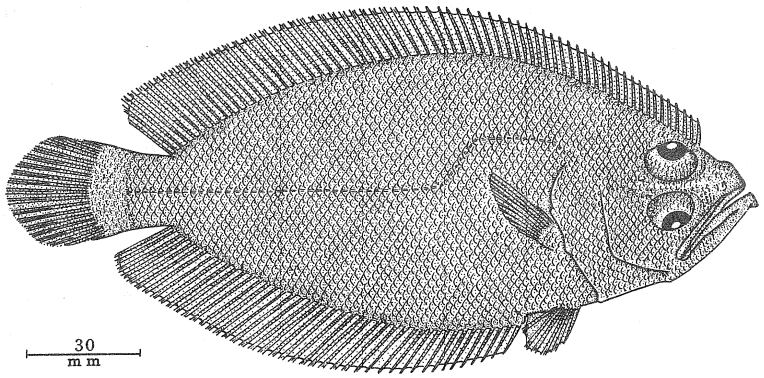

Fig. 4. Lateral view of *Lepidoblepharon ophthalmolepis* WEBER: No. 33407, 161.4 mm in standard length.

Diagnosis: A dextral flounder with scaled eyeball; branched rays on posterior half of dorsal and anal fins.

Description: Dorsal fin rays 65-70; anal fin rays 45-48; pectoral fin rays 11-12 on ocular side, 11 on blind side; gill-rakers on first arch 4-7+10-11; scales in lateral line 51-58; vertebrae including urostyle 10+20=30. Head 3.01-3.29 in standard length; depth 2.1-2.5. Snout 4.20-5.27 in head; upper eye 3.09-4.29; lower eye 3.04-4.84; maxillary 1.94-2.1 on ocular side, 2.22-2.47 on blind side; lower jaw 1.62-1.87 on ocular side, 1.68-1.93 on blind side; depth of caudal peduncle 2.78-3.19; first dorsal fin ray 8.47-12.2; longest dorsal fin ray 2.15-2.99; first anal fin ray 5.82-11.3; longest anal fin ray 2.15-2.66; pectoral fin 2.32-2.77 on ocular side, 1.82-2.38 on blind side; ventral fin 3.42-3.93 on ocular side, 2.48-3.72 on blind side.

Body elliptical, rather deep and moderately compressed, highest at middle, its depth much less than half its length; dorsal and anal contours evenly arched, except for head region. Caudal peduncle medium in depth, a little less than 1/4 depth of body.

Head large, about 3/4 depth of body; the upper profile strongly notched in front of middle part of upper eye. Snout large, rather sharp, equal to or a little shorter than eye diameter. Eyes large, a little longer than half length of maxillary, separated by a narrow ridge, its width subequal to 1/5 eye diameter; eyes on same vertical. Nostrils on ocular side set in front of interorbital ridge, anterior one tubular with triangular flap posteriorly; posterior one not tubular, without flap; those on blind side in front of origin of dorsal, anterior one tubular with short flap posteriorly, posterior one not tubular, covered with a broad membrane.

Mouth oblique, slightly arched anteriorly and large in size, maxillary extending to below middle part of lower eye; lower jaw strongly protruding at mandibular symphysis when mouth is closed. Teeth all small, pointed, in bands in both jaws (Fig. 5, C, D). Gill-rakers slender and long, well developed on upper and lower limbs of arch, armed with many

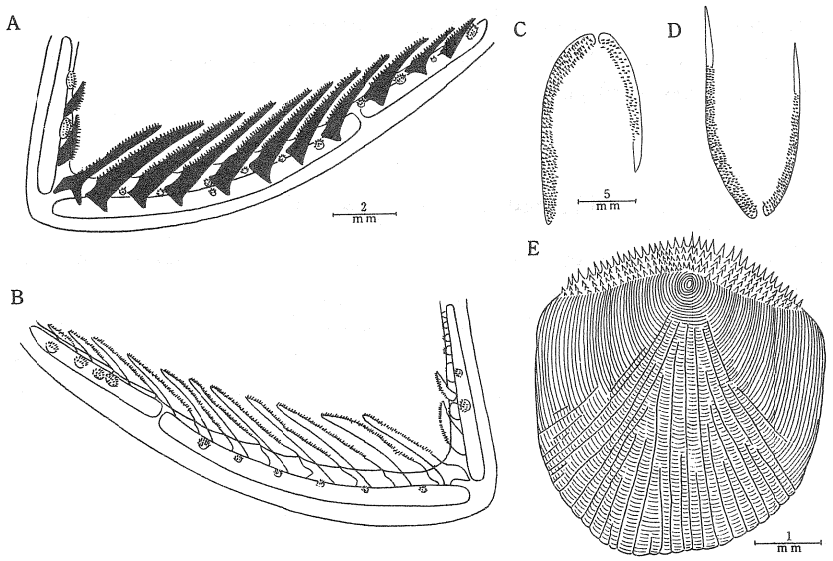

Fig. 5. First gill-arch on ocular side (A, outer side; B, inner side), upper jaw (C), lower jaw (D) and scale on ocular side (E) in *Lepidoblepharon ophthalmolepis* WEBER. Lateral view (A, B, E); ventral view (C); dorsal view (D).

spinules in bands, longest one subequal to half eye diameter; tubercles on outer side of arch small, disklike in shape, armed with many equal-sized spinules, and set somewhat regularly between each gill-raker throughout upper and lower limbs; those on inner side of arch disklike in shape, with many spinules, also arranged somewhat regularly between gill-rakers (Fig. 5, A, B).

Scales rather large and deciduous except for those on lateral line and along upper and lower margins of body; ctenoid on ocular side (Fig. 5, E), cycloid on blind side; snout, both jaws, interorbital and eyeballs scaled; posterior part of dorsal and anal fins naked. Lateral

line well developed on both sides, strongly arched above pectoral fin, length of curved portion about 2/3 length of head, height about 1/3 its length, and accessory line absent.

Dorsal fin starting on blind side, above anterior margin of upper eye, first ray shortest, succeeding rays becoming gradually higher, and highest near posterior end; rays of posterior half of dorsal fin branched, but other rays simple. Anal fin starts at vertical through rear of pectoral fin base, similar in shape and structure to dorsal. Pectoral fins well developed on both sides of body, but that on ocular side shorter and feebler than that on blind side; upper four and lower one or two rays on ocular side simple, but other inner rays branched; all rays on blind side simple. Ventral fins subequal on both sides of body, starting slightly in rear of vertical through posterior end of preopercle; that on ocular side slightly in advance of that on blind side; one spine and five branched soft rays on both sides. Caudal fin rounded, inner 15 rays branched, but upper and lower four rays simple.

Vent opens on ocular side, in front of origin of anal; genital papilla located immediately above anus.

In formalin, general ground color of body milky brownish; median fins paler than body, dorsal and anal with traces of darker spots or bands; blind side of body milky white; peritoneum on both sides jet-black.

11. Subfamily Citharinae

Eyes and color on sinistral side; nerve of right eye dorsal in chiasma. All dorsal and anal rays and all ventral soft rays branched. A pair of conspicuous spots at bases of last rays of dorsal and anal fins. Alisphenoid rather small, not extending to orbital cavity; supraoccipital connected with exoccipital at its tip, and epiotics narrowly separated from each other (Fig. 101, B1-B2).

12. Genus *Citharoides* HUBBS

Citharoides HUBBS, 1915, 453 (type-species by original designation: *Citharoides macrolepidotus* HUBBS).

Brachypleurops FOWLER, 1934, 341 (type-species by original designation: *Brachypleurops axillaris* FOWLER).

Body elliptical, tip of isthmus below space between posterior margin of lower eye and preopercle; anterior dorsal profile similar in both sexes. Caudal peduncle medium in depth. Head large, 3.2-3.5 in standard length. Eyes sinistral, separated by a narrow ridge; interorbital region similar in both sexes. Rostral, orbital and mandibular spines absent in both sexes. Nostrils two on ocular side, anterior tubular with a flap posteriorly, posterior not tubular, without flap; nostrils two on blind side, anterior tubular with a flap posteriorly, posterior not tubular, covered with a membrane. Mouth oblique, large, maxillary extending below near posterior part of eye or slightly to beyond middle part of eye; lower jaw strongly protruding at symphysis. Teeth all small, pointed, most of them in bands (Fig. 7, A, B).

Gill-rakers rather long, armed with many spinules in bands; inner and outer sides of gill-arch provided with many wartlike and disklike tubercles (Fig. 111, B1, B2). Scales large in size and deciduous, finely ctenoid on ocular side and cycloid on blind side; snout, both jaws and all fins except at base of caudal fin naked. Lateral line well developed on both sides, strongly arched above pectoral fin, a supratemporal branch of lateral line absent; tubules of lateral line typically with a single terminal branch.

Dorsal fin originating on blind side and in front of middle part of upper eye; first ray shortest, fin highest near posterior end; all rays branched. Anal fin similar in shape and structure to dorsal. Pectoral fins well developed on both sides, but that on ocular side a little shorter than that on blind side, inner rays on ocular side branched, but other rays simple; all rays on blind side simple. Ventral fins subequal on both sides of body, one spine and five soft rays, posterior rays branched (Fig. 3, B). Caudal fin rounded, inner 15 rays branched, but upper four and lower four rays simple. Vent and genital papilla open on ocular side.

Citharoides macrolepidotus HUBBS "Koke-birame or Kashibeta"

Fig. 6

Citharoides macrolepidotus HUBBS, 1915, 453, pl. 25, fig. 1. ——KAMOHARA, 1934, 461. ——KAMOHARA, 1936, 9. ——KAMOHARA, 1938, 57. ——HUBBS, 1945, 32. ——MORI, 1952, 176. ——MATSUBARA, 1955, 1250. ——MORI, 1956, 30. ——KURODA, 1962, 1.

Citharoides macrolepis (in part) NORMAN, 1934, 170. ——OKADA, 1938, 263. ——OKADA and MATSUBARA, 1938, 419, pl. 103, fig. 2. ——KURONUMA, 1940, 213. ——KAMOHARA, 1950, 239. ——KURODA, 1951, 388. ——KAMOHARA, 1958, 61. ——KAMOHARA, 1964, 81.

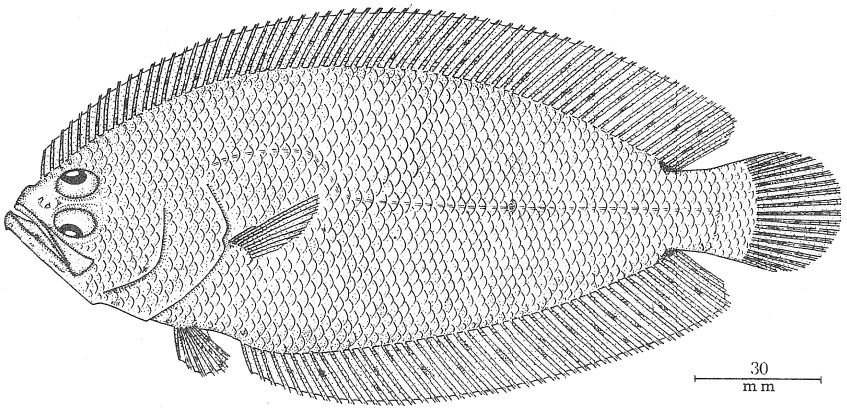

Fig. 6. Lateral view of *Citharoides macrolepidotus* HUBBS: No. 33419, 164.1 mm in standard length.

Materials: Nos. 29244-29246, 143.2-147.1 mm in standard length, Hamada, Shimane Pref., May 27, 1960. Nos. 33417-33424, 97.5-181.2 mm, Kochi Pref., December 8, 1959. No. 33837, 179.4 mm, Urado, Kochi Pref., December 15, 1960.

Diagnosis: A sinistral flounder with a pair of spots at bases of last rays of dorsal and anal fins; dorsal and anal fins all branched.

Description: Dorsal fin rays 64-68; anal fin rays 44-48; pectoral fin rays 9-10 on ocular side, 10 on blind side; gill-rakers on first arch 4-6+8-9; scales in lateral line 40-43; vertebrae including urostyle 10+22=32. Head 3.2-3.43 in standard length; depth 2.27-2.59. Snout 4.58-5.02 in head; upper eye 3.97-5.16; lower eye 3.98-5.06; maxillary 2.09-2.32 on ocular side, 2.12-2.34 on blind side; lower jaw 1.66-1.82 on ocular side, 1.65-1.82 on blind side; depth of caudal peduncle 2.56-2.94; first dorsal fin ray 5.83-7.93; longest dorsal fin ray 2.04-2.58; first anal fin ray 4.99-6.12; longest anal fin ray 2.05-2.35; pectoral fin 1.82-2.08 on ocular side, 1.65-2.05 on blind side; ventral fin 2.9-3.62 on ocular side, 2.7-3.27 on blind side.

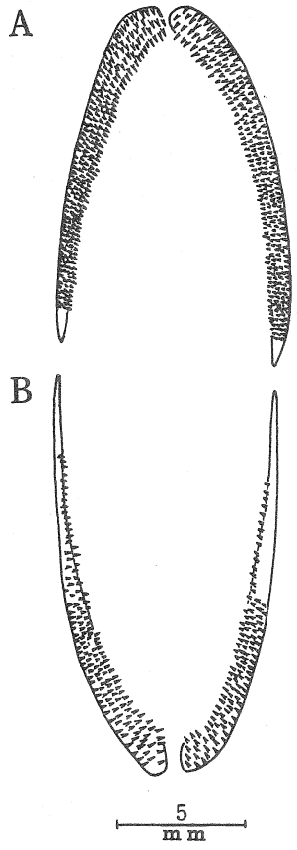

Fig. 7. Ventral view of upper jaw (A) and dorsal view of lower jaw (B) in *Citharoides macrolepidotus* HUBBS.

Body elliptical and rather elongate, moderately compressed, highest at middle, its depth much less than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather deep, subequal to 1/4 depth of body.

Head large in size, about 2/3 depth of body; upper profile slightly concave in front of upper eye. Snout blunt, rather large and strongly protruding, about as long as eye diameter. Eyes moderate, longer than half length of maxillary, separated by a narrow ridge; upper slightly in advance of lower. Nostrils on ocular side two, in front of interorbital ridge, anterior tubular with a broad flap posteriorly, posterior large, not tubular, without flap; nostrils on blind side located in front of origin of dorsal, anterior tubular with a broad flap posteriorly, posterior not tubular, covered with a broad membrane.

Mouth oblique, gently arched and large, maxillary extending nearly to below posterior part of eye (in adult) or slightly to beyond middle part of eye (in young); lower jaw strongly protruding at symphysis when mouth is closed. Teeth all small, pointed, in bands in both jaws except for posterior portion of lower jaw (Fig. 7, A,B). Gill-rakers well developed on both limbs of arch, rather long, armed with many spinules in bands, the longest one subequal to half eye diameter; tubercles on outer side of arch arranged on upper and lower limbs somewhat irregularly, and thickly covered with many spinules except at base, those on upper limb are strongly protruded, wartlike in shape, but ones on lower limb are wartlike

in shape and arranged more or less regularly between gill-rakers on ceratobranchial, and disklike in shape arranged throughout its entire length of hypobranchial. Those on inner side of arch wartlike or disklike, armed with many spinules except at basal part, set along upper and lower limbs (Fig. 111, B1, B2).

Scales large and deciduous, ctenoid on ocular side, cycloid on blind side; snout, both jaws and all fins except at base of caudal fin naked. Lateral line well developed on both sides, strongly arched above pectoral fin, length of curved portion about 2/3 length of head; height about 1/3 length, and accessory line absent.

Dorsal fin starting on blind side, in front of middle part of upper eye; first ray shortest, succeeding rays becoming gradually higher, and highest near posterior end; all rays branched. Anal fin starts on vertical through rear of basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins well developed on both sides of body, but that on ocular side shorter than that on blind side; upper two or three and lower one or two rays on ocular side simple, but other rays branched; all rays on blind side simple. Ventral fins short based, subequal in size, starting slightly in rear of vertical through posterior end of preopercular bone; that on ocular side slightly in advance of that on blind side; one spine and five branched rays on both sides. Caudal fin rounded, inner 15 rays branched, but upper and lower four rays simple.

Vent opens on ocular side, in front of origin of anal; genital papilla located above and behind anus.

In formalin, general ground color of body milky brownish, with a pair of dark spots at bases of last rays of dorsal and anal fins; dorsal, anal, caudal and left ventral fins with many dark spots; blind side of body milky white.

13. Family Paralichthyidae new

All rays of pectoral and ventral fins branched except for two or three of upper and lower rays of pectoral fins and anterior rays of ventral fins. Ventral fins short based and almost symmetrical, that on ocular side not elongate, supported by pelvic bone placed behind cleithrum (Fig. 117, C). Lateral line well developed on both sides. Caudal fin rays 17 or 18 in total number.

Supraoccipital connected with exoccipital at tip, and epiotics narrowly separated from each other; zygapophyses of exoccipitals slightly apart from each other (Fig. 101, D1-D2; Fig. 102, A1-A2); alisphenoid on ocular side large or moderate in size, not extending to orbital cavity; frontal on blind side, which forms inner side of interorbital bone, is separated from prefrontal on blind side, owing to intervention of mesethmoid (Fig. 104, C); opisthotic elliptical and very small in size, surrounded by exoccipital, and anterior part connected narrowly with pterotic; prootic articulated with pterotic dorsally, and its posterior margin connected with exoccipital and basioccipital, but not with opisthotic (Fig. 96, D1-F1, D2-F2).

Suborbital bones on ocular side scaly nodules (Fig. 109, B); a preorbital bone on blind

side present, and suborbital bones on same side short and platelike in shape, five to seven in number (Fig. 106, D-F; Fig. 107, A-C).

Lower pharyngeal bone is rodlike in shape with toothed plate; second upper pharyngeal bone armed with toothed band or one or two rows of teeth, third and fourth bones with two or three rows of teeth; third epibranchial bone with toothed band (Fig. 113, D-F).

Tip of sciatic part of urohyal truncate; cardiac apophysis small, and bifurcate (Fig. 115, D-G).

First neural spine present; platelike neural spine present on first to fourth or first to third vertebrae; parapophysial stays present; neural postzygapophyses beneath prezygapophyses absent; rib and epipleural present, but epicentrum, epimeral, hypomeral and myorhabdoi absent, epipleurals beginning with second vertebra; opening for notochord very small in size, and in middle of centrum; transverse apophysis absent (Fig. 119, A-B).

Urostyle entirely fused with hypural; last neural and haemal spines fused with centrum; uroneural 1 and epural absent or present, but uroneural 2 absent; slits of bases of last neural and haemal spines absent (Fig. 127, D-F).

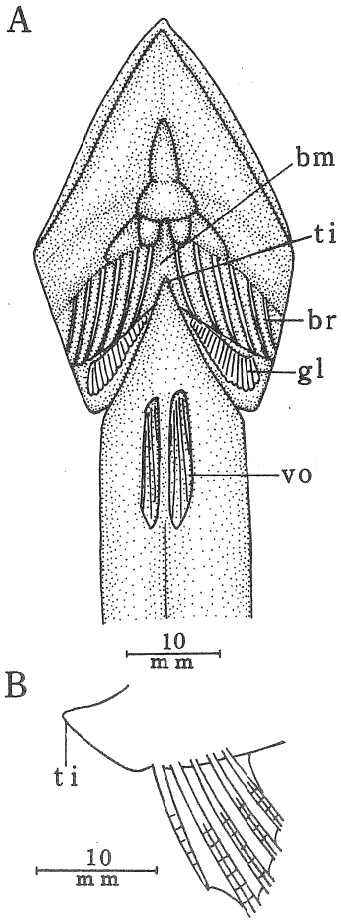

Fig. 8. Ventral view of head with jaws and anterior part of trunk slightly stretched (A) and lateral view of ventral fin on ocular side (B) in *Pseudorhombus arsius* (HAMILTON). Abbreviations as in Fig. 3.

14. Key to genera of Paralichthyidae

A^1 Pectoral fins on both sides with branched rays; a supratemporal branch of lateral line running to anterior part of dorsal fin absent; caudal rays 18 in total number ..... *Paralichthys*

A^2 Pectoral fin on blind side with simple rays; a supratemporal branch of lateral line present; caudal rays 17 in total number.

B^1 Scales small or moderate in size, more than 50 in lateral line; gill-rakers serrate on posterior margin ..... *Pseudorhombus*

B^2 Scales large, fewer than 50 in lateral line; gill-rakers large in number, not serrate on posterior margin ..... *Tarphops*

15. Genus *Paralichthys* GIRARD

Paralichthys GIRARD, 1858, 146 (type-species by original designation: *Pleuronectes maculosus* GIRARD).

Chaenopsetta GILL, 1861, 50 (type-species by original designation: *Pleunonectes oblongus* MITCHILL).

Uropsetta GILL, 1863, 330 (type-species by original designation: *Hippoglossus californicus* AYRES).

Body oblong, moderately compressed; tip of isthmus below space between posterior margin of lower eye and preopercular bone; anterior dorsal profile similar in both sexes. Caudal peduncle medium in depth. Head rather large, about 3.5 to 4 in standard length. Eyes sinistral, separated by a flat space or bony ridge of moderate width; interorbital region similar in both sexes. Rostral, orbital and mandibular spines absent in both sexes. Nostrils two on each side, anterior one tubular with slender flap posteriorly, posterior one more or less tubular, without flap. Mouth oblique and large; maxillary extending to well beyond posterior margin of lower eye. Teeth well developed on both sides, uniserial, those on upper jaw rather small, close-set, and generally enlarged anteriorly; those on lower jaw much stronger and wider apart than those on upper jaw (Fig. 10, B, C). Gill-rakers pointed and long, well developed on both limbs of arch, serrate on each posterior margin; inner and outer sides of gill-arch with numerous, small tubercles (Fig. 111, C1, C2). Scales very small in size and not deciduous, finely ctenoid on ocular side, cycloid on blind side (Fig. 10, A). Lateral line well developed on both sides, a supratemporal branch absent.

Dorsal fin originating on blind side and above middle part of upper eye, all rays simple. Anal fin starts at vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal; that on ocular side longer than that on blind side, not prolonged in either sex; upper and lower two or three rays on each side simple, but other rays branched. Ventral fins slightly in rear of vertical through posterior margin of preopercular bone; anterior one or two rays simple, but other rays branched. Caudal fin pointed posteriorly, uppermost three and lowermost two rays simple, but other rays branched.

Suborbital bones on ocular side scaly nodules, each bone on blind side short, platelike in shape and five in number (Fig. 106, D); second upper pharyngeal bone armed with toothed band, and third and fourth bones with teeth of two or three rows; first epibranchial bifurcate at tip (Fig. 113, D); tip of sciatic part of urohyal truncate, extending below middle part of tip of main part; cardiac apophysis of urohyal small (Fig. 115, E); platelike neural spines on first to fourth vertebrae; epural bone present; uroneural 1 present; four caudal plates variously divided except at basal portion (Fig. 127, D).

Paralichthys olivaceus (TEMMINCK and SCHLEGEL) "Hirame"

Fig. 9

Hippoglossus olivaceus TEMMINCK and SCHLEGEL, 1846, 184, pl. 44, fig. 84. —— NYSTRÖM, 1887, 43.

Rhombus wolffii BLEEKER, 1854, 421. ——BLEEKER, 1854-7, 122.

Pseudorhombus olivaceus. GÜNTHER, 1862, 429. ——OTAKI, 1897, 5, pl. 5, fig. 2. ——ISHIKAWA and MATSUURA, 1897, 25.
Chaenopsetta olivacea. BLEEKER, 1873, 130. ——BLEEKER, 1879, 21.
Chaenopsetta wolffii. BLEEKER, 1879, 21.
Paralichthys olivaceus. STEINDACHNER, 1896, 217. ——JORDAN and STARKS, 1906, 180. —— JORDAN, TANAKA and SNYDER, 1913, 317. ——JORDAN and TOMPSON, 1914, 308. ——JORDAN and HUBBS, 1925, 297. —— UI, 1929, 270. —— SOLDATOV and LINDBERG, 1930, 391. —— SCHMIDT and LINDBERG, 1930, 1148. ——KURODA, 1931, 121. ——SCHMIDT, 1931, 125. —— KAMOHARA, 1931, 93. —— TANAKA, 1931, 51. —— WU, 1932, 77. —— WU and WANG, 1933, 300. ——WANG, 1933, 38, fig. 17. —— MORI and UCHIDA, 1934, 22. —— NORMAN, 1934, 84, fig. 50. —— HIKITA, 1934, 256. —— SATO, 1937, 27. —— OKADA and MATSUBARA, 1938, 417. —— KURONUMA, 1939, 83. —— KURONUMA, 1940, 213. —— KAMOHARA, 1950, 238, fig. 180. ——KURODA, 1951, 388. ——HONMA, 1952, 244. —— MORI, 1952, 175. —— MATSUBARA, 1955, 1252. —— MORI, 1956, 31. —— YOSHIDA and ITO, 1957, 268. —— KAMOHARA, 1958, 62. —— KAMOHARA, 1964, 81. ——SHIH-CHIEH, 1966, 166, figs. 9-12.

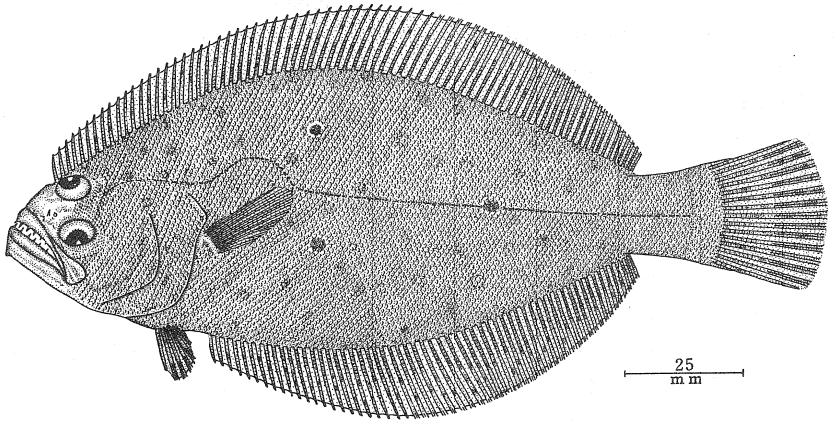

Fig. 9. Lateral view of *Paralichthys olivaceus* (TEMMINCK and SCHLEGEL): No. 33425, 149.0 mm in standard length.

Pseudorhombus swinhonis GÜNTHER, 1873, 379.
Paralichthys olivaceus var. *coreanicus* SCHMIDT, 1904, 230.
Paralichthys percocephalus JORDAN and STARKS, 1906, 181.

Materials: Nos. 33425-33427, 149.0-156.4 mm in standard length, Mimase, Kochi Pref., May 21, 1959.

Diagnosis: A paralichthid flounder without distinct supratemporal branch running upwards towards anterior part of dorsal fin; scales on lateral line more than 100 in number; upper eye nearly attached to dorsal margin.

Description: Dorsal fin rays 77-81; anal fin rays 59-61; pectoral fin rays 12-13 on ocular side, 12-13 on blind side; gill-rakers on first arch 6+15-18; scales in lateral line 107-120; vertebrae including urostyle 11+27=38. Head 3.53-3.6 in standard length; depth 2.43-2.63. Snout 4.69-5.2 in head; upper eye 5.43-5.94; lower eye 5.47-6.02; maxillary 2.06-2.11 on

ocular side, 2.06-2.11 on blind side; lower jaw 1.65-1.70 on ocular side, 1.61-1.67 on blind side; depth of caudal peduncle 2.46-2.7; first dorsal fin ray 4.66-5.08; longest dorsal fin ray 2.54-2.65; first anal fin ray 4.87-5.56; longest anal fin ray 2.24-2.39; pectoral fin 2.04-2.19 on ocular side, 2.48-3.01 on blind side; ventral fin 3.57-3.94 on ocular side, 3.6-4.12 on blind side.

Body rather elongate, moderately compressed, highest at middle part of body, its depth much more than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle moderate in depth, a little more than 1/4 depth of body.

Head rather large, subequal to 2/3 depth of body, upper profile with a little concave at upper margin of upper eye. Snout large, protruding, much longer than eye diameter. Eyes small, about 2.5 in length of maxillary, separated by a flat space, its width 1.5-1.8 in eye diameter; upper which approachs head profile, slightly in advance of lower. Nostrils on ocular side set in front of interorbital region, anterior with a slender and long flap posteriorly, which extends to posterior margin of posterior when depressed backward; posterior more or less tubular, without flap; nostrils on blind side in front of dorsal origin, similar in shape and structure to those on ocular side.

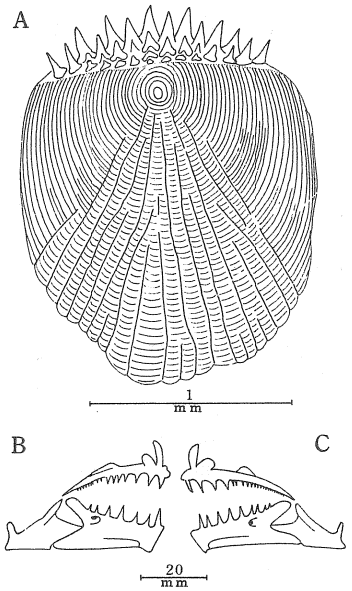

Fig. 10. Lateral view of scale on ocular side (A) and both jaws (B, blind side; C, ocular side) in *Paralichthys olivaceus* (TEMMINCK and SCHLEGEL).

Mouth oblique and large, maxillary extends well beyond posterior margin of lower eye; lower jaw scarcely protruding. Teeth uniserial, those of upper jaw strongly caninelike, four pairs on anterior half of dentition, and strongly diminishing in size on posterior half; teeth on lower jaw stronger and wider apart than those of upper, about seven to nine on each side (Fig. 10, B, C). Gill-rakers well developed on both limbs, long and slender, with spinules on each posterior margin, longest one subequal to 2/3 diameter of eye; outer side of gill-arch with numerous small tubercles extensively varied in shape, which are present along anterior and posterior margins of upper and lower limbs throughout their entire length; inner side of gill-arch with small disklike tubercles with or without several spinules at their tips arranged regularly between gill-rakers, and scattered nearly throughout its entire length (Fig. 111, C1, C2).

Scales very small and not deciduous, ctenoid on ocular side, cycloid on blind side (Fig. 10, A); tips of jaws and anterior half of interorbital area naked. Lateral line well developed on each side, strongly arched above pectoral fin, length of curved portion about half length of head, height about 1/3 of its length; and distinct accessory line absent.

Dorsal fin starting on blind side, above middle of upper eye, becoming gradually higher toward posterior 1/3 of body and decreasing in height posteriorly; all rays simple. Anal fin starts at vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin well developed on both sides, not produced, that on blind side about 1.2 in that on ocular side; upper and lower two rays on ocular side simple, but other rays branched; inner six or seven rays on blind side branched, but other rays simple. Ventral fins start slightly in rear of vertical through posterior margin of preopercular bone; anterior one or two rays on each side simple, but other rays branched. Caudal fin pointed posteriorly, upper three and lower two rays simple, but other rays branched.

Vent opens on blind side, above origin of anal; genital papilla displaced on ocular side.

In formalin, general ground color of body brownish, with darker spots and markings; numerous small white spots scattered irregularly on body; median fins mottled and spotted with darker; blind side of body milky white.

16. Genus *Pseudorhombus* BLEEKER

Pseudorhombus BLEEKER, 1862, 426 (type-species by original designation: *Rhombus polyspilus* BLEEKER).

Rhombiscus JORDAN and SNYDER, 1901, 379 (type-species by original designation: *Rhombiscus cinnamoneus* TEMMINCK and SCHLEGEL).

Spinirhombus OSHIMA, 1927, 187 (type-species by original designation: *Spinirhombus ctenosquamis* OSHIMA).

Istiorhombus WHITLEY, 1931, 322 (type-species by original designation: *Pseudorhombus spinosus* MCCULLOCH).

Body ovoid and rather deep, moderately compressed; tip of isthmus below and slightly in rear of posterior margin of lower eye; anterior dorsal profile similar in both sexes. Caudal peduncle medium in depth. Head rather large, 3.1-4.0 in standard length. Eyes sinistral, separated by narrow ridge; interorbital region similar in both sexes. Rostral, orbital and mandibular spines absent in both sexes. Nostrils two on each side, anterior one tubular with flap posteriorly, posterior one more or less or not tubular, without flap. Mouth oblique, large and gently arched anteriorly, maxillary extending below from middle part of lower eye to posterior margin of it. Teeth well developed on both sides, uniserial, those on upper jaw rather small and close-set, becoming gradually smaller posteriorly, and generally enlarged anteriorly; those on lower jaw much stronger and wider apart than those on upper jaw. Gill-rakers palmate or pointed and rather large in number, well developed on both limbs of arch, serrate on each posterior margin. Scales small in size and not deciduous; finely ctenoid or cycloid on each side; snout, tips of both jaws and interorbital area naked. A supratemporal branch of lateral line running upwards towards anterior part of dorsal fin.

Dorsal fin originating on blind side and on horizontal in front of middle part of upper eye, all rays simple. Anal fin starts on vertical through slightly in rear of basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes; upper and lower two or

three rays on ocular side simple, other rays branched; that on blind side short, all rays simple. Ventral fins start slightly in rear of vertical through posterior end of preopercle, anterior two or three rays simple, but others branched. Caudal fin pointed posteriorly, uppermost and lowermost two rays simple, but others branched.

Suborbital bones on ocular side scaly nodules (Fig. 109, B); those on blind side short, platelike in shape and five to seven in number (Fig. 106, E, F; Fig. 107, A, B); gill-arch with tubercles on inner side, and sometimes on outer side (Fig. 111, D1, D2); upper pharyngeal bones armed with teeth in two or three rows, first epibranchial not bifurcate (Fig. 113, E); tip of sciatic part of urohyal truncate, as long as or slightly longer or shorter than tip of main part, cardiac apophysis of urohyal small (Fig. 115, D, G); platelike neural spines occur from the first to third vertebrae (Fig. 119, B1-B5); epural bone, uroneural 1 and uroneural 2 absent; four caudal plates divided into many parts except for each basal portion (Fig. 127, E).

17. Key to species of *Pseudorhombus*

A[1] Gill-rakers palmate, as broad as long; two to four large double ocelli on body ..... ***P. dupliciocellatus*** REGAN

A[2] Gill-rakers pointed and long, longer than broad; with or without single ocelli on body.

B[1] Scales ctenoid on both sides; two dark spots below base of pectoral fin - on boundary of opercle and trunk ..... ***P. oligodon*** (BLEEKER)

B[2] Scales ctenoid on ocular side, cycloid on blind side.

C[1] Gill-rakers on lower limb more than 16 in number.

D[1] Scales in lateral line 76-82; anterior dorsal rays long and flattish, first ray 2.97-3.94 in head; upper eye remote from dorsal margin, much longer than half diameter of eye, lower eye generally with a dermal tentacle ..... ***P. oculocirris*** n. sp.

D[2] Scales in lateral line 67-75; anterior dorsal rays medium, first dorsal ray 4.22-5.28 in head; upper eye approaching dorsal margin, much shorter than half diameter of eye ..... ***P. pentophthalmus*** GÜNTHER

C[2] Gill-rakers on lower limb fewer than 12 in number.

E[1] Body rather slender; dorsal fin rays 74-78; anal fin rays 57-60; teeth on lower jaw of blind side fewer than 16 in number ..... ***P. arsius*** (HAMILTON)

E[2] Body rather deep; dorsal fin rays 80-85; anal fin rays 61-67; teeth on lower jaw of blind side more than 20 in number ..... ***P. cinnamoneus*** (TEMMINCK and SCHLEGEL)

B[3] Scales cycloid on both sides except for a strip of ctenoid scales at edges of body; gill-rakers on first arch 3−6+8−10 ..... ***P. levisquamis*** (OSHIMA)

Pseudorhombus dupliciocellatus REGAN "Megarei"

Fig. 11

Pseudorhombus dupliciocellatus REGAN, 1905, 25. —— JORDAN and STARKS, 1906, 177. —— JORDAN, TANAKA and SNYDER, 1913, 316. —— NORMAN, 1926, 228, fig. 2. —— NORMAN, 1927, 10. —— MCCULLOCH, 1929, 278. —— WEBER and BEAUFORT, 1929, 102. —— SCHMIDT, 1931, 124. —— NORMAN, 1934, 94, fig. 55. —— ROXAS and MARTIN, 1937, 67. —— OKADA and MATSUBARA, 1938, 417. —— HERRE, 1940, 53. —— MATSUBARA, 1955, 1252, fig. 487, B. —— PUNPOKA, 1964, 21.

Platophrys palad EVERMANN and SEALE, 1907, 105, fig. 21.
Pseudorhombus cartwrighti OGILBY, 1912, 47.

Materials: No. 33844, 236.5 mm in standard length, Yahatahama, Ehime Pref., January 12, 1961. No. 35007, 286.9 mm, Nobeoka, Miyazaki Pref., March 20, 1962.

Diagnosis: A flounder with two or four large double ocelli; gill-rakers palmate in shape and as broad as long.

Description: Dorsal fin rays 72-73; anal fin rays 57; pectoral fin rays 12 on ocular side, 11-12 on blind side; scales in lateral line 76; gill-rakers on first arch 5+9; vertebrae including urostyle 10+26=36. Head 3.67-3.82 in standard length; depth 2.19-2.20. Snout 5.13-5.81 in head; upper eye 4.93-4.97; lower eye 4.93; maxillary 2.51-2.68 on ocular side, 2.45-2.58 on blind side; lower jaw 1.94-2.07 on ocular side, 1.82-1.97 on blind side; depth of caudal

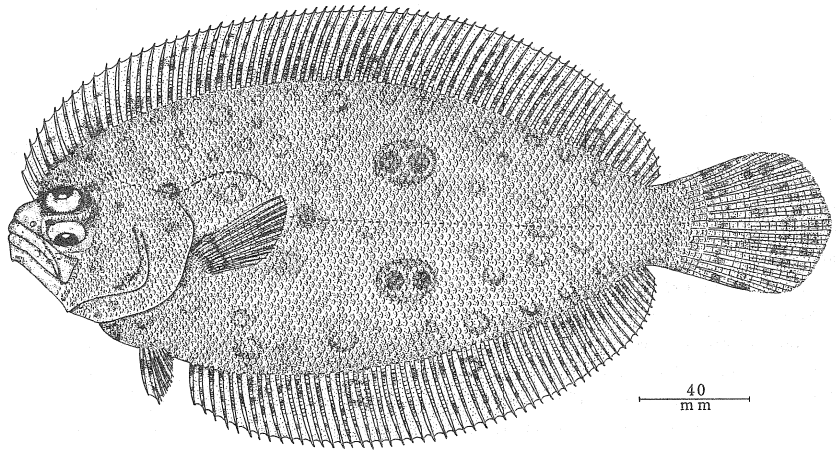

Fig. 11. Lateral view of *Pseudorhombus dupliciocellatus* REGAN: No. 33844, 236.5 mm in standard length.

peduncle 2.27-2.57; first dorsal fin ray 5.26-5.31; second dorsal fin ray 4.04-4.31; longest dorsal fin ray 2.13-2.17; first anal fin ray 4.26-4.45; second anal fin ray 3.85-3.96; longest anal fin ray 2.15-2.18; pectoral fin 1.65-1.67 on ocular side, 2.20-2.44 on blind side; ventral fin 2.93-3.2 on ocular side, 2.97-2.99 on blind side; base of ventral fin 8.43-8.68 on ocular side, 9.38-9.86 on blind side.

Body ovate, highest at middle part of body, its depth much less than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather deep, about 1/4 depth of body.

Head moderate in size, much longer than half depth of body, upper profile strongly notched in front of middle part of upper eye. Snout large, equal to or a little longer than eye diameter. Eyes moderate, about as long as half length of maxillary, separated by a narrow, high ridge; upper a little in advance of lower. Nostrils on ocular side in front of

interorbital ridge, anterior one tubular with a short flap posteriorly, posterior one more or less tubular without flap; posterior on blind side below origin of dorsal fin, anterior slightly before origin of dorsal fin, both similar in shape and structure to those on ocular side.

Mouth oblique, large and strongly arched; maxillary extending to below middle part or posterior margin of lower eye. Teeth on both jaws uniserial; those on upper jaw small and rather close-set laterally, somewhat large and wider apart anteriorly; those on lower jaw stronger and wider apart than those on upper jaw. Gill-rakers well developed on both limbs, palmate, as broad as long (Fig. 12, A, C).

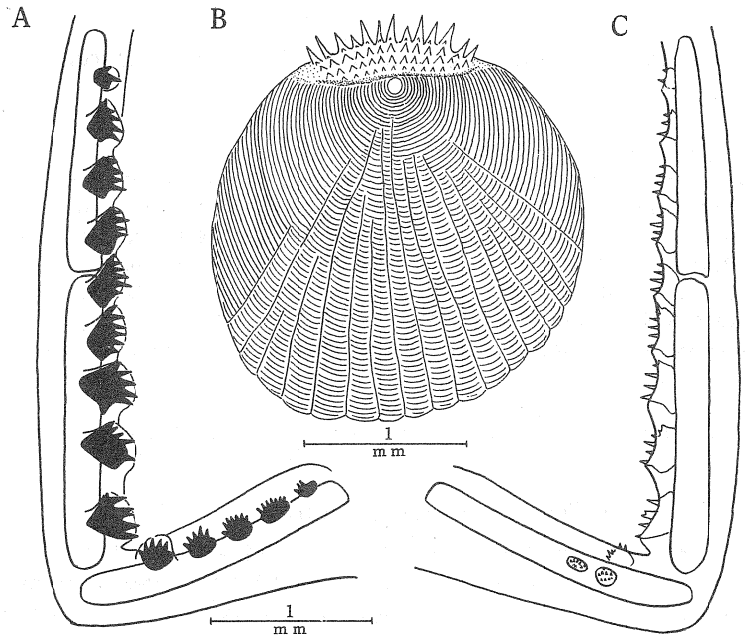

Fig. 12. Lateral view of first gill-arch on ocular side (A, outer side; C, inner side) and scale on ocular side (B) in *Pseudorhombus dupliciocellatus* REGAN.

Scales moderate in size, finely ctenoid on ocular side (Fig. 12, B), cycloid on blind side; interorbital ridge, snout and tips of both jaws naked. Lateral line on each side of body well developed; strongly arched above pectoral fin, length of curved portion subequal to length of pectoral fin and height about 1/3 its length; an accessory line running to base of seventh dorsal ray.

Dorsal fin originating above level of posterior nostril on blind side, becoming gradually higher toward rear of middle part of body, decreasing in height posteriorly; all rays simple. Anal similar in shape and structure to dorsal. Pectoral fins unequal, rather short, and not produced, that on ocular side subequal to 1.5 of that on blind side; upper and lower two rays on ocular side simple, but others branched; all rays on blind side unbranched. Ventral

fin originates slightly in front of vertical through posterior end of preopercle; posterior three rays branched. Caudal fin pointed posteriorly, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side above origin of anal. Genital papilla displaced on ocular side.

In formalin, general ground color of body brownish, with a series of darker rings along dorsal and anal margins and irregularly scattered many darker spots and rings, and with two double ocelli arranged above and below middle part of lateral line; two dark spots forming each ocellus margined with small white ring; fins paler than body, with many small brown spots; a series of indistinct rings on dorsal and anal. Blind side of body milky white except for dark brown snout.

Pseudorhombus oligodon (BLEEKER) "Nanyo-garei"

Fig. 13

Paralichthys oligodon JORDAN and SNYDER, 1901, 121.

Pseudorhombus oligodon. JORDAN and EVERMANN, 1902, 365. —— JORDAN and STARKS, 1906, 177. —— SNYDER, 1912, 438. —— JORDAN, TANAKA and SNYDER, 1913, 315. —— IZUKA and MATSUURA, 1920, 116. ——OSHIMA, 1927, 182. ——SCHMIDT and LINDBERG, 1930, 1147. —— NORMAN, 1931, 598. —— WU, 1932, 80. —— NORMAN, 1934, 99, fig. 60. —— UMALI, 1936, 82. —— OKADA and MATSUBARA, 1938, 417. —— MATSUBARA, 1955, 1252. —— KAMOHARA, 1959, 6. ——KAMOHARA, 1964, 81. ——SHIH-CHIEH, 1966, 171.

Pseudorhombus cinnamoneus JORDAN and STARKS, 1906, 174. ——HUBBS, 1915, 462. ——OSHIMA, 1927, 180.

Materials: Nos. 33428-33439, 142.1-227.2 mm in standard length, Mimase, Kochi Pref., May 21, 1959.

Diagnosis: A flounder with ctenoid scales on both sides.

Description: Dorsal fin rays 78-82; anal fin rays 61-64; pectoral fin rays 12-13 on ocular side, 11-12 on blind side; gill-rakers on first arch 2-5+8-9; vertebrae including urostyle 10+28=38. Head 3.46-3.79 in standard length; depth 1.95-2.18. Snout 4.6-5.69 in head; upper eye 4.0-5.57; lower eye 4.09-5.47; maxillary 2.14-2.31 on ocular side, 2.06-2.3 on blind side; lower jaw 1.72-1.82 on ocular side, 1.64-1.71 on blind side; depth of caudal peduncle 2.29-2.59; first dorsal fin ray 4.98-6.84; longest dorsal fin ray 2.28-2.51; first anal fin ray 4.71-6.16; longest anal fin ray 2.18-2.40; pectoral fin 1.57-2.0 on ocular side, 1.98-2.31 on blind side; ventral fin 3.12-3.7 on ocular side, 2.87-3.57 on blind side; base of ventral fin 7.68-9.68 on ocular side, 8.84-12.0 on blind side.

Body ovate, deep and rather compressed, highest at middle part of body, its depth about equal to or a little less than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle moderate in depth, as long as or a little shorter than 1/4 depth of body.

Head moderate, much longer than half depth of body, upper profile with a shallow notch in front of middle of upper eye. Snout large, protruding, longer than eye diameter. Eyes rather small, slightly shorter than half length of maxillary, separated by a narrow ridge, which extends from anterior margin of lower eye to posterior margin of upper eye; upper

slightly in advance of lower or both at about same vertical. Nostrils on ocular side in front of interorbital ridge, anterior with a triangular flap posteriorly; posterior not tubular, without flap; those on blind side below origin of dorsal fin, anterior tubular with a slender long flap posteriorly, posterior not tubular, without flap.

Mouth oblique, strongly arched and rather large, maxillary extending to beyond middle part or below posterior end of lower eye; mandibular symphysis protruding. Teeth uniserial, lateral teeth on upper jaw small, rather close-set, gradually becoming smaller posteriorly, five to six pairs of enlarged teeth anteriorly; teeth of lower jaw stronger and wider apart than those of upper; anterior teeth of upper jaw and some teeth of lower jaw provided with barbed tips (Fig. 14, A, B). Gill-rakers moderate in length and stout, well developed on upper and lower limbs of arch; serrate on each posterior margin; inner side of upper limb with three tubercles (Fig. 14, C, D).

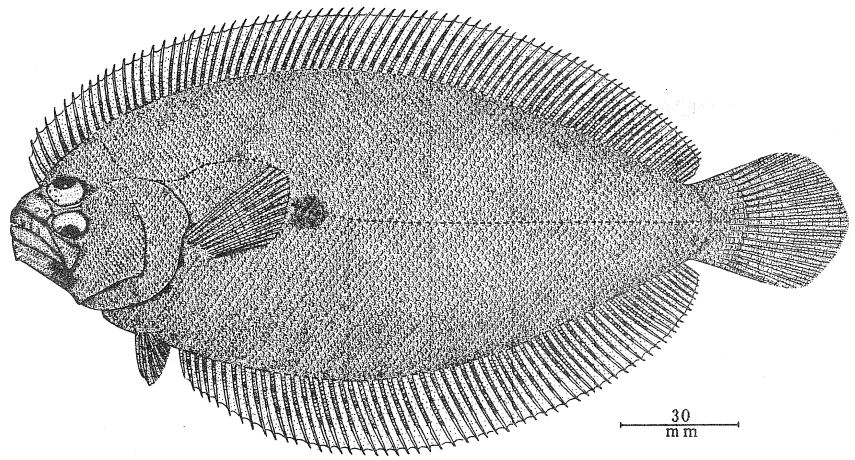

Fig. 13. Lateral view of *Pseudorhombus oligodon* (BLEEKER): No. 33434, 183.5 mm in standard length.

Scales rather small, ctenoid on both sides of body (Fig. 14, E, F); snout, tips of both jaws and interorbital area naked. Lateral line on each side well developed, strongly arched above pectoral fin, length of curved portion about 1.5 in head; an accessory line reaching seventh to ninth ray of dorsal fin.

Dorsal fin commencing above and a little in advance of posterior nostrils on blind side, becoming gradually higher to middle of body, and then decreasing in height posteriorly; all rays simple. Anal fin starts on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins well developed on both sides, not produced; that on blind side about 1.2 in that on ocular side; upper and lower two or three rays on ocular side simple, but other rays branched; all rays on blind side unbranched. Ventral fins starting slightly in rear of vertical through posterior margin of preopercular bone; anterior two rays simple, but others branched. Caudal fin pointed posteriorly, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side greenish brown with a dark blotch at junction of straight and curved parts of lateral line, and with two dark spots below base of pectoral fin – on boundary of opercle and trunk; vertical fins with irregular, indistinct brown spots and markings; blind side of body yellowish white.

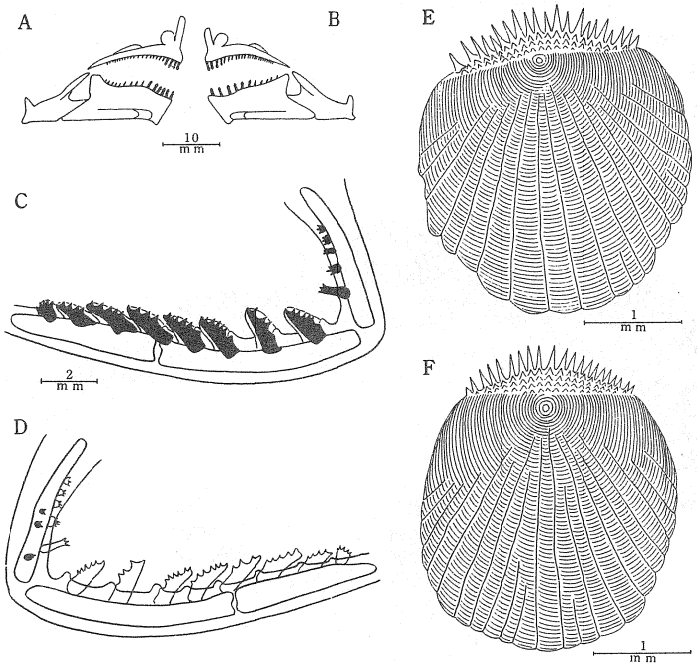

Fig. 14. Lateral view of both jaws (A, blind side; B, ocular side), first gill-arch on ocular side (C, outer side; D, inner side) and scales (E, ocular side; D, blind side) in *Pseudorhombus oligodon* (BLEEKER).

Pseudorhombus oculocirris n. sp. "Hera-ganzo"

Fig. 15

Holotype.—No. 33503, male, 181.2 mm in standard length, Mimase, Kochi Pref., June 8, 1958.

Paratypes.—Male—No. 19654, 193.9 mm, Nobeoka, Oita Pref., June 10, 1951. Nos. 33508-33509, 33511-33512, 33514, 33516, 33518-33520, 168.8-182.1 mm, Mimase, Kochi Pref., June 8, 1958. Nos. 33521-33529, 151.1-168.9 mm, Mimase, June 15, 1958. Nos. 33530-33537, 71.0-160.1 mm, Mimase, June 17, 1958. Female—Nos. 33501-33507, 176.7-192.9 mm, Urado, Kochi Pref., June 8-9, 1958. Nos. 33510, 33513, 33515, 33517, 168.2-

182.0 mm, Mimase, June 8-10, 1958.

Diagnosis: A paralichthid flounder with several dorsal rays somewhat enlarged anteriorly; lower eye generally with a dermal tentacle.

Description: *Holotype.*—Dorsal fin rays 74; anal fin rays 56; pectoral fin rays 12 on ocular side, 11 on blind side; scales in lateral line 81; gill-rakers on first arch 6+18. Head 3.82 in standard length; depth 2.16. Snout 4.69 in head; upper eye 4.78; lower eye 4.74; maxillary 2.16 on ocular side, 2.16 on blind side; lower jaw 1.76 on ocular side, 1.69 on blind side; depth of caudal peduncle 2.23; first dorsal fin ray 3.35; longest dorsal fin ray 2.36; first anal fin ray 5.15; longest anal fin ray 2.25; pectoral fin 1.44 on ocular side, 2.14 on blind side; ventral fin 2.61 on ocular side, 2.72 on blind side.

Body ovoid, rather compressed, highest at middle part of body, its depth less than half

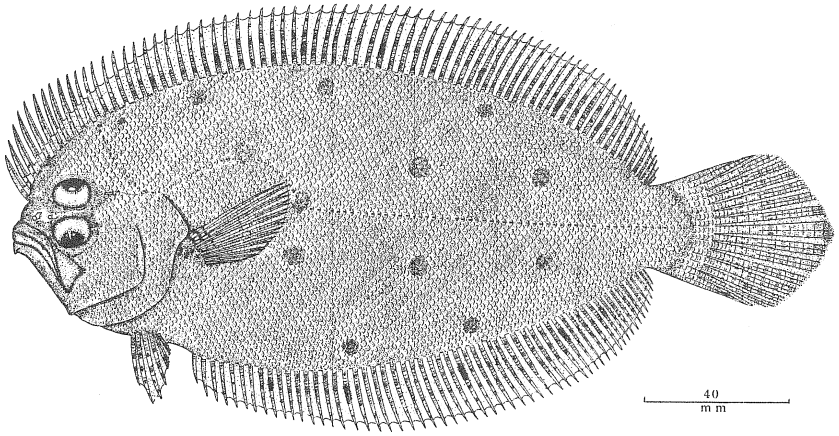

Fig. 15. Lateral view of holotype of *Pseudorhombus oculocirris* n. sp.: No. 33503, 181.2 mm in standard length.

its length; dorsal and anal contours evenly arched, except for head region. Caudal peduncle rather narrow in depth, a little less than 1/4 depth of body.

Head moderate in size, longer than half depth of body; upper profile strongly arched, with a slight notch in front of lower margin of upper eye. Snout blunt and large, about as long as eye diameter. Eyes rather small, located on same vertical, subequal to half length of maxillary, separated by a narrow high ridge; upper remote from dorsal margin, shortest distance between them about as long as half eye diameter; lower with a dermal tentacle on middle part. Nostrils two on each side, very small, anterior one tubular with a triangular flap posteriorly, which extends to anterior margin of posterior nostril when depressed backward; posterior nostril not tubular, without flap; nostrils on ocular side setting in front of interorbital ridge, and those on blind side below origin of dorsal fin.

Mouth oblique, large and arched anteriorly, maxillary extending to beyond middle part

of lower eye; lower jaw strongly protruding at symphysis. Teeth uniserial and rather small, lateral teeth on upper jaw smallest and close-set, gradually becoming smaller posteriorly, several pairs of somewhat enlarged teeth anteriorly; teeth on lower jaw stronger and wider apart than lateral teeth of upper jaw, about 20 on each side (Fig. 16, A, B). Gill-rakers long and slender, well developed on both limbs of arch, serrate on each posterior margin; longest subequal to half diameter of eye; a series of disklike tubercles with a few spinules located on inner side of upper limb and of hypobranchial of lower limb (Fig. 16, C, D).

Scales small and deciduous, ctenoid on ocular side, cycloid on blind side; snout, tips of both jaws and anterior interorbital region naked; all fins with scales at base. Lateral line well developed on each side, strongly arched above pectoral fin, length of curved portion about 3/4 length of head; height about 1/3 its length; and an accessory line running to eleventh dorsal ray.

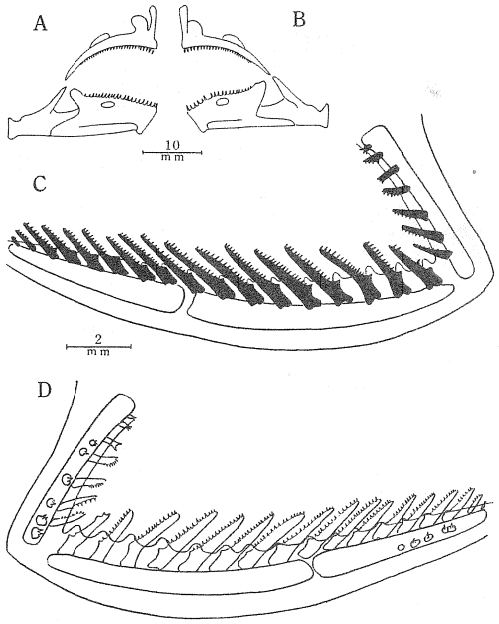

Fig. 16. Lateral view of both jaws (A, blind side; B, ocular side) and first gill-arch on ocular side (C, outer side; D, inner side) in *Pseudorhombus oculocirris* n. sp.

Dorsal fin starting on blind side, in front of middle part of upper eye; anterior several rays flattish, somewhat produced, and more or less free from fin membrane; succeeding rays becoming gradually higher slightly in rear of middle part of body, where they are highest, and then decreasing in height posteriorly; all rays simple. Anal fin starts on vertical slightly in rear of basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins well developed on both sides of body, but that on ocular side longer than that

on blind side; fourth to tenth rays on ocular side branched, but others simple; all rays on blind side unbranched. Ventral fins subequal, starting slightly in rear of a vertical line through posterior end of preopercular bone, posterior three rays on each side branched, but others simple. Caudal fin pointed posteriorly, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side, above and slightly in front of origin of anal; genital papilla displaced on ocular side.

In formalin, general ground color of body dark brownish with dark ocelli smaller than eye diameter; those with a white margin, regularly arranged, one at junction of curved and straight portions of lateral line, three above and three below lateral line, four near dorsal edge of body and two near anal edge of body; median fins paler than body, a series of fairly prominent dark spots along each ray on dorsal and anal fins; smaller spots irregularly scattered over dorsal, anal and ventral fins; blind side of body yellowish white.

Paratypes.—Dorsal fin rays 72-76; anal fin rays 54-57; pectoral fin rays 11-13 on ocular side, 10-12 on blind side; gill-rakers on first arch 4-7+17-20; scales in lateral line 76-82; vertebrae including urostyle 10+26=36. Head 3.36-3.97 in standard length; depth 2.01-2.24. Snout 4.32-5.06 in head; upper eye 4.05-5.12; lower eye 3.64-5.11; maxillary 2.04-2.29 on ocular side, 2.1-2.34 on blind side; lower jaw 1.66-1.85 on ocular side, 1.59-1.77 on blind side; depth of caudal peduncle 2.07-2.46; first dorsal fin ray 2.97-3.94; longest dorsal fin ray 2.13-2.67; first anal fin ray 4.21-5.87; longest anal fin ray 2.09-2.58; pectoral fin 1.15-1.64 on ocular side, 2.04-2.37 on blind side; ventral fin 2.22-2.87 on ocular side, 2.34-2.92 on blind side.

Remarks: The present new species is closely related to *Pseudorhombus pentophthalmus* GÜNTHER in having a larger number of gill-rakers, but is separable from that species in having a higher number of lateral line scales (76-82 as against 67-75), a longer first dorsal ray (2.97-3.94 in head as against 4.22-5.28), relatively longer and flattish anterior dorsal rays, a slight notch in the head profile and generally a dermal tentacle on the middle part of the lower eye. Additionally, the upper eye is more remote from the dorsal margin, and the distance between it and the dorsal margin of the head is much longer than half diameter of the eye, whereas in *P. pentophthalmus* it is much shorter than half diameter of the eye.

Pseudorhombus pentophthalmus GÜNTHER "Tamaganzo-birame"

Fig. 17

Pseudorhombus pentophthalmus GÜNTHER, 1862, 428. ——GÜNTHER, 1880, 69. —— JORDAN and STARKS, 1904, 626. ——FOWLER and BEAN, 1922, 66. —— NORMAN, 1931, 599. —— WU, 1932, 88. ——NORMAN, 1934, 106, fig. 65. ——KAMOHARA, 1938, 57. ——OKADA and MATSUBARA, 1938, 418. —— KURONUMA, 1939, 83. —— KURONUMA, 1940, 213. —— KAMOHARA, 1950, 237. ——MATSUBARA, 1955, 253, fig. 487, A. ——KAMOHARA, 1958, 61. ——KAMOHARA, 1964, 81.

Pseudorhombus russellii OTAKI, 1897, 6.

Pseudorhombus ocellifer REGAN, 1905, 25. —— JORDAN and STARKS, 1906, 178. —— FRANZ, 1910, 63. —— JORDAN, TANAKA and SNYDER, 1913, 316. —— JORDAN and TOMPSON, 1914, 307. ——HUBBS, 1915, 178. ——JORDAN and HUBBS, 1925, 297. ——OSHIMA, 1927, 186. —— HIKITA, 1934, 264, fig. 9, 2.

Arnoglossus wakiyai SCHMIDT, 1931, 313, fig. 1.

Materials: No. 11610, 140 mm in standard length, Choshi, Chiba Pref., May 4, 1949. Nos. 17384-17386, 144.2-149.0 mm, Owashi, Mie Pref., January 3, 1951. Nos. 29230, 29233, 29235-29239, East China Sea, May 27, 1960. Nos. 33538-33560, 33563-33566, 93.9-160.1 mm, Mimase, Kochi Pref., November 20, 1959.

Diagnosis: A paralichthid flounder with five ocelli arranged above, below and on lateral line; a large number of gill-rakers; scales small, 67-75 on lateral line.

Description: Dorsal fin rays 71-76; anal fin rays 53-57; pectoral fin rays 11-12 on ocular side, 9-11 on blind side; scales in lateral line 67-75; gill-rakers on first arch 5-7+16-19; vertebrae including urostyle 10+25-26=35-36. Head 3.1-3.55 in standard length; depth 1.92-2.28. Snout 4.33-5.06 in head; upper eye 3.68-4.95; lower eye 3.54-5.07; maxillary 1.9-2.2 on ocular side, 1.97-2.3 on blind side; lower jaw 1.61-1.79 on ocular side, 1.59-1.72 on blind side; depth of caudal peduncle 2.21-2.93; first dorsal fin ray 4.22-5.28; second

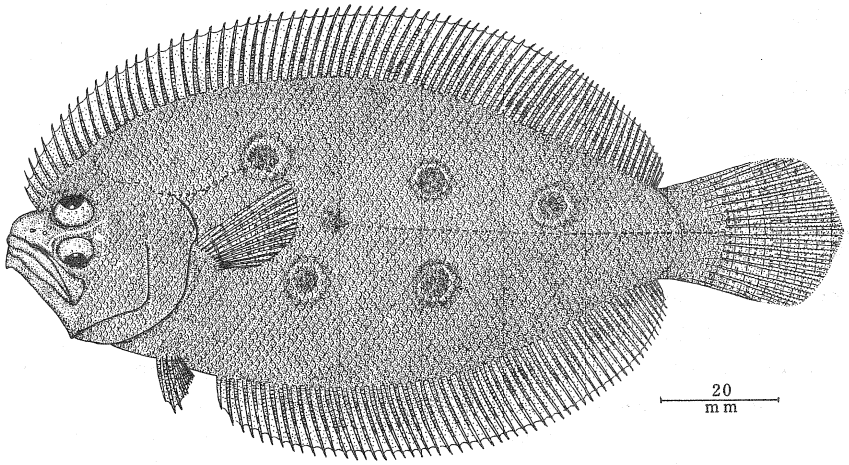

Fig. 17. Lateral view of *Pseudorhombus pentophthalmus* GÜNTHER: No. 33545, 118.9 mm in standard length.

dorsal fin ray 3.68-5.0; longest dorsal fin ray 2.1-2.63; first anal fin ray 4.45-6.1; longest anal fin ray 2.0-2.57; pectoral fin 1.4-1.89 on ocular side, 1.87-2.6 on blind side; ventral fin 2.76-3.83 on ocular side, 2.33-3.25 on blind side.

Body oval, and rather compressed, highest at middle part of body, its depth equal to or more or less than half its length; dorsal and anal contours gently curved except for head region. Caudal peduncle rather narrow in depth, about equal to 1/4 depth of body.

Head rather large, as long as or a little longer than half depth of body, upper profile with notch in front of middle part of upper eye. Snout rather large, and strongly protruding, about as long as eye diameter. Eyes large, about as long as or a little shorter than half length of maxillary, separated by a narrow ridge; upper slightly in advance of lower or both about at same vertical. Nostrils on ocular side in front of interorbital ridge, anterior tubular with a slender flap posteriorly; posterior more or less tubular with flap; those on blind side

locating below origin of dorsal fin, similar in shape and structure to those on ocular side.

Mouth oblique, gently arched anteriorly, and large; maxillary extending to below middle part of lower eye or a little beyond it. Teeth on both jaws uniserial, rather small; those on upper jaw somewhat enlarged anteriorly, and gradually becoming smaller and more close-set posteriorly; those on lower jaw larger than upper lateral ones, about 20 on each side. Gill-rakers well developed on both limbs, long and slender, with spinules on each posterior margin, longest subequal to half diameter of eye; inner side of arch armed with some tubercles on upper limb and also one on hypobranchial of lower limb.

Scales rather large and deciduous, ctenoid on ocular side, cycloid on blind side; snout, tips of both jaws and interorbital ridge naked, all fins with scales at base. Lateral line well developed on both sides, strongly curved above pectoral fin, length of curved portion about as long as length of pectoral fin; height about 1/3 its length; an accessory line running to seventh to eighth dorsal ray.

Dorsal fin originating on blind side, above in front of middle of upper eye, becoming gradually higher to slightly in rear of middle part of body, and decreasing in height posteriorly; all rays simple. Anal similar in shape and structure to dorsal. Pectoral fins unequal, and not produced, that on ocular side subequal to 1.5 that on blind side; upper and lower two rays on ocular side simple, but others branched; all rays on blind side unbranched. Ventral fin originating slightly in rear of vertical through posterior margin of preopercular bone; anterior three rays simple. Caudal fin pointed posteriorly, inner 13 rays branched, but others simple.

Vent opens on blind side above origin of anal; genital papilla displaced on ocular side.

In formalin, general ground color of body brownish, with darker spots and markings, of which four ocelli, arranged above and below lateral line and one on lateral line, are most prominent; median fins with many brown spots; blind side of body yellowish white.

Pseudorhombus arsius (HAMILTON) "Tenziku-garei"

Fig. 18

Pleuronectes arsius HAMILTON, 1822, 128.

Rhombus polyspilus BLEEKER, 1855, 503.

Pseudorhombus arsius. GÜNTHER, 1862, 426. ——DAY, 1889, 441, fig. 157. ——JORDAN and SEALE, 1907, 45. ——SNYDER, 1912, 439. ——JORDAN, TANAKA and SNYDER, 1913, 315. ——NORMAN, 1926, 231. ——NORMAN, 1927, 13. ——FOWLER, 1928, 93. ——MCCLLOCH, 1929, 279. ——WEBER and BEAUFORT, 1929, 105. ——WU, 1932, 86. —— HERRE, 1933, 5. ——HERRE, 1934, 104. —— UMALI, 1936, 81, fig. 43. —— FOWLER, 1937, 216. —— FOWLER, 1938, 80. —— OKADA and MATSUBARA, 1938, 418. ——NORMAN, 1939, 98. ——HERRE, 1941, 391. —— WHITLEY, 1948, 25. —— LIANG, 1948, 20. —— SMITH, 1949, 156, pl. 10, fig. 304. —— KURODA, 1951, 388. —— HERRE, 1953, 176. —— OGILBY, 1954, 23, fig. 24. —— MUNRO, 1955, 259. —— MATSUBARA, 1955, 1253. —— KAMOHARA, 1959, 6. —— MATSUBARA and OCHIAI, 1963, 83, fig. 2. —— PUNPOKA, 1964, 20. ——SHIH-CHIEH, 1966, 172, figs. 29-32.

Pseudorhombus russellii DAY, 1865, 172. ——BLEEKER, 1866-72, 6, pl. 2, fig. 2. —— Von BONDE, 1922, 15. ——OSHIMA, 1927, 183.

Pseudorhombus polyspilus. BLEEKER, 1866-72, 7, pl. 6, fig. 3. —— JORDAN and SEALE, 1907, 45. ——WEBER and BEAUFORT, 1929, 106, fig. 26. ——SCHMIDT, 1930, 112.

Paralichthys arsius. RUTTER, 1897, 87.
Paralichthys polyspilus. FOWLER, 1904, 555.
Platophrys russellii. EVERMANN and SEALE, 1907, 105.
Pseudorhombus cinnamoneus TANAKA, 1913, 231, fig. 238.

Materials: No. 17206, 115.2 mm in standard length, Miya, Aichi Pref., January 8, 1951. Nos. 33440-33520, 109.3-170.3 mm, Mimase, Kochi Pref., May 10, 1959. No. A45 (Amami expedition number), 109.3 mm, Nase, Amami Islands, June 30, 1958.

Diagnosis: A flounder of rather slender body with strong teeth on lower jaw; 6 to 14 teeth on blind side of lower jaw.

Description: Dorsal fin rays 74-78; anal fin rays 57-60; pectoral fin rays 11-12 on ocular side, 10-12 on blind side; scales in lateral line 70-80; gill-rakers on first arch 1-7+8-12;

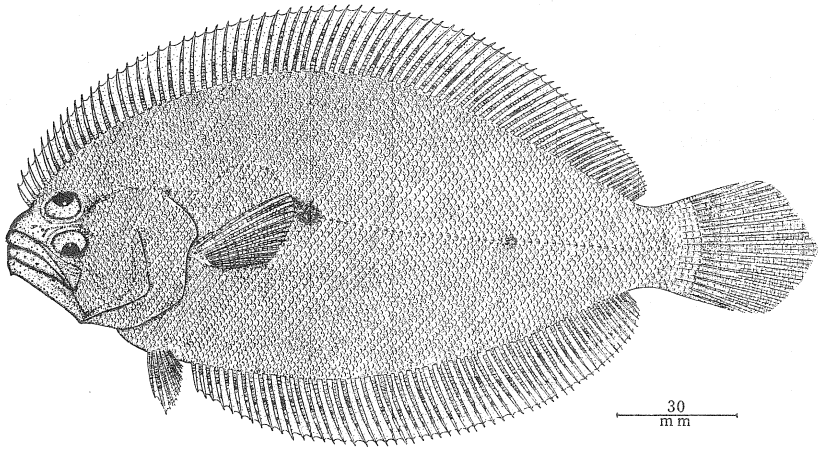

Fig. 18. Lateral view of *Pseudorhombus arsius* (HAMILTON): No. 33443, 162.2 mm in standard length.

vertebrae including urostyle 10+26=36. Head 3.25-3.52 in standard length; depth 2.02-2.18. Snout 4.75-5.53 in head; upper eye 4.67-5.46; lower eye 4.67-5.51; maxillary 2.3-2.43 on ocular side, 2.19-2.34 on blind side; lower jaw 1.8-1.93 on ocular side, 1.66-1.8 on blind side; depth of caudal peduncle 2.2-2.74; first dorsal fin ray 3.94-5.18; longest dorsal fin ray 2.2-2.48; first anal fin ray 3.32-5.35; longest anal fin ray 2.2-2.46; pectoral fin 1.45-1.88 on ocular side, 2.07-2.56 on blind side; ventral fin 2.45-3.33 on ocular side, 2.68-3.21 on blind side; base of ventral fin 4.65-9.48 on ocular side, 8.97-10.9 on blind side.

Body ovate and elongate, highest at middle part of body, its depth less than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather deep, about 1/4 depth of body. Head rather large, much longer than half depth of body, upper profile with a very slight notch in front of middle part of upper eye. Snout rather large, a little longer than eye diameter. Eyes small, a little longer than 1/3 length of maxillary, separated by a narrow ridge extending from anterior margin of lower eye to

posterior margin of upper; upper slightly in advance of lower. Nostrils two on each side, small; those on ocular side in front of interorbital ridge, anterior tubular with a slender long flap posteriorly; posterior one not tubular, without flap; nostrils on blind side below origin of dorsal fin, similar in shape and structure to those on ocular side.

Mouth oblique, rather large and strongly arched; maxillary extending to beyond middle part of lower eye, but not to posterior margin. Teeth uniserial, lateral teeth of upper jaw small and rather close-set, gradually becoming smaller posteriorly; two to four pairs of rather large canines anteriorly; teeth of lower jaw much stronger and wider apart than anterior teeth of upper jaw; 6 to 14 teeth on blind side of lower jaw (Fig. 19, A, B).

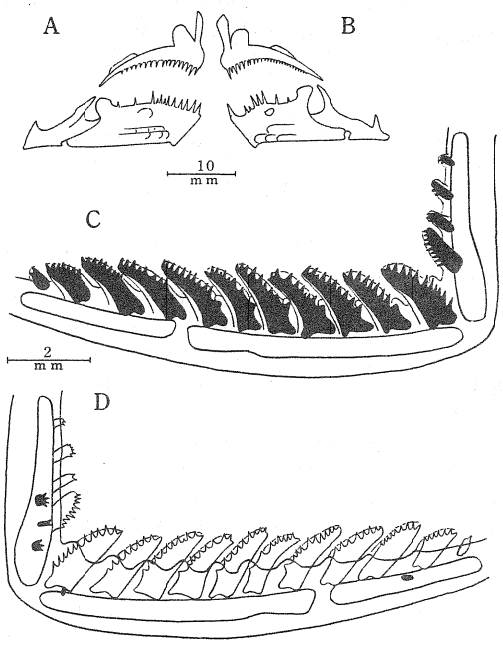

Fig. 19. Lateral view of both jaws (A, blind side; B, ocular side) and first gill-arch on ocular side (C, outer side; D, inner side) in *Pseudorhombus arsius* (HAMILTON).

Gill-rakers moderate in length and stout, their margins strongly serrate; well developed on upper and lower limbs of arch; inner side of arch armed with some tubercles (Fig. 19, C, D).

Scales moderate, ctenoid on ocular side, cycloid on blind side; snout, tips of both jaws and interorbital ridge naked, bases of all fins with scales. Lateral line on each side well developed, strongly curved above pectoral fin, the curved portion about 1.8-2.0 in head; an accessory line running to eighth to tenth ray of dorsal fin.

Dorsal fin starting above or a little in advance of nostrils on blind side, becoming higher to near middle part of body, where it is highest, and then decreasing in height posteri-

orly; all rays simple. Anal fin originates on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fin moderate in length and not produced, a little longer than half length of head; upper and lower two or three rays on ocular side simple, but others branched; all rays on blind side unbranched. Ventral fin originates slightly in rear of vertical through posterior margin of preopercular bone; posterior three or four rays branched. Caudal fin pointed posteriorly and rather long, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side above origin of anal; genital papilla displaced on ocular side.

In formalin, general ground color of body brownish or greyish brown, with irregularly scattered indistinct darker spots and rings; a dark spot at junction of straight and curved parts of lateral line, and a smaller spot on straight portion of lateral line; median fins with many brown spots and rings; blind side of body milky white.

Pseudorhombus cinnamoneus (TEMMINCK and SCHLEGEL) "Ganzo-birame"

Fig. 20

Rhombus cinnamoneus TEMMINCK and SCHLEGEL, 1846, 180, pl. 93. ——RICHARDSON, 1846, 279.
Pseudorhombus cinnamoneus. GÜNTHER, 1862, 427. ——JORDAN and SEALE, 1905, 17. ——FRANZ, 1910, 63. ——SNYDER, 1912, 438. ——JORDAN and HUBBS, 1925, 296. ——SCHMIDT, 1931, 124. ——SCHMIDT, 1931, 315. ——NORMAN, 1931, 599. ——WU, 1932, 85. ——NORMAN, 1934, 110, fig. 68. ——OKADA and MATSUBARA, 1938, 418, pl. 102, fig. 1. ——MATSUBARA, 1955, 1254. ——KAMOHARA, 1958, 61. ——KURODA, 1962, 1. ——KAMOHARA, 1964, 81. ——SHIH-CHIEH, 1966, 169, figs. 25-28.
Rhombiscus cinnamoneus. JORDAN and SNYDER, 1901, 379.
Pseudorhombus misakius JORDAN and STARKS, 1906, 175, figs. 4, 5. ——JORDAN, TANAKA and SNYDER, 1913, 316, fig. 264. —— JORDAN and TOMPSON, 1914, 306, fig. 79. —— HUBBS, 1915, 463. —— IZUKA and MATSUURA, 1920, 116. ——UI, 1929, 271. ——SCHMIDT and LINDBERG, 1930, 1147.

Materials: No. 11451, 92.9 mm in standard length, Kasumi, Hyogo Pref., May 24, 1948. No. 29240, Nos. 29242-29243, 172.9-191.9 mm, East China Sea, May 27, 1960. No. 33475, 114.3 mm, Mimase, Kochi Pref., June 23, 1960. No. 33486, 106.2 mm, Mimase, June 23, 1960. Nos. 33489-33500, 110.3-218.2 mm, Mimase, June 23, 1960.

Diagnosis: A flounder with a number of darker rings somewhat regularly arranged, and with a blotch of white margin at commencement of straight part of lateral line; teeth on lower jaw rather small, more than 20 in number on blind side.

Description: Dorsal fin rays 80-85; anal fin rays 61-67; pectoral fin rays 11-13 on ocular side, 11-13 on blind side; gill-rakers on first arch 4-6+10-12; scales in lateral line 75-85; vertebrae including urostyle 10+27-29=37-39. Head 3.27-3.82 in standard length; depth 1.86-2.05. Snout 4.92-5.43 in head; upper eye 3.8-4.99; lower eye 3.8-5.03; maxillary 2.36-2.56 on ocular side, 2.2-2.45 on blind side; lower jaw 1.73-1.97 on ocular side, 1.65-1.88 on blind side; depth of caudal peduncle 2.26-2.68; first dorsal fin ray 3.5-4.84; longest dorsal fin rays 2.06-2.49; first anal fin ray 4.37-5.88; longest anal fin ray 2.04-2.42; pectoral fin 1.51-1.87 on ocular side, 2.04-2.56 on blind side; ventral fin 2.34-3.7 on ocular

side, 2.26-2.59 on blind side; base of ventral fin 5.22-7.4 on ocular side, 6.45-8.82 on blind side.

Body ovate and rather deep, highest at middle part of body, its depth about as long as or a little longer than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather narrow in depth, much less than 1/4 depth of body.

Head moderate, about as long as or a little longer than half depth of body, upper profile with a slight notch in advance of middle part of upper eye. Snout rather small, subequal to eye diameter. Eyes small, about as long as half length of maxillary, separated by a narrow ridge; upper slightly in advance of lower or both about at same vertical. Nostrils on ocular side in front of upper margin of lower eye; anterior one tubular with a long slender flap posteriorly; posterior one not tubular, without flap; those on blind side below origin

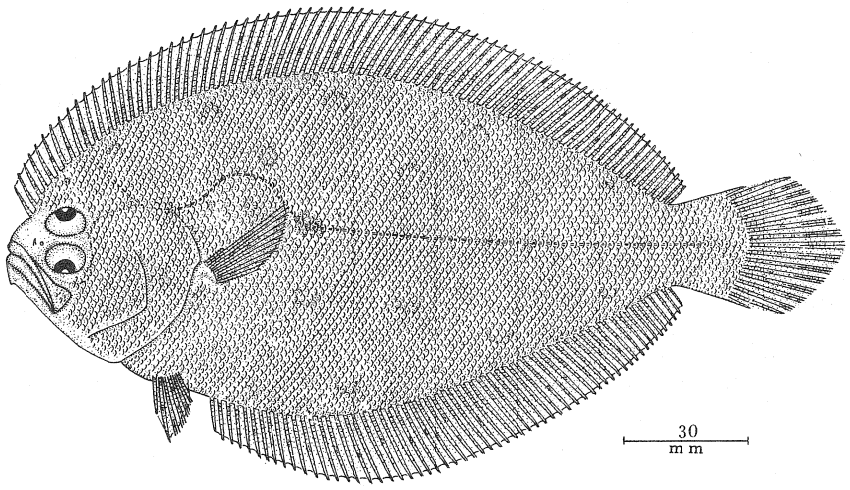

Fig. 20. Lateral view of *Pseudorhombus cinnamoneus* (TEMMINCK and SCHLEGEL): No. 33491, 159.8 mm in standard length.

of dorsal fin, similar in shape and structure to those on ocular side, but anterior nostril very small.

Mouth oblique, gently arched and rather large, maxillary extending to below middle part of eye or a little beyond it. Teeth uniserial and all rather small, lateral teeth on upper jaw small and close-set, gradually becoming smaller posteriorly, two or three pairs of somewhat enlarged teeth anteriorly; teeth on lower jaw stronger and wider apart than lateral teeth on upper jaw; teeth on blind side of lower jaw more than 20 in number (Fig. 21, A, B). Gill-rakers rather long, slender; well developed on both limbs of arch, serrate on posterior margin; a series of disklike tubercles located between bases of each gill-raker; two elliptical tubercles on inner side of hypobranchial bone (Fig. 21, D, E).

Scales rather small, ctenoid on ocular side (Fig. 21, C), cycloid on blind side; snout, tips of both jaws and anterior part of interorbital area naked. Lateral line on each side

well developed, strongly arched above pectoral fin, the curved portion about 1.7 in head length; an accessory line running to seventh and tenth rays.

Dorsal fin originating above nostrils on blind side, increasing gradually in height to middle part of body, where it is highest, and then decreasing in height posteriorly; all rays simple. Anal fin starting at vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins well developed on both sides, that on blind side about 1.2 in that on ocular side, not produced; upper and lower two rays on ocular side simple, but other rays branched; all rays on blind side unbranched. Ventral fin originating on or slightly in rear of vertical through posterior end of preopercular bone; anterior two or three rays simple, but other rays branched. Caudal fin pointed posteriorly, inner 13

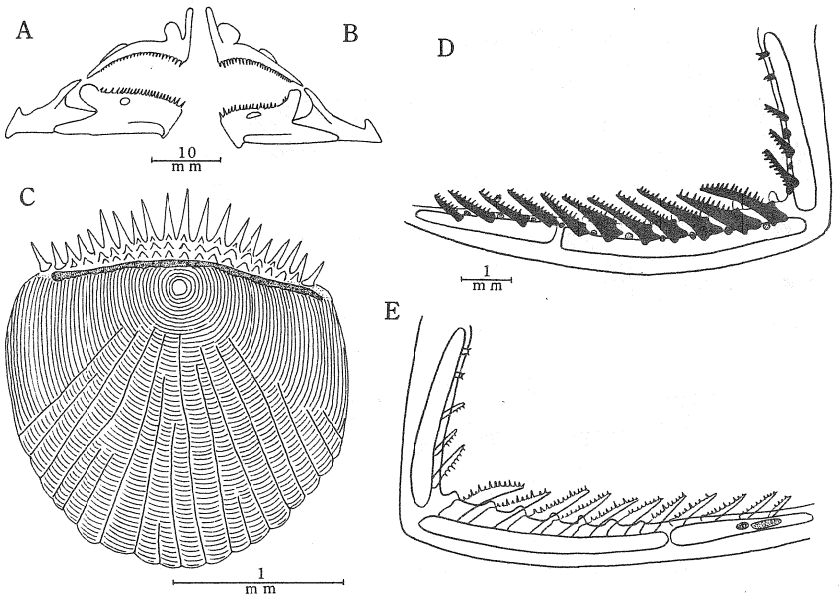

Fig. 21. Lateral view of both jaws (A, blind side; B, ocular side), scale on ocular side (C) and first gill-arch on ocular side (D, outer side; E, inner side) in *Pseudorhombus cinnamoneus* (TEMMINCK and SCHLEGEL).

rays branched, other rays simple.

Vent opens on blind side above and slightly in front of origin of anal. Genital papilla displaced on ocular side.

In formalin, general ground color of body brownish or greyish brown with a dark blotch with white margin at commencement of straight part of lateral line, and sometimes two dark spots on straight part; a number of darker rings somewhat regularly arranged on body; median fins with numerous small brown spots. Blind side of body milky white.

Pseudorhombus levisquamis (OSHIMA) "Taiwan-ganzo"

Fig. 22

Spinirhombus levisquamis OSHIMA, 1927, 189.
Pseudorhombus levisquamis. WU, 1932, 83. —— NORMAN, 1934, 111, fig. 69. —— OKADA and MATSUBARA, 1938, 419. —— MATSUBARA, 1955, 1254. —— KAMOHARA, 1959, 6. —— KAMOHARA, 1964, 81. —— SHIH-CHIEH, 1966, 168, figs. 21-24.

Materials: No. 16006, 178.8 mm in standard length, Urado, Kochi Pref., February 20, 1951. Nos. 33453-33471, 131.0-191.8 mm, Mimase, Kochi Pref., June 23, 1960. Nos. 33483-33487, 87.8-111.0 mm, Mimase, June 23, 1960.

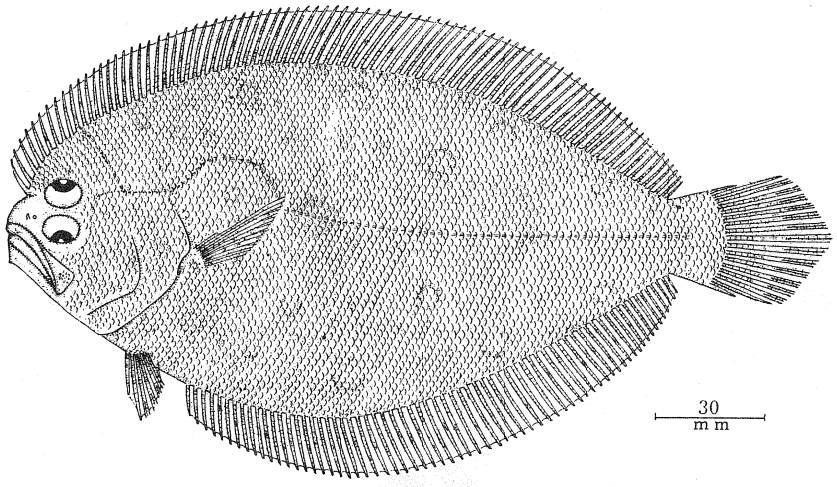

Fig. 22. Lateral view of *Pseudorhombus levisquamis* (OSHIMA): No. 33453, 191.8 mm in standard length.

Diagnosis: Very close to *P. cinnamoneus*, but has cycloid scales on ocular side except at dorsal and ventral edges of body.

Description: Dorsal fin rays 79-89; anal fin rays 59-67; pectoral fin rays 12-13 on ocular side, 11-14 on blind side; gill-rakers on first arch 4-7+17-20; scales in lateral line 76-83; vertebrae including urostyle 10+26-28=36-38. Head 3.11-3.68 in standard length; depth 1.76-2.1. Snout 4.44-5.6 in head; upper eye 3.66-5.22; lower eye 3.75-5.5; maxillary 2.22-2.48 on ocular side, 2.12-2.39 on blind side; lower jaw 1.78-2.0 on ocular side, 1.66-1.84 on blind side; depth of caudal peduncle 2.56-3.0; first dorsal fin ray 3.55-4.77; longest dorsal fin ray 2.05-2.72; first anal fin ray 4.46-6.7; longest anal fin ray 2.04-2.57; pectoral fin 1.58-2.28 on ocular side, 2.14-2.8 on blind side; ventral fin 2.42-2.96 on ocular side, 2.37-3.01 on blind side; base of ventral fin 5.25-7.59 on ocular side, 6.37-10.8 on blind side.

Body ovate and rather deep, highest at middle, its depth about equal to or more than half its length; dorsal and anal contours evenly curved except for head region. Caudal

peduncle narrow, much lower than 1/4 depth of body.

Head moderate, a little longer than half depth of body, dorsal profile deeply concave in front of middle of upper eye. Snout small, subequal to eye diameter. Eyes rather small, about as long as half length of maxillary, separated by a narrow and low ridge; the upper slightly in advance of the lower or both about at same vertical. Nostrils on ocular side setting closely in front of upper margin of lower eye, anterior one provided with a short triangular flap posteriorly, which extends to anterior edge of posterior nostril when depressed backward; posterior one without flap; those on blind side below origin of dorsal fin, similar in shape and structure to those on ocular side, but anterior nostril very small.

Mouth oblique, strongly arched, rather large, maxillary extending to below a little beyond middle part of eye, projecting slightly beyond tip of lower jaw when mouth is closed. Teeth on both jaws uniserial, those on upper jaw small, rather close-set, gradually becoming smaller posteriorly, two to three pairs of enlarged teeth anteriorly; teeth on lower jaw

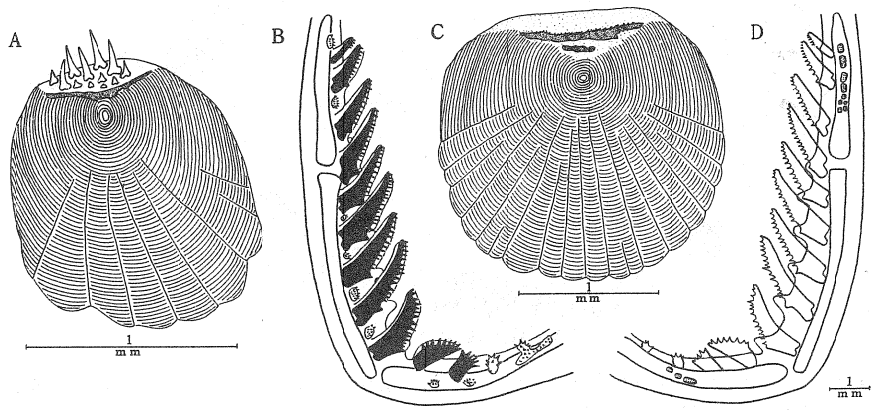

Fig. 23. Lateral view of first gill-arch on ocular side (B, outer side; D, inner side) and scales on ocular side (A, marginal portion; C, middle portion) in *Pseudorhombus levisquamis* (OSHIMA).

stronger and wider apart than those of upper; teeth on blind side of lower jaw about 14 to 18 in number. Gill-rakers stout and moderate in size, their margins strongly serrate, well developed on both limbs of arch; a series of disklike tubercles located between bases of gill-raker similar tubercles on inner side of hypobranchial and epibranchial bones (Fig. 23, B, D).

Scales all cycloid on ocular side, except at dorsal and ventral edges of body, where there is a narrow strip of ctenoid scales; all cycloid on blind side (Fig. 23, A, C). Lateral line on each side well developed; strongly arched above pectoral fin, the length of curved portion a little more than length of pectoral fin and height less than 1/3 of the fin; an accessory line running to seventh to tenth ray of dorsal fin.

Dorsal fin originates above or a little advance of nostrils on blind side, becoming higher to

slightly in rear of middle part of body, where it is highest, and then decreasing in height posteriorly; all rays simple. Anal fin originating on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fin moderate in length and not produced, that on ocular side a little longer than half length of head, that on blind side shorter than that on ocular side, about 1.5 in length on ocular side; upper and lower two or three rays on ocular side simple, but others branched; all rays on blind side unbranched. Ventral fin starting slightly in rear of vertical through posterior margin of preopercular bone; anterior two or three rays on each side simple, but others branched. Caudal fin pointed posteriorly and rather long, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side above and a little in front of origin of anal fin; genital papilla displaced on ocular side.

In formalin, general ground color of body greyish brown, with a diffuse black blotch at junction of curved and straight portions of lateral line; a series of dark rings near upper and lower edges of body, and similar ones between lateral line and upper and lower edges of body. Blind side of body milky white.

18. Genus *Tarphops* JORDAN and TOMPSON

Tarphops JORDAN and TOMPSON, 1914, 307 (type-species by original designation: *Rhombus oligolepis* BLEEKER).

Body ovate or rather elongate, moderately compressed; tip of isthmus below posterior margin of lower eye; anterior dorsal profile similar in both sexes. Caudal peduncle moderate in depth. Head moderate, 3.5-4.1 in standard length. Eyes sinistral, separated by a narrow ridge; interorbital region similar in both sexes. Rostral, orbital and mandibular spines absent in both sexes. Nostrils two on both sides, anterior one tubular with a flap posteriorly, but posterior one not tubular, without a flap. Mouth oblique, arched and rather large, maxillary not extending beyond middle part of lower eye. Teeth well developed on both sides, uniserial, rather small and close-set, not canine or enlarged teeth anteriorly. Gill-rakers well developed on both sides, long, slender, close-set; not serrate on posterior margin (Fig. 112, A; Fig. 25, A). Scales large in size, few in number on lateral line, ctenoid on both sides; snout, tip of both jaws scaleless; all the fins with scales on those bases. A supratemporal branch of lateral line running upwards towards anterior part of dorsal fin.

Dorsal fin originating on horizontal in front of middle part of upper eye, all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes; upper and lower one or two, sometimes three rays on ocular side simple, but other rays branched; all rays on blind side simple. Ventral fins starts on vertical through posterior end of preopercle, short-based; that on ocular side along edge of abdomen, that on blind side slightly removed edge; usually posterior three rays branched. Caudal fin rounded or pointed posteriorly; the uppermost and lowermost two or three rays simple, other rays branched.

Suborbital bones on ocular side scaly nodules, and those on blind side short, platelike

in shape and six in number (Fig. 107, C); gill-arch without tubercle (Fig. 112, A; Fig. 25, A); upper pharyngeal bones armed with teeth in two or three rows, first epibranchial not bifurcate (Fig. 113, F); tip of sciatic part of urohyal truncate nearly extends to that of main part, and exceedingly becomes wider towards tip; cardiac apophysis of urohyal small (Fig. 115, F); platelike neural spines occur from first to third vertebrae; epural bone, uroneural 2 and uroneural 1 absent; four caudal plates divided into many parts except for each basal portion (Fig. 127, F).

19. Key to species of *Tarphops*

A^1 Body ovate, as long as or longer than half length of body; eyes small, 3.2-4.3 in head; dorsal 63-67; anal 48-53; scales in lateral line 40-45, rather not deciduous ..... ***Tarphops oligolepis*** (BLEEKER)

A^2 Body rather elongate, less than half length of body; eyes rather large, 2.6-3.1 in head; dorsal 65-70; anal 51-56; scales in lateral line 44-48, highly deciduous ..... ***Tarphops elegans*** n. sp.

Tarphops oligolepis (BLEEKER) "Arame-garei"

Fig. 24

Rhombus oligolepis BLEEKER, 1858-9, 8, pl. 2, fig. 2.
Pseudorhombus oligolepis. GÜNTHER, 1862, 430. —— JORDAN and STARKS, 1906, 179. —— JORDAN, TANAKA and SNYDER, 1913, 316. ——SEALE, 1914, 78. ——SCHMIDT, 1931, 124.
Tarphops oligolepis. JORDAN and TOMPSON, 1914, 307, pl. 39. ——HUBBS, 1915, 462. —— JORDAN and HUBBS, 1925, 297. —— OKADA and MATSUBARA, 1938, 419, pl. 102, fig. 2. —— KURONUMA, 1939, 83. ——KURODA, 1951, 388. ——MATSUBARA, 1955, 1254. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 81.
Spinirhombus oligolepis. OSHIMA, 1927, 191.

Materials: Male- Nos. 33586-33587, 56.1-58.9 mm in standard length, Mimase, Kochi Pref., June 20, 1960. No. 33589, 54.8 mm, Mimase, June 20, 1960. Nos. 33590-33591, 55.0-56.1 mm, Mimase, June 23, 1960. Nos. 33593-33597, 50.2-56.1 mm, Mimase, July 10, 1960. Female- Nos. 33568-33585, 54.1-68.3 mm, Mimase, June 20, 1960. No. 33588, 59.9 mm, Urado, Kochi Pref., June 20, 1960. No. 33592, 59.0 mm, Urado, Kochi Pref., June 20, 1960.

Diagnosis: A dwarf paralichthid flounder with small number of scales (40-45) and large number of slender and long gill-rakers.

Description: Dorsal fin rays 63-67; anal fin rays 48-52; pectoral fin rays 10-11 on ocular side, 9-10 on blind side; scales in lateral line 40-45; gill-rakers on first arch 7-9+18-24; vertebrae including urostyle 10+23-25=33-35. Head 3.5-3.87 in standard length; depth 1.72-2.0. Snout 4.63-5.67 in head; upper eye 3.18-4.34; lower eye 2.9-3.84; maxillary 2.13-2.51 on ocular side, 2.2-2.64 on blind side; lower jaw 1.89-2.25 on ocular side, 1.78-2.08 on blind side; depth of caudal peduncle 1.82-2.28; first dorsal fin ray 3.49-4.78; longest dorsal fin ray 1.72-2.08; first anal fin ray 2.91-4.29; lengest anal fin ray 1.67-2.14; pectoral fin 1.13-1.37 on ocular side, 1.69-2.08 on blind side; ventral fin 2.29-3.06 on ocular side, 2.14-2.86 on blind side.

Body ovoid and rather deep, highest at middle part of body, its depth equal to or more than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle moderate in depth, about 1/4 depth of body.

Head moderate, as long as or shorter than half depth of body, upper profile with a slight concavity in front of middle part of upper eye. Snout short, much shorter than eye diameter. Eyes small, longer than half length of maxillary, separated by a narrow ridge; upper slightly in advance of lower. Nostrils on ocular side set in front of upper margin of lower eye; anterior one tubular with a flap posteriorly; posterior one not tubular without flap; nostrils on blind side below origin of dorsal fin, similar in shape and structure to those on ocular side.

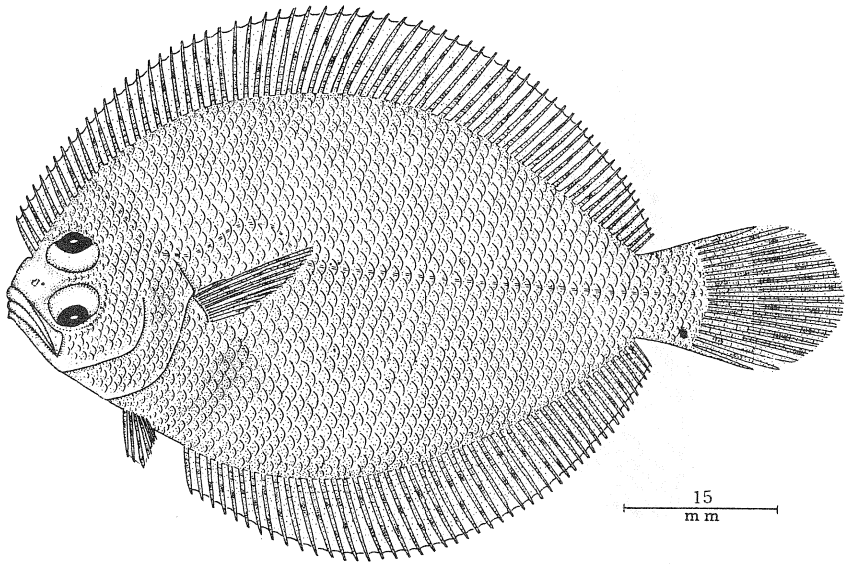

Fig. 24. Lateral view of *Tarphops oligolepis* (BLEEKER): No. 33570, 64.5 mm in standard length.

Mouth oblique, gently arched and rather large in size; maxillary extending to below anterior edge of lower eye or a little beyond it. Teeth on both sides very small, close-set and uniserial; teeth on upper jaw a little longer than those on lower jaw. Gill-rakers long and slender, well developed on upper and lower limbs of arch; not serrate on each posterior margin (Fig. 25, A).

Scales large, ctenoid on both sides (Fig. 25, B); snout and tips of both jaws naked, bases of all fins with scales. Lateral line on each side well developed, strongly arched above pectoral fin, curved portion subequal to 2/3 length of head; an accessory line running to seventh to nineth dorsal ray.

Dorsal fin originating on blind side, on horizontal from middle of upper eye, becoming

gradually higher to middle part of body, where it is highest and then decreasing in height posteriorly; all rays simple. Anal similar in shape and structure to dorsal. Pectoral fins rather short and not produced, much shorter than length of head; upper and lower one to three rays on ocular side simple, but others branched; all rays on blind side unbranched. Ventral fin originates slightly in rear of vertical through posterior end of preopercular bone; usually posterior three rays branched. Caudal fin rounded, both uppermost and lowermost three rays simple, but others branched.

Vent opens on blind side above origin of anal. Genital papilla displaced on ocular side.

In formalin, general ground color of body pale brown with irregular darker spots; all fins with irregularly scattered blackish spots paler than body; blind side of body yellowish white.

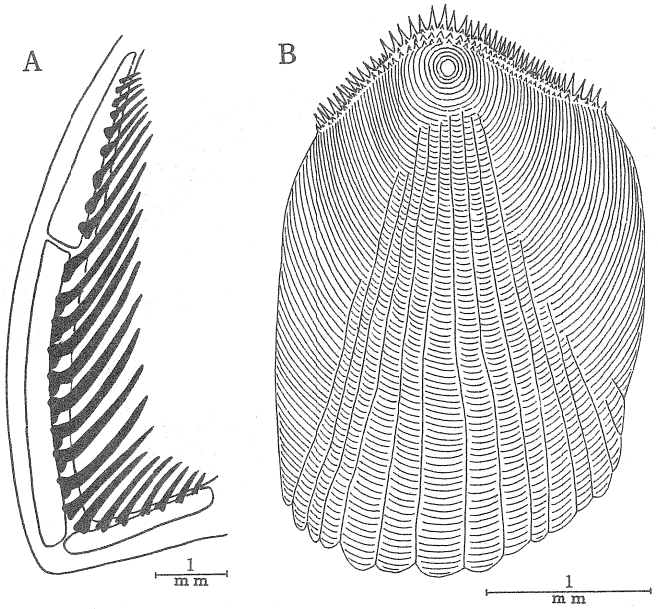

Fig. 25. Lateral view of first gill-arch on ocular side (A) and scale on ocular side (B) in *Tarphops oligolepis* (BLEEKER).

Tarphops elegans n. sp. "Yumearame-garei"

Fig. 26

Holotype.—No. 34199, 69.0 mm in standard length, Male, Choshi, Chiba Pref., April 20, 1961.

Paratypes.—Nos. 33600-33621, 51.7-60.6 mm, Nos. 33623-33625, 49.5-51.0 mm, Nos. 33627-33628, 49.5-51.2 mm, Nos. 33630-33631, 46.2-50.3 mm, No. 33634, 49.9 mm, Mimase, Kochi Pref., May 15, 1960. Nos. 33721-33724, 61.5-66.2 mm, Urado, Kochi Pref., May 30, 1960.

Diagnosis: Very close to *T. oligolepis*, but has large eye and slender body.

Description: *Holotype*.—Dorsal fin rays 67; anal fin rays 53; pectoral fin rays 10 on ocular side, 9 on blind side; scales in lateral line 47; gill-rakers on first arch 4+14. Head 3.94 in standard length; depth 2.21. Snout 5.0 in head; upper eye 2.96; lower eye 3.01; maxillary 2.33 on ocular side, 2.16 on blind side; lower jaw 1.95 on ocular side, 1.75 on blind side; depth of caudal peduncle 2.33; first dorsal fin ray 4.48; longest dorsal fin ray 1.88; first anal fin ray 3.24; longest anal fin ray 2.05; pectoral fin 1.45 on ocular side, 1.92 on blind side; ventral fin 2.96 on ocular side, 2.86 on blind side.

Body rather elongate oval, highest at middle, its depth much less than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle moderate in depth, about 1/4 depth of body.

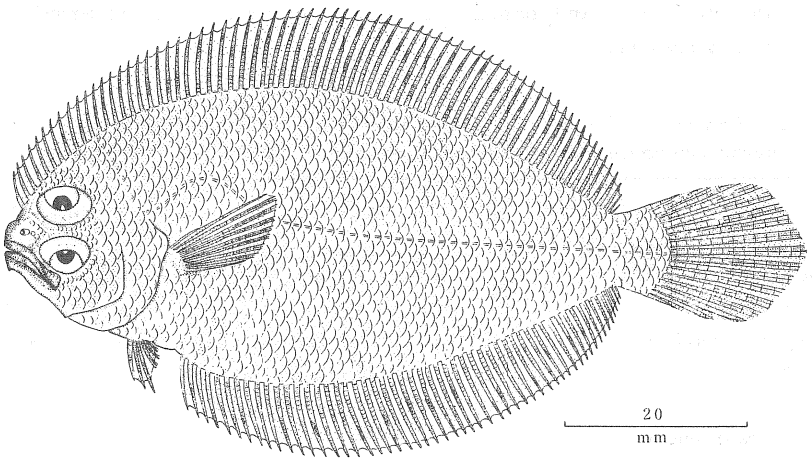

Fig. 26. Lateral view of holotype of *Tarphops elegans* n. sp.: No. 34199, 69.0 mm in standard length.

Head rather small, much longer than half depth of body; upper profile with a slight concavity in front of upper eye. Snout blunt and short, subequal to half diameter of eye. Eyes large in size, subequal to 3/4 length of maxillary, separated by a narrow ridge; upper, which closely approaches dorsal margin of head, is very slightly in front of lower. Nostrils on ocular side set in front of upper margin of lower eye; those on blind side located before origin of dorsal; anterior one tubular with a long slender flap posteriorly, posterior one not tubular, without a flap.

Mouth oblique, slightly arched anteriorly and rather large, maxillary extending to near middle part of lower eye, a little projecting beyond tip of lower jaw when mouth is closed; teeth on both jaws uniserial, all small; those on upper jaw gradually becoming smaller, shorter and more close-set backward; lower a little smaller than those on upper. Gill-rakers well developed on both limbs, long, slender and pointed, without spinules on each posterior

margin, longest one subequal to half diameter of eye (Fig. 112, A).

Scales rather small, and highly deciduous; ctenoid on both sides; snout and tips of jaws naked; all fins with scales at bases. Lateral line well developed on both sides, strongly curved above pectoral fin, length of curved portion about 2/3 length of head; an accessory line running to tenth dorsal ray.

Dorsal fin originating on blind side, on horizontal from middle of upper eye, fin rays becoming higher toward middle of body, and evenly decreasing in height posteriorly; all rays simple. Anal fin starts on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins well developed on both sides of body, but that on ocular side longer than that on blind side; third to ninth rays on ocular side branched, but all rays on blind side unbranched. Ventral fins subequal on both sides of body, starting slightly in rear of vertical through posterior end of preopercle; that on ocular side along edge of abdomen; that on blind side slightly removed edge; posterior three rays branched, others simple. Caudal fin feeble and pointed posteriorly; uppermost and lowermost three rays simple, but others branched.

Table 2. Comparison of counts and proportional measurements of bodily parts between present new species and *Tarphops oligolepis* (BLEEKER).

Items \ Species	*T. elegans*	*T. oligolepis*
Dorsal fin rays	65—70 (67.8)	63—67 (64.9)
Anal fin rays	51—56 (53.7)	48—52 (50.3)
Scales in lateral line	44—48 (45.4)	40—45 (42.7)
Vertebrae	10+25—26=35—36 (35.7)	10+23—25=33—35 (34.0)
In standard length		
Depth	2.12—2.42 (2.29)	1.72—2.0 (1.88)
In head		
Upper eye	2.64—3.13 (2.88)	3.18—4.34 (3.25)

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish without distinct marking; snout and both jaws dark; all fins paler than body with irregularly scattered blackish dots; blind side of body milky white.

Paratypes.—Dorsal fin rays 65-70; anal fin rays 52-56; pectoral fin rays 10-11 on ocular side, 9-10 on blind side; scales in lateral line 44-48; gill-rakers on first arch 6-7+18-21; vertebrae including urostyle 10+25-26=35-36. Head 3.68-4.1 in standard length; depth 2.12-2.42. Snout 4.37-5.8 in head; upper eye 2.64-3.13; lower eye 2.56-3.2; maxillary 2.08-2.5 on ocular side, 2.09-2.5 on blind side; lower jaw 1.81-2.02 on ocular side, 1.66-1.97 on blind side; depth of caudal peduncle 2.17-2.67; first dorsal fin ray 3.24-4.52; longest dorsal fin ray 1.84-2.28; first anal fin ray 3.71-4.6; longest anal fin ray 1.84-2.28; pectoral

fin 1.26-1.52 on ocular side, 1.88-2.35 on blind side; ventral fin 2.47-3.79 on ocular side, 2.36-2.98 on blind side.

Remarks: In some characters this new species closely resembles *Tarphops oligolepis* (Bleeker), but differs from the latter in having characters as indicated in Table 2.

20. Family Bothidae

All rays simple, except for middle part of caudal fin. Ventral fin on blind side short base, that on ocular side slightly or greatly elongate, supported by a cartilaginous plate placed in advance of cleithrum (Fig. 117, D-H); second to fourth rays on ocular side opposite to first on blind side. Lateral line on ocular side well developed but generally absent or feebly developed on blind side.

Supraoccipital does not meet exoccipitals, but connected with each of epiotics with a suture; zygapophyses of exoccipitals widely apart from each other (Fig. 102, B1-D1, B2-D2; Fig. 103); alisphenoid on ocular side either very small or absent (Figs. 97-100); frontal on blind side does not form interorbital bone (Fig. 104, D-G); exoccipital not connected with prootic anteriorly, but connected with opisthotic (Figs. 97-100).

Suborbital bones on ocular side entirely absent; a preorbital bone absent on blind side, but suborbital bones slender and tubular, three to five in number (Fig. 107, D-G; Fig. 108).

Lower pharyngeal bone compressed, platelike in shape and toothed in one or two rows; upper pharyngeal bones armed with one or two to three rows of teeth; third epibranchial not toothed band (Fig. 113, G-L; Fig. 114, A-L).

Cardiac apophysis large or moderate in size, with a pair of ridges or wings; sciatic part pointed at tip, rarely truncate (Taeniopsettinae) (Fig. 115, H-O; Fig. 116, A-I).

First neural spine entirely absent; platelike neural spine present in second, or second to third vertebrae; parapophysial stay absent; rib and epipleural absent, but epicentrum, epimeral, hypomeral and myorhabdoi present; position of opening for notochord more or slightly more advanced than in middle of centrum; transverse apophysis present (Figs. 120-122).

Urostyle entirely fused with hypural; last neural and haemal spines fused with centrum; slits at each base of neural and haemal spines present; uroneural 1, uroneural 2 and epural absent (Fig. 127, G-O; Fig. 128, A-H); caudal rays 17 in total number.

21. Key to subfamilies and genera of Bothidae

A[1] Taeniopsettinae: Ventral fin on ocular side slightly elongate, extending forward to near tip of isthmus, distance between tip of isthmus and origin of ventral fin on ocular side subequal to length of base of ventral fin (from first ray to last ray); second ray on ocular side opposite to first on blind side (Fig. 28, B); sciatic part of urohyal truncate at tip (Fig. 115, H); suborbital bones on blind side five in number (Fig. 107, D; Fig. 110, B) ..... *Taeniopsetta*

A[2] Bothinae: Ventral fin on ocular side greatly elongate, first ray starting at or near tip of isthmus (Fig. 30), in latter case, distance between tip of isthmus and origin of ventral fin on ocular side much shorter than base of ventral fin (Fig. 95, B); third or fourth ray on ocular side opposite

to first on blind side; sciatic part of urohyal pointed at tip (Fig. 115, I-O; Fig. 116); suborbital bones on blind side three or four in number (Fig. 107, E-G; Fig. 108).

B[1] Ventral fin on ocular side starting at tip of isthmus; mouth varies from very large to small sizes; lateral line on blind side absent.

C[1] Eyes separated by a concave space (except in very young), interorbital in male and large specimens are generally broader than that in female and small specimens; generally male with a rostral spine.

D[1] First dorsal ray not elongate, shorter than second one; gill-rakers short or moderate in size, and not palmate in shape.

E[1] Tip of isthmus extending to below posterior margin of lower eye.

F[1] Body elliptical, its depth more than 2.4 in standard length; scales 80-96 in lateral line; dorsal fin rays 104-117; anal fin rays 83-94 ..... *Parabothus*

F[2] Body deep, its depth less than 2.2 in standard length; scales 57-66 in lateral line; dorsal fin rays 96-104; anal fin rays 76-82 ..... *Tosarhombus*

E[2] Tip of isthmus extending to below middle or anterior part of lower eye.

G[1] Scales rather large, fewer than 63 in lateral line.

H[1] Scales on ocular side strongly ctenoid (Fig. 43, E), armed with long hairlike spines, more than 50 in lateral line; body dark brownish in color ..... *Crossorhombus*

H[2] Scales on ocular side feebly ctenoid, less than 50 in lateral line; body greyish green in color ..... *Engyprosopon*

G[2] Scales very small, more than 70 in lateral line ..... *Bothus*

D[2] First dorsal ray elongate, longer than second one; gill-rakers palmate in shape (Fig. 112, C) ..... *Asterorhombus*

C[2] Eyes separated by a bony ridge or very narrow concave space at anterior half, usually its width similar to both sexes.

I[1] Head large in size, less than 4.5 in standard length; vertebrae fewer than 45.

J[1] Mouth small in size, maxillary as long as eye diameter; scales on ocular side strongly ctenoid armed with long hairlike spines (Fig. 69, B; Fig. 71, C) ..... *Psettina*

J[2] Mouth large in size, maxillary much longer than eye diameter; scales on ocular side cycloid or feebly ctenoid ..... *Arnoglossus*

I[2] Head small size, more than 4.7 in standard length; vertebrae more than 49.

K[1] Mouth small or moderate in size, maxillary not protruding beyond tip of snout, 2.6-4.7 in head; lower jaw shorter than head; pectoral fin on ocular side shorter than head.

L[1] Maxillary 3.1-4.7 in head; lower jaw 2.2-3.0; upper eye 2.5-3.5; vertebrae 11-12+37-42=48-53.

M[1] Dentition more or less developed on ocular side of jaws; mouth rather small size, almost symmetrical, maxillary as long as eye diameter; head rather large, 4.87-5.69 in standard length ..... *Japonolaeops*

M[2] Dentition developed only on blind side of jaws (Fig. 85, A, B; Fig. 89, A, B); mouth very small size, asymmetrical, maxillary much shorter than eye diameter; head small, 5.71-7.28 in standard length ..... *Laeops*

L[2] Maxillary 2.6-2.7 in head; lower jaw 1.9; upper eye 4.3-4.7; vertebrae 13+38=51 ..... *Neolaeops*

K[2] Mouth very large in size, maxillary strongly protruding beyond tip of snout, 1.02-1.04 in head; lower jaw much longer than head; pectoral fin on ocular side as long as or a little longer than head; vertebrae 14+39=53 ..... *Kamoharaia*

B[2] Ventral fin on ocular side starting slightly in back of tip of isthmus, distance from origin of ventral fin to tip of isthmus subequal to half base of ventral fin on ocular side (Fig. 95, C); mouth very large, but upper jaw not projecting beyond tip of snout, maxillary more than half length of head; lateral line more or less developed on blind side ..... *Chascanopsetta*

22. Subfamily Taeniopsettinae new

Ventral fin on ocular side slightly elongate, extending forward to near tip of isthmus, distance between tip of isthmus and origin of ventral fin on ocular side subequal to length of base of ventral fin (Fig. 28, B); and the fin on ocular side supported by a cartilaginous plate placed a little before cleithrum (Fig. 117, D); second ray on ocular side opposite to first one on blind side. Lateral line absent on blind side.

Opisthotic bone spearlike in shape, its anterior tip does not extend to tip of basioccipital (Fig. 97, A1, A2).

Sciatic part of urohyal truncate at tip (Fig. 115, H).

Opening for notochord of centrum very small in size, its position slightly in advance of middle part of centrum (Fig. 120, A1-A5).

Suborbital bones on blind side five in number (Fig. 107, D).

Remarks: Of the Japanese sinistral flounders a single genus *Taeniopsetta* is referable to the present new subfamily. It is evident that the subfamily undoubtedly belongs to the family Bothidae (NORMAN's Bothinae) in having many important osteological features, as mentioned in the description of the family Bothidae.

23. Genus *Taeniopsetta* GILBERT

Taeniopsetta GILBERT, 1905, 680 (type-species by original designation: *Taeniopsetta radula* GILBERT).

Body deep ovate, moderately compressed; tip of isthmus below posterior margin of lower eye; anterior dorsal profile similar in both sexes. Caudal peduncle moderate in depth. Head rather large 3.7-4.3 in standard length. Eyes sinistral, separated by a ridge or narrow concave space; interorbital region similar in both sexes. Male with a strong rostral spine on snout, two orbital spines in front of each eye, and a knob on mandibular symphysis; in female usually those spines feeble or absent. Nostrils two on both sides, anterior one tubular with a rather long flap posteriorly, and posterior one somewhat tubular without a flap. Mouth oblique, rather small, maxillary extending to below anterior margin of lower eye or a little beyond it. Teeth well developed on both sides, uniserial on both jaws, rather small, and close-set, without canine anteriorly. Gill-rakers few in number, rather short, not serrate on its posterior margin. Scales small and not deciduous, ctenoid or cycloid on ocular side, cycloid on blind side; snout, both jaws and interorbital area naked.

Dorsal fin originating on blind side and on horizontal through interorbital area, all rays simple. Anal fin starts on vertical through posterior end of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Left ventral fin originates behind tip of isthmus, distance tip of isthmus and origin of ventral subequal to length of base of ventral fin on ocular side, second ray on ocular side opposite to first one on blind side, all rays simple (Fig. 28, B). Caudal fin rounded posteriorly, generally uppermost and lowermost

rays simple, but other rays branched.

Vomer toothless. Interorbital bone barlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Prefrontals in contact with each other above mesethmoid (Fig. 104, E). Postorbital process triangular in shape. Alisphenoid on ocular side very small, not extending to orbital cavity. Opisthotic spearlike in shape, and moderate in size, connected with pterotic dorsally, with exoccipital posteriorly and with basioccipital ventrally. Prootic articulated with pterotic dorsally and with opisthotic posteriorly, but widely separated from exoccipital and basioccipital, owing to insertion of opisthotic (Fig. 97, A1-A2).

Suborbital bones five in number (Fig. 107, D). Second hypobranchial rectangular in shape without toothed plate; third basibranchial rectangular concaved deeply in both sides of anterior part (Fig. 113, K). Urohyal fishhook-like in shape, tip of sciatic part truncate, shorter than that on main part; cardiac apophysis large in shape with a pair of ridges (Fig. 115, H). Opening for notochord very small, and slightly advanced than middle part of centrum; anterior transverse apophysis beginning with second vertebra (Fig. 120, A1-A5). Four caudal plates not branched (Fig. 127, L).

Remarks: The present genus was formerly arranged by many ichthyologists under the subfamily Paralichthyinae in having some characters as described by NORMAN (1934) in the synopsis of the subfamilies, but in detail examination, it is referred to the new subfamily Taeniopsettinae at least in having the ventral fin on the ocular side slightly elongated and extending forward to near the tip of the urohyal; the fin on the ocular side supported by a cartilaginous plate placed a little before the cleithrum; and the appearance of the transverse apophysis. Moreover, the genus is more closely related to members of the Bothinae than to those of the Paralichthyidae (not NORMAN's Paralichthyidae) in other important osteological characteristics except for both characters the sciatic part of the urohyal truncated at the tip and the opening for the notochord of the centrum very small in size.

Taeniopsetta ocellata (GÜNTHER) "Itohiki-ganzo"

Fig. 27

Pseudorhombus ocellatus GÜNTHER, 1880, 56, pl. 24, figs. A, B. —— REGAN, 1908, 232. —— KAMOHARA, 1934, 1201.

Taeniopsetta ocellata. NORMAN, 1927, 17. ——NORMAN, 1934, 122, fig. 78. ——KAMOHARA, 1938, 57. —— OKADA and MATSUBARA, 1938, 419, pl. 103, fig. 1. ——NORMAN, 1939, 98. —— KURONUMA, 1940, 31, fig. 1. —— KAMOHARA, 1950, 238. —— MATSUBARA, 1955, 1255, fig. 488. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 81.

Materials: Male- Nos. 2013, 2015-2017, 2020-2021, 128.0-152.2 mm in standard length, Owashi, Mie Pref., April 13, 1936. Nos. 33638-33650, 104.9-167.2 mm, Mimase, Kochi Pref., November 20, 1960. Female- Nos. 2014, 2018, 2022, 2106-2108, 131.3-168.3 mm, Owashi, April 13, 1936. No. 17218, 138.9 mm, Miya, Aichi Pref., January 8, 1951. No. 20544, 148.2 mm, Miya, April 30, 1953. Nos. 33651-33661, 136.6-172.0 mm, Mimase, November 20, 1960.

Diagnosis: A flounder with deep body which is spotted with U-shaped markings along dorsal and ventral margins; in male twelfth to twentith dorsal rays and first to seventh anal rays prolonged.

Description: Dorsal fin rays 85-97; anal fin rays 71-81; pectoral fin rays 12-16 on ocular side, 10-14 on blind side; scales in lateral line 95-113; gill-rakers on first arch 0+4-6; vertebrae including urostyle 10+30-32=40-42. Head 3.72-4.34 in standard length; depth 1.78-2.12. Snout 5.5-6.95 in head; upper eye 2.89-3.46; lower eye 2.83-3.59; maxillary

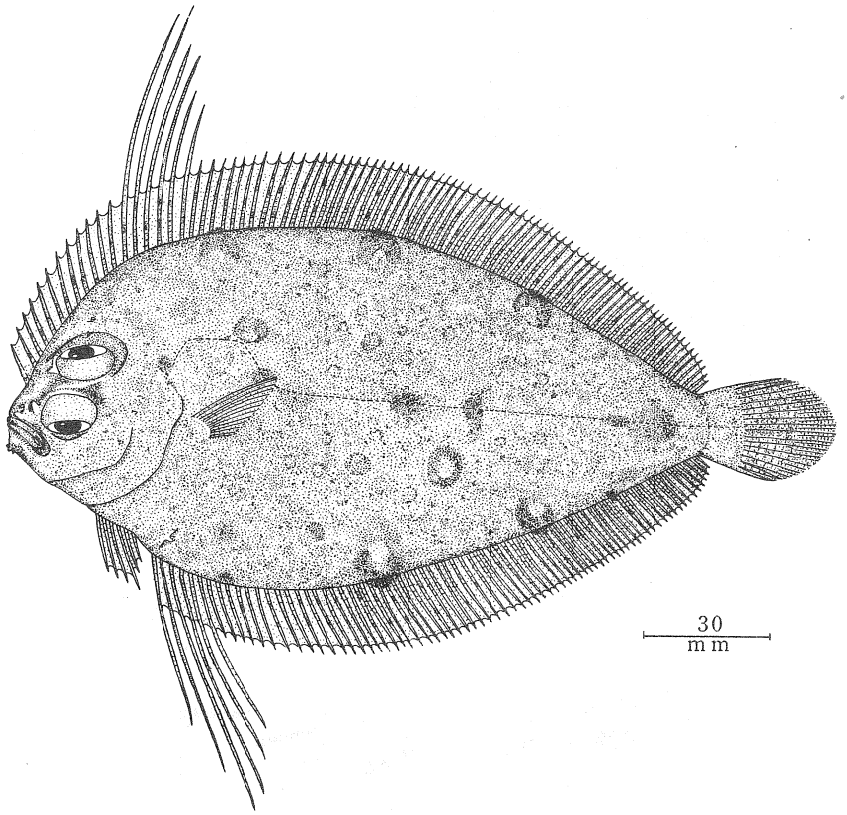

Fig. 27. Lateral view of *Taeniopsetta ocellata* (GÜNTHER) from male specimen: No. 33638, 167.2 mm in standard length.

3.11-3.52 on ocular side, 2.88-3.41 on blind side; lower jaw 2.27-2.5 on ocular side, 2.05-2.29 on blind side; depth of caudal peduncle 2.4-3.03; pectoral fin 1.5-1.98 on ocular side, 2.35-3.26 on blind side; ventral fin 2.11-3.26 on ocular side, 1.95-2.74 on blind side; base of ventral fin 4.42-6.87 on ocular side, 5.12-6.95 on blind side.

Body deep ovate, moderately compressed, highest at posterior margin of pectoral fin, about as long as or a little longer than half its length; dorsal and anal contours strongly and evenly arched. Caudal peduncle moderate in depth, merely or a little less than 1/5

depth of body.

Head rather large, a little shorter than half depth of body; upper profile with a slight notch in front of interorbital area, from which it moderately rises. Snout short, about half diameter of eye. Both eyes large, separated by a ridge or a narrow concave space; lower

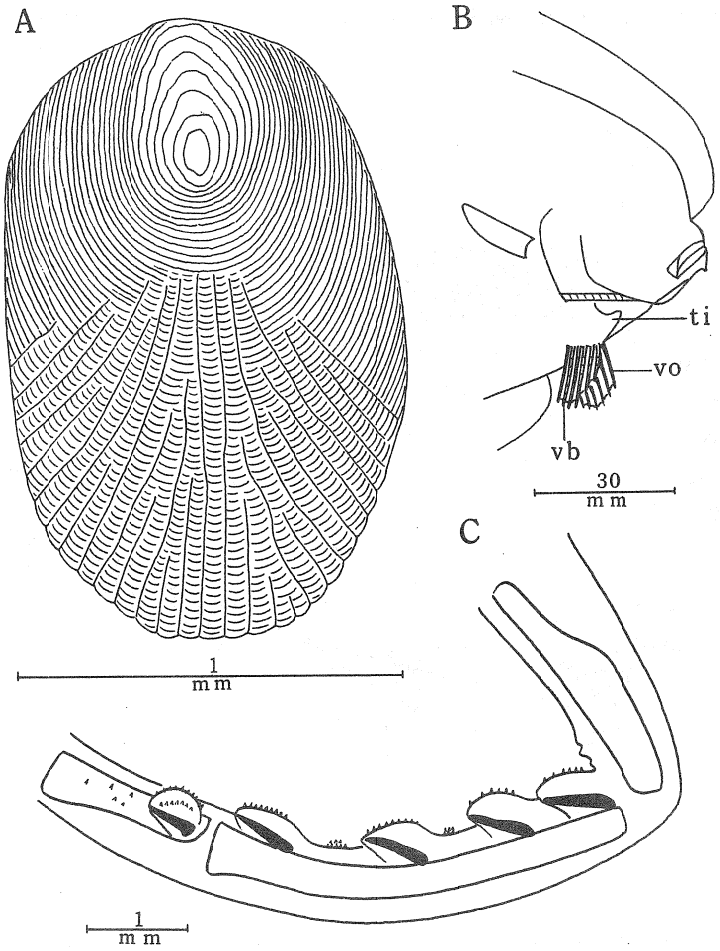

Fig. 28. Lateral view of scale on ocular side (A), right view of ventral fins and isthmus (B) and first gill-arch on ocular side (C) in *Taeniopsetta ocellata* (GÜNTHER). ti, tip of isthmus; vb, ventral fin on blind side; vo, ventral fin on ocular side.

slightly in advance of upper. Nostrils on ocular side closely set in front of middle part of lower eye, anterior one tubular with a short slender flap posteriorly, posterior one somewhat tubular, without a flap; nostrils on blind side setting closely below origin of dorsal.

Mouth oblique, rather small, maxillary about as long as eye diameter, extending below anterior margin of lower eye or a little beyond it. Teeth uniserial on both jaws, rather small, similar in shape and in size. Gill-rakers small and slender, not serrate on posterior margin; none on upper limb (Fig. 28, C).

Scales small and not deciduous, all cycloid on both sides (Fig. 28, A); snout, both jaws and interorbital area naked. Lateral line on ocular side curved above pectoral fin, curved portion about half length of head; line absent on blind side.

Dorsal fin originating on blind side, on a level with upper margin of lower eye, fin rays becoming higher towards near posterior 1/3 of body, and evenly decreasing in height posteriorly. Anal fin starting at vertical through origin of lateral line. Pectoral fins unequal

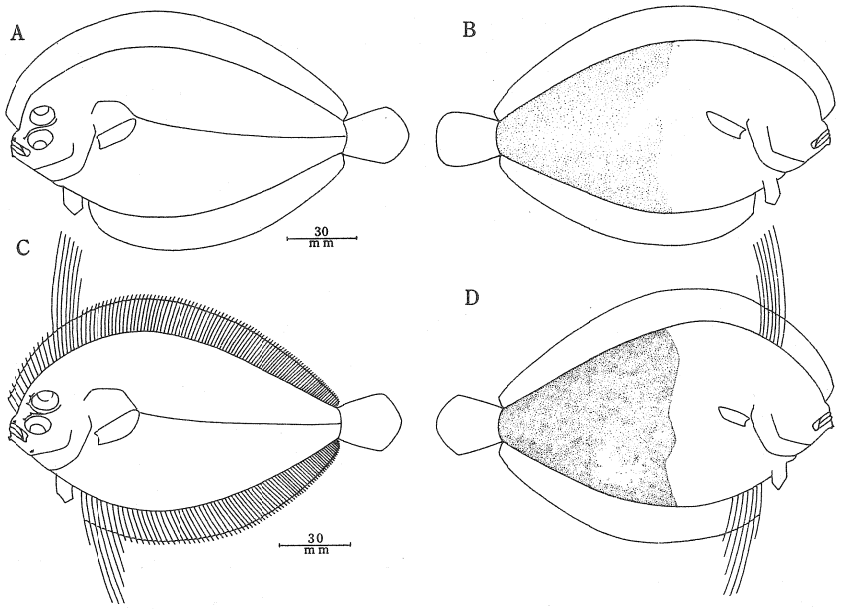

Fig. 29. Diagrammatic illustration of body parts showing sexual dimorphism in *Taeniopsetta ocellata* (GÜNTHER). Left view (A, female; C, male); right view (B, female; D, male).

on both sides, that on ocular side about equal to 1.5 of that on blind side, second or third ray longest, succeeding rays becoming shorter ventrally; all rays simple. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, rays as well as base a little longer than those on blind side; second ray opposite to first on blind side (Fig. 28, B). Caudal fin rounded posteriorly; generally uppermost and lowermost two rays simple, but remaining ones branched.

Vent located on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body dark chestnut brown; three or four pairs of prominent dark U-shaped markings along both upper and lower edges of body, and three pairs of similar color rings above and below lateral line and on a middle part of lateral line; a number of spots irregularly scattered on body; median fins are pale brown marked by irregular small spots and streaks of dark brown, paired fins pale brown. Blind side of body stained with light brown in posterior half, but milky white in anterior half; dorsal and anal fins milky white, and provided with about 9 to 13 vertical streaks of brown on each fin; pectoral fin milky white; caudal fin similar in color to posterior half of body.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species in several external characters (Fig. 29). In the male, the twelfth to eighteenth dorsal rays and the first to seventh anal rays are greatly elongate; twelfth dorsal ray 0.63-1.23 in head, thirteenth 0.6-1.38, fourteenth 0.62-1.28, fifteenth 0.62-1.74, sixteenth 0.67-1.61, seventeenth 0.73-1.74, eighteenth 0.82-1.96; first anal ray 0.84-1.54, second 0.56-0.88, third 0.57-1.22, fourth 0.62-1.18, fifth 0.58-1.92, sixth 0.78-1.6, seventh 0.79-1.72. A strong spine is on the snout and in front of each eye, and a knob is on a symphysis of the lower jaw. The body on the blind side is dark brown on the posterior half. In the female, the dorsal and anal fin rays are not elongated. The spines on the snout and the lower eye, and a knob on the symphysis of the lower jaw are feeble or absent, but a spine on the upper eye is lacking. The body on the blind side is pale brown on the posterior half.

24. Subfamily Bothinae

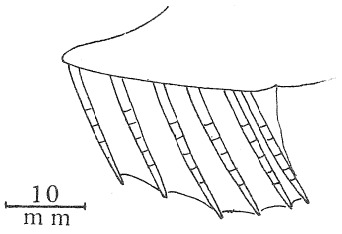

Fig. 30. Structure and position of left ventral fin origin in *Arnoglossus polyspilus* GÜNTHER.

Ventral fin on ocular side greatly elongate, extending forward to tip of urohyal (Fig. 30), supported by a cartilaginous plate placed in advance of cleithrum (Fig. 117, E-H); third or fourth ray on ocular side opposite to first on blind side. Suborbital bones on blind side three or four in number (Fig. 107, E-G; Fig. 108). Sciatic part of urohyal pointed forwardly (Fig. 115, I-O; Fig. 116, A-I). Opening for notochord moderate or large in size (Fig. 120, B4; Fig. 121, A4, B4; Fig. 122, A4, B4; Fig. 123, C-F).

25. Genus *Parabothus* NORMAN

Parabothus NORMAN, 1931, 600 (type-species by original designation: *Arnoglossus polylepis* ALCOCK).

Body elliptical and not strongly compressed. Caudal peduncle medium in depth. Tip of isthmus locates just below or slightly in rear of vertical of posterior margin of lower eye. Eyes sinistral, separated by a concave space, which is broader in male than in female

and young. Male without rostral or orbital spines. Nostrils on both sides two, anterior tubular with a flap posteriorly and posterior somewhat tubular without flap. Mouth moderate in size, maxillary extending to below or a little beyond anterior edge of lower eye, 2.2-3.2 in head. Teeth uniserial on both jaws, developed almost equally on both sides of jaws with more or less enlarged teeth anteriorly. Gill-rakers moderate in size and in number, and pointed at tip. Scales rather small; those on ocular side finely ctenoid, armed with elongate spinules (Fig. 34, C); blind side with cycloid scales; tip of snout, both jaws and pectoral fin naked.

Dorsal fin originating above nostrils on blind side, all rays simple. Anal fin similar both in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side; all rays simple. Left ventral fin originating on tip of isthmus, third ray on ocular side opposite to first on blind side; all rays simple. Caudal fin rounded, simple on two or three rays counted from upper and lower margins respectively.

Vomer toothless. Prefrontals on both sides expanded upward, and widely connected with each other above mesethmoid (Fig. 104, E). Postorbital process triangular in shape. Interorbital bone platelike in shape. Alisphenoid on ocular side very small, not extending to orbital cavity. Basioccipital triangular in shape, when viewed from lateral. Opisthotic triangular in shape, its tip extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 98, B1, B2).

Suborbital bones on blind side three in number (Fig. 108, E). Second hypobranchial rectangular or elliptical in shape without toothed plate; third basibranchial rectangular concave deeply in both sides of anterior part (Fig. 113, L). Urohyal fishhook-like in shape, tip of sciatic part extending to a little beyond vertical of tip of main part, tapering the front; cardiac apophysis moderate in size, with a pair of wings (Fig. 115, N). Opening for notochord moderate in size, and more advanced than middle part of centrum; anterior transverse apophysis beginning with second vertebra (Fig. 121, A1). Four caudal plates not branched (Fig. 128, A).

26. Key to species of *Parabothus*

A^1 Scales small, 90-96 in lateral line; upper eye rather small, 3.46-3.94 in head; two marked dark blotches at junction and curved parts of lateral line, and small dark dots along upper margin of upper eye ..... ***Parabothus coarctatus*** (GILBERT)

A^2 Scales rather large, 80-86 in lateral line; upper eye rather large, 2.98-3.48 in head; neither dark blotches at junction and curved parts of lateral line nor small dots along upper margin of upper eye ..... ***Parabothus kiensis*** (TANAKA)

Parabothus coarctatus (GILBERT) "Sumire-garei or Midori-garei"

Fig. 31

Platophrys coarctatus GILBERT, 1905, 686, fig. 267. ——JORDAN and JORDAN, 1922, 24. —— FOWLER, 1928, 92.

Rhomboidichthys coarctatus. GÜNTHER, 1909, 343.

Arnoglossus violaceus FRANZ, 1910, 61, pl. 7, fig. 56. ——JORDAN, TANAKA and SNYDER, 1913, 315. ——KAMOHARA, 1931, 542. ——KAMOHARA, 1938, 57. ——KAMOHARA, 1950, 239.
Parabothus coarctatus. NORMAN, 1931, 601. —— NORMAN, 1934, 243, fig. 185. —— KAMOHARA, 1935, 21. ——OKADA and MATSUBARA, 1938, 423. ——FOWLER, 1949, 61. ——KAMOHARA, 1950, 241. ——MATSUBARA, 1955, 1261. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82.
Parabothus (?) *violaceus*. NORMAN, 1931, 601.
Parabothus violaceus. NORMAN, 1934, 242, fig. 184. ——OKADA and MATSUBARA, 1938, 423. ——MATSUBARA, 1955, 1261. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82.

Materials: Male- Nos. 33343-33349, 193.2-208.0 mm in standard length, Mimase, Kochi Pref., December 15, 1958. No. 33351, 184.3 mm, Mimase, December 15, 1959. Nos. 33353-33354, 180.8-207.8 mm, Mimase, December 15, 1959. Nos. 33359-33361, 156.8-173.0 mm, Mimase, December 15, 1959. Female- No. 33342, 224.8 mm, Mimase, December 15, 1959. Nos. 33350-33352, 186.6-194.0 mm, Mimase, December 15, 1959. Nos. 33355-33358, 157.8-188.2 mm, Mimase, December 15, 1959. No. 33362, 100.2mm, Mimase, December 20, 1959.

Diagnosis: A *Parabothus* with two dark spots at junction and curved parts of lateral line, one on middle parts of straight portion, and a series of dark dots along upper margin of upper eye; large number of scales on lateral line (90-95) and rather small upper eye (3.46-3.94 in head).

Description: Dorsal fin rays 106-117; anal fin rays 87-95; pectoral fin rays 13-14 on ocular side, 11-12 on blind side; scales in lateral line 90-96; gill-rakers on first arch 0+8-10; vertebrae including urostyle 10+32-33=42-43. Head 3.62-4.04 in standard length; depth 2.4-2.55. Snout 4.32-5.5 in head; upper eye 3.46-3.94; lower eye 3.22-3.8; interorbital width 6.89-23.7; maxillary 2.69-3.01 on ocular side, 2.53-2.92 on blind side; lower jaw 1.92-2.1 on ocular side, 1.8-1.97 on blind side; depth of caudal peduncle 2.53-3.05; longest dorsal fin ray 2.11-2.7; longest anal fin ray 2.17-2.58; pectoral fin 1.6-1.94 on ocular side, 2.43-3.26 on blind side; ventral fin 2.73-3.23 on ocular side, 2.96-3.74 on blind side; base of ventral fin 2.86-4.16 on ocular side, 5.36-6.77 on blind side.

Body elliptical, moderately compressed, highest slightly in front of middle, its depth about 1.6 length of head; dorsal and anal contours evenly arched except for dorsal profile of head. Caudal peduncle moderate in depth, a little less than 1/4 depth of body.

Head rather small, a little shorter than 1/4 length of body; upper profile with a shallow concave before interorbital area, from which it gently rises. Snout blunt and rather long, slightly shorter than eye diameter. Eyes rather large, a little shorter than length of maxillary, separated by a deep concave space, width of which not wider than eye diameter; lower eye somewhat in advance of upper. Nostrils on ocular side set in front of upper margin of lower eye, anterior one tubular with a filamentous flap posteriorly, extending to anterior margin of posterior one when depressed backward; posterior more or less tubular and without flap; nostrils on blind side small, closely setting below origin of dorsal, anterior tubular with a short flap posteriorly, posterior with rudimentary tube.

Mouth oblique, gently curved at middle part of maxillary, which extending to slightly beyond anterior margin of lower eye, about as long as or a little longer than 1/3 length of head. Teeth uniserial on both jaws, developed almost equally on both sides of jaws; upper jaw armed with some enlarged canines anteriorly, gradually becoming smaller and

shorter backward; lower jaw with some enlarged caninelike teeth anteriorly, its lateral teeth much stronger than those of upper. Gill-rakers moderate in size and number, not serrate on posterior margin; none on upper limb (Fig. 32, C).

Scales small and rather not deciduous, strongly ctenoid on ocular side, armed with elongate spinules along apical margin; those on blind side with cycloid; tip of snout, both jaws and pectoral fin scaleless. Lateral line on ocular side with a strong curve above pectoral fin, length of curved portion about 2/3 length of head; height about 1/3 length of its portion; the line absent on blind side.

Origin of dorsal fin on blind side, before horizontal from upper margin of lower eye; fin rays gradually increasing in height towards posterior 1/3 of body, and evenly decreasing in height posteriorly. Anal fin starting below vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side moderate in length,

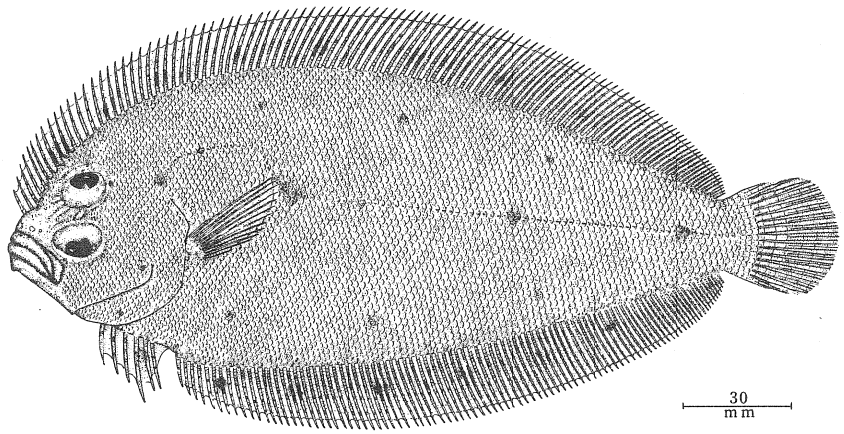

Fig. 31. Lateral view of *Parabothus coarctatus* (GILBERT), from female specimen: No. 33356, 178.0 mm in standard length.

much longer than 1/2 length of head in both sexes; that on blind side rather feeble and short, about 1.5 in length of that on ocular side; upper second or third ray longest, succeeding rays gradually becoming shorter towards lower one. Ventral fin on ocular side originating on vertical through posterior margin of lower eye; third ray on ocular side opposite to first on blind side. Caudal fin rounded, uppermost and lowermost two rays simple and others branched.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body dark brown, with two dark spots at junction of straight and curved parts of lateral line, two on middle of straight portion, and one near base of caudal fin; a series of spots near upper and lower edges of body and scattered smaller dots on body; similar dots along upper margin of upper eye; a conspicuous sharply three streaks, one of those in front of upper eye, one connecting

lower anterior margin of upper eye with anterior margin of lower eye, other connecting middle parts of both eyes. Dorsal and anal fins with a series of regularly arranged ten and eight dark blotches respectively; body on blind side sparely stained with light dark.

Sexual dimorphism: In the present species, there exists marked secondary sexual dimorphism in the interorbital space (Fig. 32, A, B; Fig. 35). In the male, the space is rather wide, 6.89-10.2 in head, while in the female, it is narrow, 10.2-23.7 in head.

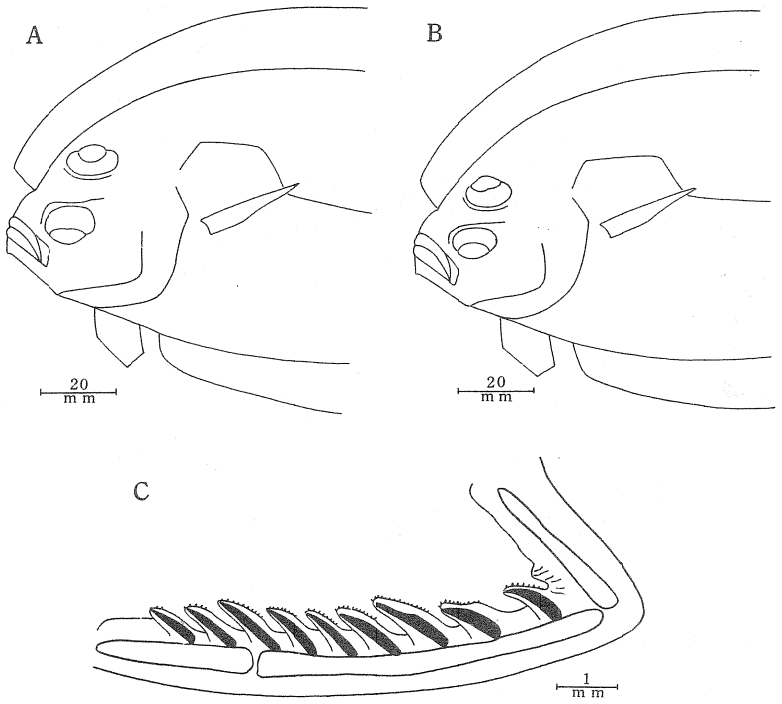

Fig. 32. Diagrammatic illustration of body parts showing sexual dimorphism (A, B) and lateral view of first gill-arch on ocular side (C) in *Parabothus coarctatus* (GILBERT). A, male; B, female.

Remarks: The present specimens agree well with the original description and figure of *Parabothus coarctatus* (GILBERT) known from Hawaiian Islands in the meristic characters, measurements and coloration. On the other hand, *Parabothus violaceus* (FRANZ) caught at Aburatsubo, Kanagawa Prefecture which is closely related to the present specimens in the many important features is not clearly separable from the present species, as already pointed out by NORMAN (1931) that *P. violaceus* appears to be close to *P. coarctatus*. The present author thinks that it is a synonym of this species.

Parabothus kiensis (TANAKA) "Kisyu-daruma"

Fig. 33

Platophrys kiensis TANAKA, 1918, 225. ——UI, 1929, 272, fig. 102. ——KAMOHARA, 1934, 301.
Parabothus kiensis. OKADA and MATSUBARA, 1938, 423. ——KAMOHARA, 1950, 241. ——MATSUBARA, 1955, 1261. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82.

Materials: Male- Nos. 33298-33303, 183.2-194.0 mm in standard length, Mimase, Kochi Pref., December 15, 1959. Nos. 33305-33307, 175.3-180.2 mm, Mimase, December 15, 1959. Nos. 33309-33317, 169.0-184.8 mm, Mimase, December 15, 1959. Nos. 33319-33325, 141.1-164.2 mm, Mimase, December 15, 1959. Female- Nos. 33326-33332, 148.5-202.9 mm, Mimase, December 15, 1959. Nos. 33334-33335, 148.5-170.9 mm, Mimase, December 15, 1959. Nos. 33336-33341, 105.8-178.5 mm, Mimase, December 15, 1959.

Diagnosis: A *Parabothus* without marked dark spots on lateral line and along upper margin of upper eye; small number of scales in lateral line (80-86) and rather large upper eye (2.98-3.48 in head).

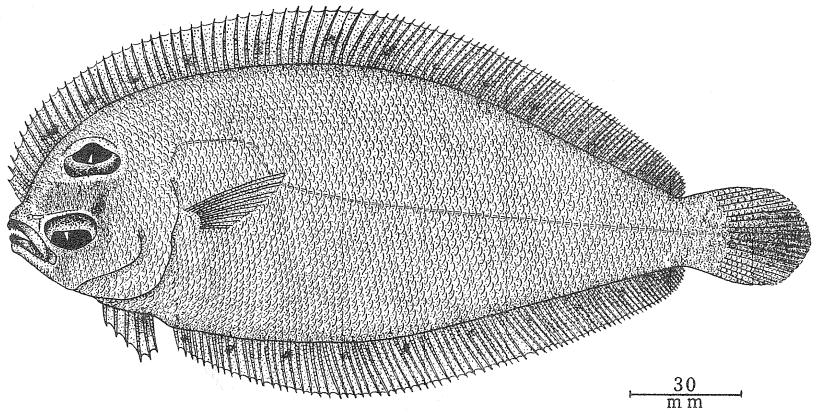

Fig. 33. Lateral view of *Parabothus kiensis* (TANAKA) from male specimen: No. 33301, 184.1 mm in standard length.

Description: Dorsal fin rays 104-113; anal fin rays 83-90; pectoral fin rays 12-13 on ocular side, 10-11 on blind side; scales in lateral line 80-86; gill-rakers on first arch 0+7-10; vertebrae including urostyle 10+31-32=41-42.

Head 3.81-4.27 in standard length; depth 2.37-2.72. Snout 4.35-6.31 in head; upper eye 2.98-3.48; lower eye 2.93-3.59; interorbital width 5.26-14.6; maxillary 2.62-3.18 on ocular side, 2.45-2.84 on blind side; lower jaw 1.93-2.2 on ocular side, 1.78-2.01 on blind side; depth of caudal peduncle 2.41-2.89; longest dorsal fin ray 2.27-2.68; longest anal fin ray 2.11-2.69; pectoral fin 1.55-1.91 on ocular side, 2.6-3.33 on blind side; ventral fin 2.44-3.76 on ocular side, 2.97-3.69 on blind side; base of ventral fin 3.07-4.64 on ocular side, 5.26-6.47 on blind side.

Body elliptical and not strongly compressed, highest slightly in front of middle part of body, its depth about 1.6 length of head; dorsal and anal contours evenly arched except for dorsal profile of head. Caudal peduncle moderate, as deep as 1/4 depth of body.

Head rather small, about 1/4 length of body; upper profile with a slightly concave in front of midline of interorbital area, from which it slowly rises. Snout blunt and rather long, much longer than half diameter of eye. Eyes rather large, a little shorter than length of maxillary, separated by a shallow concave space, of which width not wider than eye

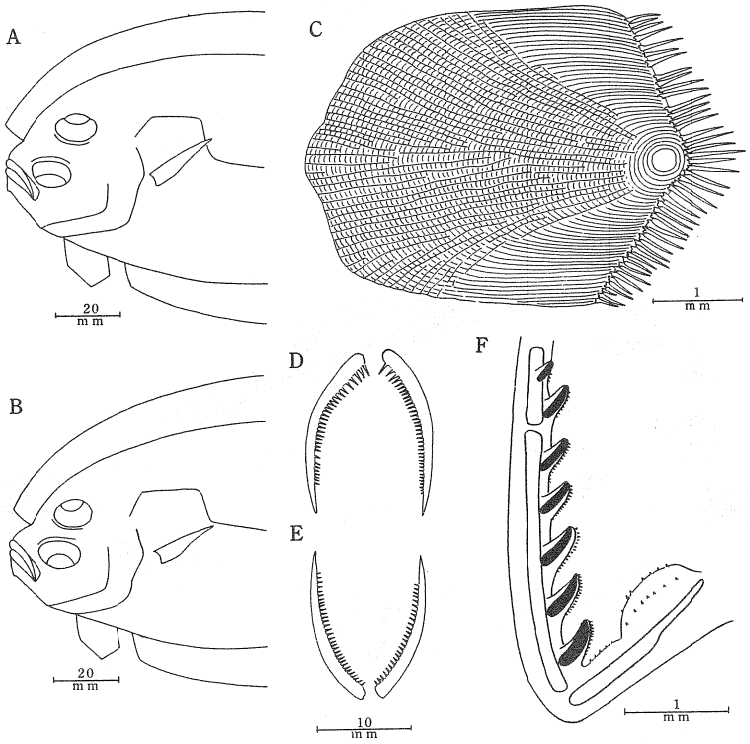

Fig. 34. Diagrammatic illustration of body parts showing sexual dimorphism (A, B) and scale on ocular side (C), both jaws (D, E) and first gill-arch on ocular side (F) in *Parabothus kiensis* (TANAKA). Left view (A, male; B, female); lateral view (C, F); ventral view (D); dorsal view (E).

diameter; lower eye more or less in advance of upper. Nostrils two on each side; those on ocular side set before horizontal from upper margin of lower eye, anterior one tubular with a flap posteriorly, posterior one more or less tubular and without flap; nostrils on blind side small, closely setting below origin of dorsal, anterior tubular with short flap posteriorly, posterior with rudimentary tube.

Mouth rather large, oblique, extending to slightly beyond anterior margin of lower eye, about equal to or a little longer than 1/3 length of head. Teeth uniserial on both jaws,

developed almost equally on both sides of jaws; upper jaw armed with some enlarged canines anteriorly, gradually becoming smaller and shorter posteriorly; lower jaw with more or less enlarged caninelike teeth anteriorly, its lateral teeth somewhat stronger than those of upper (Fig. 34, D, E). Gill-rakers moderate in size and number, not serrate on posterior margin; none on upper limb (Fig. 34, F).

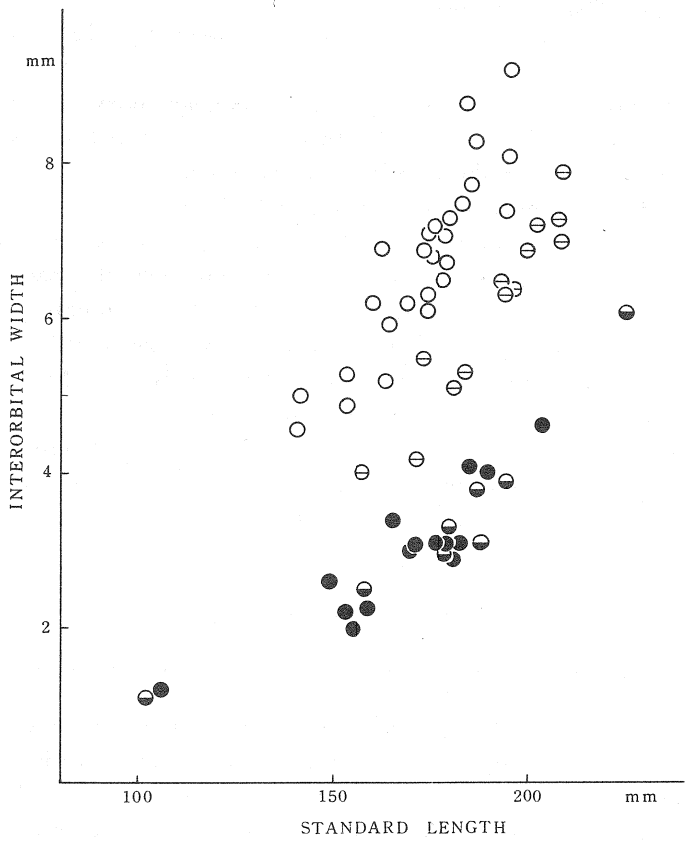

Fig. 35. Sexual dimorphism found in interorbital width of two related species of *Parabothus*. *P. coarctatus* (⊖, male; ◒, female); *P. kiensis* (○, male; ●, female).

Scales rather small and rather not deciduous, strongly ctenoid on ocular side, armed with elongate spinules along apical margin (Fig. 34, C); those on blind side with cycloid; tip of snout, both jaws and pectoral fin scaleless. Lateral line on ocular side with a strong curve above pectoral fin, length of curved portion shorter than 2/3 length of head, height about 1/3 length of its portion; the line absent on blind side.

Origin of dorsal fin on blind side, before horizontal through upper margin of lower eye; fin rays gradually increasing in height towards near posterior 1/3 of body, and evenly

decreasing in height posteriorly. Anal fin starting below vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side moderate in length, much longer than half length of head in both sexes; that on blind side rather feeble and short, about 1.5 in that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye; third ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, uppermost and lowermost two or three rays simple, but remaining ones branched.

Vent locates on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body light brown, sometimes scattered sparely indistinct dark blotches. Fins paler than body; dorsal and anal with a series of dark blotches, which become gradually paler towards posterior part of each fin; ventral fin with a dark spot. Body on blind side stained sparely light grey.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species in the interorbital space (Fig. 34, A, B; Fig. 35). In the male fish, the space is rather wide, 5.26-7.92 in head, while in the female fish, it is narrow, 11.0-14.6 in head.

Remarks: The present species briefly described by TANAKA (1918) from Tanabe, Wakayama Prefecture is closely related to *Parabothus polylepis* (ALCOCK) known off Ceylon, and *P. cholorospilus* (GILBERT) from Hawaiian Islands, but it differs from the former in having much slender body (depth of body 2.4-2.7 in standard length instead of 2.1) and no blotches at the junction and curved parts of the lateral line, and also from the latter in having no conspicuous dots, spots, rings or ocelli.

27. Genus *Tosarhombus* n. g.

Tosarhombus n. g. (type-species by original designation: *Tosarhombus octoculatus* n. sp.).

Body ovate and moderately compressed. Caudal peduncle very narrow in depth. Tip of isthmus below posterior margin of lower eye. Anterior dorsal profile steeper in male than in female and young. Eyes sinistral, separated by a concave space, which is broader in male than in young and female. Male with a orbital spine on anterior edge of upper eye and a rostral spine on snout; female without such spine. Mouth large, maxillary 2.9-3.3 in head. Teeth biserial on upper jaw and uniserial on lower jaw. Gill-rakers moderate in size, and pointed at tip. Scales rather small; those on ocular side finely ctenoid, armed with elongate spinules; blind side with cycloid scales. Snout, both jaws and anterior edge of head in front of interorbital area naked.

Dorsal fin originating above nostrils on blind side, all rays simple. Anal fin similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side; all rays simple. Left ventral fin originating on tip of isthmus; third ray on ocular side opposite to first on blind side; all rays simple. Caudal fin rounded, simple on two rays counted from upper and lower margins respectively.

Vomer toothless. Prefrontal on blind side greatly expanded upward, reaching ocular side far beyond median line of cranium, where it is widely connected with prefrontal on

ocular side and with frontal on ocular side (Fig. 97, D1, D2; Fig. 104, F). Postorbital process is triangular in shape. Interorbital bone platelike in shape. Alisphenoid on ocular side very small, not extending orbital cavity. Basioccipital triangular in shape, when viewed from lateral. Opisthotic triangular in shape, its tip extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 97, D1, D2).

Suborbital bones on blind side three in number. Second hypobranchial rectangular or elliptical in shape without teeth plate; third basibranchial rectangular in shape deeply concave in both sides of anterior part (Fig. 114, C). Urohyal bone fishhook-like in shape, sciatic part much longer than main part, tapering front; cardiac apophysis with a pair of wings (Fig. 115, M). Opening for notochord moderate in diameter, and more advanced than middle part of centrum (Fig. 123, D). Four caudal plates not branched (Fig. 127, M).

Remarks: This new genus is closely allied to *Crossorhombus* in having finely ctenoid and wide interorbital space, but it differs from it in having such characteristics as 1) tip of isthmus located below posterior part of lower eye, 2) length of base of ventral fin being very short, 3) third ray on ocular side setting opposite to first one on blind side, 4) postorbital process being triangular in shape, and 5) prefrontal on blind side connected with prefrontal on ocular side and frontal on ocular side.

On the other hand, the present genus undoubtedly differs from *Bothus,* which has a larger number of scales, small and two or more series teeth on both jaws, the nature of the scale and the tip of the isthmus located below the middle part of the lower eye; also from *Parabothus,* which has a larger number of scales, the uniserial teeth on both jaws and eyes separated by narrow concave.

Tosarhombus octoculatus n. sp. "Yatsume-daruma"

Fig. 36

Holotype.—No. 29431, 161.8 mm in standard length, male, Urado, Kochi Pref., November 20, 1958.

Paratypes.—Male—Nos. 29432-29438, 123.2-147.5 mm, Urado, November 20-24, 1958. Female—Nos. 29439-29454, 90.5-143.4 mm, Urado, November 20-24, 1958. No. 33830, 129.5 mm, Urado, December 12, 1959.

Diagnosis: A violet-blue sinistral flounder with larger number of dorsal, anal, scale and vertebrae and with a series of yellowish white patches along head profile before interorbital space and both eyes; length of base of left ventral fin short, third ray on ocular side opposite to first on blind side. Caudal peduncle very narrow in depth, 2.42-2.9 in head.

Description: *Holotype.*—Dorsal fin rays 102; anal fin rays 78; pectoral fin rays 13 on ocular side, 11 on blind side; scales in lateral line 61; gill-rakers on first arch 0+6. Head 3.92 in standard length; depth 1.97. Snout 5.92 in head; upper eye 3.96; lower eye 3.81; interorbital width 1.98; maxillary 3.21 on ocular side, 3.14 on blind side; lower jaw 2.31 on ocular side, 2.18 on blind side; depth of caudal peduncle 2.42; longest dorsal fin ray

2.43; longest anal fin ray 2.40; pectoral fin 0.86 on ocular side, 2.28 on blind side; ventral fin 2.74 on ocular side, 2.66 on blind side; base of ventral fin 3.74 on ocular side, 5.89 on blind side.

Body ovate and moderately compressed, highest a little in front of middle part of body, its depth as deep as half its length. Dorsal and anal contours except for head slowly arched above and below middle part of pectoral fin, from where they gradually incline toward caudal. Caudal peduncle very narrow in depth, much less than half length of head.

Head rather large, about half depth of body; head profile with a strong notch, steeply elevated in front of interorbital area, and strongly angulates above upper eye. Snout obtuse and short, about 1.5 in eye diameter. Rostral spine stout and blunt, not beyond anterior margin of snout. Both eyes rather large in size, a little more than length of

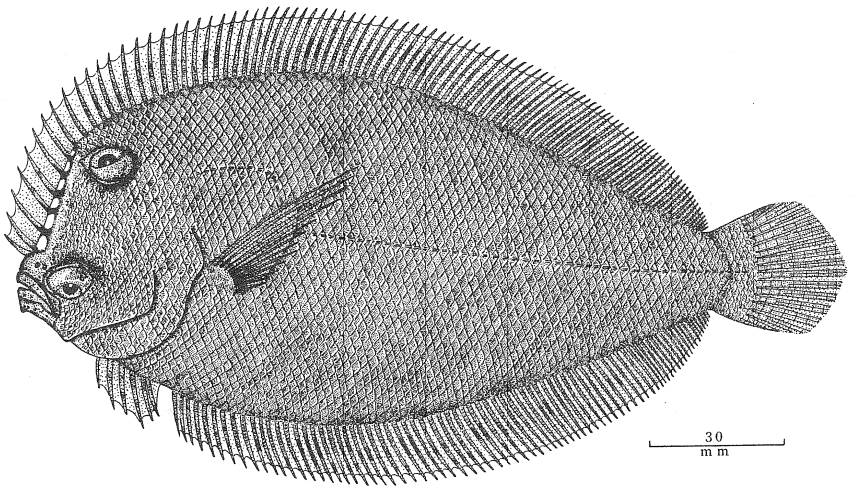

Fig. 36. Lateral view of holotype of *Tosarhombus octoculatus* n. sp.: No. 29431, 161.8 mm in standard length.

maxillary; anterior edge of upper eye above middle part of lower. A orbital spine immediately before anterior margin of upper eye, very short and low in height. Interorbital space shallowly concaved and widely separated, width about 2 diameter of upper eye. Nostrils on ocular side approximated, set in front of upper margin of lower eye; each nostril tubular, anterior with a short flap; those on blind side located closely below origin of dorsal fin, similar in shape to that on blind side.

Mouth large and curved anteriorly, maxillary reaching to vertical from middle part of lower eye, a little longer than eye diameter. Teeth on upper jaw biserial, those of outer series much shorter and wider apart than those of inner series (Fig. 37, D); teeth on lower jaw uniserial and close-set. Gill-rakers moderate in size and pointed at tip, developed only on lower limb (Fig. 37, E).

Scales rather small and not deciduous everywhere; those on ocular side finely ctenoid,

armed with elongate spinules (Fig. 37, C); blind side with cycloid scales. Snout, both jaws and anterior edge in front of interorbital area naked; pectoral fin and all fins except for basal part scaleless.

Lateral line on ocular side a strong curve above pectoral fin, length of curve portion about 1.5 in length of head; the line absent on blind side.

Dorsal fin originating immediately above nostrils on blind side, rays gradually becoming higher to near middle of body and evenly decreasing in height posteriorly. Anal fin starting below vertical through basal part of pectoral fin, similar to dorsal in shape and structure. Pectoral fin on ocular side rather short, second ray longest, as long as length of head; succeeding rays gradually decreasing toward lowermost (Fig. 40); that on blind side very short, much shorter than half length of that on ocular side. Left ventral fin starting at tip

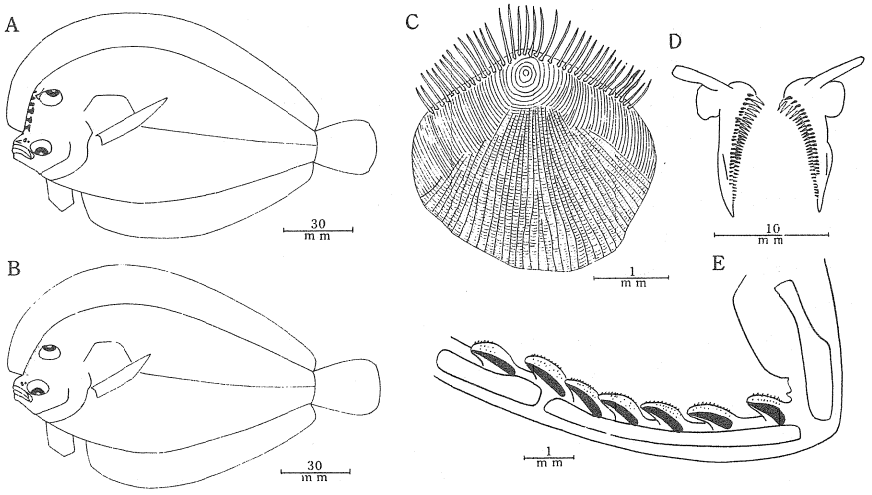

Fig. 37. Diagrammatic illustration of body parts showing sexual dimorphism (A, B) and scale on ocular side (C), upper jaw (D) and first gill-arch on ocular side (E) in *Tosarhombus octoculatus* n. sp. Left view (A, male; B, female); lateral view (C, E); ventral view (D).

of isthmus, base on ocular side longer than that on blind side, fourth ray longest, about 1/3 length of head; third ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, very short, 1.5 in head; rays all branched except for two rays both in upper and lower extremities of the fin.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body dark blue. Anterior part of interorbital space, in advance of a vertical part between eyes, marked with six horizontal dark blackish bands, and patches between these, milky white (yellowish white, before it is preserved). All fins paler than body, dorsal, anal and pectoral fins irregularly scattered

blackish spots. Body on blind side milky white.

Paratypes.—Dorsal fin rays 96-104; anal fin rays 76-82; pectoral fin rays 12-13 on ocular side, 10-12 on blind side; scales in lateral line 57-66; gill-rakers on first arch 0+6-8; vertebrae including urostyle 10+28-30=38-40. Head 3.6-3.98 in standard length; depth 1.97-2.2. Snout 4.38-6.32 in head; upper eye 3.21-3.96; lower eye 3.03-3.81; interorbital space 1.98-6.29; maxillary 2.91-3.31 on ocular side, 2.96-3.26 on blind side; lower jaw 2.16-2.48 on ocular side, 2.02-2.26 on blind side; depth of caudal peduncle 2.42-2.90; longest dorsal fin ray 1.85-2.48; longest anal fin ray 1.96-2.42; pectoral fin 0.82-1.44 on ocular side, 2.21-2.65 on blind side; ventral fin 2.43-2.92; on ocular side, 2.47-3.03 on blind side; base of ventral fin 3.25-3.96 on ocular side, 5.02-7.45 on blind side.

Sexual dimorphism: In the present species there exists in marked secondary sexual dimorphism in the rostral and orbital spines, the interorbital space, the head profile, the pectoral fin and coloration before the interorbital area (Fig. 37, A, B; Figs. 40-41).

The male fish has a blunt rostral spine on the snout and rather a low orbital spine on the anterior edge of the upper eye. Its interorbital space is exceedingly wide, 1.98-2.92 in head, and the head profile is very steep. It also has rather long pectoral fin rays on the ocular side, of which the longest one is 0.82-1.17 in head. In the male fish, anterior part of the interorbital space, in advance of a vertical part between the eyes is distinctly marked with six horizontal dark blackish bands, and patches between these are milky white (yellowish white, before they are preserved). In the female fish, the rostral and orbital spines are absent. Its interorbital space is moderately wide, 3.53-6.29 in head, and the head profile is somewhat rounded. It has rather short pectoral fin rays on the ocular side, 1.28-1.44 in head. The anterior part of the interorbital space in advance of a vertical part between the eyes is indistinctly marked with four horizontal lighter dark bands, and patches between these are milky white.

Remarks: The new species closely resembles *Crossorhombus kobensis* and *Crossorhombus kanekonis* in general appearance, but it is separable from them in having much larger number of scales, dorsal and anal fin rays, and vertebrae, and lower depth of the caudal peduncle. The present species appears to live at a much deeper water than the latter two species and grow to a larger size.

28. Genus *Crossorhombus* REGAN

Crossorhombus REGAN, 1920, 211 (type-species by original designation: *Platophrys dimorphus* REGAN).

Body ovate, rather deep, strongly or moderately compressed. Tip of isthmus locates below middle part of lower eye. Anterior dorsal profile steeper in male than in young and female. Eyes sinistral, separated by a flat or concaved space, which is broader in male than in young and female. Male usually with a strong rostral spine on snout, some orbital spines on orbital margins, and sometimes a spine on mandibular symphysis. Nostrils two on both sides, anterior tubular with a rather long flap posteriorly, and the posterior with

a rudimentary tube. Mouth oblique, small, maxillary extending to below anterior edge of lower eye or a little beyond it. Teeth small, those on upper jaw uniserial or biserial in anterior half of dentition; teeth on outer series much sparser and shorter than those of inner series; those on lower jaw uniserial. Gill-rakers very short and few in number. Scales rather small and not deciduous; those on ocular side finely ctenoid, armed with elongate spinules; blind side with cycloid scales. Snout, both jaws and at least a vertical zone immediately before interorbital area naked.

Dorsal fin originating above nostrils on blind side, all rays simple. Anal fin similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, all rays simple. Left ventral fin originating on tip of isthmus; fourth ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded, simple on two or three rays counted from upper and lower margins respectively.

Vomer toothless. Prefrontal on blind side greatly expanded upward, reaching ocular side far beyond median line of cranium, where it is widely connected only with prefrontal on ocular side. Postorbital process very slender sticklelike in shape curved forward at tip. Interorbital bone platelike in shape (Fig. 98, A1, A2; Fig. 104, G). Alisphenoid on ocular side very small, not extending orbital cavity. Opisthotic triangular in shape, its tip extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 98, A1, A2). Suborbital bones three in number. Second hypobranchial circular in shape without toothed plate; third basibranchial gourdlike in shape considerably expanded in posterior half, but very small in anterior half (Fig. 114, I). Urohyal fishhook-like in shape, tip of sciatic part more advanced than that of main part, tapering toward front; cardiac apophysis with a pair of wings (Fig. 116, E). Opening for notochord moderate in diameter, and more advanced than middle part of centrum. Anterior transverse apophysis begins with second vertebra (Fig. 120, B1-B5). All or inner two caudal plates with many grooves from margin of plate to basal part (Fig. 127, H, I).

Remarks: In the redescription given by NORMAN (1934), the present genus is characterized in having finely ctenoid, the small mouth and uniserial teeth on both jaws. The Japanese two species of *Crossorhombus*, however, have the biserial teeth on the upper jaw, at least in the anterior half of the dentition, though those of outer series is small and sparse. It is probable that the detailed examination of *Crossorhombus valde-rostratus* and *C. azreus* would lead to recognition of the biserial teeth on the upper jaw.

29. Key to species of *Crossorhombus*

A^1 Caudal fin without particular broad bands, composed of three simple rays on upper and lower margins respectively; pectoral fin produced and generally filamentous, longer than head .... *Crossorhombus kobensis* (JORDAN and STARKS)

A^2 Caudal fin with two broad bands across hinder and basal parts, composed of two simple rays on upper and lower margins respectively; pectoral fin much shorter than head .... *Crossorhombus kanekonis* (TANAKA)

Crossorhombus kobensis (JORDAN and STARKS) "Kobe-darumagarei"

Fig. 38

Scaeops kobensis JORDAN and STARKS, 1906, 170, fig. 2. ——FRANZ, 1910, 61, figs. 55, 61. ——JORDAN, TANAKA and SNYDER, 1913, 312. ——JORDAN and TOMPSON, 1914, 308, fig. 80. ——FUJITA and WAKIYA, 1915, 12. ——IZUKA and MATSUURA, 1920, 115. ——UI, 1929, 272. ——SCHMIDT, 1931, 123. ——KAMOHARA, 1938, 59. ——BÖHLKE, 1953, 140.
Scaeops ui TANAKA, 1918, 226. ——UI, 1929, 272, fig. 101.
Engyprosopon kobensis. HUBBS, 1915, 458. ——KAMOHARA, 1936, 3. ——KAMOHARA, 1938, 59.
Crossorhombus valde-rostratus. NORMAN (in part) 1934, 217, fig. 166. ——OKADA and MATSUBARA, 1938, 422, pl. 104, fig. 2. ——KAMOHARA, 1950, 240. ——MATSUBARA, 1955, 1259. ——KAMOHARA, 1958, 62. ——KURODA, 1962, 2. ——KAMOHARA, 1964, 82.
Engyprosopon ui. KAMOHARA, 1936, 3. ——KAMOHARA, 1938, 59. ——OKADA and MATSUBARA, 1938, 421. ——KURODA, 1951, 389. ——MATSUBARA, 1955, 1258. ——KAMOHARA, 1958, 62. ——KURODA, 1962, 1, fig. 1. ——KAMOHARA, 1964, 82.
Crossorhombus kobensis. KURONUMA, 1939, 84. ——KURODA, 1940, 213.
Engyprosopon valde-rostratus. KURODA, 1951, 389.

Materials: Male- No. 2389, 90.6, mm in standard length, Owashi, Mie Pref., January 4, 1936. No. 15961, 98.0 mm, No. 15973, 97.1 mm, Nos. 15980-15981, 94.8-99.0 mm, Mimase, Kochi Pref., February 20, 1951. Nos. 25611-25612, 97.5-103.3 mm, Yahatahama, Ehime Pref., March 13, 1956. No. 29821, 103.5 mm, Choshi, Chiba Pref., July 20, 1958. Nos. 29822-29847, 60.0-102.1 mm, Nos. 29849-29851, 50.0-57.0 mm, Mimase, Kochi Pref., May 23, 1959. Nos. 29895-29896, 95.1-99.0 mm, Nos. 29898-29900, 70.1-80.4 mm, Mimase, May 23, 1959. Female- No. 15947, 79.8 mm, Mimase, February 20, 1951. Nos. 29857-29862, 59.5-96.0 mm, Nos. 29864-29867, 68.9-79.0 mm, Nos. 29869-29874, 66.1-74.3 mm, Nos. 29876-29879, 64.3-69.1 mm, Nos. 29890-29894, 49.2-58.9 mm, Mimase, May 23, 1959.

Diagnosis: A *Crossorhombus* provided with caudal fin possessing three simple rays counted from upper and lower margins respectively. Pectoral fin produced and generally filamentous, longer than head. Margins of dorsal and anal fins dark. In male, body on blind side except for head region dark blue (violet).

Description: Dorsal fin rays 79-86; anal fin rays 59-67; pectoral fin rays 9-11 on ocular side, 9-10 on blind side; scales in lateral line 50-55; gill-rakers on first arch 0+5-7; vertebrae including urostyle 10+24-26=34-36. Head 3.65-4.28 in standard length; depth 1.74-2.09. Snout 4.91-7.64 in head; upper eye 2.71-3.50; lower eye 2.61-3.52; interorbital width 2.01-12.8; maxillary 3.01-3.74 on ocular side, 3.12-3.74 on blind side; lower jaw 2.13-2.74 on ocular side, 1.81-2.44 on blind side; depth of caudal peduncle 1.79-2.39; longest dorsal fin ray 1.60-2.29; longest anal fin ray 1.62-2.27; pectoral fin 0.45-0.98 on ocular side, 1.67-2.67 on blind side; ventral fin 1.91-2.54 on ocular side, 2.06-2.61 on blind side; base of ventral fin 2.01-2.69 on ocular side, 3.97-8.18 on blind side.

Body ovate, strongly compressed, highest at middle part of body, its depth much more than half length of body; dorsal and anal contours evenly arched except for head profile. Caudal peduncle rather narrow in depth, merely or less than 1/4 depth of body.

Head rather small, much shorter than half depth of body; upper profile with a slight notch above anterior nostril, from which it is very steep. Snout short, much shorter than eye diameter, about 1.5-2.0 in eye diameter. Eyes rather large, about equal to length of maxillary, separated by deep concave space; lower slightly in advance of upper. Nostrils

on ocular side closely set in front of upper margin of lower eye; anterior one tubular with rather long flap posteriorly, which extends anterior margin of posterior nostril when depressed backward; posterior one furnished with a rudimentary tube; nostrils on blind side setting closely below origin of dorsal fin.

Mouth oblique and small in size; maxillary extending to below anterior edge of lower eye or a little beyond it. Teeth on upper jaw biserial, those of outer series much smaller number, shorter and wider apart than those of inner series (Fig. 39, E), those on lower jaw uniserial and close-set; teeth on both jaws becoming gradually stouter and longer anteriorly. Gill-rakers on first arch rather short, developing only on lower limb of arch (Fig. 39, D).

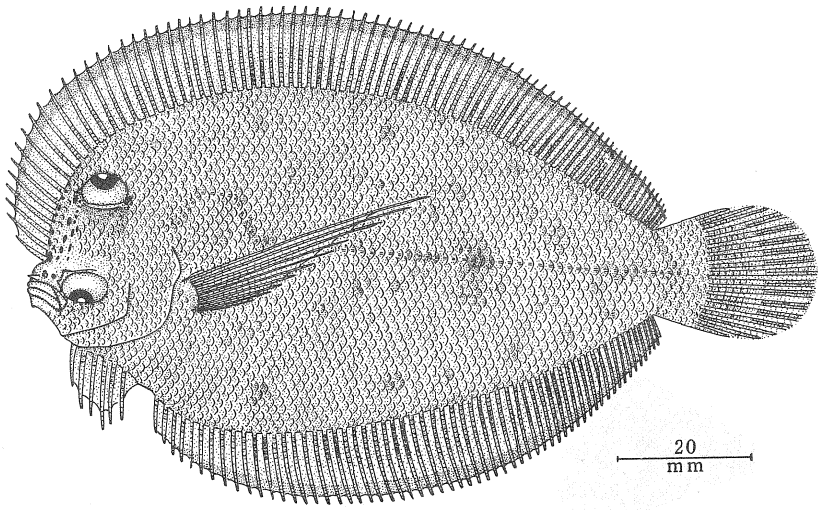

Fig. 38. Lateral view of *Crossorhombus kobensis* (JORDAN and STARKS) from male specimen: No. 29826, 88.6 mm in standard length.

Scales rather small and not deciduous; those on ocular side finely ctenoid, armed with elongate spinules; blind side with cycloid scales. Snout, both jaws and all most of head portion in front of interorbital area and both eyes naked. Lateral line on ocular side with a strong curve above pectoral fin, length of curve portion about 1/3 length of head; height a little higher than half length of its portion; the line absent on blind side.

Dorsal fin originating immediately above nostrils on blind side, rays gradually becoming higher to anterior 1/3 of body, and gradually decreasing in height posteriorly, longest ray a little more than half length of head. Anal similar in shape and structure to dorsal. Pectoral fin on ocular side well produced, filamentous and tapering, second ray longest, always longer than head in both sexes; succeeding rays gradually becoming shorter towards lowermost one (Fig. 40); fin on blind side very short and feeble, about half length of head. Left ventral fin originating on tip of isthmus, rays as well as the base longer than those on

blind side; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, both uppermost and lowermost three rays simple, others branched.

Vent opens on blind side above origin of anal fin. Genital papilla displaced on ocular side.

In formalin, general ground color of body on ocular side greyish brown, furnished with less defined blotches of very dark brown along lateral line and along body near base of dorsal and anal fins. Marginal portion of dorsal and anal fins dark brown; all fins with irregularly scattered blackish dots.

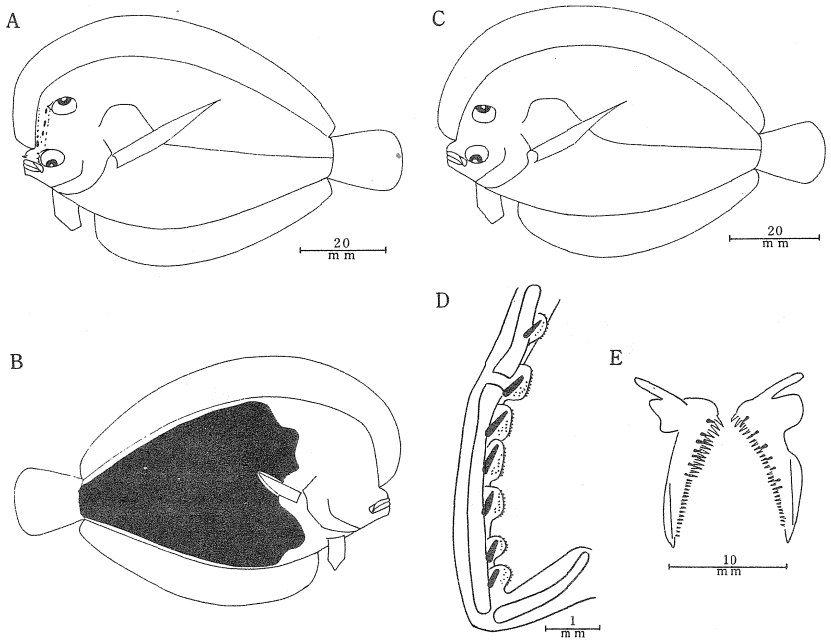

Fig. 39. Diagrammatic illustration of body parts showing sexual dimorphism (A, B, C) and first gill-arch on ocular side (D) and upper jaw (E) in *Crossorhombus kobensis* (JORDAN and STARKS). Left view (A, male; C, female); right view (B, male); lateral view (D); ventral view (E).

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species in several external characters (Fig. 39, A-C; Figs. 40-41). The male fish has its interorbital space very wide, 2.01-2.65 in head. The male fish is provided with a strong rostral spine on the snout and some smaller spines on the anterior edges of the upper and lower orbital margins. The head profile is strongly steep and nearly vertical in front of the interorbital area and both eyes. Along the head margin in front of the interorbital area and both eyes are many small dark spots. The body on the blind side is stained with dark blue, though the head and the narrow margins along the dorsal and anal are milky white. The female

fish has its interorbital space narrowly concaved, 3.45-12.8 in head. Its rostral spine is either feeble or absent, and the orbital spine being absent. The head is somewhat steep anteriorly without well-defined dark spots. The blind side of the body is everywhere milky white.

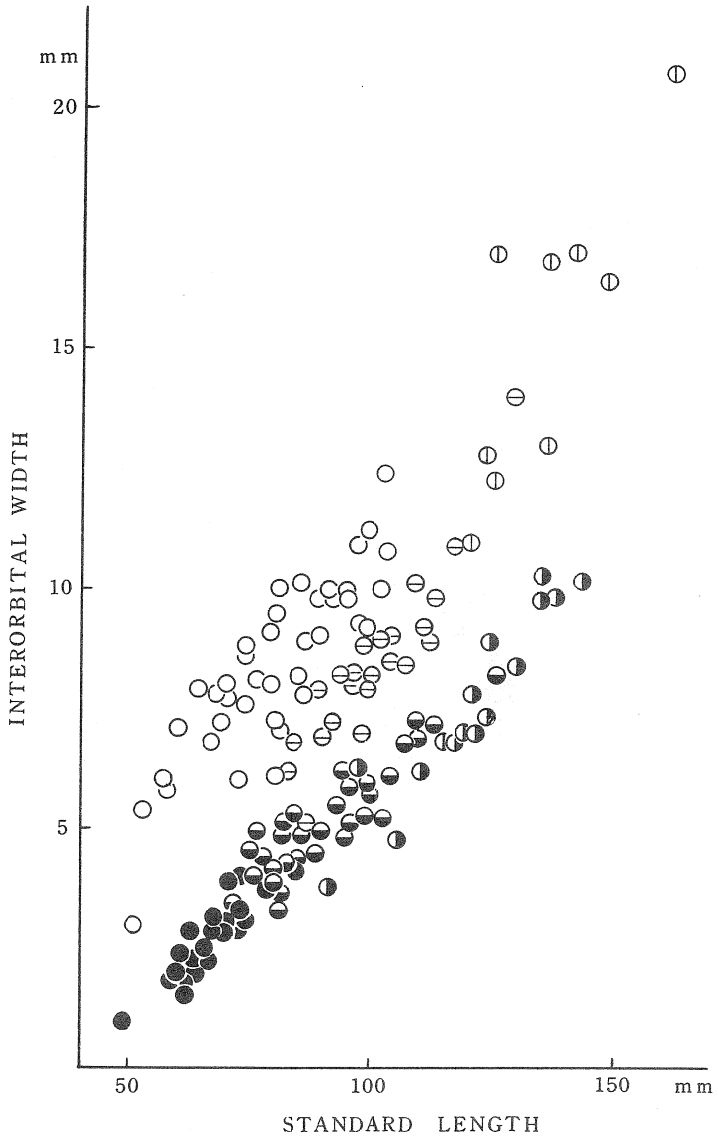

Fig. 40. Sexual dimorphism found in pectoral fin length on ocular side of three species of *Tosarhombus* and *Crossorhombus*. *T. octoculatus* (◑, male; ◑, female); *C. kobensis* (○, male; ●, female); *C. kanekonis* (⊖, male; ◒, female).

The divergence becomes conspicuous in the fish about 50 mm in standard length.

Remarks: The present species was synonymized by NORMAN (1934) with *Crossorhombus valde-rostratus* (ALCOCK) reported from Ceylon and East Africa, but differs from the latter which has uniserial teeth on both jaws, each eye with a broad membranous flap in the male, the pectoral fin shorter than the head in the female and the hinder part of the caudal fin with a broad blackish band.

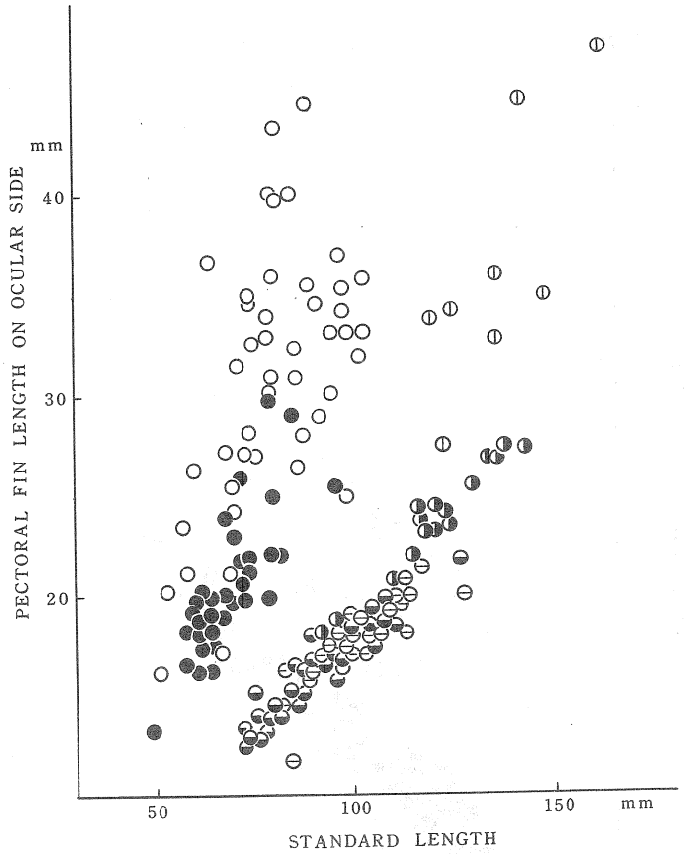

Fig. 41. Sexual dimorphism found in interorbital width of three species of *Tosarhombus* and *Crossorhombus*. *T. octoculatus* (◫, male; ◑, female); *C. kobensis* (○, male; ●, female); *C, kanekonis* (⊖, male; ◒, female).

The holotype of this species, which was described and figured originally by JORDAN and STARKS (1906) appears to be female. FRANZ (1910) has given figures and description of of the male taken from Fukuura, Japan, having the upper pectoral ray filamentous and longer than the head. HUBBS (1915) also has described additionally the male fishes collected from near Nagasaki and the Vincennes Strait, having the body on the blind side stained with dark blue behind the pectoral.

On the other hand, *Scaeops ui,* described briefly to be new species from Tanabe, Wakayama Prefecture, by TANAKA (1918), is synonymized with this species with doubtlessness, especially in having the posterior half of the body on the blind side stained with dark blue.

Crossorhombus kanekonis (TANAKA) "Kaneko-daruma"

Fig. 42

Scaeops kanekonis TANAKA, 1918, 226.
Engyprosopon kanekonis. OKADA and MATSUBARA, 1938, 421. ——KAMOHARA, 1950, 240. ——MATSUBARA, 1955, 1258. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82.

Materials: Male- Nos. 29157-29159, 113.2-128.5 mm in standard length, Susaki, Kochi Pref., July 20, 1959. Nos. 29160-29163, 104.3-111.8 mm, Nos. 29165-29170, 98.0-101.5 mm, Nos. 29172-29173, 98.4-111.3 mm, Nos. 29175-29178, 96.3-103.2 mm, Nos. 29180-29184, 83.5-93.5 mm, Mimase and Susaki, Kochi Pref., July 20, 1959. Female- Nos. 29186-29191, 107.3-126.5 mm, Nos. 29196-29202, 92.9-111.1 mm, Nos. 29204-29211, 85.8-95.5 mm, Nos. 29221-29228, 85.6-87.1 mm, Susaki and Mimase, July 20, 1959. Young- Nos. 29221-29228, 72.0-78.4 mm, Mimase, July 20, 1959.

Diagnosis: A *Crossorhombus* with caudal fin composed of two simple rays on upper and lower extremities, and with pectoral fin much shorter than head in both sexes; caudal fin with two broad bands across hinder and basal parts; in male middle portion of body on blind side within limit of narrow area stained with dark blue.

Description: Dorsal fin rays 84-91; anal fin rays 63-73; pectoral fin rays 11-13 on ocular side, 9-12 on blind side; scales in lateral line 56-63; gill-rakers on first arch 1-4+6-8; vertebrae including urostyle 10+25-27=35-37. Head 3.79-4.47 in standard length; depth 1.71-1.96. Snout 4.69-6.72 in head; upper eye 3.11-4.0; lower eye 3.08-4.0; interorbital width 2.15-6.0; maxillary 3.31-4.26 on ocular side, 3.48-4.38 on blind side; lower jaw 2.27-2.85 on ocular side, 2.22-2.60 on blind side; depth of caudal peduncle 1.64-2.12; longest dorsal fin ray 1.71-2.06; longest anal fin ray 1.70-2.08; pectoral fin 1.23-1.70 on ocular side, 1.76-2.89 on blind side; ventral fin 1.98-2.60 on ocular side, 2.13-2.73 on blind side; base of ventral fin 2.13-2.73 on ocular side, 4.07-6.54 on blind side.

Body ovate and moderately compressed, highest at middle part of body, its depth a little more than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle moderate in depth, about 1/4 depth of body.

Head small, much shorter than half depth of body; dorsal profile of head with a large notch above anterior nostril, from which it rises steeply to above upper eye. Snout obtuse and small, much shorter than eye diameter, 1.5-2.0 in eye diameter. Eyes rather small, a little longer than length of maxillary, separated by deep concave space; lower slightly in advance of upper. Nostrils on ocular side closely set in front of lower eye, anterior one tubular with rather long flap posteriorly, extending anterior edge of posterior nostril when depressed backward; posterior one with feeble and short tube; nostrils on blind side setting closely below origin of dorsal.

Mouth oblique and very small in size, lips on both jaws with rather flesh; maxillary

extending to below anterior edge of lower eye or a little beyond it. Teeth biserial on upper jaw, those of outer series much shorter and sparser than those of inner series; teeth on lower jaw uniserial and close-set; those on jaws becoming gradually stouter and longer anteriorly; teeth on blind side much stouter and longer than those on ocular side. Gill-rakers on first arch short and pointed, those on upper limb much smaller than those on lower limb (Fig. 43, D).

Scales small and not deciduous; those on ocular side finely ctenoid (Fig. 43, E), armed with elongate spinules along apical margin; those on blind side with cycloid. Snout, both jaws and narrow vertical zone immediately before interorbital area naked; pectoral fin and hinder part of all fins scaleless.

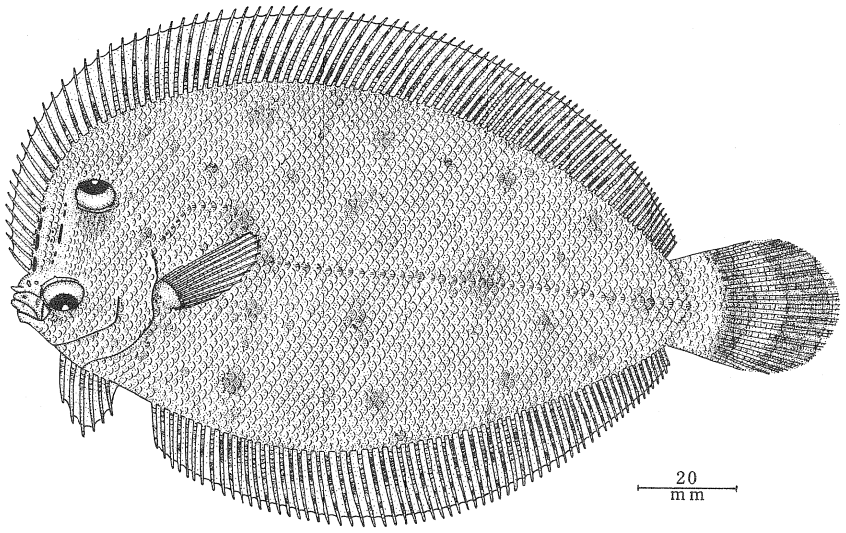

Fig. 42. Lateral view of *Crossorhombus kanekonis* (TANAKA) from male specimen: No. 29157, 128.5 mm in standard length.

Lateral line on ocular side with a strong curve above pectoral fin; length of curved portion about 2/3 length of head, height about half length of its portion; the line on blind side absent.

Origin of dorsal fin on blind side, before horizontal through upper margin of lower eye; fin rays gradually increasing in height towards middle of fin, and evenly decreasing in height posteriorly. Anal fin starting below vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side very short, much shorter than head in both sexes; the fin on blind side feeble and very short, 1.5 in length of that on ocular side. Ventral fin on ocular side inserts at tip of isthmus, rays as well as base longer than those on blind side, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, rays all branched except for two rays both in upper and lower extremities of fin.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body greyish brown, furnished indistinctly with darker spots and blotches, of which two or three larger ones stain on the lateral line and a series of smaller one near upper and lower edges of body. All fins paler than body, vertical fins irregularly scattered blackish spots. Caudal fin provided with two broad distinct blackish bands across the hinder and basal portions.

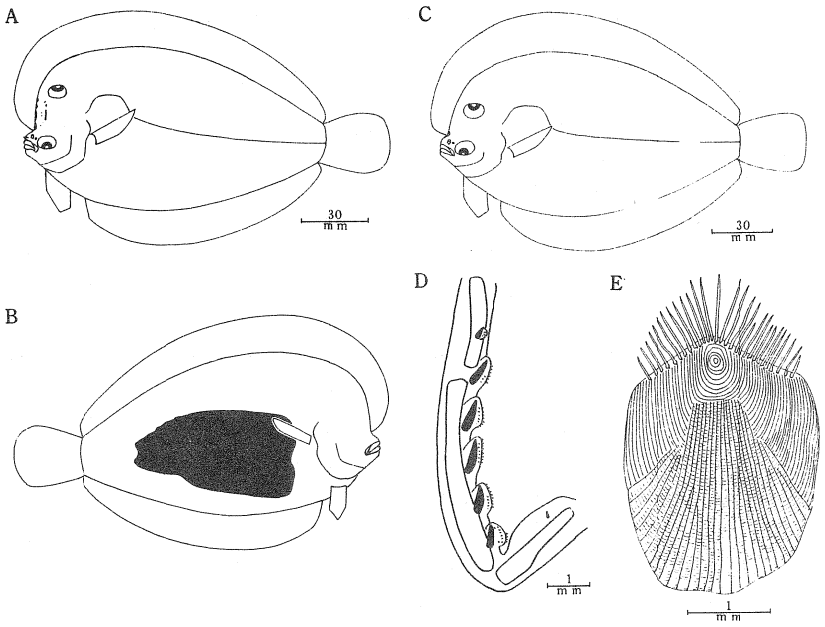

Fig. 43. Diagrammatic illustration of body parts showing sexual dimorphism (A, B, C) and first gill-arch on ocular side (D) and scale on ocular side (E) in *Crossorhombus kanekonis* (TANAKA). Left view (A, male; C, female); right view (B, male); lateral view (D, E).

Sexual dimorphism: The present species exhibits the sexual difference in the external characters (Fig. 43, A, B, C; Figs. 40-41). The male fish has a strong rostral spine on the snout and two or three orbital spines on the lower orbital margin, and its interorbital space being wide, 2.15-3.35 in head. It has somewhat the steep head before the eyes in its anterior profile. Along the head margin in front of the interorbital area is a series of small blackish spots. In the male fish, the middle part of the body on the blind side within the limit of narrow area is stained with dark blue. The female fish has its interorbital space narrow, 2.52-6.0 in head, its rostral and orbital spines are absent. The head is somewhat rounded anteriorly in its anterior profile. The blind side of the body is milky white.

Remarks: The present species closely resembles *Crossorhombus azreus* (ALCOCK) from Ceylon and south-eastern India in having the pectoral fin much shorter than the head in both sexes and the caudal fin with two broad bands across the hinder and basal parts, but it is separable from the latter in having biserial teeth on the upper jaw, each eye without the membranous flap in the larger male and rather a smaller number of scales in the lateral line and of gill-rakers on the lower limb: the former has 52 to 57 scales and five or six gill-rakers, while the latter has 56 to 63 and six to eight respectively.

30. Genus *Engyprosopon* GÜNTHER

Engyprosopon GÜNTHER, 1862, 431 (type-species by original designation: *Rhombus mogkii* BLEEKER).

Scaeops JORDAN and STARKS, 1904, 627 (type-species by original designation: *Rhombus grandisquama* TEMMINCK and SCHLEGEL).

Body ovate or rather deep elliptical, strongly compressed. Tip of isthmus below middle of lower eye. Anterior dorsal profile steeper in male than in young and female. Eyes sinistral, separated by a flat or concave space, which is broader in male than in young and female. Male usually with one or more spines on snout, and sometimes on orbital margin and mandibular symphysis; female with or without feeble spines. Nostrils two on each side, the anterior one tubular with a short slender flap posteriorly, and posterior one with a rudimentary tube. Mouth oblique, rather small, maxillary 2.2-3.6 in head. Teeth on upper jaw generally biserial; those on outer series stouter and wider apart than those of inner series, and sometimes with enlarged teeth anteriorly; teeth on lower jaw uniserial and close-set. Gill-rakers comparatively few in number, and of moderate length. Scales large; those on ocular side weakly ctenoid, with feeble and short spinules along apical margin, those on blind side cycloid. Snout and jaws naked. Lateral line with a strong curve anteriorly, the line absent on blind side.

Dorsal fin originating above nostrils on blind side, becoming gradually higher to middle of body, where it is highest, and then decreasing in height posteriorly, all rays simple, scaled except for margin. Anal fin similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side larger than that on blind side, all rays simple. Left ventral fin originating on tip of isthmus, rays as well as base longer than those on blind side, all rays simple. Caudal fin rounded, simple in three rays counted from upper and lower margins respectively.

Vomer toothless. Prefrontal on blind side greatly expanded upward, reaching ocular side far beyond median line of cranium, where it is widely connected with prefrontal on ocular side and with frontal on ocular side. Postorbital process is triangular in shape (Fig. 97, B1, B2, C1, C2; Fig. 104, F). Interorbital bone platelike in shape; alisphenoid on ocular side very small, not extending orbital cavity; basioccipital triangular in shape, when viewed from lateral; opisthotic triangular in shape, its tip extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 97, B1, B2, C1, C2).

Suborbital bones on blind side three in number (Fig. 108, D). Second hypobranchial circular in shape without toothed plate; third basibranchial gourdlike in shape, considerably

expanded in posterior half, but very small in anterior half (Fig. 114, H). Urohyal bone fishhook-like in shape, sciatic part much longer than main part, tapering toward front; cardiac apophysis with a pair of wings (Fig. 116, D). Opening for notochord moderate in diameter, and more advanced than middle part of centrum. Four caudal plates divided into many parts except for each basal portion (Fig. 127, J).

31. Key to species of *Engyprosopon*

A[1] Caudal fin with a pair of large jet-black blotches; maxillary extending to below or a little beyond anterior margin of lower eye.
  B[1] Six to eight gill-rakers on lower limb of first arch.
    C[1] Body ovate, more than half length of body; eye diameter much more than length of snout; pectoral rays not filamentous, equal to or less than head; scales in lateral line 37 to 43; a pair of jet-black blotches on caudal fin placed between third and fourth rays counted from above and below respectively ..... ***Engyprosopon grandisquama*** (TEMMINCK and SCHLEGEL)
    C[2] Body rather elongate, equal to or less than half length of body; eye diameter equal to or less than length of snout; pectoral rays filamentous, generally second one longer than head; scales in lateral line 45 to 50; a pair of jet-black blotches on caudal fin placed between second and fourth rays counted from above and below respectively..... ***Engyprosopon multisquama*** AMAOKA
  B[2] Thirteen to fourteen gill-rakers on lower limb of first arch ..... ***Engyprosopon xystrias*** HUBBS
A[2] Caudal fin without particular marking; maxillary extending to below middle of lower eye.
    D[1] Nine to eleven gill-rakers on lower limb of first arch, not serrate; head 3.94-4.24 in standard length; maxillary 2.45-2.78 in head; dorsal 85-90; anal 65-68; scales in lateral line 45-47 ..... ***Engyprosopon macroptera*** AMAOKA
    D[2] Six to seven gill-rakers on lower limb of first arch, serrate; head 3.49-3.89 in standard length; maxillary 2.26-2.5 in head; dorsal 79-83; anal 60-64; scales in lateral line 37-42.... ..... ***Engyprosopon longipelvis*** n. sp.

Engyprosopon grandisquama (TEMMINCK and SCHLEGEL) "Daruma-garei"

Fig. 44

Rhombus grandisquama TEMMINCK and SCHLEGEL, 1846, 183, figs. 3, 4. ——BOESEMAN, 1947, 183, figs. 3, 4.

Rhomboidichthys grandisquama. GÜNTHER, 1862, 437. ——ISHIKAWA and MATSUURA, 1897, 25.

Platophrys (*Arnoglossus*) *poecilurus* BLEEKER, 1866-72, 13, pl. 5, fig. 1.

Scaeops grandisquama. JORDAN and STARKS, 1904, 627, pl. 8, fig. 2. ——JORDAN and STARKS, 1906, 168, fig. 1. —— SNYDER, 1912, 438. —— JORDAN, TANAKA and SNYDER, 1913, 311. —— IZUKA and MATSUURA, 1920, 116. ——UCHIDA, 1927, 41. ——UI, 1929, 271. ——FOWLER and BEAN, 1922, 67. ——Von BONDE, 1922, 6. ——BARNARD, 1925, 387. ——JORDAN and HUBBS, 1925, 294. ——SCHMIDT, 1931, 123. ——KURODA, 1931, 121. ——YANAI, 1950, 21.

Scaeops poecilurus. JORDAN and SEALE, 1905, 803. ——REGAN, 1908, 233. ——WEBER, 1913, 429. ——FOWLER, 1928, 92. ——FOWLER, 1931, 320.

Scaeops spilura JORDAN and SEALE, 1906, 412. ——FOWLER, 1928, 92.

Scaeops orbicularis JORDAN and SEALE, 1907, 45. ——JORDAN and RICHARDSON, 1909, 201. —— OSHIMA, 1927, 179.

Engyprosopon grandisquama. NORMAN, 1926, 250. ——NORMAN, 1927, 25, fig. 5. ——MCCULLOCH, 1929, 276. ——NORMAN, 1934, 209, fig. 156. ——KAMOHARA, 1936, 3. —— KAMOHARA, 1938,

57. ——OKADA and MATSUBARA, 1938, 422. ——NORMAN, 1939, 100. ——KURONUMA, 1939, 85. ——KURONUMA, 1940, 213. ——BLEGRAD, 1944, 202, fig. 123. ——LIANG, 1948, 19. ——SMITH, 1949, 159. ——KAMOHARA, 1950, 240. ——MUNRO, 1955, 756, pl. 50. ——KURODA, 1951, 389. ——OKADA, 1955, 371, fig. 338. ——MORI, 1956, 31. ——MUNRO, 1958, 284. ——KAMOHARA, 1958, 62. ——AMAOKA, 1963, 108. ——KAMOHARA, 1964, 82. ——PUNPOKA, 1964, 16, fig. 3.
Bothus (Arnoglossus) poecilurus. WEBER and BEAUFORT, 1929, 131, fig. 31. ——SURATTI, 1936, 94.

Materials: Male- No. 19648, 89.1 mm in standard length, Nobeoka, Miyazaki Pref., December 10, 1952. Nos. 23359-28920, 79.2-122.2 mm, Mimase and Susaki, Kochi Pref., June 20-July 10, 1958. Female- Nos. 28933-28954, 78.2-108.3 mm, Mimase and Susaki, June 20-July 10, 1958.

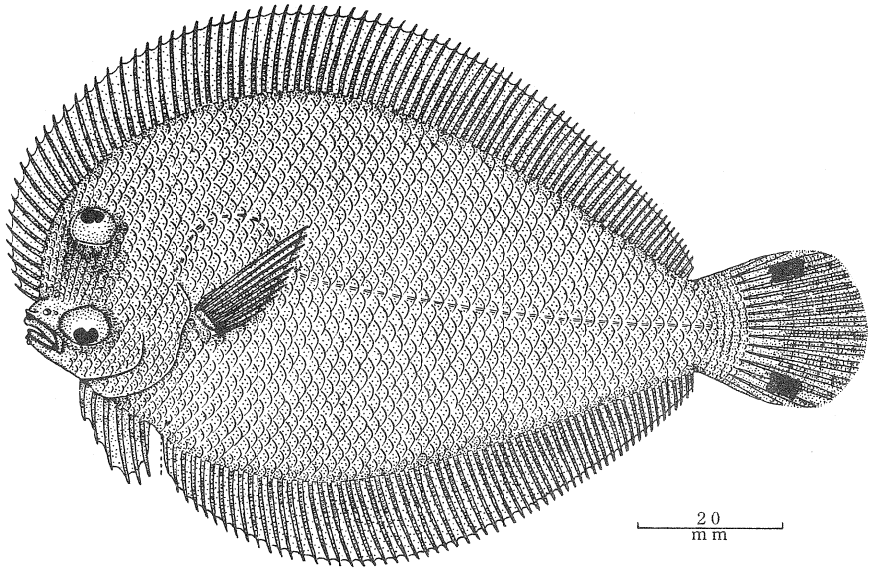

Fig. 44. Lateral view of *Engyprosopon grandisquama* (TEMMINCK and SCHLEGEL) from male specimen: No. 28869, 92.5 mm in standard length.

Diagnosis: Caudal fin with a pair of large jet-black blotches. Body rather deep, 1.7-1.9 in standard length. Pectoral fin short, 0.95 to 1.25 in head. Scales in lateral line fewer, 37 to 43. Pectoral fin rays 11 to 12 on ocular side.

Description: Dorsal fin rays 79-87; anal fin rays 59-65; pectoral fin rays 11-12 on ocular side, 9-10 on blind side; scales in lateral line 37-43; gill-rakers on first arch 0+6; vertebrae including urostyle 10+23-25=33-35. Head 3.59-4.24 in standard length; depth 1.70-1.93. Snout 4.27-6.13 in head; upper eye 2.95-4.31; lower eye 2.81-3.57; interorbital width 2.36-6.84; maxillary 2.80-3.57 on ocular side, 2.85-3.46 on blind side; lower jaw 1.95-2.5 on ocular side, 1.89-2.3 on blind side; depth of caudal peduncle 1.73-2.2; longest dorsal fin ray 1.73-2.23; longest anal fin ray 1.65-2.14; pectoral fin 0.95-1.25 on ocular side, 1.58-2.2 on blind side; ventral fin 1.91-2.48 on ocular side, 1.91-2.5 on blind side; base of ventral fin 2.13-2.76 on ocular side, 4.7-6.85 on blind side.

Body ovoid and deep, highest at middle part of body, its depth much longer than half its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather narrow, about 1/4 depth of body.

Head rather large, shorter than half depth of body, upper profile with a slight notch above anterior nostril, from which it is steep. Snout rather large, much shorter than diameter of eye. Eyes large, about equal to length of maxillary, separated by concave space; lower slightly in advance of upper. Nostrils on ocular side in front of upper margin of lower eye; anterior one tubular with a short flap posteriorly; posterior one furnished with a rudimentary tube.

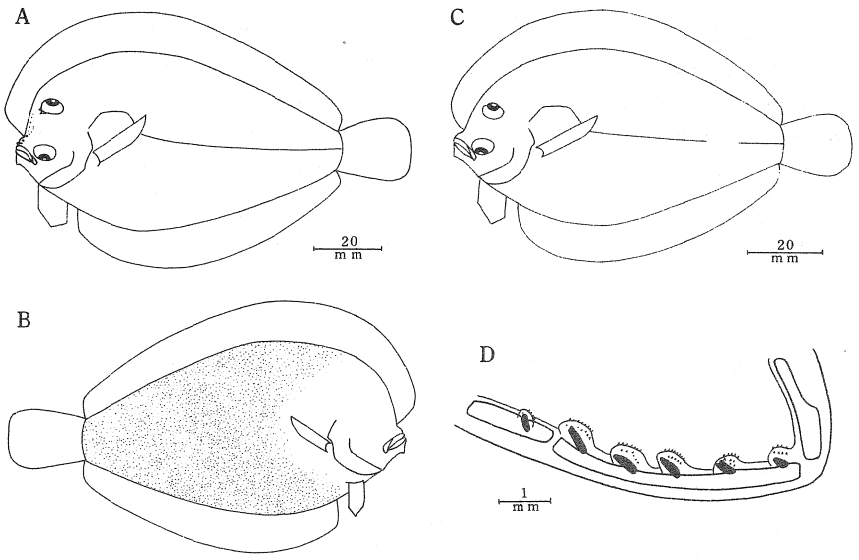

Fig. 45. Diagrammatic illustration of body parts showing sexual dimorphism (A, B, C), and first gill-arch on ocular side (D) in *Engyprosopon grandisquama* (TEMMINCK and SCHLEGEL). Left view (A, male; C, female); right view (B, male).

Mouth oblique and moderate in size; maxillary extending to below anterior edge of eye or a little beyond it. Teeth on upper jaw biserial, those on outer series shorter, stouter and wider apart than those on inner series; teeth on lower jaws uniserial and close-set. Gill-rakers on first arch short, developing on lower limb of arch (Fig. 45, D).

Scales large, those on ocular side weakly ctenoid with feeble short spinules along apical margin; scales on blind side cycloid. Snout and both jaws naked. Lateral line on ocular side with a strong curve above pectoral fin; the line absent on blind side.

Dorsal fin orginating above nostrils on blind side, becoming gradually higher to middle part of body, where it is highest and then decreasing in height posteriorly. Anal similar in shape and structure to dorsal. Pectoral fin rather short and not produced, second longest, a little shorter than head length in both sexes; succeeding rays becoming shorter toward lowermost one. Left ventral fin originating on tip of isthmus, rays as well as base longer

than those on blind side. Caudal fin rounded, both uppermost and lowermost three rays simple, but others branched.

Vent opens on blind side above origin of anal fin. Genital papilla displaced on ocular side.

In formalin, general ground color of body pale greyish green. All fins with irregularly scattered blackish spots. Caudal fin with a pair of large jet-black blotches placed between third and fourth rays counted from upper and lower margins respectively.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species, appearing in several external characters (Fig. 45, A, B, C; Fig. 46), thus: the male fish has its interorbital space relatively wide, 2.4-3.2 in head; the head is very steep before the eyes in its anterior profile. It has a strong rostral spine and orbital one, the latter of which is developed on the upper margin of the lower eye. The male fish has the blind side of body stained with dark grey, though the head is milky white. When well matured, it has usually developed spinules at the symphysis of the lower jaw. The female fish has its interorbital space rather narrow, 3.8-6.8 in head. Head is rounded before the eyes in the anterior profile. It has no spine on the head, and the blind side of body is milky white. Divergence is apparent when the fish gets about 40 mm in standard length.

Engyprosopon multisquama AMAOKA "Chikame-daruma"

Fig. 47

Engyprosopon multisquama AMAOKA, 1963, 111, fig. 3. ——KAMOHARA, 1964, 82.

Materials: Male- Nos. 28982-28987, 113.2-137.0 mm in standard length, Mimase, Kochi Pref., June 20, 1958. No. 28988, 113.5 mm, Susaki, Kochi Pref., July 8, 1959. Nos. 28989-28991, 114.0-117.1 mm, Susaki, July 8, 1959. Nos. 28992-28996, 109.2-114.2 mm, Mimase, June 20, 1958. Nos. 28997-29045, 78.0-135.1 mm, Mimase and Susaki, July 8-19, 1959. Female- Nos. 29046-29049, 109.5-137 mm, Mimase, June 20, 1958. Nos. 29050-29055, 113.2-124.1 mm, Susaki, July 8, 1959. Nos. 29056-29063, 69.0-92.8 mm, Mimase and Susaki, July 8-19, 1959.

Diagnosis: An *Engyprosopon* with a pair of large jet-black blotches on caudal fin. Body rather elongate, 2.0-2.5 in standard length. Pectoral fin produced and filamentous, 0.52 to 0.9 in head. Scales in lateral line 45 to 50 in number. Pectoral fin rays 9 to 11 on ocular side.

Description: Dorsal fin rays 83-96; anal fin rays 62-73; pectoral fin rays 9-11 on ocular side, 9-10 on blind side; scales in lateral line 45-50; gill-rakers on first arch 0+5-8; vertebrae including urostyle 10+25-27=35-37. Head 3.97-4.78 in standard length; depth 1.92-2.49. Snout 4.08-5.09 in head; upper eye 3.58-4.32; lower eye 3.5-4.48; interorbital width 3.03-8.35; maxillary 2.62-3.51 on ocular side, 2.7-3.34 on blind side; lower jaw 2.06-2.46 on ocular side, 1,93-2.25 on blind side; depth of caudal peduncle 1.64-2.03; longest dorsal fin ray 1.73-2.14; longest anal fin ray 1.64-2.26; pectoral fin 0.52-0.9 on ocular side, 1.54-2.16 on blind side; ventral fin 1.8-2.42 on ocular side, 1.8-2.42 on blind side; base of ventral fin 1.91-2.5 on ocular side, 4.59-6.51 on blind side.

Body elliptical, rather deep, highest at middle part of body, its depth a little less than half its length. Caudal peduncle moderate, more than 1/4 depth of body.

Head small, always shorter than half depth of body, upper profile with a salient notch above anterior nostril, from which it rises steeply. Snout short, about equal to eye diameter. Eyes rather small, subequal to 1/4 of head, separated by a concave space; their anterior margins about a level or lower slightly in advance of upper; upper eye approaches dorsal

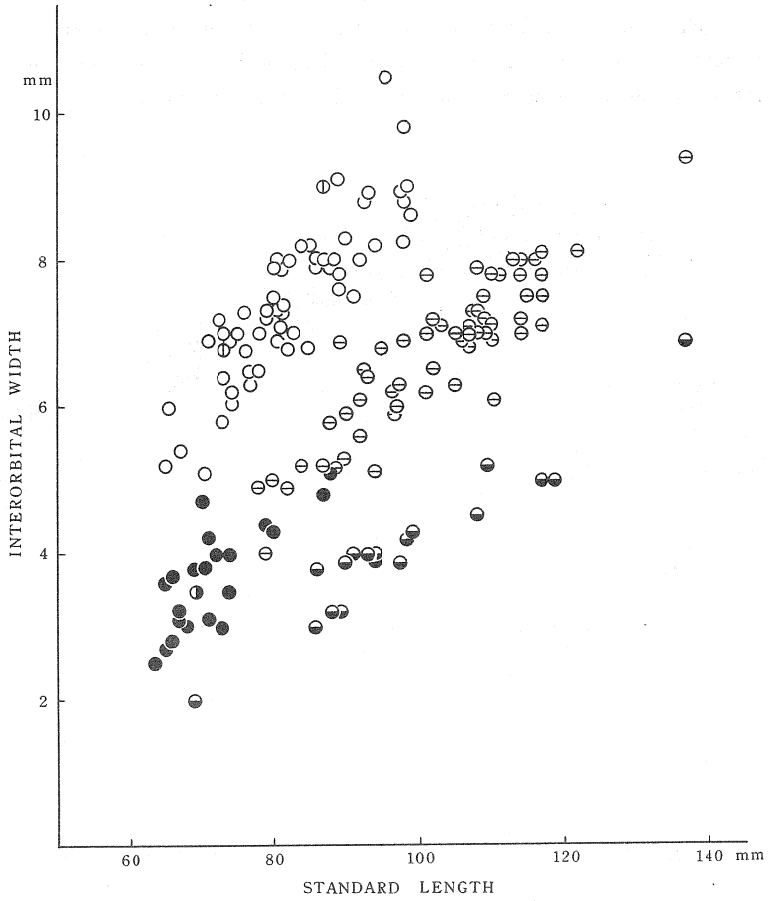

Fig. 46. Sexual dimorphism found in interorbital width of three related species of *Engyprosopon*. *E. grandisquama* (○, male; ●, female); *E. multisquama* (⊖, male; ◒, female); *E. xystrias* (ⓘ, male; ◑, female).

margin of head, distance between it and dorsal margin of head subequal to half of eye diameter. Nostrils on ocular side closely approximated, anterior one tubular, with a short slender flap posteriorly, which is not extending anterior edge of posterior nostril when depressed backward; posterior placed immediately in front of upper-anterior angle of lower

eye, furnished with a rudimentary tube.

Mouth oblique, symmetrical in shape, not arched, maxillary extending to slightly beyond anterior edge of pupil of lower eye. Upper jaw projecting slightly in front of the tip of lower jaw when mouth is closed. Teeth on upper jaw biserial, those on outer series shorter and stouter than those of inner series, but with largest teeth anteriorly (Fig. 48, E); teeth on lower jaw uniserial. Gill-rakers on first arch similar in shape on both sides, rather long, developing on lower limb of arch, and not serrate on each margin (Fig. 48, D).

Scales large, those on ocular side weakly ctenoid (Fig. 48, F), with feeble short spinules along apical margin; scales on blind side cycloid. Snout and jaws naked, anterior parts of dorsal and pectoral fins also scaleless. Lateral line with a strong curve anteriorly, length of curve portion about 2/3 length of head; the line absent on blind side.

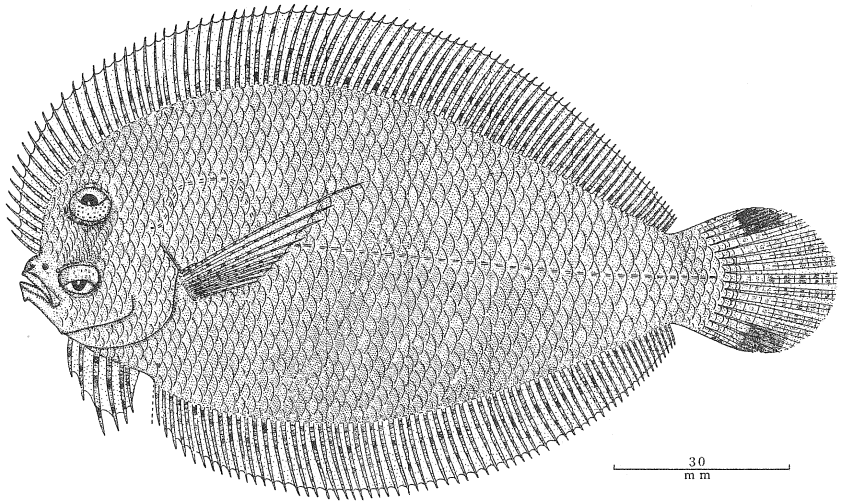

Fig. 47. Lateral view of *Engyprosopon multisquama* AMAOKA from male specimen: No. 29064, 113.5 mm in standard length.

Dorsal fin originating above nostrils on blind side, becoming higher posteriorly to middle of body, where it is highest, and then decreasing in height posteriorly, highest ray subequal to half length of head; first ray about 1/4 of head. Anal similar in shape to dorsal. Pectoral filamentous and upper several rays produced except for first ray which is very short, second ray longest, and succeeding rays becoming shorter toward lowermost one; the fin on blind side shorter than that on ocular side. Left ventral fin originating on tip of isthmus, rays as well as base longer than those on blind side. Caudal fin rounded, both uppermost and lowermost three rays simple, but others branched.

Vent located on blind side immediately in front of origin of anal fin. Genital papilla displaced on ocular side.

In formalin, general ground color on ocular side of body pale greyish green. All fins

with irregularly scattered blackish spots paler than body. Caudal fin with a pair of large jet-black blotches which ranged between second and fourth counted from upper and lower margins respectively.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species (Fig. 48, A, B, C; Fig. 46; Fig. 49). The male fish is interorbital space moderately wide, 3.03-4.8 in head. It has long pectoral fin rays on ocular side tapered into filaments, of which the longest one is always 0.52-0.89 in head. The head is somewhat steep before the eyes

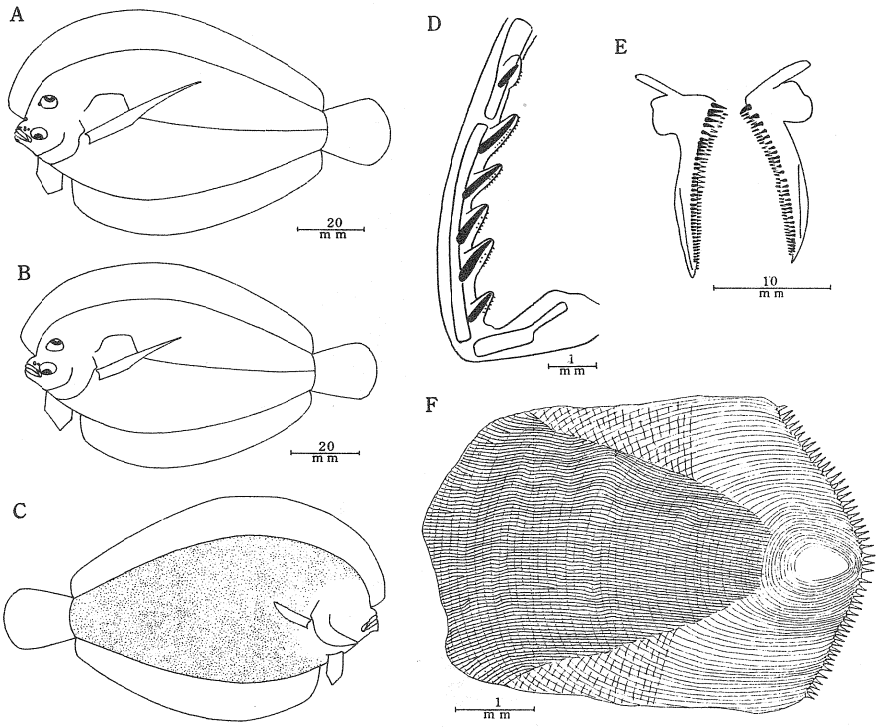

Fig. 48. Diagrammatic illustration of body parts showing sexual dimorphism (A, B, C) and first gill-arch on ocular side (D), upper jaw (E) and scale on ocular side (F) in *Engyprosopon multisquama* AMAOKA. Left view (A, male; B, female); right view (C, male); lateral view (D, F); ventral view (E).

in its anterior profile. The male fish has rather strong rostral spines, the blind side of the body being light grey, though its head is milky white. The female fish has its interorbital space rather narrow, 4.36-8.35 in head. It has shorter pectoral fin rays on ocular side, of which the longest one is always 0.83-0.9 in head. The head is rounded before the eyes in its anterior profile. The female fish has either a feeble rostral spine or none whatever, the blind side of the body being milky white. The divergence appears to be related to the age of the fish and becomes conspicuous in the fish longer than 50 mm in standard length.

Remarks: As pointed out by AMAOKA (1963), the present species closely resembles *Engyprosopon grandisquama* (TEMMINCK and SCHLEGEL) known commonly from the southern and middle coasts of Japan and *Engyprosopon xystrias* HUBBS known rarely from the southern Japan at least in having a pair of jet-black blotches on the caudal fin, but un-

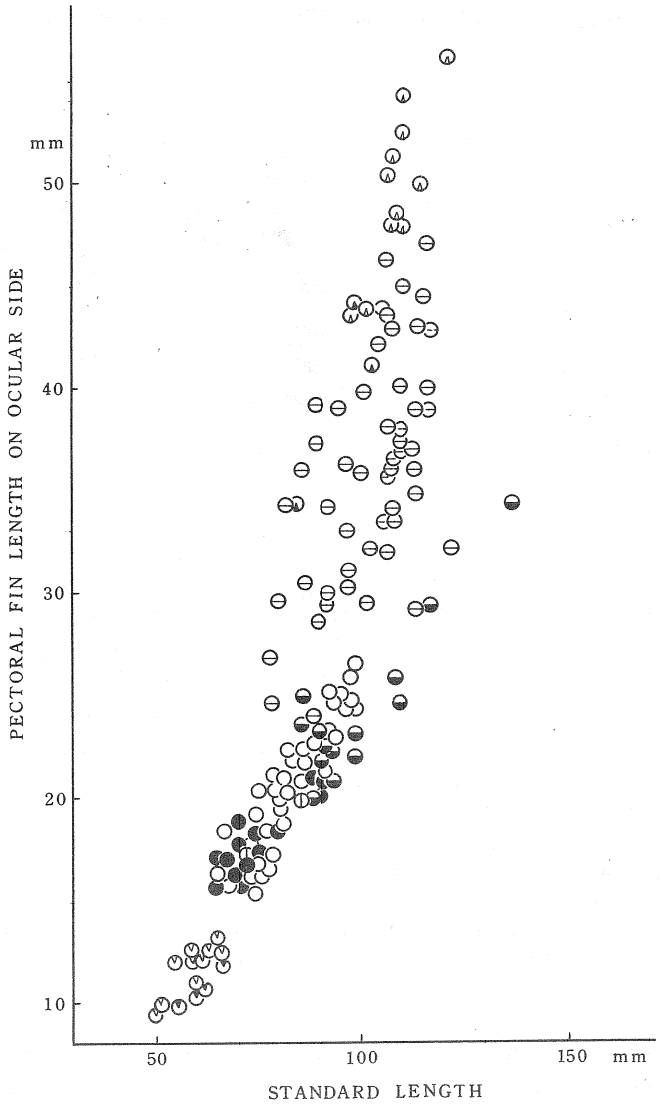

Fig. 49. Sexual dimorphism found in pectoral fin length of five species of *Engyprosopon*. *E. grandisquama* (○, male; ●, female); *E. multisquama* (⊖, male; ◒, female); *E. xystrias* (◑, male; ◑, female); *E. macroptera* (◬, male; ◭, female); *E. longipelvis* (◥, male; ◤, female).

doubtedly differs from the former, which has eye as long as or smaller than the snout, and has same markings arranged between the third and the fourth ray when counted from either extremity. On the other hand, it also differs from the latter with 13 to 14 gill-rakers on the lower limb. The comparison of counts and proportional measurements between the present species and *Engyprosopon grandisquama* may be summarized as indicated in Table 3.

It was observed that the present species has the biserial teeth on the upper jaw through the reexamination of the holotype and the paratypes, though AMAOKA (1963) described the teeth on the upper jaw as biserial anteriorly and uniserial laterally.

Table 3. Comparison of counts and proportional measurements of bodily parts between present species and *Engyprosopon grandisquama* (TEMMINCK and SCHLEGEL).

Species / Items	*E. multisquama*		*E. grandisquama*	
	Range	Average	Range	Average
Dorsal fin rays	83—96	91.2	79—87	82.5
Anal fin rays	62—73	68.7	59—65	61.8
Pectoral fin rays (ocular side)	9—11	10.5	11—12	11.2
Scales in lateral line	45—50	47.9	37—43	40.0
Vertebrae	35—37	35.7	33—35	34.1
In standard length:				
Head	3.97—4.78	4.23	3.95—4.24	3.87
Depth	1.92—2.49	2.03	1.70—1.93	1.82
In head:				
Interorbital width (male)	3.03—4.80	3.62	2.36—3.22	2.85
Interorbital width (female)	4.36—8.35	5.54	3.78—6.84	5.29
Pectoral fin length (male)	0.52—0.89	0.68	0.95—1.25	1.09
Pectoral fin length (female)	0.83—0.90	0.71	1.0 —1.14	1.07

Engyprosopon xystrias HUBBS "Nise-daruma"

Fig. 50

Engyprosopon xystrias HUBBS, 1915, 457, pl. 25, fig. 3. ——OKADA and MATSUBARA, 1938, 422. ——MATSUBARA, 1955, 1259.

Materials: Male- No. 26177, 87.1 mm in standard length, August 9, 1956. No. 26451, 73.0 mm, Tanegashima, Kagoshima Pref., August 28, 1956.

Diagnosis: An *Engyprosopon* with 13-14 gill-rakers on lower limb and a pair of large black blotches on caudal fin. Along head margin in front of the interorbital area and both eyes are some light dark bands, where the scales are reverse arrangement, apical margin takes front.

Description: Dorsal fin rays 88-91; anal fin rays 60-64; pectoral fin rays 12 on ocular side, 10 on blind side; scales in lateral line 39-41; gill-rakers on first arch 0-3+13-14; vertebrae including urostyle 10+26=36. Head 3.98-4.07 in standard length; depth 2.08-2.10. Snout 4.37-4.87 in head; upper eye 2.75-3.04; lower eye 2.81-2.98; interorbital width 2.43-2.63; maxillary 2.59-2.74 on ocular side, 2.56-2.81 on blind side; lower jaw 2.21-2.23 on ocular side, 2.18-2.21 on blind side; depth of caudal peduncle 2.08-2.1; longest dorsal fin ray 1.5-2.01; longest anal fin ray 1.7-1.95; pectoral fin 1.0-1.08 on ocular side, 1.99-2.01 on blind side; ventral fin 2.5-2.9 on ocular side, 2.62-2.81 on blind side.

Body ovoid, highest a little in front of middle part of body, its depth slightly less than half its length. Dorsal and anal contours evenly arched except for head. Caudal peduncle rather narrow, a little less than half length of head.

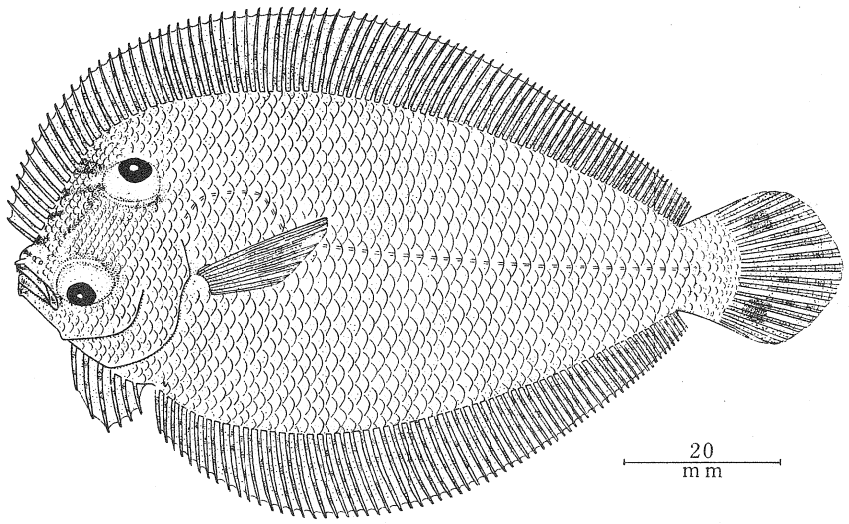

Fig. 50. Lateral view of *Engyprosopon xystrias* HUBBS from male specimen: No. 26177, 87.1 mm in standard length.

Head small, slightly shorter than half depth of body, upper profile with a narrow concave above anterior nostril, from which it rises slightly slow. Snout very short, about 1.5 in diameter of eye. Rostral spine strong and blunt in male. Both eyes large in size, longer than snout; anterior edge of upper eye above posterior 1/3 of lower. Interorbital space rather wide, width a little longer than diameter of eye in male. Nostrils on ocular side approximated, in front of upper margin of lower eye, anterior one tubular with short slender flap posteriorly, posterior not tubular and without flap; nostrils on blind side setting closely below origin of dorsal, anterior one tubular.

Mouth oblique and rather large, maxillary reaching to vertical of anterior margin of lower eye, as long as diameter of eye, a little projecting beyond tip of lower jaw when mouth is closed. Teeth on upper jaw, biserial; those on outer series stronger and wider apart

than those on inner series; anterior end of premaxillary armed with two enlarged teeth, which are outside the mandibular symphysis; teeth on lower jaw uniserial, much stronger and wider apart than those on inner series of upper. Gill-rakers moderate in length and rounded, 10 on ceratobranchial, three or four on hypobranchial and none or three on epibranchial (Fig. 51, C).

Scales large, those on ocular side weakly ctenoid, with feeble short spinules and deciduous except for along head portion in front of interorbital area and both eyes, where those are rather stronger ctenoid than those of other portion, not deciduous and apical margin of each scales occuping front (Fig. 51, A, D); those on blind side cycloid; tip of snout and jaws naked. Lateral line curved anteriorly on ocular side, length of curved portion about half length of head; height about half length of its length; the line absent on blind side.

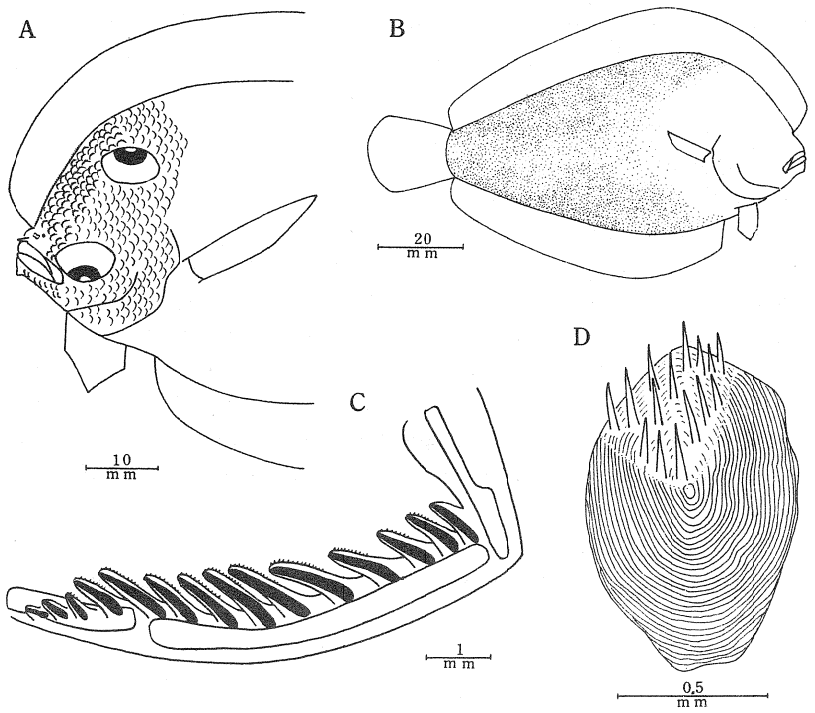

Fig. 51. Arrangement of scale on head (A), body on blind side (B), first gill-arch on ocular side (C) and scale before eyes and interorbital area (D) in *Engyprosopon xystrias* HUBBS. Male (A, B).

Dorsal fin originating slightly on blind side, on a level with upper margin of lower orbit; fin rays becoming gradually higher posteriorly toward middle of fin, and evenly decreasing in height posteriorly. Anal fin starting in front of vertical through basal part of pectoral fin, similar to dorsal fin in shape and structure. Pectoral fin on ocular side simple, and rather short, second ray longest, a little shorter than head; that on blind side

very short, equal to half length of that on ocular side. Left ventral fin originating at tip of isthmus, rays as well as base longer than those on blind side. Caudal fin rounded posteriorly, both uppermost and lowermost three rays simple, but remaining ones branched.

Vent located on blind side, immediately in front of origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body light brown. Along head portion in front of interorbital area and both eyes there is some light dark bands. All fins paler than body, with irregularly scattered blackish spots. Caudal fin with a pair of large jet-black blotches which ranged between third and fifth rays counted from above and below respectively. Body on blind side light dark except for milky white head (Fig. 51, B).

Sexual dimorphism: Remarkable sexual difference is found to exist in this species on the interorbital width, the dorsal profile of the head and the rostral spine (Fig. 46; Fig. 51, A). In the male fish, the profile is very steep, the interorbital space is moderately wide, 2.43-2.63 in head (0.09-0.1 of standard length), and the rostral spine is rather strong. In the female fish, according to description and figure of HUBBS (1915), because the female specimen has not come under this examination, the dorsal profile of the head is rather round, the interorbital space is narrow, 4.71 in head* (0.06 of standard length), and the rostral spine is small.

Sexual dimorphism which is thought to exist in the pigmentation of the body on the blind side can not be ascertained.

Remarks: The present species closely resembles *Engyprosopon grandisquama* and *E. multisquama* known from the southern and middle coasts of Japan, at least in having a pair of jet-black blotches on the caudal fin, but it differs from the latter in having a larger number of the gill-rakers of the lower limb and reversed arrangement of the scales along the head portion in front of the interorbital area and both eyes. This species was described by HUBBS from a single specimen, which appears to be a female. Only the holotype has hitherto been known. Two specimens which have come under the examination appear to be the male.

Engyprosopon macroptera AMAOKA "Tenaga-daruma"

Fig. 52

Engyprosopon macroptera AMAOKA, 1963, 115, fig. 5. ——KAMOHARA, 1964, 82.

Materials: Male- No. 26452, No. 29064, 114.5-122.9 mm in standard length, Mimase, Kochi Pref., October 10, 1958. Nos. 29065-29066, 107.8-110.9 mm, Susaki, Kochi Pref., July 21, 1959. Nos. 29067-29071, 106.5-108.1 mm, Mimase, October 10, 1958. No. 29072, 102.0 mm, Susaki, July 21, 1959. Female- No. 26453, Nos. 29074-29076, 82.8-111.2 mm, Mimase, June 21-July 10, 1958.

Diagnosis: An *Engyprosopon* without particular markings on caudal fin. Maxillary extending to vertical through about middle of lower eye. Pectoral fin well produced and filamentous, 0.51-0.63 in head.

Description: Dorsal fin rays 85-91; anal fin rays 65-68; pectoral fin rays 11-13 on ocular

* base the calculation on HUBBS' figure (1915).

side, 9-11 on blind side; scales in lateral line 45-47; gill-rakers on first arch 0+8-11; vertebrae including urostyle 10+25=35. Head 3.94-4.24 in standard length; depth 1.83-2.0. Snout 4.41-5.19 in head; upper eye 3.15-3.48; lower eye 3.15-3.53; interorbital width 1.76-2.88; maxillary 2.45-2.78 on ocular side, 2.45-2.8 on blind side; lower jaw 2.05-2.26 on ocular side, 1.95-2.24 on blind side; depth of caudal peduncle 1.75-2.11; longest dorsal ray 1.64-1.96; longest anal ray 1.68-1.95; pectoral fin 0.51-0.63 on ocular side, 1.66-1.92 on blind side; ventral fin 1.96-2.47 on ocular side, 2.18-2.64 on blind side; base of ventral fin 2.1-2.46 on ocular side, 4.92-6.62 on blind side.

Body ovate, very deep, highest in front of middle part of body, its depth equal to or a little more than half its length; dorsal and anal contours evenly arched, except for head region. Caudal peduncle rather narrow, about 1/4 depth of body.

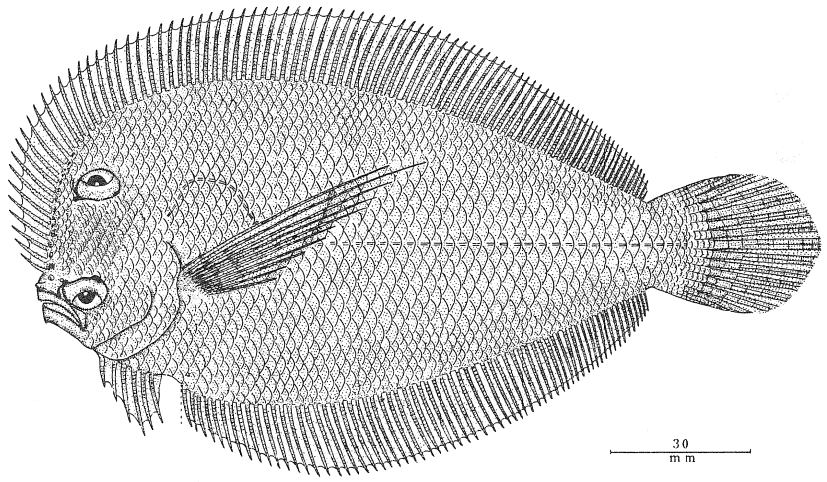

Fig. 52. Lateral view of *Engyprosopon macroptera* AMAOKA from male specimen: No. 28980, 114.5 mm in standard length.

Head small, always shorter than half depth of body; upper profile very steep, almost vertical in front of upper eye except for slightly produced snout. Snout short, about 2/3 eye diameter. Both eyes rather large, subequal in size, separated by an exceedingly wide and deeply concave interorbital space; lower slightly in advance of upper, which approaches to the dorsal margin of head; distance between upper eye and dorsal margin of head nearly equal to half diameter of eye, lower located approximately above middle part of maxillary. Nostrils on ocular side closely set in front of upper margin of lower eye, anterior one tubular with a short slender flap posteriorly, extending to anterior margin of posterior nostril when depressed posteriorly; posterior one very slightly tubular, furnished with a flap, much shorter than anterior one; nostrils on blind side setting closely below origin of dorsal.

Mouth rather large, almost symmetrical in shape, curved; upper jaw very long, projecting

beyond tip of lower jaw and extending posteriorly as far below middle of pupil of lower eye when mouth is closed. Teeth on upper jaw biserial; teeth on outer series stronger than those on inner series; anterior end of premaxillary armed with two enlarged teeth, which are outside mandibular symphysis when mouth is closed; teeth on lower jaw much stronger and wider apart with each other than those on inner series of upper. Gill-rakers similar in shape on both sides of body, developed only on lower limb, being rather slender, pointed, and not serrate on each margin (Fig. 112, B).

Scales large, those on ocular side weakly ctenoid, with feeble short spinules along apical margin; those on blind side cycloid; snout and jaws naked, anterior parts of both dorsal and pectoral fins also scaleless. Lateral line with a strong curve anteriorly, curved portion about 2/3 length of head; the line entirely absent on blind side.

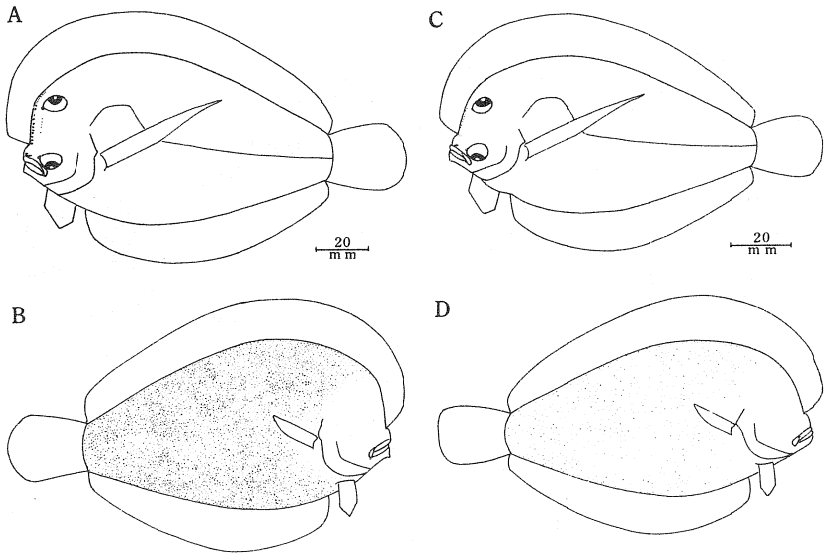

Fig. 53. Diagrammatic illustration of body parts showing sexual dimorphism in *Engyprosopon macroptera* AMAOKA. Left view (A, male; B, female); right view (B, male; D, female).

Origin of dorsal slightly on blind side, on horizontal from upper margin of lower orbit; fin becoming gradually higher posteriorly, more or less beyond in middle of fin, then evenly decreasing in height posteriorly to end of fin, highest ray about 2/3 length of head. Anal fin similar in shape to dorsal. Pectoral fin on ocular side well produced and more or less filamentous, first ray very short, slightly shorter than eye diameter, third ray longest and succeeding rays becoming rapidly short ventrally; pectoral fin on blind side shorter than that on ocular side, longest ray on blind side 1/3 of longest ray on ocular side. Origin of left ventral fin at tip of isthmus, rays as well as base on ocular side longer than those on blind side. Caudal rounded posteriorly, rays all branched except for three rays both in

upper and lower edges of fin.

Vent opens on blind side above origin of anal fin. Genital papilla displaced on ocular side.

In formalin, general ground color of body pale greyish green, with a series of small light dark spots along anterior edge of head, and a dark spot on antero- and postero- inner margins of eyes. Fins paler than body; body on blind side light grey except for milky white head.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species, appearing in several external characters (Fig. 53; Fig. 56). The male fish has its interorbital space extremely wide, 1.8-2.1 in head, its rostral spine being very strong. The head is strongly steep and nearly vertical before the eyes in its anterior profile. Along the head margin in front of the interorbital area is a series of small light dark spots. The blind side of the body is stained with light grey, though the head is milky white. The female fish has its interorbital space moderately wide, 2.6-2.9 in head, its rostral spine being either feeble or absent. The head is somewhat steep anteriorly in its anterior profile, either with or without a series of small deep grey spots. The blind side of the body is lighter than that of the male fish, but the head is milky white. The divergence appears to be related to fish's age and becomes conspicuous in the fish about 60 mm in standard length.

Remarks: The present species comparatively resembles *Engyprosopon longipelvis* n. sp. from the southern coast of Japan, because it has not a pair of large jet-black blotches on the caudal fin, but undoubtedly differs from the latter which has the serrate gill-rakers and the ventral fin on ocular side well produced in the male. On the other hand, as pointed out by Amaoka (1963), this species is allied to the Hawaiian species, *Engyprosopon hawaiiensis* Jordan and Evermann, and to the Indian species of *Engyprosopon macrolepis* (Regan) in general physiognomy, but differs from *Engyprosopon hawaiiensis* in having a much longer pectoral fin, the number of rays on the dorsal and anal fins and of gill-rakers on the lower limb of the first arch. To be exact, the present species has its pectoral fin 0.5-0.6 in head, as against 1.4 of *Engyprosopon hawaiiensis;* 85-90 dorsal rays and 65-68 anal rays as against 79-80 and 56-58 of the latter, respectively; and 9-11 gill-rakers on the lower limb, as against seven of the latter. Those characteristic features which enable us to separate the present species from *Engyprosopon macrolepis* and *Engyprosopon filimanus* may be the number of scales in lateral line, or of the rays, both dorsal and anal. Correctly speaking, the present species has 45-47 scales while the latter two species have each 40, and 78-84 dorsal and 60-62 anal rays.

I was observed that the present species has the biserial teeth on the upper jaw through the reexamination of the holotype and the paratypes, though Amaoka (1963) described the teeth on the upper jaw as biserial anteriorly and uniserial laterally.

Engyprosopon longipelvis n. sp. "Hime-daruma"

Fig. 54

Holotype.—No. 36625, 65.8 mm in standard length, male, Mimase, Kochi Pref., July 8, 1960.

Paratypes.—Male—No. 28960, 55.2 mm, Mimase, May 10, 1958. No. 36624, Nos.

36626-36628, No. 36631, No. 36633, No. 36636, Nos. 36644-36645, 49.5-63.0 mm, Mimase, July 8, 1960. Female—No. 36623, 65.8 mm, Miya, Aichi Pref., April 10, 1960. No. 36632, No. 36637, No. 36642, 56.1-61.0 mm, Mimase, July 8, 1960.

Diagnosis: A dwarf *Engyprosopon* with the serrate gill-rakers, exceedingly long ventral fin in male and rather large mouth. Ventral fin on ocular side in male 1.33-1.76 in head; maxillary on ocular side 2.26-2.5 in head.

Description: *Holotype.*—Dorsal fin rays 80; anal fin rays 60; pectoral fin rays 11 on ocular side, 9 on blind side; scales in lateral line 42; gill-rakers on first arch 0+7. Head 3.82 in standard length; depth 2.12. Snout 4.2 in head; upper eye 3.44; lower eye 3.44; interorbital width 3.58; maxillary 2.45 on both sides; lower jaw 1.91 on ocular side, 1.89 on blind side; depth of caudal peduncle 2.15; longest dorsal fin ray 1.93; longest anal fin ray 1.93; pectoral fin 1.5 on ocular side, 2.12 on blind side; ventral fin 1.56 on ocular side, 1.95 on blind side.

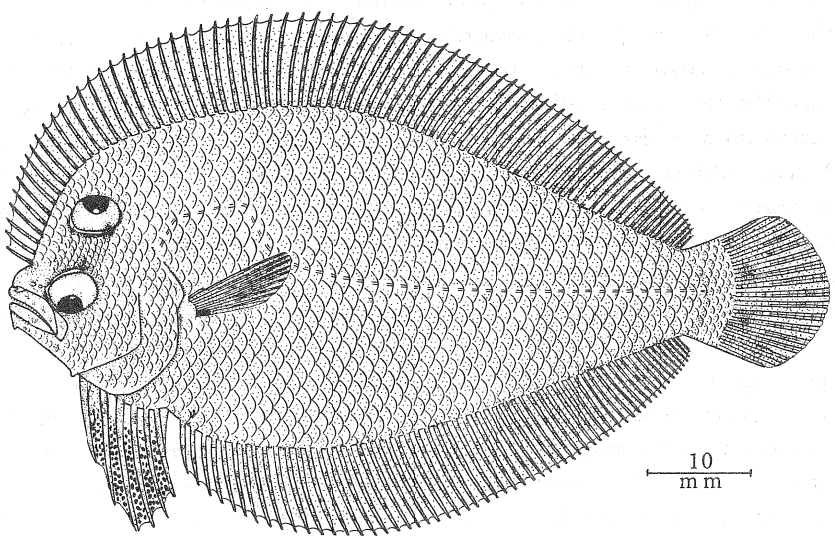

Fig. 54. Lateral view of holotype of *Engyprosopon longipelvis* n. sp. (male specimen): No. 36625, 65.8 mm in standard length.

Body elliptical, highest at middle part of body, its depth a little less than half its length. Dorsal border descending gradually from middle portion of body to upper margin of upper eye, from which it rapidly inclines towards origin of first dorsal fin, where it is provided with a large notch. Ventral border almost evenly arched.

Head rather large, longer than half depth of body. Snout obtuse, strongly protruding, large, a little shorter than eye diameter. A feeble rostral spine on snout, directed forward. Both eyes rather large, anterior edge of upper eye above middle part of lower one. Interorbital space rather narrow, slightly shorter than eye diameter. Nostrils on ocular side

closely set in front of lower eye, anterior one tubular with a short slender flap posteriorly.

Mouth oblique, large, symmetrical in shape, about twice as long as snout; maxillary extending below anterior 1/3 length or middle of lower eye. Teeth on upper jaw biserial; those of outer series much stouter and wider apart than those on inner series, and enlarged anteriorly; teeth on lower jaw uniserial and close-set. Gill-rakers on both sides similar in shape, developed only on lower limb, rahter slender, pointed, and each of them armed with some small spines on their margins (Fig. 55, A).

Scales rather large, strikingly deciduous everywhere; those on ocular side feeble ctenoid, those on blind side cycloid; snout, jaws and basal part of pectoral fin naked. Lateral line with strong curve anteriorly, curved portion about 1/3 length of head; the line absent on blind side.

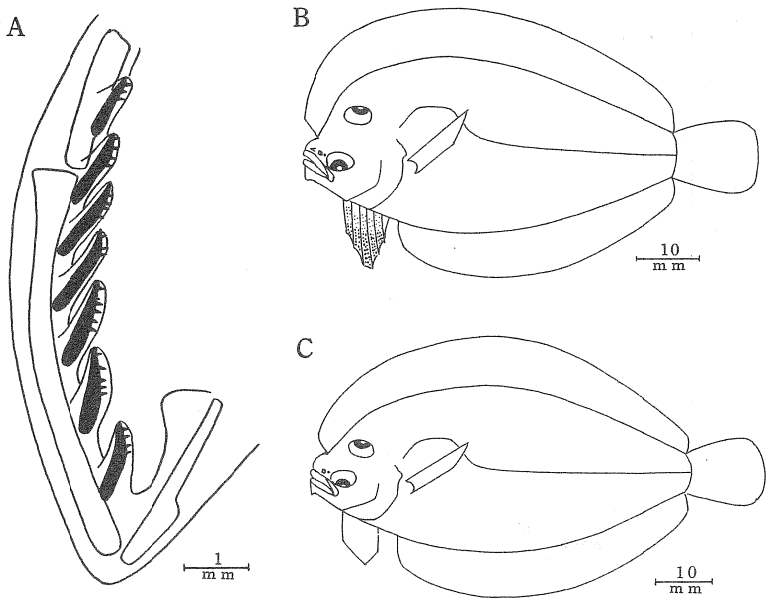

Fig. 55. Diagrammatic illustration of body parts showing sexual dimorphism (B, C) and first gill-arch on ocular side (A) in *Engyprosopon longipelvis* n. sp. Male (B); female (C).

Origin of dorsal slightly on blind side, before horizontal through upper margin of lower eye; fin rays gradually increasing in height toward middle of fin, and evenly decreasing in height posteriorly. Anal fin starting below vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side rather short, exceedingly shorter than head; that on blind side very short and slender, a little shorter than half length of head. Origin of left ventral fin at tip of isthmus, base on ocular side longer than that on blind side, rays on ocular side well elongate, third longest, much longer than length of pectoral fin ray on ocular side; the fin on blind side moderate in length, 1.5 in length

of pectoral fin ray on ocular side. Caudal fin rounded posteriorly, the rays all branched except for three rays both in upper and lower extremities of fin.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body light brown. All fins paler than body, irregularly scattered blackish spots. Ventral fin on ocular side provided with many small jet-black spots on fin membrane except for basal portion. Body on blind side milky white.

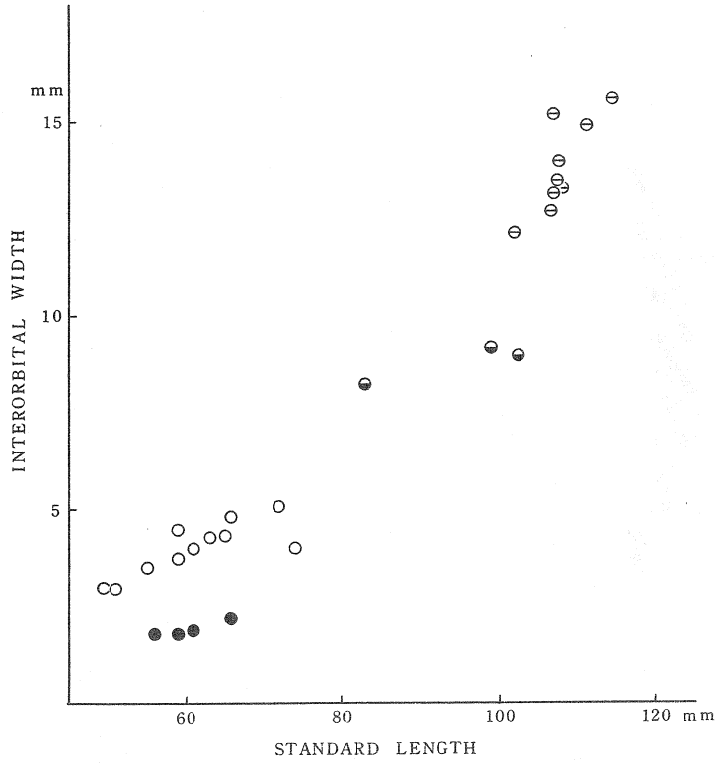

Fig. 56. Sexual dimorphism found in interorbital width of two related species of *Engyprosopon*. *E. macroptera* (⊖, male; ◒, female); *E. longipelvis* (○, male; ●, female).

Paratypes.—Dorsal fin rays 79-83; anal fin rays 60-64; pectoral fin rays 11-12 on ocular side, 8-10 on blind side; scales in lateral line 37-42; gill-rakers on first arch 0+6-7; vertebrae including urostyle 10+24=34. Head 3.49-3.89 in standard length; depth 1.98-2.27. Snout 3.98-4.96 in head; upper eye 3.15-3.6; lower eye 3.16-3.57; interorbital width 3.13-8.9; maxillary 2.26-2.58 on ocular side, 2.22-2.54 on blind side; lower jaw 1.8-1.95 on ocular side, 1.75-1.89 on blind side; depth of caudal peduncle 2.1-2.46; longest dorsal fin ray

1.79-2.25; longest anal fin ray 1.83-2.22; pectoral fin 1.37-1.63 on ocular side, 2.03-2.53 on blind side; ventral fin 1.33-2.57 on ocular side, 1.89-2.57 on blind side.

Sexual dimorphism: The present species exhibits the sexual differences in the rostral spine, the head profile, the interorbital width, the ventral fin and the pigmentation (Fig. 55, B, C; Fig. 56). The male fish has a strong rostral spine, the head profile somewhat steep and the interorbital space moderately wide, 3.13-5.56 in head. It has long ventral fin rays on the ocular side, of which the longest one is 1.33-1.76 in head, and the its fin membrane except for basal portion is stained with many small jet-black spots. The female fish has no rostral spine, the head profile rounded and the interorbital space is exceedingly narrow, 8.13-8.9 in head. It has shorter ventral fin rays on the ocular side than those of the male fish, of which the longest one is 2.3-2.57 in head, and its fin membrane has not such spots.

Remarks: *Engyprosopon longipelvis* n. sp. rather closely resembles *E. cocosensis* (BLEEKER) from the Bay of Bengal in having a much longer maxillary and *E. latifrons* (REGAN) from the Indian Ocean in having small number of scales in lateral line. But it differs from these and all other known species of the genus *Engyprosopon* in having moderate and pointed gill-rakers with their serrate margins, and the sexual differences in both the length and the pigmentation of the ventral fin on the ocular side.

32. Genus *Bothus* RAFINESQUE

Bothus RAFINESQUE, 1810, 23 (type-species by original designation: *Bothus rumulo* RAFINESQUE).
Platophrys SWAINSON, 1839, 187, 302 (type-species by original designation: *Rhombus ocellatus* AGASSIZ).
Rhomboidichthys BLEEKER, 1856, 67 (type-species by original designation: *Rhomboidichthys myriaster* BLEEKER).
Psettylis ALCOCK, 1890, 436 (type-species by original designation: *Psettylis pellucida* ALCOCK).
Symboulichthys CHABANAUD, 1927, 76 (type-species original designation: *Platophrys maculifer* JORDAN and GOSS).

Body ovate, strongly or rather moderately compressed. Caudal peduncle moderate in depth. Tip of isthmus below vertical of middle part of lower eye or slightly advanced. Eyes widely separated by a concave space, which is generally broader in male than in female and young. Male generally with spines on snout and sometimes on symphysis of lower jaw and orbital margins; eyes in male and sometimes in female with some dermal appendages. Nostrils on both sides two, anterior one tubular with a flap, and posterior one more or less tubular, without flap. Mouth moderate in size or rather small, maxillary extending to below or beyond anterior edge of lower eye, but not middle part of lower eye, 2.7-4.6 in head. Teeth on both jaws almost developed equally on both sides, one or two rows, without distinct canines. Gill-rakers moderate or rather short, and pointed, not serrate at its posterior margin. Scales small not deciduous, moderately ctenoid or cycloid on ocular side, but cycloid on blind side; snout, both jaws and pectoral fin naked.

Dorsal fin originating above nostrils on blind side, all rays simple. Anal fin similar both in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side; all rays simple. Left ventral fin originating on tip of isthmus, the fourth

ray on ocular side opposite to first on blind side; all rays simple. Caudal fin rounded posteriorly, simple on two or three rays counted from upper and lower margins respectively.

Vomer toothless. Prefrontal on blind side greatly expanded upward, and widely connected with frontal on ocular side, but it separated from prefrontal on ocular side. Interorbital bone widely platelike in shape (Fig. 98, C1, D1, C2, D2; Fig. 104, G). Alisphenoid on ocular side very small, not extending to orbital cavity. Basioccipital roughly rectangular in shape, when viewed from lateral. Opisthotic square in shape, its tip not extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital. Prootic widely connected with basioccipital posteriorly (Fig. 98, C1, D1, C2, D2).

Suborbital bone on blind side four in number (Fig. 107, E, F). Second hypobranchial rectangular or elliptical in shape without toothed plate; third basibranchial rectangular concave deeply in both sides of anterior part (Fig. 114, A, B). Urohyal fishhook-like in shape, tip of sciatic part exceedingly more advanced than that of main part, tapering front; cardiac apophysis rather large, with a pair of wings (Fig. 116, G; Fig. 117, F). Opening for notochord moderate in size, and more advanced than middle part of centrum. Anterior transverse apophysis beginning with second vertebra. First haemal spine particularly expanded. Haemapophysis is so well expanded backward at tip as to almost extends to next one (Fig. 121, B1-B5). Four caudal plates not branched (Fig. 127, N, O).

33. Key to species of *Bothus**

A^1 Scales on ocular side cycloid, except for upper and lower margins of body; lower jaw small, that on ocular side, 2.3-2.9 in head ..... ***Bothus myriaster*** (TEMMINCK and SCHLEGEL)

A^2 Scales on ocular side ctenoid; lower jaw rather large, that on ocular side, 2.0-2.1 in head.

B^1 Eyes small, 5.2-6.0 in head; dorsal 96-102; anal 74-81; gill-rakers 9-11 on lower arch..... ..... ***Bothus mancus*** (BROUSSONET)

B^2 Eyes rather large, 3.9-4.5 in head; dorsal 88-93; anal 65-72; gill-rakers six to eight on lower arch ..... ***Bothus pantherinus*** (RÜPPELL)

Bothus myriaster (TEMMINCK and SCHLEGEL) "Hoshi-darumagarei"

Fig. 57

Rhombus myriaster TEMMINCK and SCHLEGEL, 1846, 181, pl. 92, fig. 2.

Platophrys myriaster. JORDAN and EVERMANN, 1902, 365. ——JORDAN and STARKS, 1906, 167. ——SNYDER, 1912, 517. ——JORDAN, TANAKA and SNYDER, 1913, 312. ——HUBBS, 1915, 457. ——IZUKA and MATSUURA, 1920, 115. ——KAMOHARA, 1931, 542. ——KAMOHARA, 1938, 59.

Platophrys ovalis REGAN, 1908, 232, pl. 27, fig. 6.

Platophrys circularis REGAN, 1908, 233, pl. 26, fig. 3.

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*KURONUMA (1942) added *B. bleekeri* STEINDACHNER from a larva taken from Kanagawa Prefecture to the fauna of Japanese waters. The larva, however, has not agreement with *B. bleekeri* in meristic characters and body form, but well with *Taeniopsetta ocellata*. Consequently, the author excludes *B. bleekeri* from the genus *Bothus* of Japanese fauna.

Bothus ovalis (part). NORMAN, 1927, 32, fig. 7. ——NORMAN, 1934, 238, fig. 180. ——OKADA and MATSUBARA, 1938, 422. ——KURONUMA, 1942, 135, figs. 1-2. ——KAMOHARA, 1950, 240. ——KURODA, 1951, 389. ——MATSUBARA, 1955, 1260. ——KURODA, 1962, 2.

Bothus myriaster. CHABANAUD, 1929, 379. ——WU, 1932, 95. ——NORMAN, 1934, 236, fig. 179. ——OKADA and MATSUBARA, 1938, 422. ——SMITH, 1949, 160, fig. 316. ——KAMOHARA, 1950, 241. ——MORI, 1952, 176. ——MATSUBARA, 1955, 1260, fig. 491. ——MORI, 1956, 32. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82. ——AMAOKA, 1964, 12, figs. 1-2.

Materials: Male- Nos. 19642-19643, 118.6-122.2 mm in standard length, Nobeoka, Miyazaki Pref., December 10, 1952. No. 19645, 105.0 mm, Nobeoka, December 10, 1952. Nos. 33077-33080, 116.9-215.0 mm, Susaki, Kochi Pref., November 15, 1957. Nos. 33081-33094, 80.9-116.2 mm, Mimase, Kochi Pref., November 20, 1957. Nos. 33096-33097, 74.2-77.0 mm, Mimase, November 20, 1957. Female- Nos. 33098-33101, 113.6-140.9 mm, Susaki, November 15, 1957. Nos. 33102-33107, 95.9-106.8 mm, Mimase, November 20, 1957. Nos. 33108-33117, 75.9-89.0 mm, Mimase, November 20, 1957. Young- Nos. 33122-33127, 60.9-69.5 mm, Mimase, November 20, 1957. Nos. 33129-33132, 60.9-63.5 mm, Mimase, November 20, 1957. Nos. 33134-33140, 49.8-61.0 mm, Mimase, November 20, 1957. Nos. 33143-33146, 41.0-52.1 mm, Mimase, November 15, 1957.

Diagnosis: A *Bothus* with small cycloid scales except for marginal portions of body, and shortest lower jaw.

Description: Dorsal fin rays 87-97; anal fin rays 61-73; pectoral fin rays 8-10 on ocular side, 7-10 on blind side; scales in lateral line 74-108; gill-rakers on first arch 0-5+5-8; vertebrae including urostyle 10+27-29=37-39. Head 3.34-4.46 in standard length; depth 1.25-2.04. Snout 4.0-8.0 in head; upper eye 2.07-4.36; lower eye 2.72-3.80; maxillary 2.72-4.63 on ocular side, 2.17-2.53 on blind side; depth of caudal peduncle 2.14-2.92; longest dorsal fin ray 1.73-2.74; longest anal fin ray 1.7-2.53; pectoral fin 0.39-1.15 on ocular side, 1.44-2.38 on blind side; ventral fin 1.62-2.80 on ocular side, 2.04-3.12 on blind side; base of ventral fin 2.11-2.94 on ocular side, 3.44-5.32 on blind side.

Body ovate or rather deep elliptical, strongly compressed, highest at middle part or slightly before middle part of body, its depth less than half length of body, becoming gradually low in according to age of fish; dorsal and anal contours evenly arched except for head region. Caudal peduncle rather narrow in depth, much more than 1/3 length of head.

Head rather small, much smaller than 1/3 length of body; dorsal profile of head with a large concave on horizontal through upper margin of lower eye, from which it steeply rises to above upper eye, and then distinctly convex. Snout small, about equal to or shorter than eye diameter. Eyes rather large, about as long as length of maxillary, separated by wider concave space; lower a little or more in advance of upper. Nostrils on ocular side closely set in front of upper margin of lower eye, the anterior one tubular with long flap anteriorly, posterior one without flap and tube; nostrils on blind side setting below origin of dorsal, tubular; anterior one with a long flap posteriorly.

Mouth very small in size, about horizontal on anterior half; maxillary extending to just below or a little beyond anterior margin of lower eye; lower jaw slightly projecting beyond tip of upper. Teeth on upper jaw biserial, those of outer series much stronger and wider apart with each other than those of inner series; teeth on lower jaw biserial on anterior half of dentition, but uniserial on posterior half, outer series stronger and wider

apart with each other, inner series small and close-set (Fig. 58, A, B). Gill-rakers on first arch small and pointed at tip, not serrate at its posterior margin; none or rudimentary on upper limb (Fig. 58, C).

Scales extremely small, all cycloid on ocular side except for at extreme upper and lower edges of body, where they are ctenoid; those on blind side cycloid (Fig. 58, D, E); snout, both jaws, head margin before interorbital area and pectoral fin naked. Lateral line on ocular side with a small curve above pectoral fin, length of curve portion a little shorter than half length of head, height about half length of its portion; the line absent on blind side.

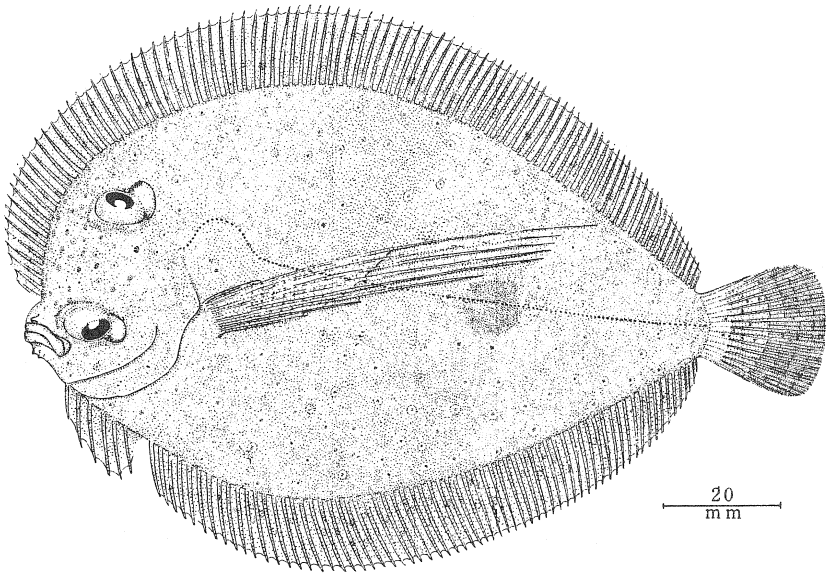

Fig. 57. Lateral view of *Bothus myriaster* (TEMMINCK and SCHLEGEL) from male specimen: No. 19642, 122.2 mm in standard length.

Origin of dorsal fin on blind side, before horizontal through upper margin of lower eye, fin rays gradually increasing in height towards middle of fin, and evenly decreasing in height posteriorly. Anal fin starting immediately behind ventral fin on ocular side, similar in shape and structure to dorsal. Pectoral fins asymmetrical in size, that on ocular side elongate, all rays simple. Ventral fin on ocular side inserted on vertical through middle part of lower eye or slightly advanced; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, inner 13 rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish or greenish, with numerous dark brown spots ringed with pale brown; a diffuse dark ocelli smaller than

eye above junction of straight and curved parts of lateral line and anterior distinct blotch at middle of its straight portion; dorsal and anal fins paler than body, furnished with a

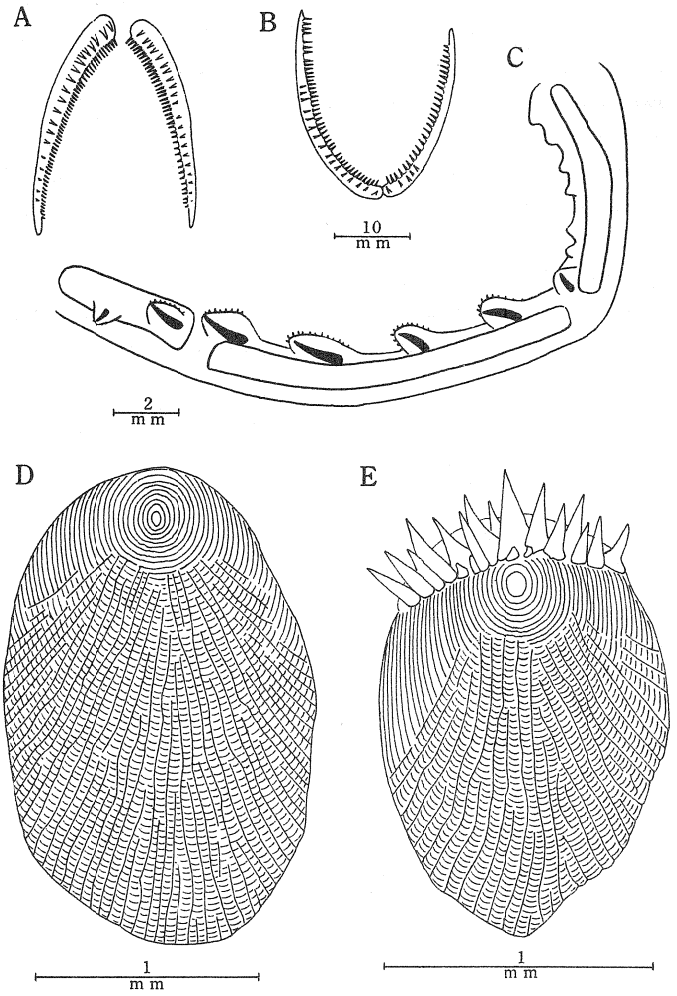

Fig. 58. Upper jaw (A), Lower jaw (B), first gill-arch on ocular side (C) and scales (D, middle portion; E, marginal portion) in *Bothus myriaster* (TEMMINCK and SCHLEGEL). Ventral view (A); dorsal view (B); lateral view (C, D, E).

series of dark spots, and each fin with small brown dots; pectoral fin with pale brownish spots, arranged as cross bars. Caudal fin dark at tip of rays. Blind side of body yellowish white at anterior half, becoming dark brown posteriorly; a number of narrow wavy, dark

transverse bars just in front of posterior dark portion.

Sexual dimorphism: Remarkable sexual dimorphism exists in many external characters (Fig. 59, A-D; Figs. 62, 65). It appeared to be related to the age of the fishes, inasmuch as it becomes conspicuous when the fish attains about 70 mm in standard length (AMAOKA, 1964). In the male fish, the pectoral fin on the ocular side is well produced into filament which is much longer than the head, 0.39-0.67 in head. The interorbital space is extremely wide, 2.07-3.00 in head. The male fish has a strong spine on the snout, another one at symphysis of lower jaw and some smaller ones around orbits. Each eye has a large membranous flap on its hinder part. The blind side of the body is stained with distinct dark posteriorly, possessing a number of narrow distinct, wavy, dark transverse bars just in front of the dark portion. On the other hand, in the female, the pectoral fin is well produced into filament, but rather shorter than that of male, 0.57-0.88 in head. The interorbital space is rather narrow, 2.73-3.76 in head. The female fish has neither spines on the snout, symphysis and orbital margins nor flaps on each eye. The blind side of the body is stained with paler dark than that of the male fish, and the narrow, wavy bars being paler or none.

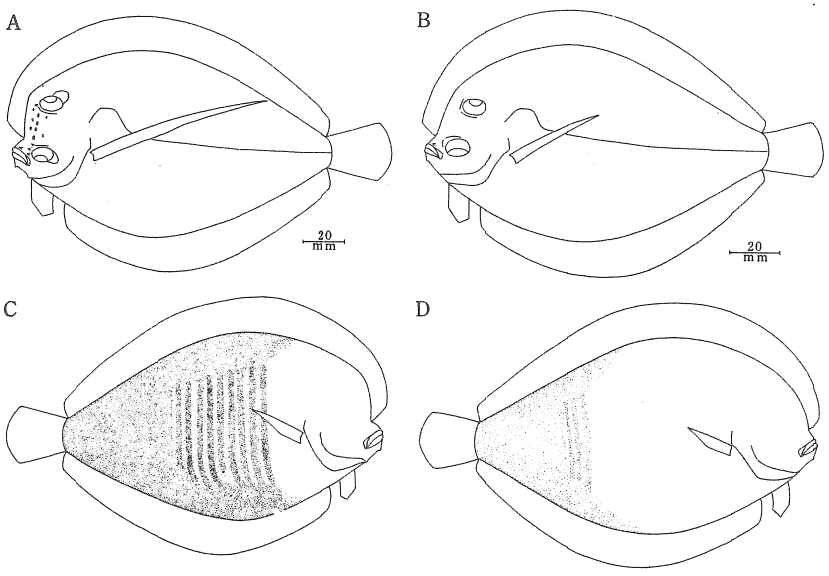

Fig. 59. Diagrammatic illustration of body parts showing sexual dimorphism in *Bothus myriaster* (TEMMINCK and SCHLEGEL). Left view (A, male; B, female); right view (C, male; D, female).

Remarks: The present species changes so much in head length and body depth in the course of its growth that it was mistaken in its larval and young stages for two different species. As already pointed out by AMAOKA (1964) *B. ovalis* (REGAN) is nothing but a synonym of *B. myriaster* (TEMMINCK and SCHLEGEL).

Bothus mancus (BROUSSONET) "Mon-darumagarei"

Fig. 60

Platophrys (*Platophrys*) *pavo* BLEEKER, 1866-72, 11, fig. 2.
Platophrys mancus. JORDAN and SNYDER, 1904, 946. —— JORDAN and EVERMANN, 1905, 513. ——GILBERT, 1905, 684. ——JORDAN and SEALE, 1906, 412. ——JORDAN and JORDAN, 1922, 24. ——FOWLER, 1928, 90, pl. 4, fig. b. ——FOWLER, 1931, 320. ——MUNRO, 1958, 283.
Rhomboidichthys mancus. GÜNTHER, 1909, 342.
Bothus mancus. NORMAN, 1927, 34. —— NORMAN, 1931, 509. —— NORMAN, 1934, 230, fig. 174. ——ROXAS and MARTIN, 1937, 65. ——FOWLER, 1938, 166. ——SMITH, 1949, 160. ——FOWLER, 1949, 61. ——MARSHALL, 1950, 201. ——HERRE, 1953, 180. ——KAMOHARA, 1954, 293. —— MATSUBARA, 1955, 1260. ——MATSUBARA and OCHIAI, 1963, 88.
Bothus (*Platophrys*) *mancus*. WEBER and BEAUFORT, 1929, 122.
Parabothus mancus. WU, 1932, 96.

Materials: Female- Nos. 31811-31816, 64.4-173.0 mm in standard length, Okinawa Islands, August 4, 1960. Nos. 33021-33022, 166.1-198.3 mm, Amami Islands, June 30, 1958. Nos. 32383-32385, 127.5-189.4 mm, Okinawa Islands, August 4, 1960.

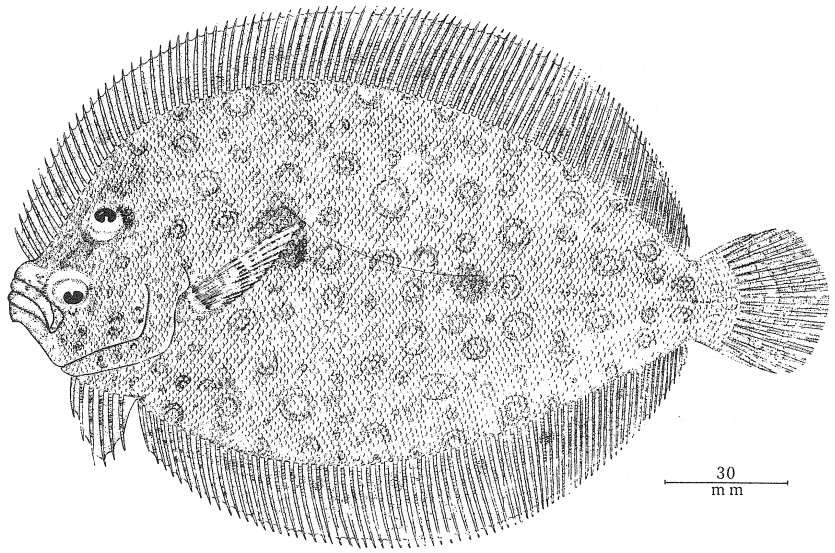

Fig. 60. Lateral view of *Bothus mancus* (BROUSSONET) from female specimen: No. 33022, 166.1 mm in standard length.

Diagnosis: A *Bothus* with smaller eye, 5.2-6.0 in head; dorsal profile more or less convex above upper eye.

Description: Dorsal fin rays 96-102; anal fin rays 74-81; pectoral fin rays 11-13 on ocular side, 10-13 on blind side; scales in lateral line 76-89; gill-rakers on first arch 0+9-11; vertebrae including urostyle 10+29-30=39-40. Head 3.42-3.81 in standard length; depth 1.72-1.90. Snout 3.96-4.62 in head; upper eye 5.15-5.96; lower eye 5.15-6.33; interorbital

width 3.44-4.35; maxillary 2.8-3.09 on ocular side, 2.75-3.05 on blind side; lower jaw 1.97-2.11 on ocular side, 1.97-2.1 on blind side; depth of caudal peduncle 2.53-2.64; longest dorsal fin ray 2.07-2.32; longest anal fin ray 2.05-2.28; pectoral fin 1.18-1.53 on ocular side, 1.67-1.95 on blind side; ventral fin 2.22-2.66 on ocular side, 2.67-3.02 on blind side; base of ventral fin 2.86-3.33 on ocular side, 5.51-6.66 on blind side.

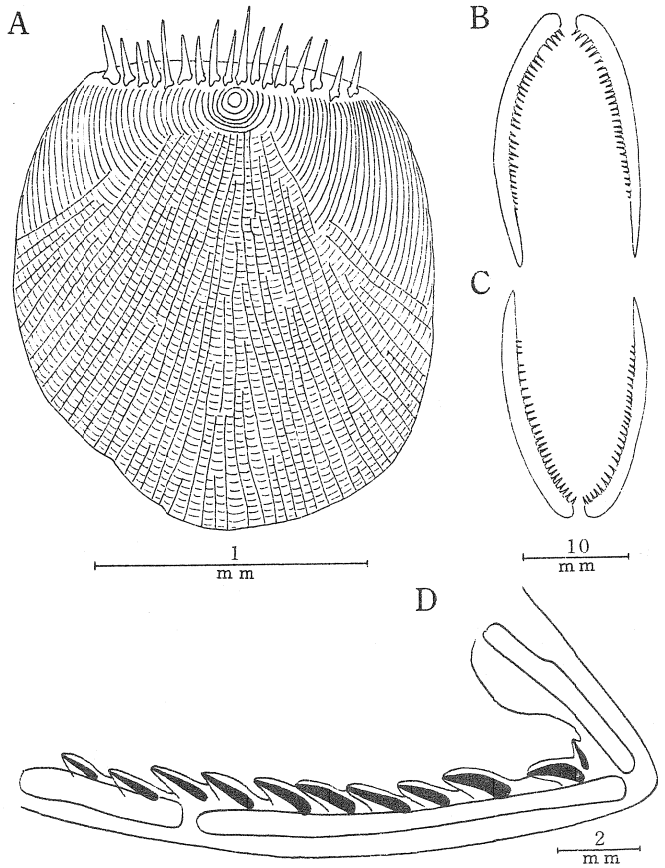

Fig. 61. Scales on ocular side (A), upper jaw (B), lower jaw (C) and first gill-arch on ocular side (D) in *Bothus mancus* (BROUSSONET). Lateral view (A, D); ventral view (B); dorsal view (C).

Body ovate and rather deep, moderately compressed, highest at middle part of body, its depth more or less higher than half its length; dorsal and anal contours well arched evenly. Caudal peduncle rather deep, about equal to 1/5 depth of body.

Head obtuse, rather large in size, about equal to half depth of body; upper profile with a deep concave before upper margin of lower eye, from which it gently rises and more or

less convex above upper eye. Snout blunt and rather long, about equal to 1.5 eye diameter. Eyes small, about half length of maxillary, separated by a broad flattish space; upper eye strongly posterior in position, anterior margin slightly behind vertical line through posterior margin of lower. Nostrils closed together, set in front of upper margin of lower eye, anterior one tubular with a elongate flap posteriorly, posterior one more or less tubular and without a flap; nostrils on blind side small, closely setting below origin of dorsal, anterior one tubular with a flap.

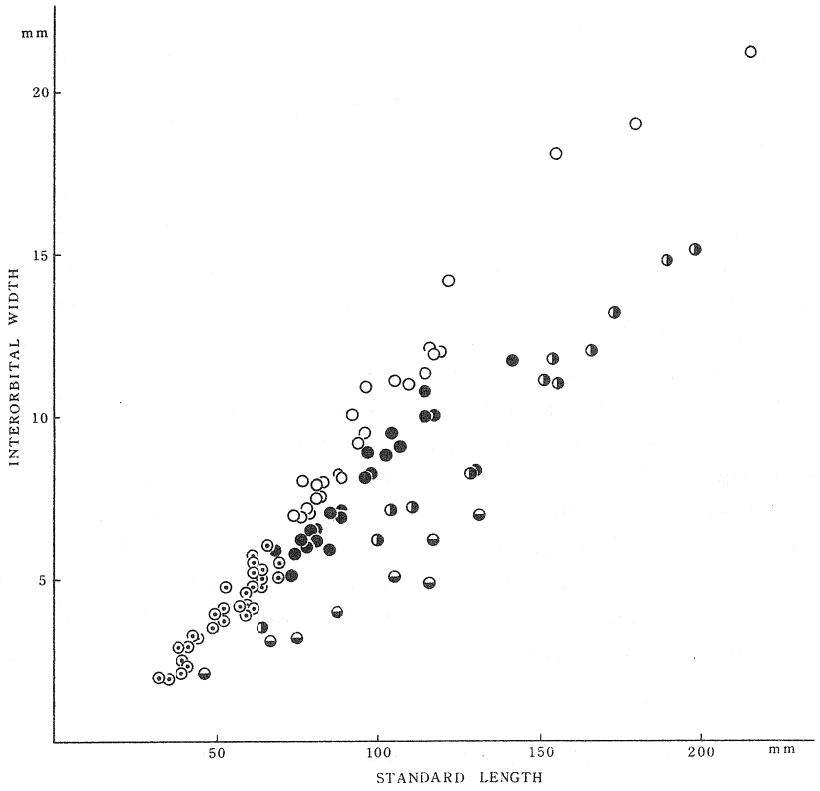

Fig. 62. Sexual dimorphism found in interorbital width of three species of *Bothus*. *B. myriaster* (○, male; ●, female; ⊙, young); *B. mancus* (◑, female); *B. pantherinus* (◒, female).

Mouth large, oblique and gently curved, maxillary extending to below or a little beyond anterior border of lower eye; lower jaw slightly projecting beyond tip of upper, with a prominent triangular symphysial knob. A rounded dermal flap projecting at middle part of chin. Teeth small and uniserial, about equally developed on both sides; those on upper jaws more or less enlarged anteriorly (Fig. 61, B, C). Gill-rakers moderately long, pointed at tip, not serrate on posterior margin; none on upper limb (Fig. 61, D).

Scales small and not deciduous, moderately ctenoid on ocular side with short spinules on apical margin (Fig. 61, A), those on blind side with cycloid; snout, both jaws and pectoral fin naked. Lateral line on ocular side with a strong curve above pectoral fin, length of curved portion as long as or longer than half length of head, height a little higher than half length of its portion, the line on blind side absent.

Origin of dorsal fin on blind side, before horizontal through upper margin of lower eye; fin rays gradually becoming higher to posterior 1/4 of body, and then decreasing in height rather sharply. Anal fin inserted immediately behind ventral fin, and resembles dorsal fin in both shape and structure. Pectoral fins unequal in both sides, that on blind side about 1.5 in that on ocular side, all rays simple. Ventral fin on ocular side inserted on vertical through middle part of lower eye; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, inner 13 rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body brownish, with numerous dark or blackish brown markings; numerous ringlike markings equal to or smaller than eye, scattered irregularly everywhere body; a difuse dark blotch at junction of straight and curved parts of lateral line, another on middle of straight part of it, and smaller and less distinct blotch near base of caudal fin; a series of less defined dark blotches placed along upper and lower contours of body. Vertical and ventral fins brownish, with difused blackish brown or dark blotches, and pale roundish specks. Pectoral fin rather pale, with blackish brown spots arranged as cross bars. Blind side of body yellowish milky.

Sexual dimorphism: No male specimens have come under author's examination, but according to NORMAN (1934), the male fish of this species can be distinguished from the female and young in the following points: 1) a strong spine on the snout, and another in front of the lower orbital ridge, 2) three or four small spines anteriorly on the upper orbital ridge, 3) some dermal appendages on the eyes, 4) wider interorbital space, 5) greatly produced pectoral fin on the ocular side.

Bothus pantherinus (RÜPPELL) "Toge-daruma"

Fig. 63

Rhombus pantherinus RÜPPELL, 1830-31, 121.
Rhomboidichthys pantherinus. GÜNTHER, 1862, 436. ——GÜNTHER, 1909, 342.
Platophrys (Platophrys) pantherinus. BLEEKER, 1866-72, 11, pl. 2, fig. 3.
Platophrys pantherina. DAY, 1889, 443, fig. 158.
Platophrys pantherinus. JORDAN and EVERMANN, 1905, 512. ——JORDAN and SEALE, 1906, 412. ——JORDAN and RICHARDSON, 1908, 280. ——REGAN, 1908, 232. ——JORDAN and JORDAN, 1922, 24. ——FOWLER, 1928, 91. ——HERRE, 1934, 104. ——MUNRO, 1958, 283.
Bothus pantherinus. BERNARD, 1925, 385. ——NORMAN, 1926, 252. ——NORMAN, 1927, 33. ——MCCULLOCH, 1929, 276. ——BORODIN, 1932, 74. ——NORMAN, 1934, 234, fig. 177. ——ROXAS and MARTIN, 1937, 66. ——FOWLER, 1938, 272. ——OKADA and MATSUBARA, 1938, 423. ——NORMAN, 1939, 100. ——HERRE, 1941, 390. ——SCHULTZ, 1943, 59. ——SMITH, 1949, 160, fig. 317. ——FOWLER, 1949, 61. ——MARSHALL, 1950, 201. ——HERRE, 1953, 181. ——MATSU-

BARA, 1955, 1260. —— MUNRO, 1955, 261. ---- NIELSEN, 1961, 219. ---- MATSUBARA and OCHIAI, 1963, 86.

Materials: Female- Nos. 33023-33026, 45.8-117.0 mm in standard length, Amami Islands, June 30, 1958. Four specimens (no number), 66.9-131.0 mm, Amami Islands, June 30, 1958.

Diagnosis: A *Bothus* with rather large eye, 3.9-4.5 in head; dorsal profile not convex above upper eye, but evenly arched.

Description: Dorsal fin rays 88-93; anal fin rays 65-72; pectoral fin rays 10-11 on ocular side, 9-11 on blind side; scales in lateral line 70-78; gill-rakers on first arch 0-5+6-7; vertebrae including urostyle 10+27-28=37-38. Head 3.32-3.6 in standard length; depth 1.73-1.86. Snout 4.06-4.71 in head; upper eye 3.85-4.46; lower eye 3.45-4.53; interorbital width 5.37-6.62; maxillary 2.76-3.27 on ocular side, 2.54-2.76 on blind side; lower jaw 1.95-2.14 on ocular side, 1.83-1.98 on blind side; depth of caudal peduncle 2.37-2.85; longest dorsal fin ray 2.26-2.47; longest anal fin ray 2.22-2.47; pectoral fin 1.31-1.44 on ocular side, 1.72-2.21 on blind side; ventral fin 2.07-2.40 on ocular side, 2.62-2.79 on blind side; base of ventral fin 2.4-2.68 on ocular side, 4.61-4.93 on blind side.

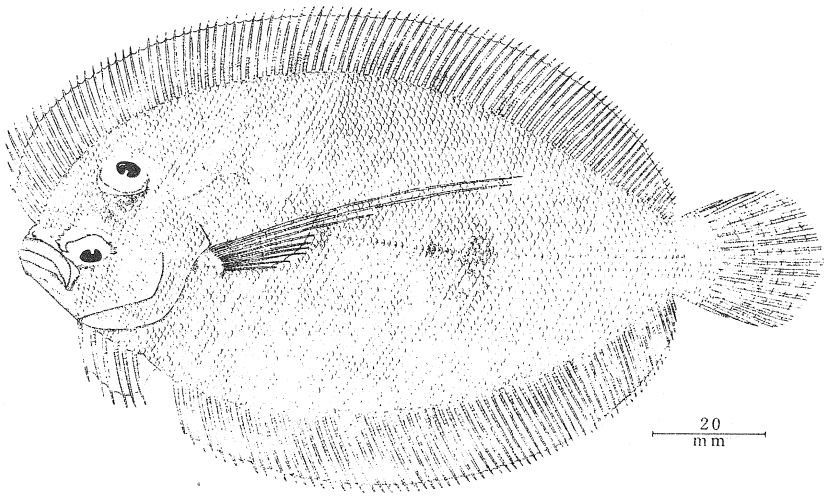

Fig. 63. Lateral view of *Bothus pantherinus* (RÜPPELL) from female specimen: No. 33023, 117.0 mm in standard length.

Body ovate, moderately compressed, highest at middle part of body, its depth much more than half its length; dorsal and anal contours well convex and evenly arched. Caudal peduncle moderate in depth, a little higher than 1/5 depth of body.

Head obtuse, rather large in size, about equal to or slightly longer than half depth of body; upper profile with a feebly notched before middle part of lower eye, from which it roundly rises. Snout rather long, about as long as or a little less than eye diameter. Eyes large, about 1.5 length of maxillary, widely separated by a flattish concave space; upper

eye posterior in position than in lower one, its anterior border on vertical through middle part of lower eye; one or two short fleshly tentacles on hinder margin of eye-lid. Nostrils closed together; those on ocular side tubular, anterior one furnished with a flap on anterior tip of tube; nostrils on blind side very small, tubular, anterior one with a flap posteriorly, posterior one without such flap.

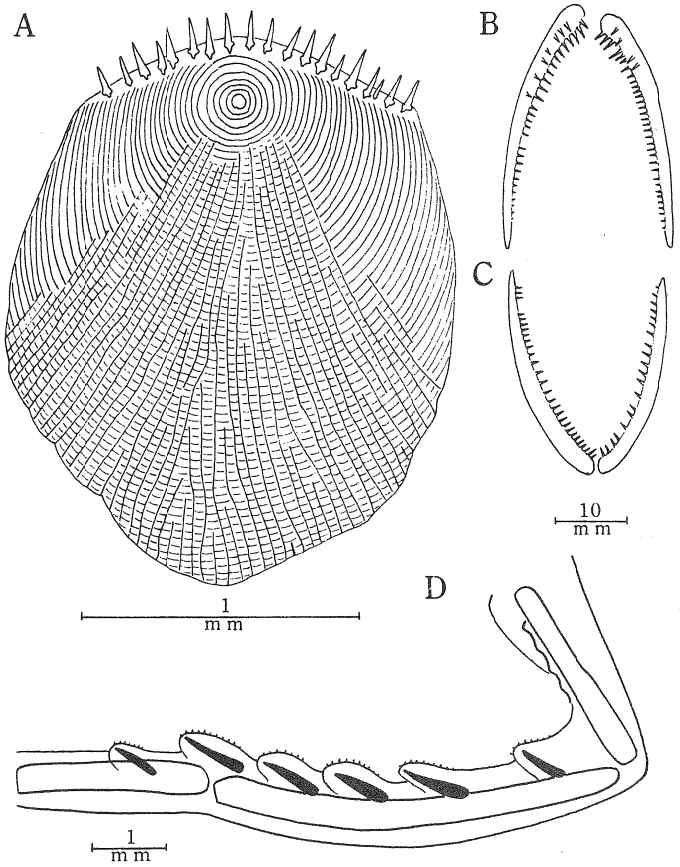

Fig. 64. Scale on ocular side (A), upper jaw (B), lower jaw (C) and first gill-arch on ocular side (D) in *Bothus pantherinus* (RÜPPELL). Lateral view (A, D); ventral view (B); dorsal view (C).

Mouth rather large, oblique and gently curved, maxillary extending to below or slightly beyond anterior border of pupil of lower eye, about 1/3 length of head; lower jaw slightly projecting in advance of tip of upper one without symphysial knob. Teeth small and close-set, about equally developed on both sides; those on upper jaws biserial on its anterior half, and more or less enlarged anteriorly; teeth on lower jaws uniserial, a little stronger than

lateral teeth of upper jaw (Fig. 64, B, C). Gill-rakers slender and rather short, not serrate on posterior margin; none or rudimentary on upper limb (Fig. 64, D).

Scales small and not deciduous, moderately ctenoid on ocular side with short spinules on apical margin (Fig. 64, A), those on blind side with cycloid; snout, both jaws and pectoral fin naked. Lateral line on ocular side with a small curve above pectoral fin; length of curve portion much shorter than half length of head; height a little less than half length of its portion; the line absent on blind side.

Dorsal fin inserted on blind side, before horizontal through upper margin of lower eye; fin rays gradually becoming higher to posterior 1/3 of body, and then decreasing in height gently. Anal fin starting immediately behind ventral fin on ocular side, fin similar in shape and structure to dorsal. Pectoral fins asymmetrical in both sides, all rays simple. Ventral fin on ocular side originating on vertical through middle part of lower eye, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, inner 13 rays branched, but others simple.

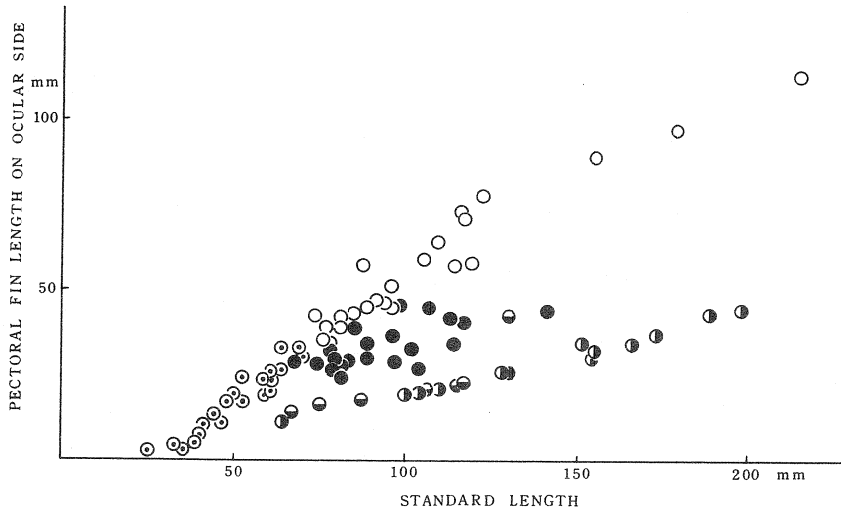

Fig. 65. Sexual dimorphism found in pectoral fin length of three species of *Bothus*. *B. myriaster* (○, male; ●, female); *B. mancus* (◑, female); *B. pantherinus* (◒, female).

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body brownish with numerous dark or blackish brown markings; a large blackish brown blotch on middle of straight part of lateral line, sometimes similar one at junction of straight and curved parts of lateral line. Vertical and ventral fins darkish brown, with dark or blackish spots and specks; dorsal and anal fins with a series of markings. Pectoral fin pale, with blackish brown spots arranged as cross bars.

Sexual dimorphism: No male fishes have come under author's examination, but according to NORMAN (1934), the male fish of this species can be distinguished from the female and young in the following points: 1) one or more irregular bony tubercles on the snout and in front of lower eye, and often one or two in front of upper eye, 2) wider interorbital space, 3) upper rays of the pectoral fin greatly prolonged, sometimes reaching the base of the caudal fin.

Remarks: The present species is closely related to the preceding species, *B. mancus* in general physiognomy and coloration, but differs from it in having large number of dorsal and anal fin rays and gill-rakers, and larger eye.

34. Genus *Asterorhombus* TANAKA

Asterorhombus TANAKA, 1915, 567 (type-species by original designation: *Asterorhombus stellifer* TANAKA).

Body ovate, moderately compressed; tip of isthmus below posterior margin of lower eye. Anterior dorsal profile similar in both sexes. Caudal peduncle very deep in depth. Head rather large, much longer than 1/4 standard length. Eyes sinistral, separated by a narrow concave space, which is deep in depth, interorbital region similar in both sexes. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one tubular with a flap posteriorly and posterior one somewhat tubular without a flap. Mouth oblique, heavy, rather large in size, maxillary extending below anterior margin of lower eye. Teeth uniserial on both jaws, teeth on upper jaw somewhat enlarged anteriorly, gradually becoming small, short and close-set backward; teeth on lower jaw similar in size to anterior teeth on upper jaw. Gill-rakers rather few in number, palmate. Scales rather large, feebly ctenoid on ocular side, cycloid on blind side; snout, jaws and interorbital area scaleless; pectoral and ventral fins naked.

Dorsal fin originating on horizontal through lower margin of upper eye, all rays simple; first ray somewhat prolonged in both sexes. Anal fin originating on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, the fin on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Left ventral fin starting on tip of isthmus, third ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded; uppermost and lowermost two rays simple, other rays branched.

Vomer toothless. Interorbital bone somewhat wide, composed of interorbital bar and prefrontal on ocular side, and interorbital process entirely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 99, D1, D2; Fig. 104, D). Alisphenoid on ocular side very small in size, not extending to orbital cavity. Opisthotic large, triangular in shape, tip of which extends to tip of basioccipital, surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 99, D1, D2).

Suborbital bones on blind side three in number. Urohyal fishhook-like in shape, tip of sciatic part a little beyond that of main part, tapering front; cardiac apophysis somewhat

large in size, with a pair of lateral ridges (Fig. 115, L). Opening for notochord moderate in diameter, and more advanced than middle part of centrum. Anterior transverse apophysis beginning with second vertebra. Four caudal plates branched in many parts (Fig. 127, K).

Remarks: The characters distinguishing the present genus from the genus *Arnoglossus* appear in eyes well separated by a concave space, rather small number of vertebrae (10+26=36), palmate gill-rakers and four caudal plates branched. Such differentiations are enough to separate this group from *Arnoglossus* as a distinct genus.

Asterorhombus intermedius (BLEEKER) "Seiten-birame or Madara-daruma"

Fig. 66

Platophrys (*Arnoglossus*) *intermedius* BLEEKER, 1866, 47. ——BLEEKER, 1866-72, 14, pl. l, fig. 1.
Engyprosopon intermedius. REGAN, 1908, 235.
Asterorhombus stellifer TANAKA, 1915, 567. ——OKADA and MATSUBARA, 1938, 419. ——MATSUBARA, 1955, 1254.
Arnoglossus intermedius. NORMAN, 1926, 248. ——NORMAN, 1927, 22, pl. 4. ——FOWLER, 1928, 90. ——MCCULLOCH, 1929, 277. ——HERRE, 1931, 104. ——NORMAN, 1934, 198, fig. 146. ——ROXAS and MARTIN, 1937, 66. ——MUNRO, 1958, 283. ——KAMOHARA, 1959, 7. ——KAMOHARA, 1964, 81. ——SHIH-CHIEH, 1966, 177, figs. 36-38.

Materials: Male- Kochi Univ. No. 8376, 122.0 mm in standard length, Mimase, Kochi Pref., July 1, 1958. Female- No. 17541, 103.5 mm, Miya, Aichi Pref., March 15, 1952.

Diagnosis: An *Asterorhombus* having eyes separated by a narrow concave space, palmate gill-rakers and elongate first dorsal ray.

Description: Dorsal fin rays 82-85; anal fin rays 63; pectoral fin rays 11 on ocular side, 9-10 on blind side; scales in lateral line 53-54; gill-rakers on first arch 0+8-9; vertebrae including urostyle 10+26=36. Head 3.47-3.59 in standard length; depth 2.19-2.3. Snout 3.47-4.05 in head; upper eye 5.24-5.4; lower eye 5.64-5.94; interorbital width 1.6-1.67; maxillary 2.35-2.59 on ocular side, 2.52-2.56 on blind side; lower jaw 1.8-1.85 on ocular side, 1.7-1.82 on blind side; depth of caudal peduncle 2.1-2.13; longest dorsal fin ray 2.24-2.42; first dorsal fin ray 2.23-2.5; longest anal fin ray 2.08-2.35; pectoral fin 1.93-2.0 on ocular side, 2.4-2.54 on blind side; ventral fin 2.3-2.68 on ocular side, 2.79-3.07 on blind side; base of ventral fin 2.66-3.13 on ocular side, 4.64-6.95 on blind side.

Body ovate, rather compressed, highest at middle part of body, about 1.6 length of head; dorsal and anal contours evenly arched with a deep notch on horizontal through lower margin of upper eye. Caudal peduncle deep, a little less than 1/3 depth of body.

Head blunt and large about two depth of caudal peduncle. Snout blunt and rather long, about 1.5 diameter of lower eye; swell at tip and deeply concave in front of interorbital area. Eyes small in size, separated narrowly by a deep concave space, its width about 1/3 diameter of upper eye; lower eye a little smaller than upper, and anterior margin of lower eye a little advance of or about at same level to anterior margin of upper eye. Nostrils on ocular side in front of interorbital area, anterior one tubular with a short flap posteriorly, posterior one somewhat tubular, without a flap; nostrils on blind side below

origin of dorsal, anterior tubular with a short flap dorsally.

Mouth oblique and curved gently at middle part of maxillary, which nearly extends to below anterior edge of lower eye or a little beyond it, a little more than two diameter of lower eye. Teeth uniserial on both jaws, developed almost equally on both sides of jaws; teeth on upper jaw somewhat enlarged anteriorly, gradually becoming small, short and close-set backward; teeth on lower jaw similar in size to anterior teeth on upper jaw, stronger and wider apart than lateral teeth on upper jaw. Gill-rakers palmate, with five to eight strong spinules on its margin; none on upper limb (Fig. 112, C).

Scales rather large in size, feeble ctenoid on ocular side (Fig. 67), cycloid on blind side; snout, jaws and interorbital area scaleless; pectoral and ventral fins naked. Lateral line curved above pectoral fin on ocular side, length of curved portion a little less than 2/3 length of head, the height about 1/3 length of its portion; the line absent on blind side.

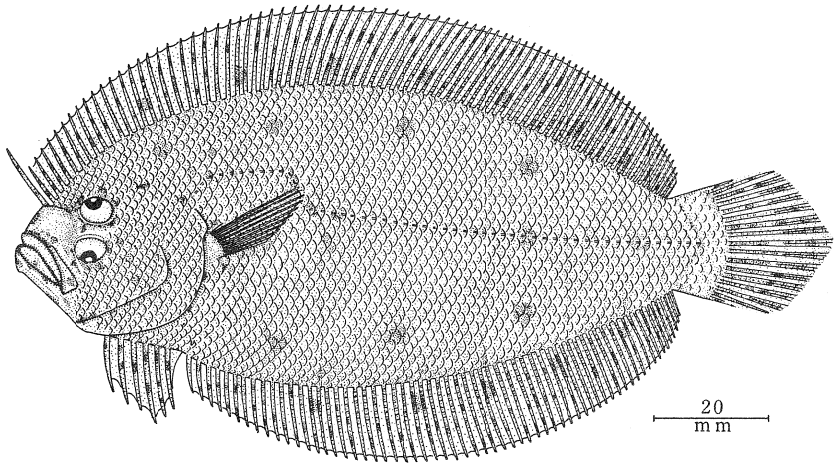

Fig. 66. Lateral view of *Asterorhombus intermedius* (BLEEKER) from male specimen: Kochi University No. 8373, 122.0 mm in standard length.

Dorsal fin originating on blind side, on horizontal through lower margin of upper eye, the first ray prolonged, about 1.5 length of snout; remaining rays becoming higher toward posterior 1/3 on body, and evenly decreasing in height posteriorly; all rays simple. Anal fin starts on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side feeble and short, a little more than half length of head, second or third ray longest; the succeeding rays becoming shorter ventrally; that on blind side feeble, but rather long, equal to or a little less than that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, base as well as rays longer than those on blind side; fourth ray opposite to first on blind side. Caudal fin pointed, uppermost and lowermost two rays simple, others branched.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular

side, on opposite side of vent.

In formalin, general ground color on ocular side of body brownish, with a series of dark brown blotches along upper and lower edges of body; less defined blotches on lateral line; head with irregularly scattered blackish spots. All fins with numerous dark brown spots; a row of larger spots along basal parts of dorsal and anal. Body on blind side milky white.

Remarks: The specimens examined here agree well with BLEEKER's original description of the species. On the other hand, *Asterorhombus stellifer* briefly described by TANAKA (1915) as new species and new genus is thought to be a synonym of this species which is allied well with the present species in the meristic characters, the proportional measurements of the body parts, the number and shape of the gill-rakers, prolonged first dorsal ray and coloration.

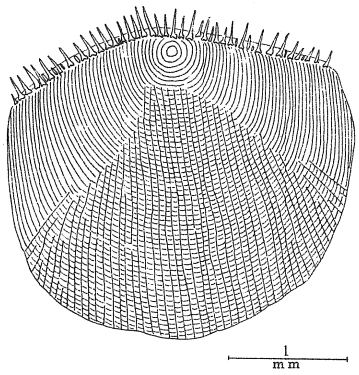

Fig. 67. Scale on ocular side in *Asterorhombus intermedius* (BLEEKER).

35. Genus *Psettina* HUBBS

Psettina HUBBS, 1915, 456 (type-species by original designation: *Engyprosopon iijimae* JORDAN and STARKS).

Crossolepis NORMAN, 1927, 22 (type-species by original designation: *Arnoglossus brevirictis* ALCOCK).

Body elliptical, moderately compressed; tip of isthmus below posterior margin of or slightly in front of lower eye. Anterior dorsal profile similar in either sex. Head small, 3.5-4.5 in standard length. Eyes sinistral, separated by a narrow ridge or very narrow space; lower slightly before upper or both about at same vertical; interorbital region similar in both sexes. A blunt rostral and mandibular spines present or not. Nostrils on both sides two, anterior one tubular with a flap posteriorly and posterior one more or less tubular, without a flap; those on blind side setting below origin of dorsal, similar in shape and structure to those on ocular side. Mouth oblique, rather small in size, maxillary extending to below anterior edge of lower eye; teeth all small, scarcely enlarged anteriorly; teeth on upper jaw uniserial or biserial, but those on lower jaw always uniserial. Gill-rakers small in size and rather slender; rather few in number; not serrate on posterior margin. Scales small in size and not deciduous; strongly ctenoid on ocular side, armed with the elongate spinules; blind side with cycloid scales.

Dorsal fin originating on blind side and on horizontal through interorbital area, highest

at middle part of body; all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in either sex, all rays simple. Left ventral fin originating on tip of isthmus, fourth ray on ocular side opposite to the first on blind side, all rays simple. Caudal fin rounded posteriorly; uppermost and lowermost two rays simple, other rays branched.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated with each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 99, C1, C2; Fig. 104, D). Alisphenoid on ocular side very small, not extending to orbital cavity. Basioccipital triangular in shape, when viewed from lateral. Opisthotic triangular in shape, its tip extending to tip of basioccipital, and surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 99, C1, C2).

Suborbital bone on blind side three in number (Fig. 108, C). Second hypobranchial rectangular or elliptical in shape without toothed plate; third basibranchial rectangular concave deeply in both sides of anterior part (Fig. 113, J). Urohyal fishhook-like in shape, tip of sciatic part extending to vertical of tip of main part, tapering front; cardiac apophysis moderate in size, with a pair of wings (Fig. 115, K). Opening for notochord moderate in diameter, and more advanced than middle part of centrum; anterior transverse apophysis beginning with second vertebra. Four caudal plates with several grooves on each surface (Fig. 127, G).

Remarks: The present genus closely related to *Arnoglossus* in having the eyes separated by a narrow ridge or very narrow space and in the many osteological features, but separable from it in having strongly ctenoid scales armed with long hairlike spinules, rather the small mouth, and teeth scarcely enlarged anteriorly. It also resembles *Crossorhombus* and *Tosarhombus* in the feature of scales on the body, but apparently differs from the latters in many osteological features.

36. Key to species of *Psettina*

A^1 Dark spots along upper and lower edges of body enter basal parts of dorsal and anal fins; a dark patch on distal part of pectoral fin; hinder part of caudal fin with a broad blackish band; teeth on both jaws uniserial; upper limb with gill-rakers ..... ***Psettina iijimae*** (JORDAN and STARKS)

A^2 Dark spots along upper and lower edges of body not enter bases of dorsal and anal fins; pectoral and caudal fins without blackish band; teeth on upper jaw biserial but on lower jaw uniserial; no gill-rakers on upper limb.

B^1 Maxillary rather large, 2.7-3.2 in head (Fig. 73); scales in lateral line 56-61; pectoral fin with 11-12 rays on ocular side; snout and both jaws dark ..... ***Psettina gigantea*** AMAOKA

B^2 Maxillary short, 3.3-3.9 in head (Fig. 73); scales in lateral line 45-53; pectoral fin with 8-11 rays on ocular side; snout and both jaws pale brown ..... ***Psettina tosana*** AMAOKA

Psettina iijimae (JORDAN and STARKS) "Iijima-darumagarei"

Fig. 68

Engyprosopon iijimae JORDAN and STARKS, 1904, 626, pl. 8, fig. 1. ——JORDAN and STARKS, 1906, 171, fig. 3. ——FRANZ, 1910, 62. ——JORDAN, TANAKA and SNYDER, 1913, 311, fig. 263. *Psettina iijimae*. HUBBS, 1915, 456. ——JORDAN and HUBBS, 1925, 295. ——KAMOHARA, 1936, 4. ——KAMOHARA, 1938, 59. ——OKADA and MATSUBARA, 1938, 421. ——KURONUMA, 1940, 213. ——KAMOHARA, 1950, 240.——KURODA, 1951, 389. ——MORI, 1952, 177. ——MATSUBARA, 1955, 1258. ——KAMOHARA, 1958, 62. ——AMAOKA, 1963, 54, fig. 1. ——KAMOHARA, 1964, 81.

Materials: Nos. 15842-15846, 64.1-82.0 mm in standard length, Mimase, Kochi Pref., February 20-28, 1951. Nos. 17560-17561, 64.2-79.9 mm, Miya, Aichi Pref., March 15, 1952. No. 19658, 69.5 mm, Nobeoka, Miyazaki Pref., December 10, 1952. Nos. 28654-28697, 50.9-85.1 mm, Mimase and Urado, Kochi Pref., July 1956.

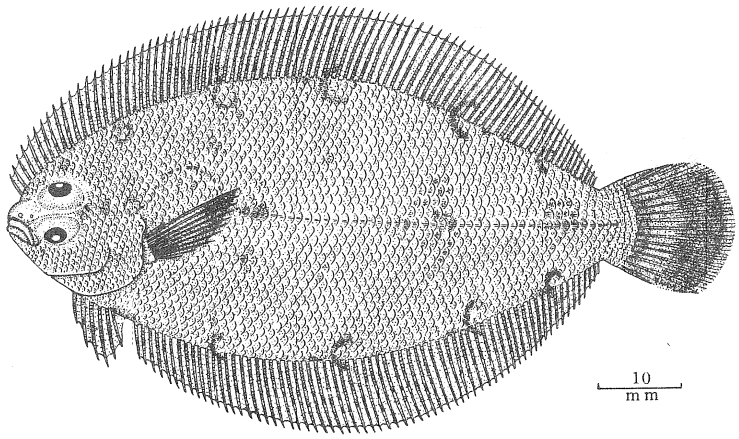

Fig. 68. Lateral view of *Psettina iijimae* (JORDAN and STARKS): No. 28688, 73.8 mm in standard length.

Diagnosis: A dwarf *Psettina* with a dark patch on pectoral fin and a blackish band on caudal fin; teeth uniserial on both jaws.

Description: Dorsal fin rays 81-93; anal fin rays 62-71; pectoral fin rays 11-13 on ocular side, 8-12 on blind side; scales in lateral line 53-61; gill-rakers on first arch 2-5+4-6; vertebrae including urostyle 10+26-28=36-38. Head 3.79-4.42 in standard length; depth 2.03-2.34. Snout 3.89-6.8 in head; upper eye 2.59-4.49; lower eye 2.88-3.92; maxillary 3.11-4.06 on ocular side, 3.02-3.82 on blind side; lower jaw 2.14-2.63 on ocular side, 2.01-2.56 on blind side; depth of caudal peduncle 1.7-2.17; longest dorsal fin ray 1.78-2.6; longest anal fin ray 1.69-2.37; pectoral fin 1.26-1.55 on ocular side, 2.2-3.01 on blind side; ventral fin 2.24-3.0 on ocular side, 2.36-3.23 on blind side; base of ventral fin 2.66-4.25 on ocular side, 5.02-9.4 on blind side.

Body elliptical, moderately compressed, highest at middle part of body, its depth a little less than half length of body; dorsal and anal contours evenly arched. Caudal peduncle moderate in depth, merely or more than 1/4 depth of body.

Head rather small, about half depth of body; upper profile with a slight notch in front of eye, from which it slowly rises. Snout short, about half eye diameter. Eyes small in size, a little shorter than length of maxillary, separated by a narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one; lower very slightly in front of upper or both about at same vertical. Nostrils on ocular side in front of interorbital ridge; those on blind side very small, located below origin of dorsal; anterior one tubular with a short slender flap, posterior one not tubular, without flap.

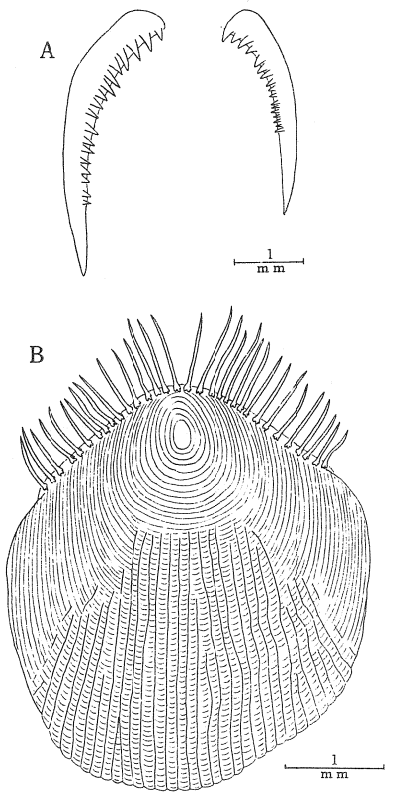

Fig. 69. Upper jaw (A) and scale on ocular side (B) in *Psettina iijimae* (JORDAN and STARKS). Ventral view (A); lateral view (B).

Mouth asymmetrical and curved, very small (Fig. 73), maxillary extending to below or slightly beyond anterior margin of lower eye; lower jaw with a very small symphysial knob. Dentition on blind side more developed than that on ocular side; teeth uniserial and close-set on both sides gradually becoming small posteriorly; teeth on blind side stronger than those on ocular side (Fig. 69, B). Gill-rakers on first arch and slender, diminishing in size on upper limb, two to five on epibranchial and four to six on ceratobranchial; not serrate on each margin (Fig. 112, E).

Scales small, and not deciduous; those on ocular side of body ctenoid with elongate spinules (Fig. 69, B), but those on blind side with cycloid opposite being case with the former; snout, both jaws and interorbital ridge naked. Lateral line curved anteriorly on ocular side; the line absent on blind side.

Dorsal fin starting on blind side, on level with interorbital area, fin rays becoming higher posteriorly toward near middle of body, and evenly decreasing in height posteriorly. Anal fin originating on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side short, second ray longest, but much less than head; succeeding rays becoming shorter ventrally; that on blind side very short, about 1.5 in

length of that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, uppermost and lowermost two rays simple, but others branched.

Vent located on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite of vent.

In formalin, general ground color on ocular side of body darkish brown, a series of rather prominent dark blotches along both upper and lower edges of body enter basal regions of dorsal and anal fins respectively; two or four large, but less defined blotches on lateral line; a dark patch on distal part of pectoral fin; hinder part of caudal fin with a broad blackish band.

Remarks: As pointed out by AMAOKA (1963), the present species is closely related to *Psettina brebirictis* (ALCOCK) known from Indian and Celebes in the coloration, but differs from it in having the small head and a smaller number of gill-rakers and scales on lateral line.

On the other hand, the present species is clearly distinguishable from any other Japanese species referable to the present genus in having uniserial teeth on both jaws, gill-rakers on the upper limb of the gill-arch and the particular coloration.

Psettina gigantea AMAOKA "Soko-daruma"

Fig. 70

Psettina iijimae. NORMAN (in part), 1931, 600. ——NORMAN, 1934, 200, fig. 148.
Psettina profunda. KAMOHARA, 1959, 7.
Psettina gigantea AMAOKA, 1963, 56, fig. 3. ——KAMOHARA, 1964, 82.

Materials: No. 15849, 96.5 mm in standard length, Mimase, Kochi Pref., February 25, 1951. No. 18232, 109.5 mm, Mimase, October 10, 1952. Nos. 28705-28712, 103.4-121.9 mm, Mimase, September 5, 1958. No. 28713, 105.6 mm, Susaki, Kochi Pref., September 10, 1958. Nos. 28714-28726, 58.1-105.3 mm, Mimase, October 13, 1958. Nos. 28727-28729, 120.2-108.9 mm, Susaki, October 25, 1958. Nos. 28730-28733, Nos. 28735-28740, 86.7-109.2 mm, Mimase, February 14, 1959.

Diagnosis: A *Psettina* with large number of scales in lateral line; both jaws dark.

Description: Dorsal fin rays 90-103; anal fin rays 69-80; pectoral fin rays 11-12 on ocular side, 9-11 on blind side; scales in lateral line 56-61; gill-rakers on first arch 0+6-8; vertebrae including urostyle 10+28-30=38-40. Head 3.84*-4.26 in standard length; depth 2.04-2.41. Snout 4.83-6.34 in head; upper eye 2.88-3.62; lower eye 2.88-3.64; maxillary 2.7-3.2 on ocular side, 2.73-3.34 on blind side; lower jaw 2.02-2.36 on ocular side, 1.84-2.35 on blind side; depth of caudal peduncle 1.89-2.38; longest dorsal fin ray 1.46-2.11; longest anal fin ray 1.67-2.1; pectoral fin 1.38-1.79 on ocular side, 2.08-3.06 on blind side; ventral fin 2.0-2.95 on ocular side, 2.6-3.45 on blind side; base of ventral fin 2.4-3.2 on

*No. 28734 described by AMAOKA (1963) as the paratype has the head 3.3 in standard length, but it is excluded from the measurements of the paratypes for a teratological specimen.

ocular side, 4.68-7.2 on blind side.

Body elliptical, moderately compressed, highest at middle part of body, its depth less than half its length; dorsal and anal outlines evenly arched except for head profile. Caudal peduncle comparatively narrow, about 1/4 depth of body.

Head blunt, small, about half depth of body; upper profile deeply concave in front of lower margin of upper eye. Snout blunt, short, 1.6 in eye diameter and shorter than 1/4 length of head. Eyes rather large, about equal to length of maxillary, separated by a very narrow space or ridge in anterior half, and by a ridge in posterior half; lower slightly in advance of upper. Nostrils on ocular side in same horizontal; anterior one tubular with a short slender flap posteriorly; posterior one more or less tubular without a flap; nostrils on blind side setting closely below origin of dorsal. Blunt spine on snout; a similar, but larger one at symphysis of lower jaw.

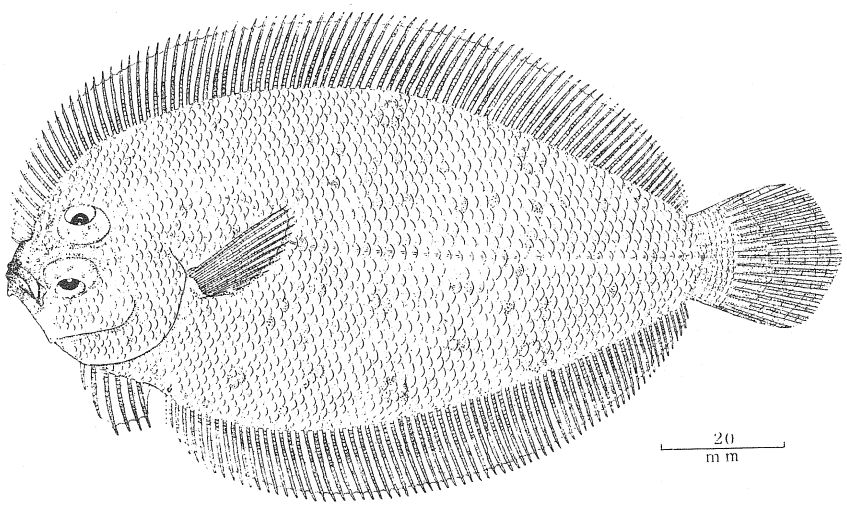

Fig. 70. Lateral view of *Psettina gigantea* AMAOKA: No. 33786, 114.2 mm in standard length.

Mouth oblique, curved and rather large (Fig. 73), maxillary extending to below anterior edge of lower eye; lower projecting slightly in advance of tip of upper jaw when mouth is closed. Teeth small, scarcely enlarged anteriorly; teeth on upper jaw set somewhat regularly in two series, inner ones longer than those on outer ones (Fig. 71, A); teeth on lower jaw uniserial. Gill-rakers on first arch, short and pointed, not serrate on posterior margin; none on epibranchial (Fig. 71, B).

Scales rather small, those on ocular side of body everywhere finely ctenoid, armed with elongate spinules (Fig. 71, C); blind side with cycloid scales; snout and tip of jaws naked, but posterior part of maxillary scaled. Lateral line a strong curve anteriorly, curved portion about 1.5 in head; the line on blind side absent.

Dorsal fin inserted on blind side and before upper eye, fin rays gradually becoming higher to slightly beyond middle of fin and then evenly and gradually decreasing in height posteriorly to end of fin, longest ray being less than half length of head. Anal similar in shape and structure to dorsal. Pectoral short, slender, third ray longest, succeeding ones becoming shorter toward lowermost ray; that on blind side very short, subequal to 2/3 of that on ocular side. Ventral fin on ocular side originating on vertical through slightly before posterior margin of lower eye; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, rays all branched except for two rays both in upper and lower margins of the fin.

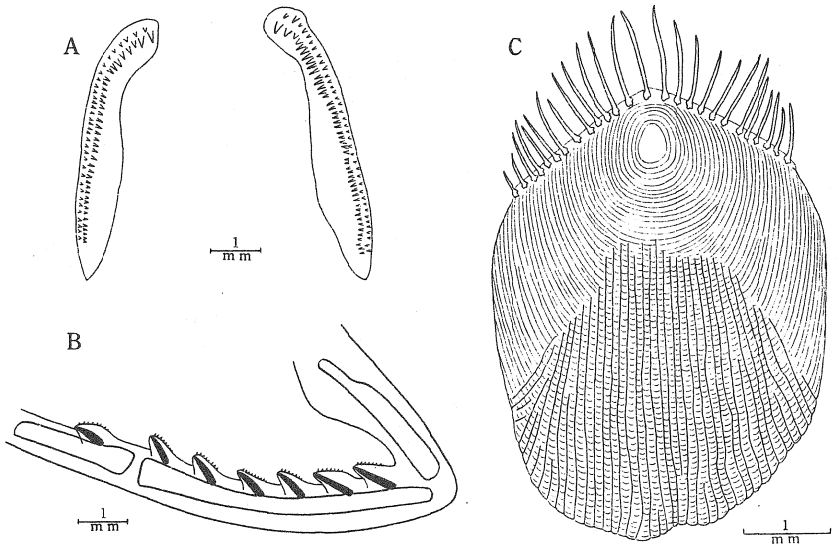

Fig. 71. Upper jaw (A), first gill-arch on ocular side (B) and scale on ocular side (C) in *Psettina gigantea* AMAOKA. Ventral view (A); lateral view (B, C).

Vent opens on blind side, above origin of anal fin; genital papilla displaced on ocular side.

In formalin, general ground color of body on ocular side greyish brown, furnished with dark brown ocellated spots running along both upper and lower contours of body, and also irregularly scattered with several small dark blotches. Snout and both jaws darkish; all fins paler than body; dorsal and anal fins scattered with more or less irregular dark dots. Blind side of body uniformly milky white.

Remarks: As already pointed out by the present author (1963), the present species closely resembles *P. profunda* (WEBER) in a number of the scales in the lateral line, in somewhat large maxillary and in the arrangement of some dark spots along both upper and lower contours of the body, but differs from it in having the short ventral fin on the ocular side, a larger number of pectoral fin rays, somewhat larger eye and more or less shorter snout.

Psettina tosana AMAOKA "Tosa-daruma"

Fig. 72

Psettina tosana AMAOKA, 1963, 59, fig. 5. ——KAMOHARA, 1964, 82.

Materials: No. 28742, 98.6 mm in standard length, Mimase, Kochi Pref., February 14, 1959. Nos. 28743-28764, 28766-28780, 121.6-183.2 mm, Mimase, April 10, 1959. Nos. 28781-28816, 70.0-93.1 mm, Mimase, April 18, 1959. Nos. 28817-28842, 70.9-91.8 mm, Mimase, April 28, 1959.

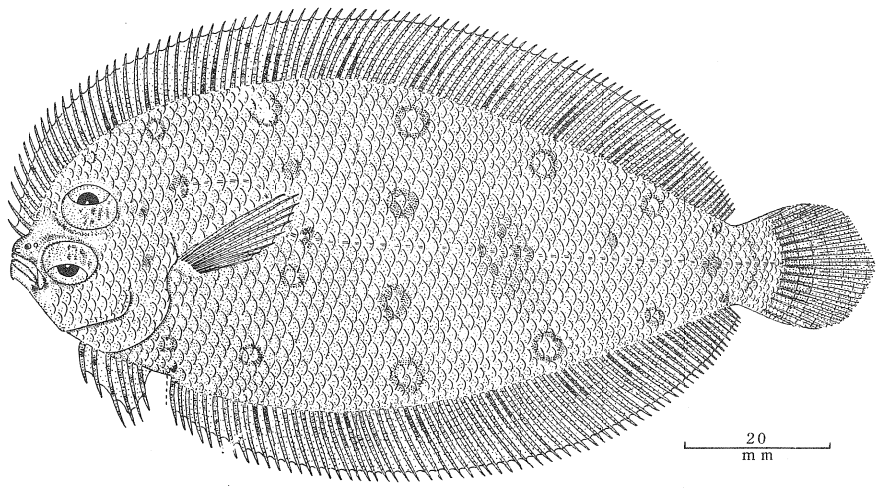

Fig. 72. Lateral view of *Psettina tosana* AMAOKA: No. 28742, 98.6 mm in standard length.

Diagnosis: A *Psettina* with smaller number of scales in lateral line (45 to 53); snout and jaws pale brown.

Description: Dorsal fin rays 89-99; anal fin rays 69-79; pectoral fin rays 8-11 on ocular side, 8-10 on blind side; scales in lateral line 45-53; gill-rakers on first arch 0+6-8; vertebrae including urostyle 10+28-30=38-40. Head 3.91-4.46 in standard length; depth 2.03-2.41. Snout 4.89-7.67 in head; upper eye 2.81-3.73; lower eye 2.7-3.7; maxillary 3.3-3.88 on ocular side, 3.15-3.96 on blind side; lower jaw 2.09-2.7 on ocular side, 1.91-2.5 on blind side; depth of caudal peduncle 1.92-2.39; longest dorsal fin ray 1.91-2.24; longest anal fin ray 1.61-2.28; pectoral fin 0.84-1.5 on ocular side, 2.33-3.39 on blind side; ventral fin 1.97-3.09 on ocular side, 2.4-3.25 on blind side; base of ventral fin 2.0-3.09 on ocular side, 4.1-6.91 on blind side.

Body elliptical, moderately compressed, highest at middle part of body, its depth a little less than half its length; dorsal and anal contours evenly arched with a shallowly concave before upper eye. Caudal peduncle relatively narrow in depth, narrower than 1/4 depth of body.

Head obtuse, small, about half depth of body. Snout short, about 1.8 in eye diameter. Eyes rather large in size, shorter than maxillary on ocular side, separated by a narrow concave space or ridge, lower eye slightly in advance of upper one. Nostrils on ocular side setting closely in front of upper margin of lower eye, anterior one with a short slender flap posteriorly, posterior one more or less tubular; nostrils on blind side setting closely below origin of dorsal, similar in shape and structure to those on ocular side.

Mouth oblique, small, maxillary extending below anterior part of eye; lower projecting slightly beyond tip of upper jaw when mouth is closed. Teeth on upper jaw set in two series, teeth on inner series longer than those of outer series; those on lower jaw uniserial. Gill-rakers on first arch, short pointed and not serrate on posterior margin; none on epibranchial.

Scales rather large, those on ocular side finely ctenoid with elongate slender spinules; those on blind side cycloid. Snout, jaws and pectoral fins naked. Lateral line with strong curve anteriorly, curved portion about 1.4 in head length; the line absent on blind side.

Origin of dorsal on blind side, before horizontal through upper margin of lower orbit; fin rays gradually increasing in height toward longest one near middle of fin, and evenly decreasing in height posteriorly, highest ray about half length of head. Anal fin originating on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fin on ocular side moderate in length, third ray longest, a little shorter or longer than head, succeeding ones becoming shorter toward lowermost ray. Left ventral fin originating on vertical through slightly before posterior margin of lower eye, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, uppermost and lowermost two rays simple, but others branched.

Vent opens on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color of body reddish brown, with dark brown ocellated spots, four above and two below lateral line, a series of well separated seven spots along body near base of dorsal fin and six similar ones along body near base of anal fin; a row of three large, but less defined spots along lateral line. Median fins paler than body; dorsal, anal and left ventral fin with more or less regular dark dots. Blind side of body uniformly milky white.

Remarks: As pointed out by Amaoka (1963), the present species closely resembles *Psettina gigantea,* but differs from it in having a fewer scales in lateral line; a smaller number of pectoral fin rays on the ocular side; a shorter maxillary; and snout and jaws brownish in color at the tip.

37. Genus *Arnoglossus* Bleeker

Arnoglossus Bleeker, 1862, 427 (type-species by original designation: *Pleuronectes arnoglossus* Schneider).

Anticitharus Günther, 1880, 47 (type-species by original designation: *Anticitharus polyspilus* Günther).

Caulopsetta GILL, 1893, 124 (type-species by original designation: *Pleuronectes scaphus* (FORSTER) SCHNEIDER).

Scidorhombus TANAKA, 1915, 567 (type-species by original designation: *Scidorhombus pallidus* TANAKA).

Body elliptical, moderately compressed; tip of isthmus below posterior margin of lower eye. Anterior dorsal profile similar in both sexes. Head rather small, 3.6-4.2 in standard length. Eyes sinistral, separated by a narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one or by very narrow space at anterior half; interorbital region similar in both sexes. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one tubular with a flap posteriorly and posterior one not

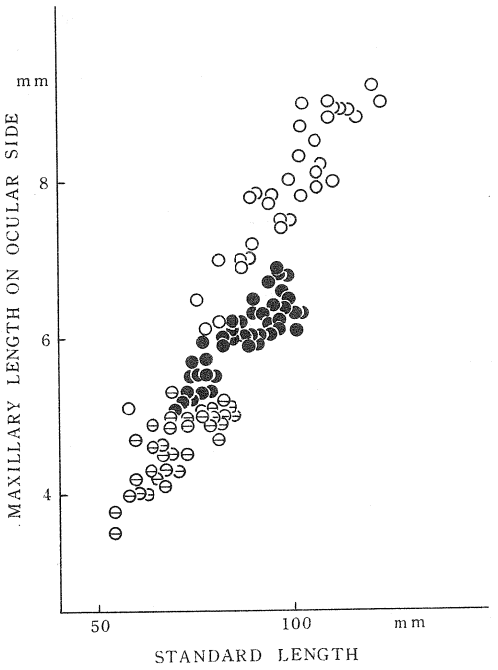

Fig. 73. Maxillary length on ocular side in relation to standard length in three species of *Psettina*. ○, *P. gigantea*; ●, *P. tosana*; ⊖, *P. iijimae*.

tubular, without a flap. Mouth oblique, rather large or moderate in size, maxillary extending below from anterior margin of lower eye to slightly beyond middle part of it, 2.0-2.9 in head; teeth small or moderate in size, sometimes enlarged and caninelike anteriorly, generally lateral teeth on upper jaw becoming smaller and shorter backward; usually those on lower jaw stronger, longer and wider apart than those on upper jaw; teeth on both jaws uniserial. Gill-rakers rather few in number, slender and moderate in length,

sometimes serrate on its posterior margin. Scales moderate or rather small in size, and deciduous; weakly ctenoid with short feeble spines on apical margin, or cycloid on ocular side; cycloid on blind side; snout, both jaws and base of pectoral fin scaleless.

Dorsal fin originating on horizontal through interorbital area and above nostrils on blind side, all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Left ventral fin originating on tip of isthmus, third or fourth ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded; uppermost and lowermost two or three rays simple, other rays branched.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 99, A1, A2, B1, B2; Fig. 104, D). Alisphenoid on ocular side very small, not extending to orbital cavity. Opisthotic large, triangular in shape, tip of which extends to tip of triangular basioccipital, surrounded by prootic, pterotic, exoccipital and basioccipital (Fig. 99, A1, A2, B1, B2).

Suborbital bones on blind side slender, three in number (Fig. 108, A, B; Fig. 110, C). Second hypobranchial rectangular or elliptical in shape without toothed plate; third basibranchial rectangular concave deeply in both sides of anterior part (Fig. 113, G, H). Urohyal fishhook-like in shape, tip of sciatic part extending to vertical from tip of main part, tapering the front; cardiac apophysis moderate in size, with a pair of wings (Fig. 115, I, J; Fig. 117, E). Opening for notochord moderate in diameter, and more advanced than middle part of centrum; anterior transverse apophysis beginning with second vertebra. Four caudal plates not branched (Fig. 128, B).

38. Key to species of *Arnoglossus*

A[1] Scales large, 49-53 in lateral line; mouth small, maxillary on ocular side 2.6-2.9 in head; teeth on upper jaw scarcely enlarged anteriorly, those on lower jaw small, close-set; gill-rakers slender and pointed, without spinules on posterior margin; dorsal 90-95; anal 70-74 ..... ***Arnoglossus tenuis*** GÜNTHER

A[2] Scales small, more than 65 in lateral line; mouth large, maxillary on ocular side less than 2.6 in head; teeth on upper jaw well-enlarged anteriorly; those on lower jaw stronger and wider apart than lateral teeth of upper jaw; gill-rakers rather strong, with spinules on posterior margin; dorsal 99-114; anal 76-91.

B[1] Maxillary extending to below anterior margin or anterior 1/3 of lower eye, 2.3-2.6 in head; generally one to two gill-rakers on upper limb; caudal fin composed of upper and lower two simple rays; snout blunt; body greyish brown ..... ***Arnoglossus polyspilus*** GÜNTHER

B[2] Maxillary extending to below or slightly beyond middle part of lower eye, 2.04-2.3 in head; none gill-rakers on upper limb; caudal fin composed of upper and lower three simple rays; snout sharp; body pale brownish.

C[1] Scales cycloid on ocular side; shortest distance between upper eye and dorsal margin of head nearly equal to half eye diameter; pectoral fin without distinct marking; head 3.6-3.9 in standard length; dorsal 99-106; anal 76-83; scales in lateral line 65-73; vertebrae 10+32–33=42–43 ..... ***Arnoglossus japonicus*** HUBBS

C^2 Scales ctenoid on ocular side; shortest distance between upper eye and dorsal margin of head nearly equal to 1/3 eye diameter; pectoral fin on ocular side with jet-black marking at posterior margin; head 4.0-4.2 in standard length; dorsal 108-113; anal 84-89; scales in lateral line 87-94; vertebrae 11+35=46 ..... ***Arnoglossus oxyrhynchus*** n. sp.

Arnoglossus tenuis GÜNTHER "Naga-darumagarei"

Fig. 74

Arnoglossus tenuis GÜNTHER, 1880, 55. ——JORDAN and SEALE, 1905, 528. ——JORDAN and HUBBS, 1925, 295. ——WU, 1932, 89. ——OKADA and MATSUBARA, 1938, 421. ——KURONUMA, 1940, 213. ——KURODA, 1951, 388. ——MATSUBARA, 1955, 1257. ——SHIH-CHIEH, 1966, 176, figs. 39-41.
Scidorhombus pallidus TANAKA, 1915, 567. ——MATSUBARA, 1955, 1255.

Materials: Nos. 34376-34381, 67.3-72.9 mm in standard length, Mimase, Kochi Pref., July 15, 1960. Nos. 35157-35161, 70.0-96.0 mm, Nagasaki, March 15, 1962. No. 35164, Nos. 35167-35168, 66.9-82.0 mm, Nagasaki, March 15, 1962.

Diagnosis: A dwarf *Arnoglossus* with small number of dorsal, anal and scales in lateral line and small mouth; maxillary extending below anterior margin of lower eye.

Description: Dorsal fin rays 90-95; anal fin rays 70-74; pectoral fin rays 11-13 on ocular side, 9-11 on blind side; scales in leteral line 49-53; gill-rakers on first arch 0+8-9; vertebrae including urostyle 10+30=40. Head 4.05-4.32 in standard length; depth 2.49-2.92. Snout 4.15-5.65 in head; upper eye 3.27-4.09; lower eye 3.27-3.88; maxillary 2.61-2.91 on ocular side, 2.95-3.26 on blind side; lower jaw 2.0-2.2 on ocular side, 2.05-2.26 on blind side; depth of caudal peduncle 2.23-2.47; longest dorsal fin ray 1.62-2.01; longest anal fin ray 1.65-2.03; pectoral fin 1.49-1.83 on ocular side, 2.52-3.11 on blind side; ventral fin 2.39-3.01 on ocular side; 2.36-3.01 on blind side; base of ventral fin 2.8-3.46 on ocular side, 5.5-8.6 on blind side.

Body elliptical, strongly compressed, highest at middle part of body, its depth always more than 1/3 length of body; dorsal and anal contours evenly arched with a slight notch on horizontal through middle part of upper eye. Caudal peduncle rather deep, about 1/4 depth of body.

Head much compressed than body, and very small, a little longer than half depth of body. Snout blunt and rather large, slightly shorter than eye diameter. Eyes moderate in size, shorter than maxillary on ocular side, separated by a low narrow ridge which extends from the anterior margin of lower eye to posterior margin of upper one; lower very slightly in front of upper which closely approaches to dorsal margin of head, shortest distance subequal to 1/4 to 1/5 diameter of eye. Nostrils on ocular side in front of interorbital area; those on blind side very small, located below origin of dorsal; anterior one tubular with a short slender flap, posterior one not tubular, without a flap.

Mouth slightly arched anteriorly and rather small, maxillary extending below or slightly beyond anterior margin of lower eye, a little longer than 1/3 length of head. Teeth on both jaws uniserial, all small, rather close-set, scarcely enlarged anteriorly; teeth on blind side

much longer and stronger than those on ocular side; teeth of lower jaw on ocular side curved inwards (Fig. 75, B, C). Gill-rakers rather long, slender and pointed, without spinules on each posterior margin; none on upper limb (Fig. 75, D).

Scales large and deciduous, feebly ctenoid on ocular side (Fig. 75, A), cycloid on blind side. Snout, jaws and pectoral fin naked; base of ventral fin and interorbital area with scales. Lateral line curved anteriorly on ocular side; absent on blind side.

Dorsal fin starting on blind side, on a level with interorbital area, fin rays becoming higher posteriorly toward near middle of body, and evenly decreasing in height posteriorly. Anal fin originating on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins simple; that on ocular side short and feeble, third ray longest, about equal to 1/3 depth of body; succeeding rays becoming shorter ventrally; that on blind side very short, subequal to half length of that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, ray as well as base longer than those on blind side; third ray opposite to first on blind side. Caudal fin pointed posteriorly; generally uppermost and lowermost three rays simple, but remaining ones branched.

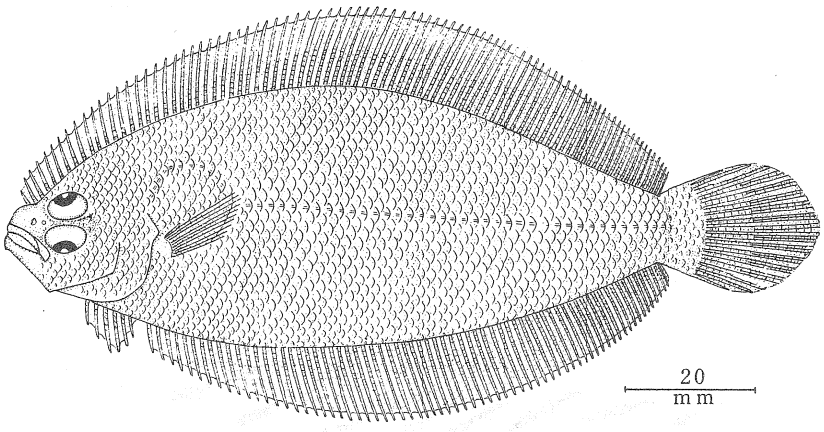

Fig. 74. Lateral view of *Arnoglossus tenuis* GÜNTHER: No. 35157, 89.9 mm in standard length.

Vent located on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body uniformly pale brownish; all fins paler than body, without marked spots.

Remarks: The present species clearly differs from the other Japanese species of the same genus in having scarcely enlarged teeth on the upper jaw anteriorly, close-set teeth on the lower jaw, the small mouth, a small number of dorsal, anal and scales in lateral line, and slender gill-rakers without spinules on posterior margin. It perphaps may represent a distinct genus.

On the other hand, *Scidorhombus pallidus* briefly described by TANAKA (1915), which is thought to be a synonym of this species, is allied well with the present species in the meristic characters and proportional measurements of the body part, but the former has exceedingly a small number of the anal fin rays. TANAKA (1915) indicated in original de-

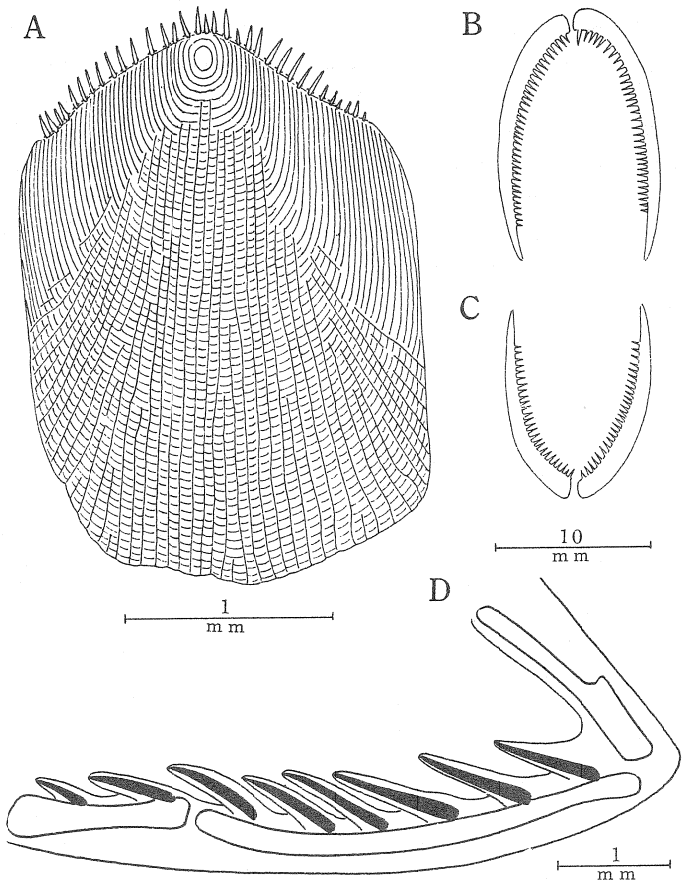

Fig. 75. Scale on ocular side (A), upper jaw (B), lower jaw (C) and first gill-arch cn ocular side (D) in *Arnoglossus tenuis* GÜNTHER. Lateral view (A, D); ventral view (B); dorsal view (C).

scription that *S. pallidus* has a larger number of dorsal and anal fin rays than those of the species of the genus *Pseudorhombus,* but the anal rays are much smaller number of 54 though the dorsal rays are 93. Generally, the number of dorsal rays minus 20 is about equal to anal rays. Therefore, it is pointed out that the anal rays are not 54, but 74 in number.

Arnoglossus polyspilus (GÜNTHER) "Nanyo-darumagarei"

Fig. 76

Anticitharus polyspilus GÜNTHER, 1880, 48, pl. 22, fig. A.
Arnoglossus polyspilus. NORMAN, 1927, 20. ——NORMAN, 1934, 190, fig. 137. ——OKADA and MATSUBARA, 1938, 421. ——MATSUBARA, 1955, 1257. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 81.
Bothus (*Anticitharus*) *polyspilus*. WEBER and BEAUFORT, 1929, 124.

Materials: Male- No. 33163, 171.0 mm in standard length, Mimase, Kochi Pref., November 15, 1957. Nos. 33165-33168, 149.4-167.8 mm, Mimase, November 15, 1957. Nos. 33171-33173, 178.0-189.6 mm, Mimase, November 15, 1957. Nos. 33175-33180, 139.9-176.1 mm, Mimase, November 15, 1957. Nos. 33182-33184, 145.8-151.7 mm, Mimase, November 20, 1957. Nos. 33187-33191, 98.0-145.0 mm, Mimase, November 20, 1957. Female- No. 33164, 178.2 mm, Mimase, November 15, 1957. No. 33169, 147.1 mm, Mimase, November 15, 1957. No. 33170, 203.0 mm, Mimase, November 20, 1957. No. 33174, 170.5 mm, Mimase, November 15, 1957. No. 33181, 156.1 mm, Mimase, November 20, 1957. Nos. 33185-33186, 149.5-156.1 mm, Mimase, November 20, 1957.

Diagnosis: This species with intermediate mouth in Japanese *Arnoglossus;* maxillary extending to anterior 1/3 of lower eye. Body not strongly compressed. Most of specimens provided with gill-rakers on upper limb.

Description: Dorsal fin rays 100-114; anal fin rays 78-91; pectoral fin rays 11-13 on ocular side, 8-13 on blind side; scales in lateral line 70-81; gill-rakers on first arch 1-2+8-9; vertebrae including urostyle 10+30-32=40-42. Head 3.78-4.19 in standard length; depth 2.45-2.72. Snout 4.3-5.3 in head; upper eye 3.12-3.97; lower eye 3.31-4.33; maxillary 2.30-2.60 on ocular side, 2.26-2.57 on blind side; lower jaw 1.88-2.02 on ocular side, 1.68-1.94 on blind side; longest dorsal fin ray 2.1-2.7; longest anal fin ray 1.98-2.57; pectoral fin 1.51-2.02 on ocular side, 2.47-3.71 on blind side; ventral fin 3.01-3.81 on ocular side, 2.97-4.09 on blind side; base of ventral fin 2.88-3.84 on ocular side, 4.64-6.26 on blind side.

Body elliptical and not strongly compressed, highest slightly in front of middle part of body, its depth about 1.5-1.6 length of head; dorsal and anal contours evenly arched except for dorsal profile of head. Caudal peduncle moderate in depth, equal to or more than 1/4 depth of body.

Head blunt anteriorly and rather small, upper profile with a slight notch on horizontal through interorbital area, from which it roundly rises. Snout blunt, rather small, much shorter than eye diameter. Eyes moderate in size, separated by a low narrow ridge which extends from the anterior margin of lower eye to posterior margin of upper one; lower a little in advance of upper which somewhat approaches to dorsal margin of head, shortest distance between them about 1/3 eye diameter. Nostrils on ocular side in front of upper margin of lower eye, anterior one tubular with a short flap posteriorly, extending anterior margin when depressed backward; posterior one not tubular, without flap; nostrils on blind side below origin of dorsal, anterior one tubular with a short flap posteriorly, posterior one not tubular, without flap.

Mouth oblique and slightly curved, moderate in size, maxillary nearly extending to below anterior margin or anterior 1/3 of lower eye, about 1.3-1.5 diameter of eye. Teeth uniserial

on both jaws, developed almost equally on both sides of jaws; upper jaw armed with some enlarged canines anteriorly, gradually becoming smaller and shorter backward, lower jaw with somewhat enlarged caninelike teeth anteriorly, its lateral teeth much stronger and wider apart than those of upper. Gill-rakers rather elongate, armed with two to seven spinules on each posterior margin, generally one to two epibranchial including rudimentary one, six on ceratobranchial and two to three on hypobranchial (Fig. 77, C).

Scales moderate in size and deciduous, feeble ctenoid on ocular side (Fig. 77, D), cycloid on blind side; snout, jaws and narrow patch between both eyes naked; pectoral and ventral fins also scaleless. Lateral line curved anteriorly on ocular side, length of curved portion about 1.8 in head, height about 1/3 length of its portion; the line absent on blind side.

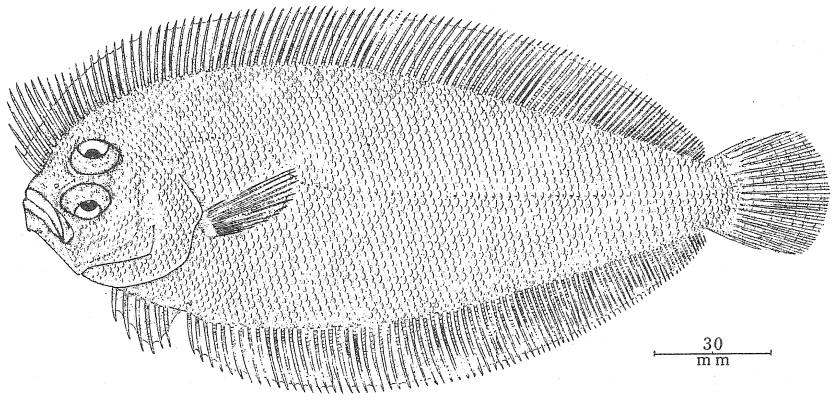

Fig. 76. Lateral view of *Arnoglossus polyspilus* GÜNTHER from male specimen: No. 33171, 189.6 mm in standard length.

Dorsal fin originating on blind side, on horizontal through interorbital area, fin rays except for anterior some rays which show sexual difference, becoming higher toward middle of body, and evenly decreasing in height posteriorly; all rays simple. Anal fin starting on vertical through basal part of pectoral fin, similar both in shape and structure to dorsal. Pectoral fins simple; that on ocular side feeble and short, second ray longest, much longer than half length of head, succeeding rays becoming shorter ventrally; that on blind side very short, about as long as or a little longer than half length of that on ocular side. Ventral fin on ocular side originating slightly behind vertical through posterior margin of lower eye, its base longer than that on blind side, third or fourth ray opposite to first on blind side. Caudal fin rounded, uppermost and lowermost two rays simple, but remaining ones branched.

Vent located on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body pale greyish brown; all fin similar color to body; dorsal, anal and ventral fins with a series of somewhat regular dark blotches.

Body on blind side milky white, except for part of abdominal cavity which stained with light blue.

Sexual dimorphism: In this species, there exists somewhat marked sexual difference in the dorsal fin. In the male fish, the anteriormost several dorsal rays are elongate, the fourth or fifth ray is the longest, about 1.9-2.5 in head. In the female fish, however, those are scarcely ever elongate.

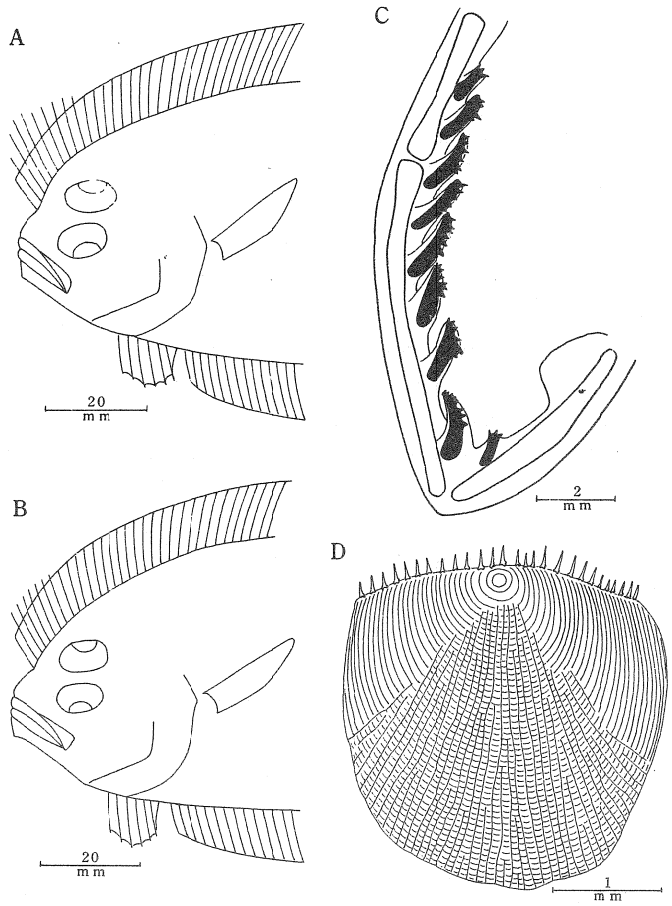

Fig. 77. Diagrammatic illustration of body parts showing sexual dimorphism (A, B), first gill-arch on ocular side (C) and scale on ocular side (D) in *Arnoglossus polyspilus* (GÜNTHER). Male (A); female (B).

Remarks: The specimens examined here agree well with GÜNTHER's original description of the species in counts and proportional measurements of bodily parts, but those differ from original figure given by GÜNTHER in having no pair of marked dark spots at the base

of the caudal fin. The fresh specimen, however, probably may reveal the presence of marked spots.

Arnoglossus japonicus HUBBS "Nihon-darumagarei"

Fig. 78

Arnoglossus japonicus HUBBS, 1915, 454, pl. 25, fig. 2. ——NORMAN, 1934, 192, fig. 139. ——OKADA and MATSUBARA, 1938, 421, pl. 104, fig. 1. ——KURODA, 1951, 389. ——BÖHLKE, 1953, 139. ——MATSUBARA, 1955, 1258. ——KURODA, 1962, 1.

Materials: Male- No. 33199, 136.1 mm in standard length, Mimase, Kochi Pref., November 15, 1957. No. 33200, 132.0 mm, Mimase, November 15, 1957. Nos. 33206-33207, 110.1-131.9 mm, Mimase, November 15, 1957. No. 33725, 140.2 mm, Urado, Kochi Pref., January 15, 1960. No. 33730, 135.9 mm, Urado, January 20, 1960. Female- Nos. 33213-33220, 115.5-144.2 mm, Mimase, November 15, 1957. Nos. 33727-33728, 135.1-136.1 mm, Urado, January 20, 1960.

Diagnosis: An *Arnoglossus* with cycloid scales on ocular side and large mouth. Maxillary extending to vertical through about middle of lower eye, 2.04-2.72 in head. Scales on lateral line rather large, 65-73 in number.

Description: Dorsal fin rays 99-106; anal fin rays 76-83; pectoral fin rays 13-14 on ocular side, 10-12 on blind side; scales in lateral line 65-73; gill-rakers on first arch 0+7-9; vertebrae including urostyle 10+32-33=42-43. Head 3.6-3.9 in standard length; depth 2.45-2.65. Snout 4.03-4.59 in head; upper eye 3.62-4.22; lower eye 3.37-4.13; maxillary 2.04-2.32 on ocular side, 1.89-2.05 on blind side; lower jaw 1.74-1.86 on ocular side, 1.58-1.7 on blind side; depth of caudal peduncle 2.67-3.35; longest dorsal fin ray 2.12-2.48; longest anal fin ray 2.12-2.47; pectoral fin 1.69-2.07 on ocular side, 2.95-3.64 on blind side; ventral fin 2.95-3.59 on ocular side, 2.59-3.34 on blind side; base of ventral fin 2.92-3.54 on ocular side, 5.81-7.31 on blind side.

Body elliptical, strongly compressed, highest slightly in front of middle part of body, its depth about 1.5 length of head; dorsal and anal contours evenly arched except for head profile. Caudal peduncle narrow in depth, a little less than 1/4 depth of body.

Head rather large, about 2/3 depth of body; upper profile with a slight notch before interorbital area, from which it slowly rises. Snout sharp and rather long, about as long as eye diameter. Eyes moderate in size 1.5-2.0 in length of maxillary, separated by a narrow low ridge which extends from anterior margin of lower eye to posterior margin of upper one; lower very slightly in advance of upper which approaches to dorsal margin of head, shortest distance between upper eye and dorsal margin of head nearly equal to 1/2 eye diameter. Nostrils on ocular side set in front of upper margin of lower eye, anterior one tubular with a filamentous flap posteriorly, extending posterior one when depressed backward; posterior one not tubular and without flap; nostrils on blind side setting below origin of dorsal, anterior one tubular with a short flap posteriorly, posterior one with rudimentary tube.

Mouth strongly curved anteriorly and large, maxillary reaching to below or slightly beyond middle of lower eye, about as long as or a little shorter than 1/2 length of head; a

little projecting beyond tip of lower jaw when mouth is closed. Teeth more or less uniserial on both jaws, upper jaw armed with two to four caninelike teeth on ocular side and with four to five ones on blind side anteriorly, which are outside mandibular symphysis, and lateral teeth small, gradually becoming smaller and shorter backward; lower jaw with 8 to 16 moderate canines on each side, those apart from each other (Fig. 79, D, E). Gill-rakers moderate in length and strong, armed with three to five spinules on posterior margin; none on upper limb (Fig. 79, C).

Scales rather large and deciduous, cycloid on both sides (Fig. 79, F). Snout, jaws and interorbital area naked; pectoral and ventral fins scaleless. Lateral line curved anteriorly on ocular side; absent on blind side.

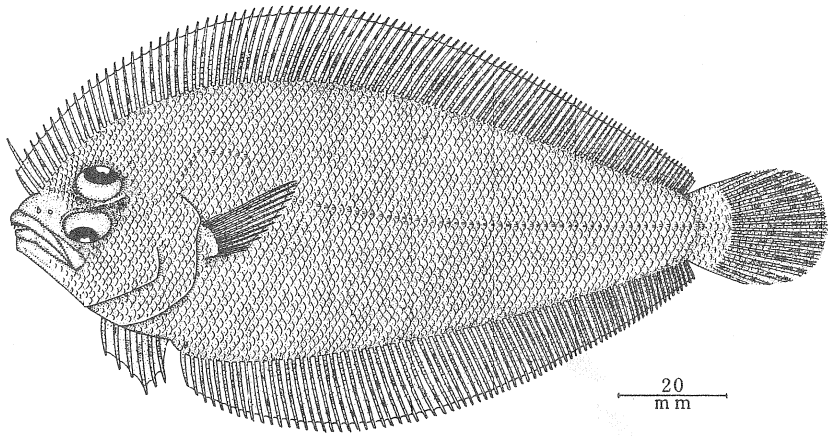

Fig. 78. Lateral view of *Arnoglossus japonicus* HUBBS from male specimen: No. 33206, 131.9 mm in standard length.

Dorsal fin originating on blind side, on level with lower margin of upper eye, fin rays becoming higher posteriorly toward middle of body, and evenly decreasing in height posteriorly. Anal fin starting on vertical through basal part of pectoral fin, similar both in shape and structure to dorsal. Pectoral fins unequal; that on ocular side short and rather feeble, second or third ray longest, about as long as or a little longer than half length of head, succeeding rays becoming shorter ventrally; that on blind side very short, a little longer than half length of that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, rays as well as base longer than those on blind side; fourth ray opposite to first on blind side. Caudal fin rounded posteriorly, uppermost and lowermost three rays simple, but remaining ones branched.

Vent opening on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish; all fins provided with many darker spots. Body on blind side milky white.

Sexual dimorphism: The present species shows the secondary sexual dimorphism in the second dorsal ray (Fig. 79, A, B). In the male fish, it is much elongate than the other rays near it, 2.68-3.45 in head. In the female fish, it is not elongate.

Remarks: The present species is clearly distinguished from the other hitherto known Japanese species of this genus, *A. tenuis* and *A. polyspilus* at least in having the cycloid

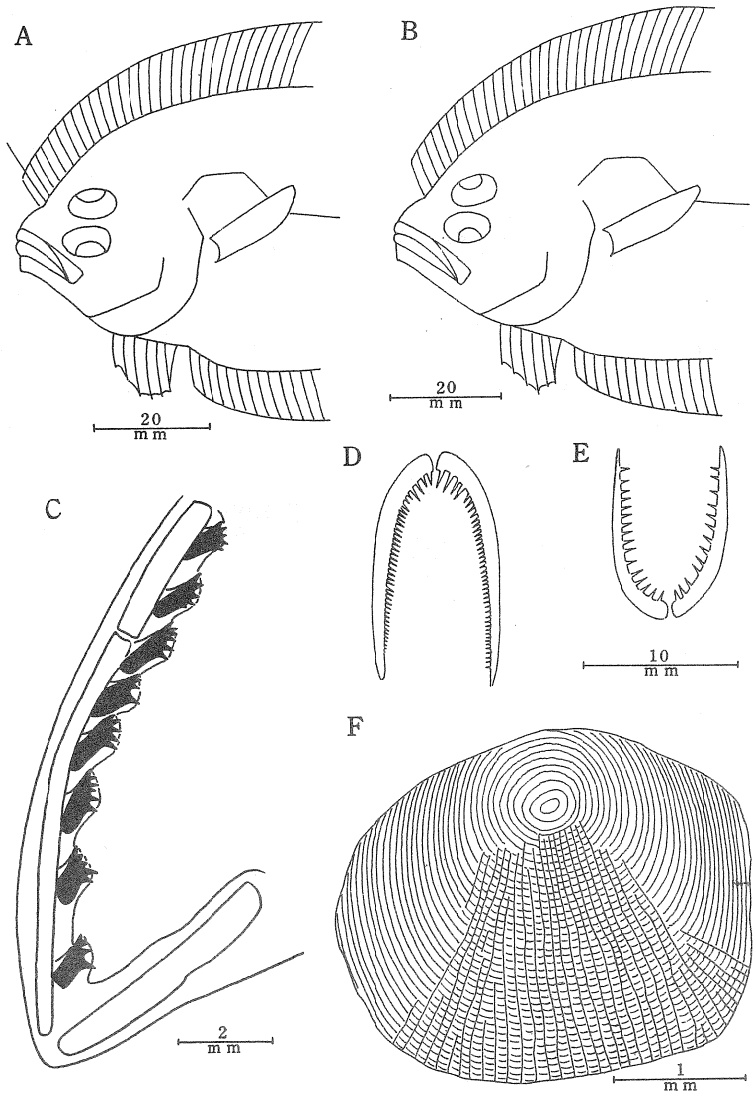

Fig. 79. Diagrammatic illustration of body parts showing sexual dimorphism (A, B), first gill-arch on ocular side (C), upper jaw (D), lower jaw (E) and scale on ocular side (F) in *Arnoglossus japonicus* HUBBS. Male (A); female (B). Ventral view (D); dorsal view (E).

scales on both sides, rather large the mouth (2.04-2.32 in head instead of 2.3-2.91 in the latters) and elongated the second dorsal ray in the male. On the other hand, it is closely related to *A. oxyrhynchus* n. sp. The difference between them is discussed in remarks of *A. oxyrhynchus*.

Arnoglossus oxyrhynchus n. sp. "Hanatogo-daruma"

Fig. 80

Holotype.—No. 33193, 194.1 mm in standard length, male, Mimase, Kochi Pref., December 10, 1958.

Paratypes.—Male—Nos. 33194-33198, 150.3-180.0 mm, Mimase, December 10-25, 1958. Female—Nos. 33208-33212, 164.1-190.9 mm, Mimase, December 10-25, 1958. No. 33726, 186.9 mm, Mimase, December 7, 1959.

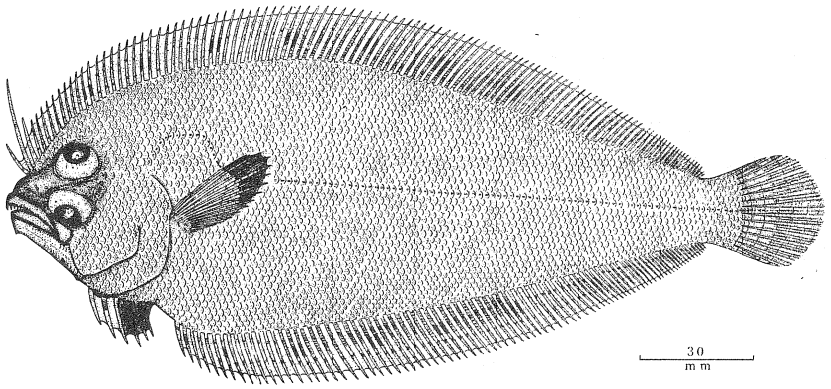

Fig. 80. Lateral view of holotype of *Arnoglossus oxyrhynchus* n. sp. (male specimen): No. 33193, 194.1 mm in standard length.

Diagnosis: An *Arnoglossus* with a large number of scales on lateral line (87-94) and of vertebrae (11+35=46). Pectoral fin on ocular side stained with jet-black at posterior margin.

Description: *Holotype.*—Dorsal fin rays 111; anal fin rays 85; pectoral fin rays 14 on ocular side, 12 on blind side; scales in lateral line 91; gill-rakers on first arch 0+8. Head 4.12 in standard length; depth 2.58. Snout 4.28 in head; upper eye 3.92; lower eye 3.65; maxillary 2.29 on ocular side, 1.97 on blind side; lower jaw 1.92 on ocular side, 1.73 on blind side; depth of caudal peduncle 2.73; longest dorsal fin ray 2.48; longest anal fin ray 2.47; pectoral fin 1.6 on ocular side, 3.36 on blind side; ventral fin 3.32 on ocular side, 3.36 on blind side; base of ventral fin 3.06 on ocular side, 6.83 on blind side.

Body elliptical, rather compressed, highest near posterior margin of pectoral fin, its depth about 1.7 length of head; dorsal contour evenly arched except for head profile; ventral contour strongly curved behind ventral fin, from where it gradually decreasing in

height posteriorly. Caudal peduncle narrow in depth, about 1/4 depth of body.

Head small, a little shorter than 1/4 length of body; upper profile with two slight notches on upper edge of premaxillary and in front of lower margin of upper eye. Snout sharp and rather long, slightly less than eye diameter. Eyes rather large in size, about 1.6 in length of maxillary, separated by a narrow, rather high ridge which extends from anterior margin of lower eye to posterior margin of upper one; lower very slightly in front of upper which exceedingly approaches to dorsal margin of head, shortest distance between upper eye and dorsal margin of head nearly equal to 1/3 eye diameter. Nostrils on ocular side set in front of upper margin of lower eye, anterior tubular and with a slender flap posteriorly, extending posterior one when depressed backward; posterior one not tubular and without flap; nostrils on blind side setting below origin of dorsal, anterior one tubular and with a short flap posteriorly, posterior one with rudimentary tube.

Mouth well-curved anteriorly and large, maxillary reaching to slightly beyond middle of lower eye, a little shorter than half length of head; slightly projecting beyond tip of lower jaw when mouth is closed. Teeth on upper jaw with four canine teeth anteriorly, which are outside mandibular symphysis; lateral teeth small, gradually becoming smaller and shorter backward, those on ocular side uniserial, about 36 teeth, but those on blind side at least biserial on posterior half of dentition; teeth on lower jaw provided with 14 moderate canines on ocular side and 22 ones on blind side, much stronger and wider apart than lateral teeth on upper jaw (Fig. 81, D, E). Gill-rakers rather short and strong, armed with three to four spinules on posterior margin; none on upper limb (Fig. 81, C).

Scales small and deciduous, those on ocular side weakly ctenoid (Fig. 81, F), with feeble short spinules along the apical margin; those on blind side cycloid; snout, jaws and interorbital area naked; pectoral and ventral fins also scaleless. Lateral line with a strong curve above pectoral fin, curved portion about half length of head; the line entirely absent on blind side.

Origin of dorsal slightly on blind side, on horizontal from upper margin of lower eye; fin except for first rhree rays gradually higher to middle part of body, and then evenly decreasing in height posteriorly to end of fin; first three rays elongate, length of first ray 4.28 in head, second ray longest, 1.68 in head, third ray 3.5. Anal fin starting on vertical through basal part of pectoral fin, similar in shape and structure to dorsal except for first three rays. Pectoral fin on ocular side simple and rather short, fourth ray longest, about half length of head, succeeding rays gradually decreasing in length ventrally; that on blind side very short and feeble, shorter than half length of that on ocular side. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, rays as well as base longer than those on blind side; fourth ray opposite to first on blind side. Caudal fin rounded posteriorly, uppermost and lowermost three rays simple, but remaining ones branched.

Vent opening on blind side, above origin of anal fin. Genital papilla displaced on ocular side, on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish with traces of dark marking on body, snout dark; all fins paler than body, dorsal and anal fins furnished regularly with a series of dark blotches. Pectoral fin on ocular side provided with blackish

marking on posterior margin; ventral fin on ocular side also with similar marking between the third and last rays. Body on blind side milky white.

Paratypes.—Dorsal fin rays 108-113; anal fin rays 84-89; pectoral fin rays 13-15 on ocular side, 10-13 on blind side; scales in lateral line 87-94; gill-rakers on first arch 0+8-9; vertebrae including urostyle 11+35=46. Head 3.97-4.55 in standard length; depth 2.41-2.71. Snout 4.14-4.55 in head; upper eye 3.67-3.98; lower eye 3.52-4.15; maxillary

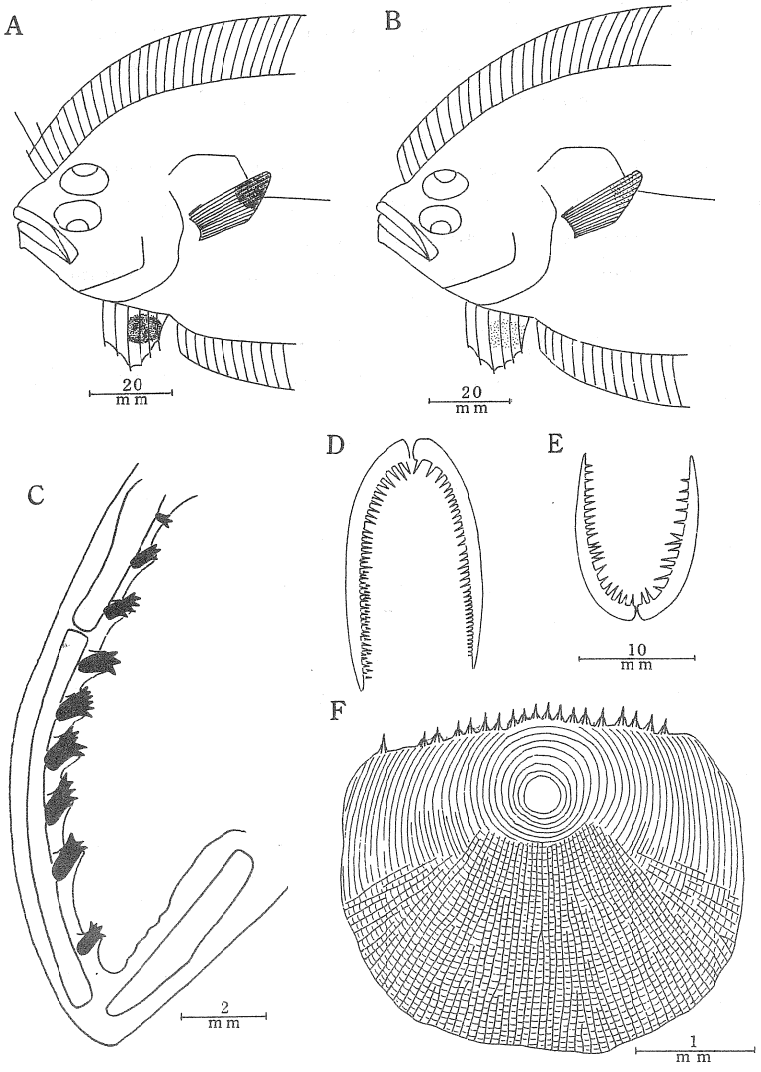

Fig. 81. Diagrammatic illustration of body parts showing sexual dimorphism (A, B), first gill-arch on ocular side (C), upper jaw (D), lower jaw (E) and scale on ocular side (F) in *Arnoglossus oxyrhynchus* n. sp. Male (A); female (B). Ventral view (D); dorsal view (E).

2.11-2.30 on ocular side, 1.82-1.98 on blind side; lower jaw 1.75-1.91 on ocular side, 1.52-1.73 on blind side; depth of caudal peduncle 2.73-3.02; longest dorsal fin ray 2.19-2.57; longest anal fin ray 2.14-2.55; pectoral fin 1.59-1.88 on ocular side, 3.13-4.22 on blind side; ventral fin 2.91-3.66 on ocular side, 2.85-3.61 on blind side; base of ventral fin 2.76-3.16 on ocular side, 6.25-7.53 on blind side.

Sexual dimorphism: Remarkable sexual dimorphism is found to exist in this species in the coloration and the shape of the dorsal fin (Fig. 81, A, B). In the male fish, the first three rays are well-elongated; the first ray 4.28-5.79 in head; the second ray is the longest, 1.68-2.13; the third ray 3.21-4.2. The distal part of the pectoral fin and the posterior half of the ventral fin are stained with the blackish marking. In the female fish, the dorsal fin ray is not elongate. The distal part of the pectoral fin and the posterior half of the ventral fin are stained with the paler blackish marking.

Remarks: The present new species resembles *Arnoglossus japonicus* HUBBS in general physiognomy, but undoubtedly differs from the latter in having the ctenoid scales on the ocular side and the upper eye exceedingly approached to the dorsal margin of the head.

The differences between this species and *A. japonicus* may be summarized as indicated in Table 4.

On the other hand, the species is comparatively allied to the New Zealand species, *A. scapha* in meristic characters, but differs from the latter in having the exceedingly large mouth (2.11-2.3 in head instead of 2.5-2.7 in the latter).

Table 4. Comparison of counts and proportional measurements of body parts between present new species and *Arnoglossus japonicus* HUBBS.

Items \ Species	*A. oxyrhynchus*	*A. japonicus*
Dorsal fin rays	108—113	96—106
Anal fin rays	84— 89	76— 83
Scales in lateral line	87— 94	65— 73
Vertebrae	11+35=46	10+32—33=42—43
In standard length:		
Head	3.97—4.21	3.6—3.9
In head length:		
Second dorsal fin in male	1.68—2.13	2.68—3.45

39. Genus *Japonolaeops* n. g.

Japonolaeops n. g., (type-species by original designation: *Japonolaeops dentatus* n. sp.).

Body elongate, elliptical and strongly compressed. Caudal peduncle very narrow in depth. Tip of isthmus locates below posterior margin of lower eye. Anterior dorsal profile

similar in either sex. Head rather small, 4.9-5.7 in standard length. Eyes sinistral, separated by narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one, interorbital region similar in both sexes. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one tubular and with a flap posteriorly and posterior one not tubular and without flap. Mouth oblique, small in size, maxillary extending below anterior margin of lower pupil, 3.1-3.7 in head; posterior end of lower jaw extending to slightly in rear of anterior margin of lower eye. Teeth small, well developed on both sides; uniserial on upper jaw, and uniserial and biserial or narrow bands on lower jaw. Gill-rakers slender and moderate in number, not serrate on its posterior margin. Scales very small in size, and deciduous, cycloid on both sides; snout, both jaws, interorbital area and pectoral fin naked.

Dorsal fin originating above nostrils on blind side, first two rays not separated from other rays of fin; all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Left ventral fin at tip of isthmus, fourth ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded; uppermost and lowermost three rays simple, other rays branched.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 99, E1, E2; Fig. 104, D). Alisphenoid absent. Basioccipital roughly rectangular in shape, when viewed from lateral. Opisthotic square in shape, its tip not extending to tip of basioccipital. Prootic widely connected with basioccipital posteriorly (Fig. 99, E1, E2).

Suborbital bone on blind side three in number. Second hypobranchial elliptical in shape without toothed plate; third basibranchial rectangular concaved deeply in both sides of anterior part (Fig. 114, D). Urohyal fishhook-like in shape, tip of sciatic part extending to anterior 1/3 of distance from tip of main part to angular portion, tapering the front; cardiac apophysis exceedingly large, having a pair of lateral ridges on both sides (Fig. 116, C). Opening for notochord large in size, and more advanced than middle part of centrum. Anterior transverse apophysis beginning with second vertebra. Four caudal plates not branched (Fig. 128, C).

Remarks: The new genus is closely allied to *Laeops* in general physiognomy (lanceolate-shape body, rather small mouth and head) and in osteological features, but differs from it in having both jaws fully armed with many teeth and the first two rays of the dorsal fin not separated from other rays of the fin. It also is related to *Laeoptichthys* established by Hubbs (1915), but differs from the latter, of which dentition almost entirely is confined to the blind side.

On the other hand, the present genus closely related to *Arnoglossus*, but clearly separable from it by following characters: smaller head and maxillary; alisphenoid lacking; opisthotic square in shape, its tip not extending to tip of basioccipital; opening for notochord large in size.

Japonolaeops dentatus n. sp. "Hina-daruma"

Fig. 82

Holotype.—No. 34043, 176.2 mm in standard length, male, Miya, Aichi Pref., April 15, 1961.

Paratypes.—Male—Nos. 33224-33251, 103.4-169.1 mm, Mimase, Kochi Pref., October 10-20, 1959. Female—Nos. 33252-33271, 119.1-181.2 mm, Mimase, Kochi Pref., October 10-20, 1959.

Diagnosis: A lanceolate-shaped sinistral flounder with teeth on both sides, dorsal first two rays not well separated from remainder of fin.

Description: *Holotype.*—Dorsal fin rays 118; anal fin rays 97; pectoral fin rays 15 on ocular side, 14 on blind side; scales in lateral line 106; gill-rakers on first arch 6+8. Head 5.69 in standard length; depth 3.09. Snout 5.46 in head; upper eye 3.22; lower eye 3.19; maxillary 3.8 on ocular side, 3.84 on blind side; lower jaw 2.44 on ocular side, 2.27 on blind side; depth of caudal peduncle 2.52; longest dorsal fin ray 1.78; longest anal fin ray 1.94; pectoral fin 1.49 on ocular side, 2.27 on blind side; ventral fin 3.26 on ocular side, 3.12 on blind side; base of ventral fin 2.6 on ocular side, 5.27 on blind side.

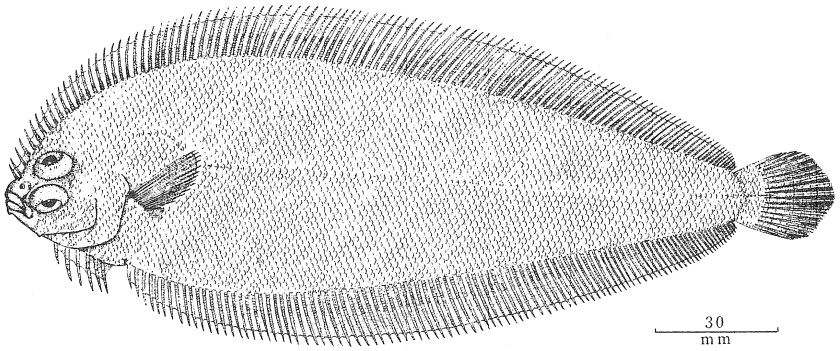

Fig. 82. Lateral view of holotype of *Japonolaeops dentatus* n. sp.: No. 34043, 176.2 mm in standard length.

Body elongate, elliptical, strongly compressed, highest at anterior 1/3 of body, equal to 1/3 length of body; dorsal and anal contours except for head slowly arched above and below anterior 1/3 part of body, from which it gradually inclines toward caudal. Caudal peduncle very narrow in depth, much less than 1/2 length of head.

Head small, subequal to half depth of body (Fig. 86); head profile with a deep notch on horizontal through middle part of upper eye, from which it gradually rises. Snout protruded and short, about 1.5 in eye diameter. Eyes rather large, about as long as length of maxillary, separated by a narrow and high ridge which extends from anterior margin of lower eye to posterior margin of upper eye; lower a little in advance of upper. Nostrils two on each

side; those on ocular side set in front of interorbital ridge, anterior one tubular with a triangular short flap posteriorly, posterior one somewhat tubular, without flap; nostrils on blind side below origin of dorsal similar in structure to those on ocular side.

Mouth very small (Fig. 88), oblique and gently curved anteriorly, not very asymmetrical; maxillary nearly extending to anterior margin of lower pupil. Jaws and dentition well developed on both sides; teeth on upper jaws on both sides uniserial, teeth on blind side more or less enlarged, and stronger than those on ocular side, teeth on lower jaw on ocular side biserial or narrow band anteriorly and uniserial posteriorly, teeth on outer series much larger and stronger than those of inner series; teeth on lower jaw of blind side uniserial posteriorly and more or less narrow bands anteriorly (Fig. 83, B, C). Gill-rakers slender, six on epibranchial smallest in size, six on ceratobranchial moderate and two near on hypobranchial short and small; each one not serrate on posterior margin (Fig. 83, A).

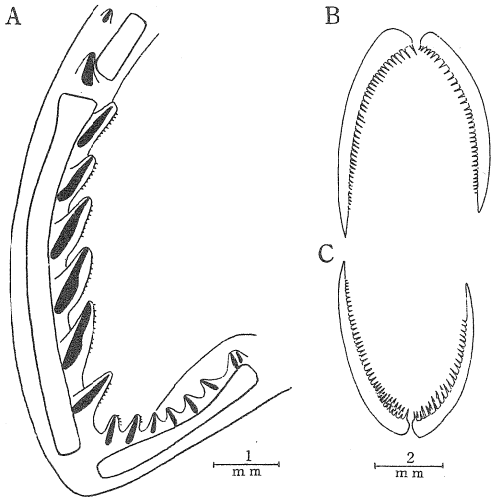

Fig. 83. First gill-arch on ocular side (A), upper jaw (B) and lower jaw (C) in *Japonolaeops dentatus* n. sp. Ventral view (B); dorsal view (C).

Scales very small and deciduous, cycloid on both sides; snout, both jaws, interorbital area and pectoral fin naked. Lateral line on ocular side a strong curve above pectoral fin, length of curved portion a little longer than half length of head; the line absent on blind side.

Dorsal fin originating above nostrils on blind side, rays gradually becoming higher to slightly behind at middle part of body, and evenly decreasing in height to caudal peduncle; first two rays not well separated from other rays of fin. Anal fin starting slightly in front of vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal; that on ocular side very short, about 1.5 that on blind side, second

or third ray longest, about 2/3 length of head, succeeding rays gradually decreasing toward lowermost. Left ventral fin inserts below at middle part of lower pupil or slightly behind, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, rather short, about 3/4 length of head; rays all branched except for three rays both in upper and lower extremities of fin.

In formalin, general ground color on ocular side of body dark yellowish without distinct blotch and spot. All fins pale greyish, caudal fin blackish on some rays at middle portion, but it not extending to base of caudal fin. Body on blind side yellowish white.

Paratypes.—Dorsal fin rays 109-125; anal fin rays 90-101; pectoral fin rays 12-16 on ocular side, 12-14 on blind side; scales in lateral line 88-106; gill-rakers on first arch 3-8+6-10; vertebrae including urostyle 11+41-42=52-53. Head 4.87-5.69 in standard length; depth 2.76-3.33. Snout 4.87-6.27 in head; upper eye 2.64-3.51; lower eye 2.72-3.58; maxillary 3.1-3.7 on ocular side, 3.31-4.02 on blind side; lower jaw 2.19-2.53 on ocular side, 2.13-2.52 on blind side; depth of caudal peduncle 2.52-3.57; longest dorsal fin ray 1.6-2.09; longest anal fin ray 1.51-2.08; pectoral fin 1.4-2.13 on ocular side, 2.1-3.11 on blind side; ventral fin 2.69-3.8 on ocular side, 2.63-4.09 on blind side; base of ventral fin 2.63-4.09 on ocular side, 2.45-3.25 on blind side.

Remarks: The new species closely resembles *Laeops kitaharae* in general appearance, it is separable from the latter in having the large head (4.87-5.69 in standard length instead of 5.92-7.28) (Fig. 86), the short ventral fin (2.67-3.8 in head instead of 1.67-2.28), rather the large mouth (3.1-3.7 in head instead of 3.9-4.74) (Fig. 88), jaws provided with teeth on both sides, the first two rays of the dorsal fin not separated from other rays of the fin and dark yellowish in general ground color.

40. Genus *Laeops* GÜNTHER

Laeops GÜNTHER, 1880, 29 (type-species by original designation: *Laeops parviceps* GÜNTHER).
Scianectes ALCOCK, 1889, 284 (type-species by original designation: *Scianectes macrophthalmus* ALCOCK).
Lambdopsetta SMITH and POPE, 1906, 496 (type-species by original designation: *Lambdopsetta kitaharae* SMITH and POPE).
Laeoptichthys HUBBS, 1915, 460 (type-species by original designation: *Laeoptichthys fragilis* HUBBS).

Body elongate, elliptical, moderately or strongly compressed. Caudal peduncle very narrow in depth. Tip of isthmus located below vertical of middle part of lower eye or slightly behind it. Anterior dorsal profile similar in both sexes. Eyes sinistral, separated by narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one, lower a little in advance of upper or at same vertical; interorbital region similar in either sex. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one tubular and with a flap posteriorly, and posterior one not tubular and without flap. Mouth oblique, small, and asymmetrical in shape, curved towards blind side, maxillary extending below anterior margin of lower eye or slightly beyond it; teeth almost entirely confined to blind side, all very small, pointed, more or less uniserial or narrow bands on

jaws. Gill-rakers short and slender, not serrate on its posterior margin. Scales very small and deciduous; cycloid on both sides; snout, both jaws and pectoral fin naked.

Dorsal fin originating above nostrils on blind side, first two rays generally not detached from other rays of fin or first three rays prolonged; all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, generally not prolonged in both sides, all rays simple. Left ventral fin on tip of isthmus, fourth ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded, inner 9 to 13 rays branched, others simple.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process entirely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 100, A1, A2, B1, B2; Fig. 104, D). Alisphenoid completely lacking. Basioccipital roughly rectangular in shape, when viewed from lateral. Opisthotic square in shape, its tip not extending to tip of basioccipital. Prootic widely connected with basioccipital posteriorly (Fig. 100, A1, A2, B1, B2).

Suborbital bone on blind side three in number. Second hypobranchial elliptical or circular in shape without toothed plate; third basibranchial rectangular, considerably expanded laterally in posterior half, and small in anterior half (Fig. 114, E, F). Urohyal fishhook-like in shape, tip of sciatic part extending to anterior 1/3 of distance from tip of main part to angular portion, tapering the front; cardiac apophysis exceedingly large, pointed posteriorly, and has a pair of lateral ridges on both sides (Fig. 116, A, B). Opening for notochord large in size, and more advanced than middle part of centrum (Fig. 123, F). Anterior transverse apophysis beginning with second vertebra. Four caudal plates unbranched (Fig. 128, D, E).

41. Key to species of *Laeops*.

A^1 First two rays of dorsal fin not detached from others of fin, first to third a little prolonged; lower jaw on ocular side 2.8-3.0 in head; depth of caudal peduncle 2.9-3.1 in head; body with many small spots ..... *Laeops nigromaculatus* Von BONDE

A^2 First two rays of dorsal fin detached from others of fin, but none of rays prolonged; lower jaw 2.1-2.7 in head; depth of caudal peduncle 2.1-2.7 in head; body without smaller spots than eye diameter ..... *Laeops kitaharae* SMITH and POPE

Laeops nigromaculatus Von BONDE "Hoshi-yarigarei"

Fig. 84

Laeops nigromaculatus Von BONDE, 1922, 10, pl. 3. ——BERNARD, 1925, 392. ——NORMAN, 1931, 510. ——NORMAN, 1934, 254, fig. 194. ——KAMOHARA, 1935, 21. ——KAMOHARA, 1938, 60. ——OKADA and MATSUBARA, 1938, 424. ——SMITH, 1949, 158, fig. 309. ——KAMOHARA, 1950, 242. ——MATSUBARA, 1955, 1252. ——KAMOHARA, 1958, 63. ——KAMOHARA, 1964 82.

Materials: Male- No. 33295, 174.3 mm in standard length, Mimase, Kochi Pref., December 20, 1958. No. 33297, 159.0 mm, Mimase, December 20, 1958. Female- No. 33296, 158.2 mm, Mimase, December 25, 1958.

Diagnosis: A *Laeops* with small black spots over body; first two rays of dorsal not detached from other rays of fin, and first three rays a little prolonged.

Description: Dorsal fin rays 100; anal fin rays 82-83; pectoral fin rays 15-16 on ocular side, 13 on blind side; scales in lateral line 140-144; gill-rakers on first arch 2-4+6-7; vertebrae including urostyle 12+37=49. Head 5.71-6.05 in standard length; depth 2.64-2.89. Snout 4.38-5.23 in head; upper eye 2.95-3.4; lower eye 3.17-3.31; maxillary 3.81-4.36 on ocular side, 4.38-5.08 on blind side; lower jaw 2.77-2.99 on ocular side, 2.75-2.99 on blind side; depth of caudal peduncle 2.86-3.08; longest dorsal fin ray 1.38-1.58; longest anal fin ray 1.43-1.44; pectoral fin 1.39-1.61 on ocular side, 2.36-2.99 on blind side; ventral fin 2.19-2.36 on ocular side, 2.41-2.5 on blind side; base of ventral fin 2.17-2.22 on ocular side, 4.46-4.69 on blind side.

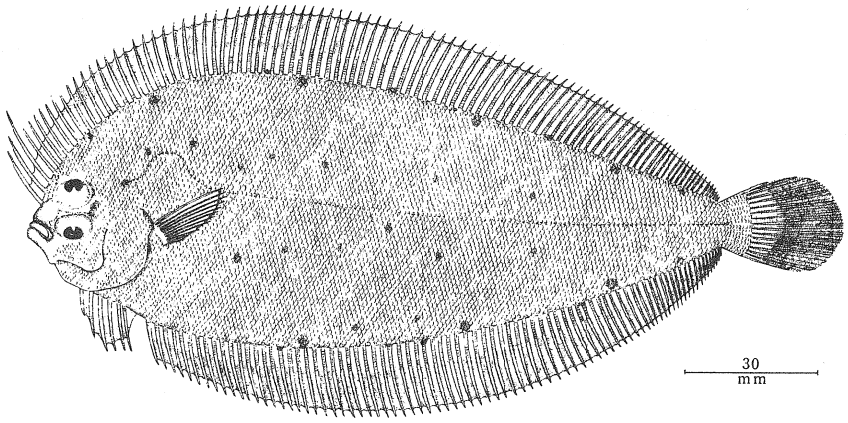

Fig. 84. Lateral view of *Laeops nigromaculatus* Von BONDE: No. 33295, 174.3 mm in standard length.

Body elliptical, strongly compressed, highest slightly in front of 1/3 of body, its depth somewhat more than 1/3 its length; dorsal and anal contours evenly arched except for head region. Caudal peduncle very narrow in depth, about equal to 1/3 length of head.

Head very small in size (Fig. 86), a little less than half depth of body; upper profile with a deep concavity in front of upper eye, and it steeply rises after more or less convex in front of middle part of upper eye. Snout pointed at tip and short, somewhat shorter than eye diameter. Eyes moderate in size, a little more than length of maxillary, separated by a low, narrow ridge which extends from the anterior margin of lower eye to posterior margin of upper one, lower eye scarcely in advance of upper or about same level. Nostrils on ocular side closely set in front of interorbital ridge, anterior one tubular and with a short

triangular flap posteriorly; posterior one without tube and flap; nostrils on blind side setting below origin of dorsal, anterior one tubular with a short flap posteriorly, posterior one more or less tubular, without flap.

Mouth oblique, very small in size (Fig. 88), and rather asymmetrical, maxillary scarcely extending below anterior edge of lower eye; lower jaw slightly projecting beyond tip of upper when mouth is closed. Teeth on both jaws uniserial on blind side, small, almost same size; those on ocular side absent (Fig. 85, A, B). Gill-rakers on first arch slender, moderate in length, and pointed at tip, not serrate at its posterior margin, those on upper limb shorter and slender than those on ceratobranchial bone (Fig. 112, D).

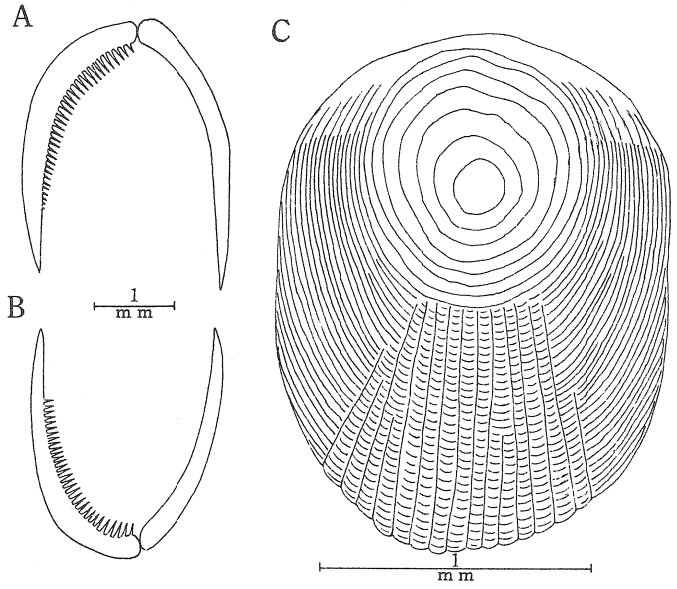

Fig. 85. Upper jaw (A), lower jaw (B) and scale on ocular side (C) in *Laeops nigromaculatus* Von BONDE. Ventral view (A); dorsal view (B).

Scales extremely small and deciduous, cycloid on both sides (Fig. 85, C); snout, jaws and pectoral fin scaleless. Lateral line on ocular side with a strongly curve above pectoral fin, length of curved portion about as long as half length of head; the line absent on blind side.

Origin of dorsal fin on blind side, before horizontal through middle part of upper eye; fin rays gradually higher to middle part of body except for first three rays, then evenly decreasing in height posteriorly; first two rays not detached from other rays of fin; first to third rays a little prolonged, a little longer than half length of head, but these rays not longer than longest ray of middle of dorsal fin. Anal fin starting at horizontal through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins very unequal

in size, all rays simple. Ventral fin on ocular side inserted on vertical through posterior margin of lower eye or slightly in advance of its line; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, rather long and slender, about as long as length of head; inner nine rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish, with small black spots scattered irregularly over body, snout dark; dorsal and anal fins black along outer parts; a series of small black spots along basal portions of dorsal and anal fins, same spots scattered on inner parts of dorsal and anal fins. Caudal fin black except for its basal part. Blind side of body milky white.

Remarks: In the species, the first two rays of the dorsal fin are not detached from the other rays of the fin, but in other respects, especially, in having the teeth almost entirely confined to the blind side, this species appears to be that of *Laeops*.

Laeops kitaharae (SMITH and POPE) "Natsu-garei or Yari-garei"

Fig. 87

Lambdopsetta kitaharae SMITH and POPE, 1906, 496, fig. 12. —— JORDAN, TANAKA and SNYDER, 1913, 317, fig. 265.

Laeops lanceolata FRANZ, 1910, 62, pl. 8, fig. 60. ——JORDAN, TANAKA and SNYDER, 1913, 314. ——HUBBS, 1915, 460. ——JORDAN and HUBBS, 1925, 295. ——NORMAN, 1934, 259, fig. 201. ——KAMOHARA, 1938, 60. ——OKADA and MATSUBARA, 1938, 424. ——KAMOHARA, 1950, 242. ——KURODA, 1951, 389. ——MORI, 1952, 176. ——MATSUBARA, 1955, 1262. ——KAMOHARA, 1958, 63. ——KURODA, 1962, 3, fig. 2. ——SHIH-CHIEH, 1966, 189, fig. 71. ——KAMOHARA, 1964, 83.

Laeops variegata FRANZ, 1910, 63, pl. 8, fig. 59. ——JORDAN, TANAKA and SNYDER, 1913, 314. ——HUBBS, 1915, 460. ——NORMAN, 1934, 260, fig. 202. ——OKADA and MATSUBARA, 1938, 424, pl. 105, fig. 3. ——MATSUBARA, 1955, 1262. ——KAMOHARA, 1958, 63. ——KAMOHARA, 1964, 83. ——SHIH-CHIEH, 1966, 189, fig. 72.

Laeops kitaharae. HUBBS, 1915, 460. ——NORMAN, 1931, 601. ——WU and WANG, 1933, 298. ——KAMOHARA, 1934, 461. ——NORMAN, 1934, 259, fig. 200. ——KAMOHARA, 1938, 60. ——OKADA and MASTUBARA, 1938, 424, pl. 105, fig. 2. ——KURONUMA, 1940, 213. ——SMITH, 1949, 158. ——KAMOHARA, 1950, 242. ——MORI, 1952, 176. ——MATSUBARA, 1955, 1262. ——MORI, 1956, 32. ——KAMOHARA, 1958, 63. ——KAMOHARA, 1964, 83.

Laeoptichthys fragilis HUBBS, 1915, 460, pl. 26, fig. 4.

Materials: Male- Nos. 15797-15798, 136.5-142.8 mm in standard length, Mimase, Kochi Pref., February 20, 1951. No. 17552, 141.4 mm, Miya, Aichi Pref., March 15, 1952. No. 18254, 162.1 mm, Mimase, October 10, 1952. Nos. 33363-33372, 133.0-149.9 mm, Mimase, December 20, 1957. Nos. 33400-33406, 130.0-148.9 mm, Mimase, December 20, 1957. Female- No. 15794, 144.5 mm, Mimase, February 20, 1951. No. 17210, 132.2 mm, Miya, January 8, 1951. No. 18254, 162.1 mm, Mimase, October 10, 1952. Nos. 33373-33387, 135.0-164.0 mm, Mimase, December 20, 1957. Nos. 33398-33399, 130.8-144.2 mm, Mimase, December 20, 1957. Young- Nos. 33388-33397, 93.9-112.5 mm, Mimase, December, 1957.

Diagnosis: A lanceolate-shaped flounder without dentition on both jaws on ocular side; first two rays of dorsal not continuous with other rays of fin.

Description: Dorsal fin rays 105-114; anal fin rays 85-93; pectoral fin rays 12-16 on ocular side, 10-15 on blind side, scales in lateral line 93-105; gill-rakers on first arch 1-9+5-8; vertebrae including urostyle 12+39-41=51-53. Head 5.92-7.28 in standard length; depth 2.51-3.05. Snout 4.75-7.93 in head; upper eye 2.51-3.54; lower eye 2.53-3.2; maxillary 3.9-4.74 on ocular side, 3.84-5.17 on blind side; lower jaw 2.11-2.68 on ocular side, 2.19-2.85 on blind side; depth of caudal peduncle 2.12-2.73; longest dorsal fin ray 1.28-1.87; longest anal fin ray 1.23-1.82; pectoral fin 1.22-2.0 on ocular side, 1.54-2.4 on blind side; ventral fin 1.67-2.28 on ocular side, 1.71-2.62 on blind side; base of ventral fin 1.9-2.66 on ocular side, 3.94-6.82 on blind side.

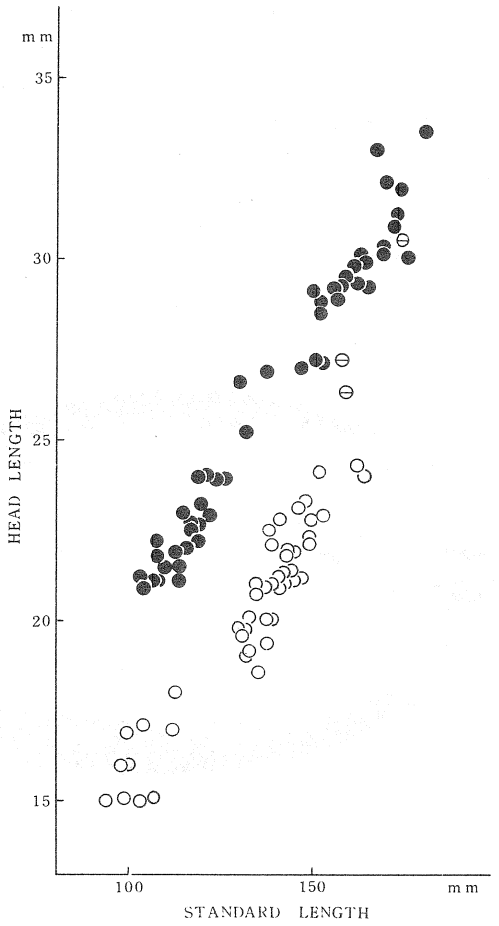

Fig. 86. Head length in relation to standard length in three species of *Japonolaeops* and *Laeops*. ●, *J. dentatus*; ⊖, *L. nigromaculatus*; ○, *L. kitaharae*.

Body elongate, elliptical, moderately compressed, highest at anterior 1/3 of body, its depth about 2.5 length of head; dorsal and anal contours evenly arched except for dorsal profile of head. Caudal peduncle very narrow in depth, a little less than half length of head.

Head extremely small, much shorter than half depth of body (Fig. 86); dorsal profile of head with the slight convex on snout and just before anterior margin of upper eye, from which it gently rises to anterior 1/3 of body. Snout short and very small in size about equal to half diameter of eye. Eyes rather large, about 1.5 length of maxillary, separated by narrow ridge which extends from anterior margin of lower eye to posterior margin of upper eye; lower eye very slightly in front of upper, which touches edge of head. Nostrils on ocular side in front of interorbital ridge, anterior one tubular with a short triangular flap posteriorly, the posterior one not tubular and without flap; nostrils on blind side setting

below origin of dorsal similar in shape and structure to those on ocular side.

Mouth oblique, very small (Fig. 88) and rather asymmetrical in shape, curved on blind side; maxillary extending below anterior edge of lower eye; lower jaw well projecting beyond tip of upper when mouth is closed. Teeth on both jaws on blind side, narrow bands, small, curved at tip towards inner side of mouth; but those on both jaws of ocular side entirely absent (Fig. 89, A, B). Gill-rakers on first arch, short and small in size, not serrate at its posterior margin (Fig. 89, D). Scales very small and deciduous; cycloid on both sides (Fig. 115, C); snout, both jaws and pectoral fin naked. Lateral line curved anteriorly on ocular side, length of curved portion as long as or longer than half length of head; the line absent on blind side.

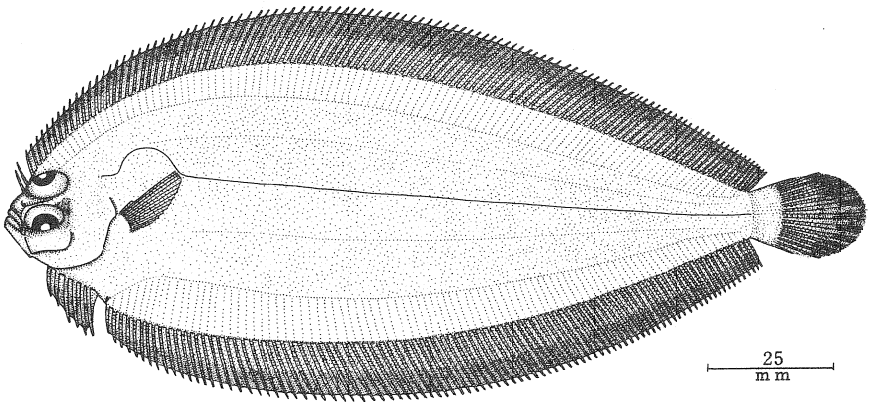

Fig. 87. Lateral view of *Laeops kitaharae* (SMITH and POPE): No. 33383, 153.0 mm in standard length.

Dorsal fin originating on blind side, on horizontal through lower margin of upper eye, fin rays gradually becoming higher towards middle of body, and evenly decreasing in height posteriorly; first two rays detached from other rays of fin. Anal fin starts on vertical through basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal; that on ocular side feeble and short, third or fourth ray longest, much longer than half length of head, succeeding rays becoming shorter ventrally; that on blind side very short, about equal to half length of head. Ventral fin on ocular side originating on vertical through middle part of lower eye; fourth ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, inner 11-13 rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body yellowish white; snout dark; vertical fin and ventral fin on ocular side blackish towards their margins. Body on blind side yellowish white.

Remarks: The specimens agree better with the characters of *L. lanceolata,* described by Franz (1910) and by Jordan and Hubbs (1925) than with those of *L. kitaharae* by Smith and Pope (1906) in having a number of anal fin rays 85-93, but in some respects the two species are apparently inseparable. It is said that in the flounders the number of the anal fin is about 20 fewer than that of the dorsal fin. In such a case, it is probably thought whether the description given by Smith and Pope is mistaken or its specimen is teratological condition. Consequently *L. lanceolata* Franz is thought to be a synonym of this species, as pointed out by Norman (1931, 1934) and Jordan and Hubbs (1925).

On the other hand, *L. variegata* Franz appears to be a larval form in the following points; first dorsal ray prolonged; dorsal and anal rays enlarged; intestine projecting to outside of abdominal cavity. Such larval characters show also remarkable resemblance to those of a giant larva reported by Hubbs and Chu (1934) as *Laeops parviceps.*

The present author has enough specimens of this species at hand, which represent many stages of development from before the migration of the eye to the juvenile. In these specimens, the fishes of post-larval stage agree well with description and figure of *L. variegata* established by Franz (1910). Such being the case, *L. variegata* is nothing but a larval-form of *L. kitaharae.*

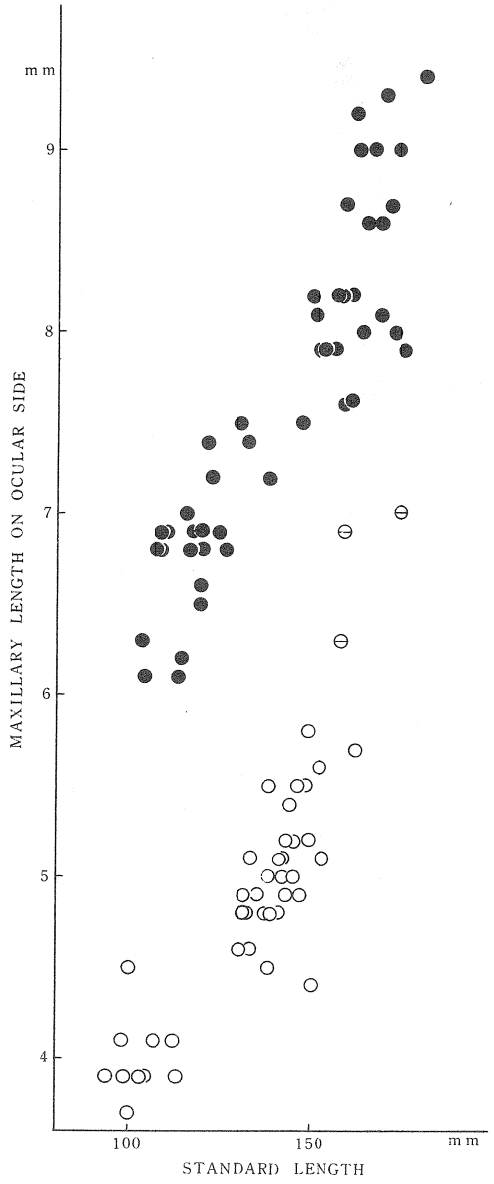

Fig. 88. Maxillary length on ocular side in relation to standard length in three species of *Japonolaeops* and *Laeops.* ●, *J. dentatus;* ⊖, *L. nigromaculatus;* ○, *L. kitaharae.*

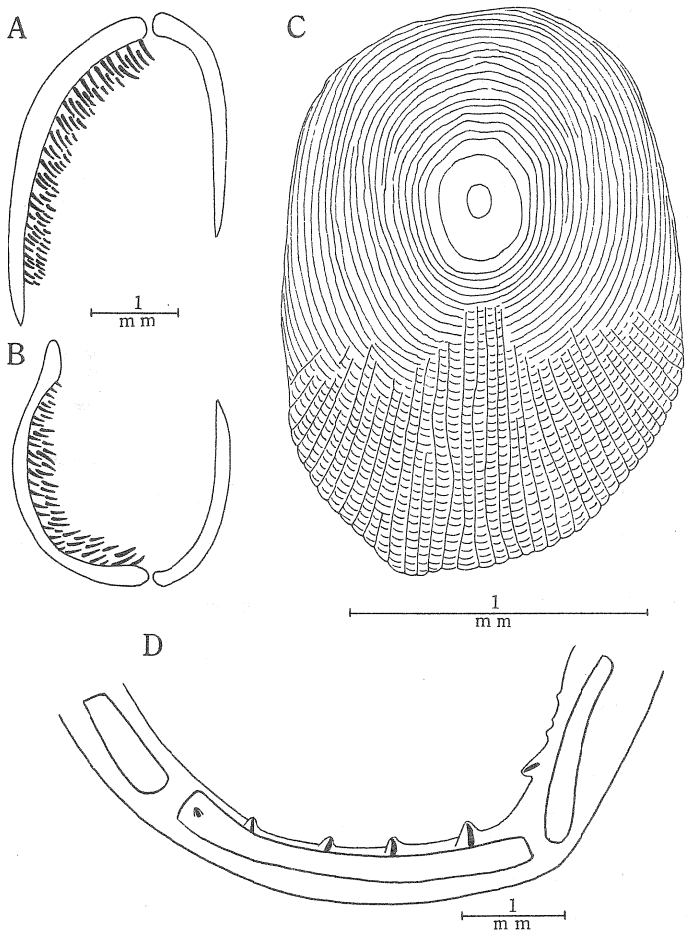

Fig. 89. Upper jaw (A), lower jaw (B), scale on ocular side (C) and first gill-arch on ocular side (D) in *Laeops kitaharae* (SMITH and POPE). Ventral view (A); dorsal view (B).

42. Genus *Neolaeops* n. g.

Neolaeops n. g., (type-species by original designation: *Laeops microphthalmus* Von BONDE).

Body elliptical, strongly compressed. Caudal peduncle very narrow in depth. Tip of isthmus below posterior margin of lower eye. Anterior dorsal profile similar in both sexes. Head small, 4.6-5.1 in standard length. Eyes sinistral, very small, separated by narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one, interorbital region similar in both sexes. No rostral and orbital spines. Nostrils on both sides two, anterior one tubular with a flap posteriorly and posterior one more or less tubular and without flap. Mouth oblique, moderate in size, maxillary extending to below anterior

part of lower eye or slightly beyond it; posterior end of lower jaw extending to middle part of lower eye or to posterior margin of it. Teeth on both sides uniserial, enlarged canine anteriorly; lateral teeth on lower jaw stronger and wider apart than those on upper. Gill-rakers slender, moderate in size and pointed, not serrate on its posterior margin. Scales very small, cycloid on both sides; snout, both jaws and interorbital area naked.

Dorsal fin originating above nostrils on blind side, first two rays not separated from other rays of fin, not prolonged; all rays simple. Anal fin starts immediately behind ventral fin on ocular side, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Origin of left ventral fin at tip of isthmus, fourth ray on ocular side opposite to first on blind side, all rays simple. Caudal fin rounded, rather feeble and elongate, inner 11 rays branched, but others simple.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid. Postorbital process triangular in shape (Fig. 100, C1, C2; Fig. 104, D). Alisphenoid entirely absent. Basioccipital roughly rectangular when viewed from lateral, rather large. Opisthotic rather small, square in shape, its tip not extending to tip of basioccipital. Prootic widely connected with basioccipital posteriorly (Fig. 100, C1, C2).

Suborbital bone on blind side slender, three in number. Second hypobranchial elliptical in shape, without toothed plate; third basibranchial gourd-shape (Fig. 114, G). Urohyal fishhook-like in shape, tip of sciatic part extending to slightly beyond tip of main part, tapering forward; cardiac apophysis exceedingly large, projecting backward, and has a pair of lateral ridges on both sides (Fig. 115, O). Opening for notochord large in size, and more advanced than middle part of centrum (Fig. 123, F). Anterior transverse apophysis beginning with fourth vertebra. Four caudal plates unbranched (Fig. 128, F).

Remarks: The present new genus closely resembles *Arnoglossus* in the arrangement of the teeth, but is easily distinguished from it in many osteological features: the arrangement of the opisthotic, the basioccipital and the prootic; the shape of the opisthotic and the basioccipital; the alisphenoid absent; the opening for notochord large in size; anterior transverse apophysis beginning with fourth or fifth vertebra.

On the other hand, the present genus closely related to *Laeops* and *Japonolaeops* in the some important osteological features, as mentioned above except for the last one character, but is sharply separable from the former genus at least in having teeth well developed on both sides, the first two rays of the dorsal fin touched the remaining of the fin and the large mouth, and from the latter genus in having uniserial teeth on both sides, a smaller eye, a larger mouth and a larger number of the abdominal vertebrae.

Neolaeops microphthalmus (Von BONDE) "Semushi-daruma"

Fig. 90

Laeops microphthalmus Von BONDE, 1922, 11, pl. 4, fig. 1. ——BARNARD, 1925, 392. ——KAMOHARA, 1935, 21.

Arnoglossus microphthalmus. NORMAN, 1931, 508. ——NORMAN, 1934, 197, fig. 145. ——OKADA and MATSUBARA, 1938, 421. ——SMITH, 1949, 159, fig. 312. ——MATSUBARA, 1955, 1258. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 81.

Materials: Male- No. 33192, 116.2 mm in standard length, Owashi, Mie Pref., December 15, 1957. No. 36173, 179.1 mm, off Tokushima, January 23, 1961. Female- Kochi Univ. No. 7769, 161.2 mm, Urado, Kochi Pref., October, 1957.

Diagnosis: A sinistral flounder with a deep concavity in front of upper eye, small deciduous scales and small eye.

Description: Dorsal fin rays 108-110; anal fin rays 83-87; pectoral fin rays 14-15 on ocular side, 11-14 on blind side; scales in lateral line 85-110; gill-rakers on first arch 5-6+8; vertebrae including urostyle 13+38=51. Head 4.69-5.09 in standard length; depth 2.35-2.59. Snout 5.06-5.42 in head; upper eye 4.27-4.89; lower eye 4.51-5.04; maxillary 2.58-2.67 on ocular side, 2.71-2.76 on blind side; lower jaw 1.87-1.91 on ocular side, 1.86-1.92 on blind side; depth of caudal peduncle 2.75-3.03; longest dorsal fin ray 1.46-1.72; longest anal fin rays 1.57-1.73; pectoral fin 1.87-2.01 on ocular side, 2.27-2.66 on blind side; ventral fin 2.7-2.78 on ocular side, 2.6-2.8 on blind side; base of ventral fin 2.47-2.73 on ocular side, 5.17-6.12 on blind side.

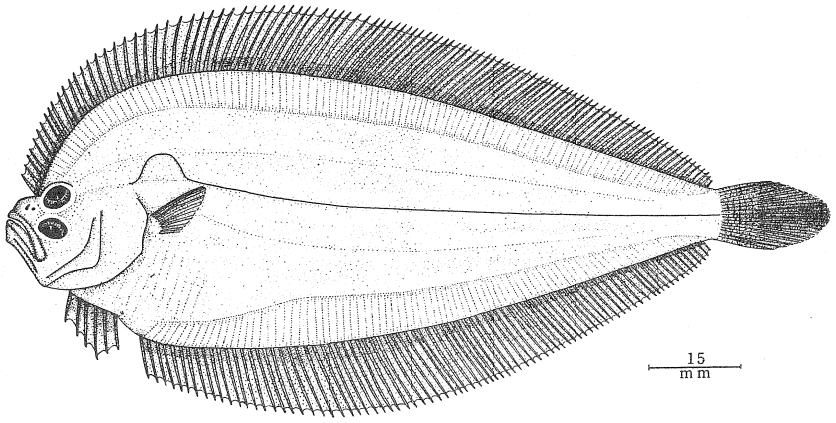

Fig. 90. Lateral view of *Neolaeops microphthalmus* (Von BONDE): No. 33192, 116.2 mm in standard length.

Body elliptical, strongly compressed, highest at anterior 1/3 of body or a little before it, its depth much more than 1/3 length of body; dorsal and anal contours except for head slowly arched above and below anterior 1/3 part of body, from which it gradually inclines towards caudal. Caudal peduncle very narrow in depth, about 1/3 length of head.

Head small, about half depth of body; head profile with a very deep concavity on horizontal through middle part of upper eye, from which it steeply rises. Snout protruding upward and rather short, about equal to eye diameter. Eyes very small, about half length of maxillary, separated by a narrow ridge which extends from the anterior margin of

lower eye to posterior margin of upper eye; lower a little in advance of upper or both about at same vertical. Nostrils on ocular side closely set in front of interorbital area; anterior one tubular with a long flap posteriorly, posterior one more or less tubular, without flap; nostrils on blind side below origin of dorsal, similar in shape and structure to those on ocular side.

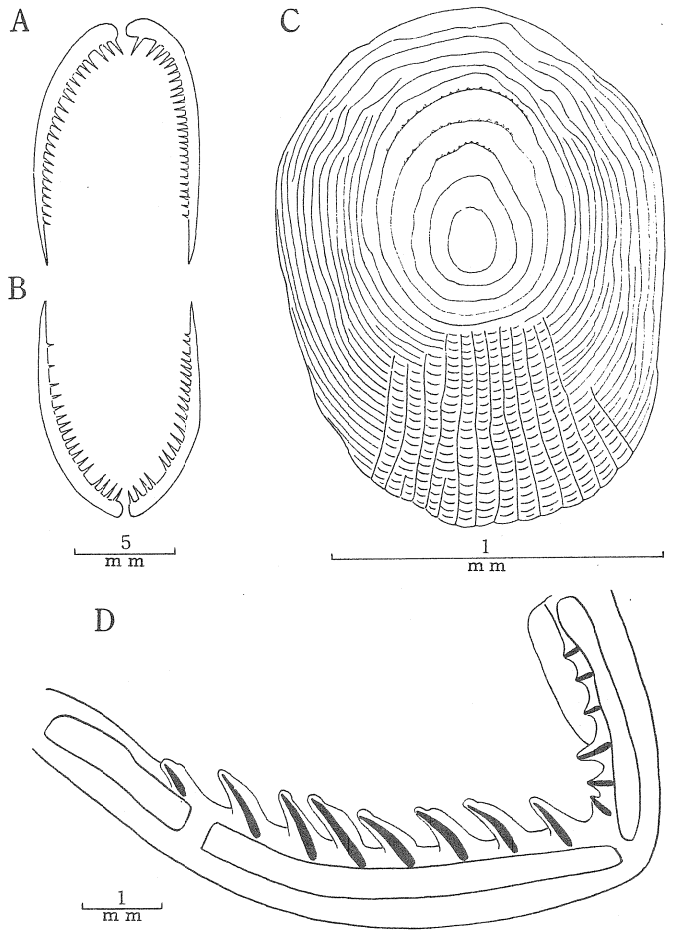

Fig. 91. Upper jaw (A), lower jaw (B), scale on ocular side (C) and first gill-arch on ocular side (D) in *Neolaeops microphthalmus* (Von BONDE). Ventral view (A); dorsal view (B).

Mouth moderate in size, oblique, and almost symmetrical; maxillary extending to below anterior part of lower eye or slightly beyond it; lower jaw with a small symphysial knob, rather large, a little more than half length of head. Teeth uniserial on both sides; those on upper jaw enlarged canine anteriorly, other lateral teeth small and rather close-set; those on lower jaw enlarged canine anteriorly, lateral teeth stronger and wider apart than those

on upper, and gradually becoming smaller and shorter backward (Fig. 91, A, B). Gill-rakers slender, moderate in length, and pointed; not serrate on each posterior margin; upper limb with some gill-rakers (Fig. 91, D).

Scales small and deciduous, cycloid on both sides (Fig. 91, C); snout, jaws, interorbital area and pectoral fin naked. Lateral line with a small curve above pectoral fin, length of curved portion much shorter than half length of head, the height about 1/5 length of head; the line absent on blind side.

Origin of dorsal slightly on blind side, before on horizontal from interorbital ridge, fin gradually higher to posterior 1/3 of body, and then evenly decreasing in height posteriorly to the end of fin. Anal fin starting immediately behind ventral fin on ocular side, similar in shape and structure to dorsal. Pectoral fins unequal, rather short; that on ocular side about half length of head, all rays simple. Ventral fin on ocular side originating on vertical through posterior margin of lower eye, fourth ray on ocular side opposite to first on blind side. Caudal fin rounded, feeble, rather enlarged, inner 11 rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body pale brownish; dorsal and anal fins and ventral fin on ocular side darker, caudal fin blackish on some rays at middle portion, but it not extending to base of caudal fin. Body on blind side yellowish white.

Remarks: The present species is allied to *Japonolaeops dentatus* in the number of dorsal and anal fin rays and of vertebrae, but easily separable from it in having a smaller eye, a larger mouth and the dorsal profile steeply rised above the pectoral fin.

43. Genus *Kamoharaia* KURONUMA

Kamoharaia KURONUMA, 1940, 35. (type-species by original designation: *Chascanopsetta megastoma* KAMOHARA).

Body elliptical, strongly compressed, tip of isthmus far behind lower eye, and above posterior end of lower jaw. Anterior dorsal profile similar in both sexes. Head rather small and oblique. Eyes sinistral, separated by a narrow ridge which extends from the anterior margin of lower eye to posterior margin of upper one, upper eye oblique, a little in front of lower; interorbital region similar in both sexes. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one tubular with a flap posteriorly and posterior one somewhat tubular, without flap. Mouth oblique exceedingly large in size; maxillary extending posteriorly far beyond lower eye, and projecting anteriorly beyond tip of snout; teeth on upper jaw small and uniserial on anterior half, anteriorly with somewhat enlarged teeth, and villiform in narrow band on posterior half; teeth on lower jaw uniserial with three pairs of curved strong canines developed on anterior part, other teeth weaker than canines, becoming smaller and narrower posteriorly. Tip of vomer projecting into mouth cavity. Gill-rakers slender and short, not serrate on posterior margin. Scales small and deciduous, cycloid in both sides; snout, jaws and interorbital area naked. Lateral line on ocular side

curved above base of pectoral fin; the line on blind side absent.

Dorsal fin originating on horizontal through interorbital ridge, first ray longer than those of anterior portion; all rays simple. Anal fin starting on vertical through base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins very asymmetrical, that on ocular side longer than that on blind side, not prolonged in both sexes, all rays simple. Ventral fins rather short bases on both sides, locates below base of pectoral fin; that on ocular side originating on tip of isthmus, third ray opposite to first on blind side, all rays simple. Caudal fin rounded posteriorly, uppermost and lowermost four rays simple, and other rays branched.

Vomer very elongate and toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid (Fig. 100, D1, D2; Fig. 104, D). Postorbital process triangular in shape. Alisphenoid on ocular side absent. Opisthotic roughly elliptical in shape, narrowly connected to prootic anteriorly. Basioccipital roughly triangular in shape, when viewed from lateral, widely connected to prootic anteriorly (Fig. 100, D1, D2).

Suborbital bone on blind side slender and three in number. Second hypobranchial elliptical in shape, without toothed plate; third basibranchial hourglasslike in shape with a posterior projection; glossohyal rather elongate, extending upward on first basibranchial (Fig. 114, K). Urohyal fishhook-like in shape, main part short, curved sharply towards ventral; cardiac part projecting largely upward, without ridge and wing; sciatic part exceedingly elongate vertically, but scarcely beyond tip of main part, becoming gradually wider downward and pointed at tip (Fig. 116, I; Fig. 117, G). Opening for notochord large in size, and more advanced than middle part of centrum. Anterior transverse apophysis beginning with fourth vertebra. Anterior part of vertebrae exceedingly curved towards ventral side (Fig. 122, A1-A5; Fig. 123, F). Four caudal plates not branched (Fig. 128, G).

Remarks: The present genus established by KURONUMA (1940) based on *Chascanopsetta megastoma* KAMOHARA, is apparently related to *Chascanopsetta* at least in having extremely large mouth and rather a large number of abdominal vertebrae, but it is clearly distinguished from the latter in having the following external and internal characters: 1) canine teeth well armed on anterior tip of lower jaw; 2) anterior part of maxillary protruding beyond tip of snout; 3) opisthotic bone surrounded by prootic, pterotic, exoccipital and basioccipital bones; 4) vomer very elongate, its tip protruding into mouth cavity; 5) suborbital bone on blind side three in number; 6) peculiar urohyal; 7) abdominal vertebrae 14 in number; 8) opening for notochord large in size, more advanced than middle part.

Kamoharaia megastoma (KAMOHARA) "Wani-garei"

Fig. 92

Chascanopsetta megastoma KAMOHARA, 1936, 308, fig. 1. ——OKADA and MATSUBARA, 1938, 423.

Kamoharaia megastoma. KURONUMA, 1940, 36, fig. 2. ——KAMOHARA, 1950, 242. ——MATSUBARA, 1955, 1261. ——KAMOHARA, 1958, 62. ——KAMOHARA, 1964, 82, fig. 53.

Materials: Male- No. 33222, 153.1 mm in standard length, Mimase, Kochi Pref., December 10, 1957. No. 33223, 126.4 mm, off Tokushima, November 8, 1958. Female- No. 33221, 152.1 mm, Mimase, November 8, 1957.

Diagnosis: A peculiar sinistral flounder with extremely large mouth; upper jaw projecting below tip of snout; canine teeth well developed on anterior tip of lower jaw; tip of vomer protruding into mouth cavity.

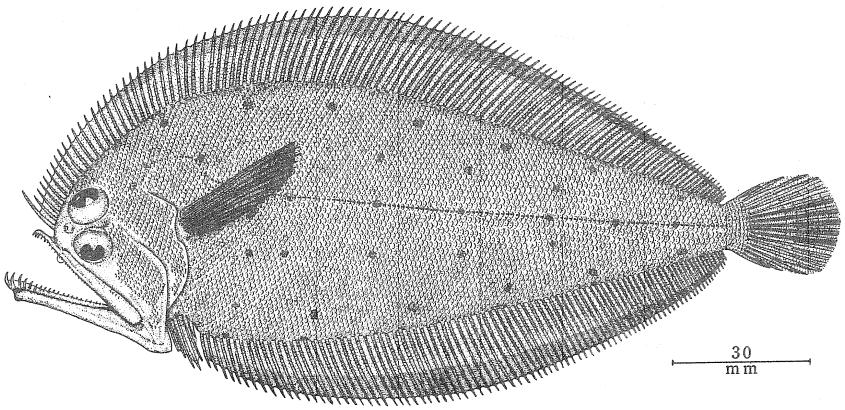

Fig. 92. Lateral view of *Kamoharaia megastoma* (KAMOHARA): No. 33222, 153.1 mm in standard length.

Description: Dorsal fin rays 109-112; anal fin rays 84-86; pectoral fin rays 15-16 on ocular side, 11-12 on blind side; scales in lateral line 126-127; gill-rakers on first arch 7+8-9; vertebrae including urostyle 14+39=53. Head 4.91-5.02 in standard length; depth 2.58-2.7. Snout 3.87-4.2 in head; upper eye 3.31-3.48; lower eye 3.56-3.65; maxillary 1.02-1.04 on ocular side, 9.75-10.1 on blind side; lower jaw 8.0-8.36 on ocular side, 8.0-8.36 on blind side; depth of caudal peduncle 3.23-3.45; first dorsal fin ray 2.51-2.77; longest dorsal fin ray 1.63-1.8; longest anal fin ray 1.56-1.71; pectoral fin 0.89-0.92 on ocular side, 2.22-2.34 on blind side; ventral fin 2.49-2.61 on ocular side, 2.49-2.56 on blind side; base of ventral fin 5.14-5.77 on ocular side, 7.43-9.73 on blind side.

Body elliptical, strongly compressed, highest at posterior end of pectoral fin, more than 1/3 length of body; dorsal contour evenly arched except for head region, ventral contour nearly straight. Caudal peduncle very narrow, about equal to 1/6 depth of body.

Head small, well curved to ventral side, a little more than half depth of body; upper profile with a deep concavity in front of interorbital area, and it roundly rises after more or less convex before upper eye. Snout very short, a little longer than eye diameter. Eyes rather small, about equal to 1/3 length of maxillary, separated by a narrow ridge which extends from anterior margin of lower eye to posterior margin of upper one; upper eye

oblique, a little in advance of lower which placed nearly horizontally. Nostrils on ocular side closely set in front of interorbital ridge, anterior one tubular with a triangular dermal flap posteriorly; posterior one more or less tubular, without flap; nostrils on blind side situated close to tip of snout and below origin of dorsal, nearly similar in shape and structure to those on ocular side.

Mouth oblique, extremely large and equally developed on both sides; maxillary not curved, protruding anteriorly beyond tip of snout by distance equal to about half diameter of eye, extending posteriorly to far beyond lower eye and middle part about same vertical

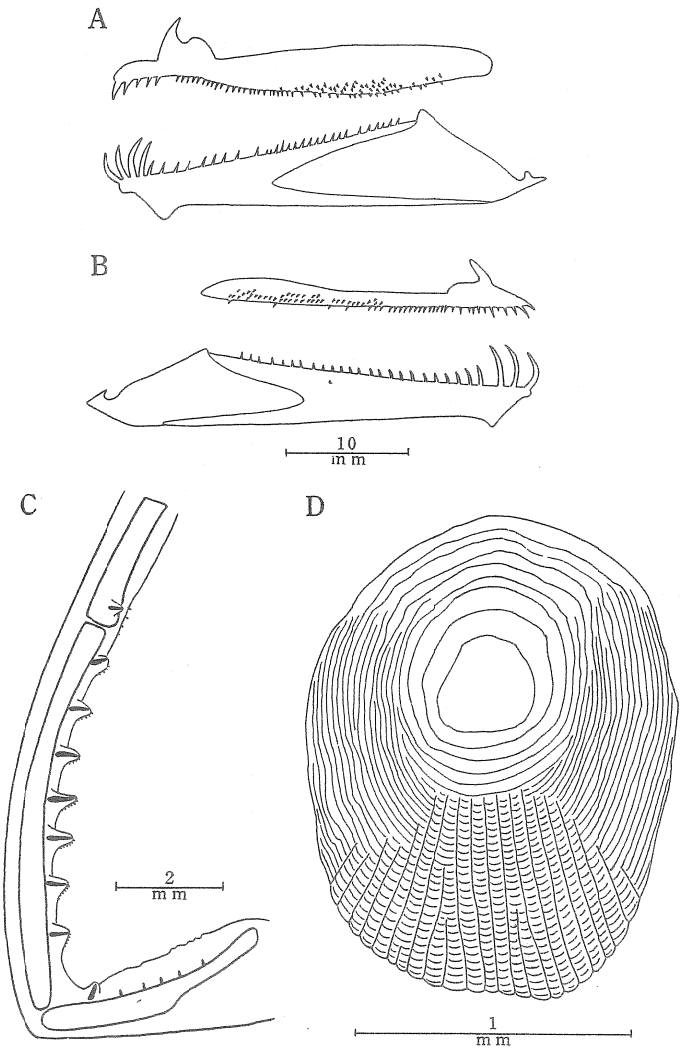

Fig. 93. Lateral view of both jaws (A, ocular side; B, blind side), first gill-arch on ocular side and scale on ocular side in *Kamoharaia megastoma* (KAMOHARA).

line with posterior margin of lower eye; lower jaw slightly projecting anteriorly in advance of tip of upper one, and slightly covers anterior part of ventral fins; tip of vomer projecting into mouth cavity. Teeth on upper jaw uniserial on anterior half, anteriorly with three to four pairs of larger teeth than other ones, and villiform in narrow bands on posterior half; teeth on lower jaw uniserial with three pairs of curved strong canines developed on anterior part, and other teeth weaker than canines, becoming smaller and narrower posteriorly (Fig. 93, A, B). Gill-rakers slender and short, not serrate on posterior margin; most gill-rakers on upper limb smaller than those on lower limb, rudimentary (Fig. 93, C). Scales small and deciduous, cycloid on both sides (Fig. 93, D); snout, jaws and interorbital area naked.

Lateral line on ocular side with a curve above base of pectoral fin; length of curved portion about half length of head, height about 1/3 length of its portion; the line absent on blind side.

Dorsal fin inserted on blind side, slightly beyond median edge of head, before horizontal through interorbital ridge; first ray longer than those of anterior portion, and fin rays gradually becoming higher posteriorly to middle part of body, and then gradually decreasing in height posteriorly. Anal fin starting below basal part of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on blind side about equal to half that on ocular side, all rays simple. Ventral fins short base, that on ocular side starting nearly above posterior end of lower jaw; third ray on ocular side opposite to first on blind side. Caudal fin rounded posteriorly, slender and rather elongate, about 1.5 in head, inner nine rays branched, but others simple.

Vent opens on blind side, above origin of anal fin. Genital papilla occurring in similar position on ocular side.

In formalin, general ground color on ocular side of body uniformly brownish with darker blotches; pectoral fin on ocular side, marginal portions of dorsal and anal fins and middle portion of caudal fin not extending to base of fin stained with dark. Body on blind side yellowish white.

Remarks: The present species is closely related to *Chascanopsetta lugubris* ALCOCK in having the large mouth, but can sharply be separated from it at least in having the maxillary strongly protruding anteriorly beyond the tip of the snout, three pairs of canine teeth on the lower jaw and tip of vomer projecting into the mouth cavity.

44. Genus *Chascanopsetta* ALCOCK

Chascanopsetta ALCOCK, 1894, 128 (type-species by original designation: *Chascanopsetta lugubris* ALCOCK).

Trachypterophrys FRANZ, 1910, 60 (type-species by original designation: *Trachypterophrys raptator* FRANZ).

Body elongate, elliptical, strongly compressed and flexible. Caudal peduncle very narrow in depth. Tip of isthmus inner side of posterior end of maxillary. Anterior dorsal profile similar in both sexes. Head rather small, less than 1/4 of standard length.

Eyes sinistral, separated by a narrow and flat space and about at same vertical; interorbital region similar in both sexes. No rostral, orbital and mandibular spines. Nostrils on both sides two, anterior one on ocular side tubular with long flap posteriorly. Mouth exceedingly large and oblique, maxillary extending to below horizontal through posterior margin of lower eye or extremely behind it, more than 1/2 length of head; tip of lower jaw projecting in advance of upper; teeth on jaws uniserial and slender; those on lower jaw well curved towards inner side and depressible; no distinct canines. Gill-rakers absent or rudimentary, disklike in shape, not serrate; none on upper limb. Scales extremely small, cycloid on both sides, more or less embeded; fins except for caudal fin, snout, both jaws and interorbital area naked. Lateral line equally developed on both sides.

Dorsal fin originating above nostrils on blind side; anterior rays slightly elongate, connected by membrane at their bases; all rays simple. Anal fin starts slightly in rear of base of pectoral fin, similar in shape and structure to dorsal. Pectoral fins unequal, that on ocular side longer than that on blind side, all rays simple. Left ventral fin originates below and backward tip of isthmus (Fig. 95, C); third ray on ocular side opposite to first on blind side; last ray on ocular side connected to origin of anal fin by a membrane; all rays simple. Caudal fin rounded posteriorly; uppermost and lowermost two rays simple, and other rays branched.

Vomer toothless. Interorbital bone rodlike in shape, composed of interorbital bar and prefrontal on ocular side, and interorbital process completely lacking. Each of prefrontals widely separated from each other by intervention of mesethmoid (Fig. 100, E1, E2; Fig. 104, D). Alisphenoid entirely absent. Basioccipital roughly rectangular in shape, when viewed from lateral. Opisthotic square in shape, anteriorly not connected to prootic by intervention of pterotic, and surrounded by basioccipital, exoccipital and pterotic (Fig. 100, E1, E2).

Suborbital bone on blind side four in number. The upper pharyngeal bones with a small number of teeth of two rows in second, of two to three rows in third and of a single row in fourth. The second basibranchial exceedingly expanded in posterior half, but extremely reduced in anterior half; third basibranchial with a pair of short wings on anterior concave portions; glossohyal very elongate (Fig. 114, L). Urohyal fishhook-like in shape; sciatic part very short, its tip extending to posterior 1/4 distance from tip of main part to angular portion, pointed upward; cardiac apophysis simple, rodlike in shape and projecting backward (Fig. 116, F). Opening for notochord moderate in size, and slightly advanced than middle part of centrum; anterior transverse apophysis beginning with fifth vertebra (Fig. 122, B1-B5; Fig. 123, C). Four caudal plates not branched (Fig. 128, H).

Chascanopsetta lugubris ALCOCK, "Zara-garei"

Fig. 94

Chascanopsetta lugubris ALCOCK, 1894, 129, pl. 6, fig. 4. ——ALCOCK, 1899, 125. ——NORMAN, 1927, 35, fig. 9. ——NORMAN, 1931, 601. ——NORMAN, 1934, 250, fig. 191. ——KAMOHARA, 1934,

1201. ——KAMOHARA, 1938, 59. ——OKADA and MATSUBARA, 1938, 421, pl. 105, fig. 1. ——KURONUMA, 1940, 213. ——KURONUMA, 1940, 43. ——SMITH, 1949, 157, fig. 306. ——KURODA, 1951, 389. ——MUNRO, 1955, 259, pl. 49, 749. ——MATSUBARA, 1955, 1262. ——KAMOHARA, 1950, 241, fig. 182. ——KAMOHARA, 1958, 62. ——NIELSEN, 1961, 122. ——KAMOHARA, 1964, 82. ——SHIH-CHIEH, 1966, 186, figs. 62-65.

Trachypterophrys raptator FRANZ, 1910, 60, pl. 7, fig. 54. —— JORDAN, TANAKA and SNYDER, 1913, 315. ——KAMOHARA, 1931, 93.

Chascanopsetta raptator. HUBBS, 1915, 452.

Chascanopsetta gilchristi Von BONDE, 1922, 7. ——BARNARD, 1925, 390.

Chascanopsetta maculata Von BONDE, 1922, 8.

Chascanopsetta lugubris danae BRUUN, 1937, 126, pl. l, fig. 1.

Chascanopsetta normani KURONUMA, 1940, 40, figs. 3-4. ——MATSUBARA, 1955, 1262.

Materials: Nos. 1550-1556, 218.0-286.0 mm in standard length, Owashi, Mie Pref., December 6, 1935. Nos. 6155-6157, 207.2-240.0 mm, Heta, Shizuoka Pref., date unknown. No. 6174, 145.9 mm, Heta, March 26, 1939. No. 6209, 173.2 mm, Heta, March 26, 1939. Nos. 7256-7258, 144.1-225.5 mm, Heta, January 6, 1940. No. 10073, 159.8 mm, Nos. 10076-10080, 203.2-258.0 mm, Heta, March 15, 1938. No. 10359, 159.8 mm, Nos. 10363-10364, 203.3-258.0 mm, Nos. 10401-10404, 173.6-281.0 mm, No. 10411, 187.0 mm, Onomichi, Hiroshima Pref., July 15, 1948. Nos. 10630-10634, 201.0-325.0 mm, Nos. 10637-10641, 174.6-205.9 mm, No. 10643, 154.9 mm, Nos. 10650-10654, 182.1-240.0 mm, East China Sea, December 25, 1948. No. 15852, 159.3 mm, Urado, Kochi Pref., February 20, 1951. Nos. 17379-17380, 237.4-248.2 mm, Owashi, January 3, 1951. No. 17525, 157.3 mm, Miya, Aichi Pref., March 15, 1952. No. 24570, 210.2 mm, Owashi, October 25, 1954. Nos. 33275-33293, 125.9-250.5 mm, Mimase, Kochi Pref., November 15, 1957.

Diagnosis: A sinistral flounder inhabiting in deep water, and having strongly compressed and flexible body and exceedingly large mouth; canine teeth never develope.

Description: Dorsal fin rays 111-124; anal fin rays 76-86; pectoral fin rays 14-17 on ocular side, 12-15 on blind side; scales in lateral line 152-185; gill-rakers on first arch 0+0-3; vertebrae including urostyle 16-17+37-40=53-57. Head 4.09-5.84 (18.2-24.4)* in standard length; depth 2.82-3.82. Snout 5.2-7.39 in head; upper eye 2.93-4.67; lower eye 2.86-5.16; maxillary 1.0-1.48 (13.1-18.0)* on ocular side, 1.01-2.04 on blind side; lower jaw 1.04-1.22 (16.0-20.9)* on ocular side, 1.04-1.21 on blind side; depth of caudal peduncle 3.09-4.14; longest dorsal fin ray 2.0-2.94; longest anal fin ray 1.97-2.68; pectoral fin 1.23-2.0 on ocular side, 2.31-3.95 on blind side; ventral fin 2.38-3.76 on ocular side, 2.38-3.63 on blind side; base of ventral fin 3.33-5.34 on ocular side, 5.58-8.28 on blind side.

Body elongate, elliptical, strongly compressed and flexible, highest nearly at posterior margin of abdominal cavity, its depth about equal to 1.5 length of head; dorsal and anal contours gently arched or almost horizontal except for head region. Caudal peduncle very narrow in depth, about equal to 1/5 depth of body.

Head rather small in size, much longer than half depth of body; upper profile with a slight concavity in front of interorbital space, and it roundly rises after somewhat convex before middle part of upper eye. Snout blunt and rather short, about equal to 2/3 eye diameter. Eyes sinistral and moderate in size, separated by a narrow flat space, about 1/3 to 1/4 eye diameter; upper eye slightly in advance of lower or both about at same

*in hundredth of standard length

vertical. Nostrils on ocular side closely set in front of upper margin of lower eye, anterior one tubular with a rather long flap posteriorly, posterior one more or less tubular with flap; nostrils on blind side setting below origin of dorsal, anterior one tubular, without flap, posterior one not tubular.

Mouth oblique and exceedingly large in size, about equally developed on each side; maxillary slender and not curved, extending to well beyond lower eye; lower jaw slightly projecting below upper when mouth is closed. Teeth uniserial in both jaws and slender; those on upper jaw becoming rather small on posterior half; those on lower jaw curved to inner side, and depressible, some posterior ones smaller than others (Fig. 95, A, B). Gill-rakers on first arch absent or rudimentary, disklike in shape, not serrate at its posterior margin, none on upper limb (Fig. 112, F).

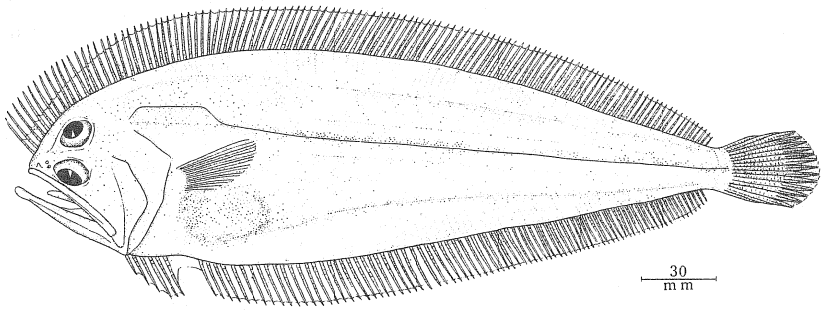

Fig. 94. Lateral view of *Chascanopsetta lugubris* ALCOCK: No. 17380, 237.4 mm in standard length.

Scales exceedingly small, more or less embeded and cycloid on both sides; fins except for caudal fin, jaws, snout and interorbital area scaleless. Lateral line equally developed on both sides with a low flat curve above pectoral fin, length of curve portion about 2/3 length of head, and its height about 1/5 to 1/6 its length.

Dorsal fin starting slightly on blind side, before horizontal through lower margin of upper eye; fin rays except for anterior some rays gradually higher in middle part of body, then evenly decreasing in height posteriorly; some anterior rays slightly elongate but slightly shorter than those of middle part; all rays simple. Anal fin beginning slightly in rear of base of pectoral fin, and first ray connecting to last ventral fin on ocular side by a low membrane; anal fin similar in shape and structure to dorsal. Pectoral fins asymmetrical and slender, all rays simple. Ventral fin on ocular side inserted below and backward tip of isthmus; third ray on ocular side opposite to first on blind side. Caudal fin slender and rounded posteriorly, inner 13 rays branched, but others simple.

Vent opens on blind side, between last ventral ray and origin of anal. Genital papilla on opposite side of vent.

In formalin, general ground color on ocular side of body dark brown with numerous small dark spots; peritoneum light blue which is visible through thin abdominal wall;

vertical fins dusky; paired fins paler than body. Blind side of body pale brownish with light blue on peritoneum portion.

Remarks: In original description by KURONUMA (1940) *C. normani* was separated from the present species in having the higher meristic characters, the lower jaw projecting about 1/9 the length below the upper, the posterior end of the lower jaw together with lower corners of opercular bones strongly protruded downwardly, the length of the maxillary more than 16 in hundredth of standard length and the length of the lower jaw more than 20 in hundredth of standard length. In the examination of many specimens of *Chascanopsetta lugubris* ALCOCK taken from Japanese waters, however, they are well undistinguishable in meristic characters and propotional measurements, as mentioned above, which fall under specific variation of *C. lugubris*. Here, the present author placed *C. normani* as a synonym of the present species.

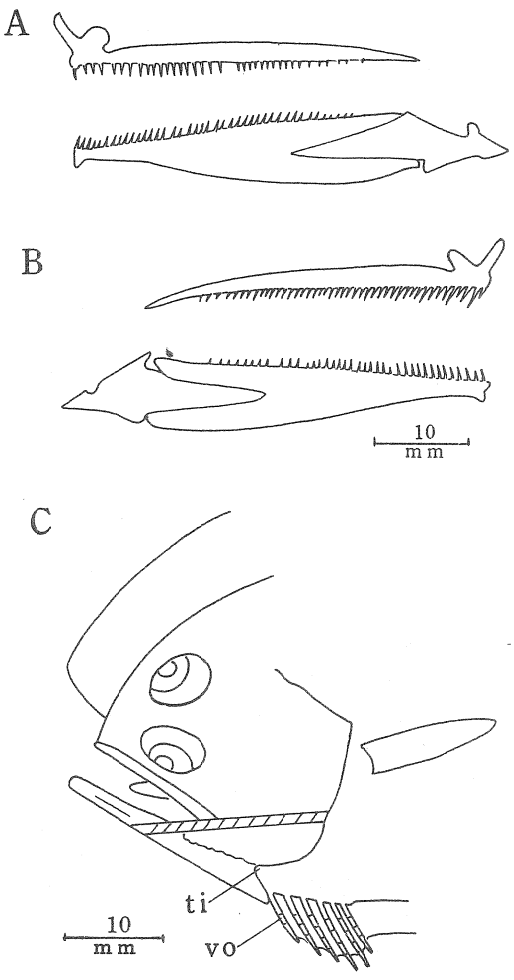

Fig. 95. Lateral view of both jaws (A, ocular side; B, blind side) and left view of ventral fin and isthmus (C) in *Chascanopsetta lugubris* ALCOCK. ti, tip of isthmus; vo, ventral fin on ocular side.

Chascanopsetta microstoma KURONUMA was described by KURONUMA from a single specimen taken from Heta, Shizuoka Prefecture. No specimens have come under our examination, but according to the original description the species is closely related to *C. lugubris* in general feature, but distinguished from it in having the following points: length of maxillary 11 in hundredth of standard length, length of lower jaw 13.2 in hundredth of standard length and length of pectoral fin 7.3 in hundredth of standard length. However, it is doubtful whether the present specimen established as *C. microstoma* is normal condition or not.

V. Comparative anatomy

1. Cranium

Description: The cranium of the flounders is so asymmetrical that the skeletal elements constituting the cranium and their general arrangement very on each side and throughout the species of the sinistral flounders and the related species.

The vomer is an unpaired bone, situated on the foremost region of the cranium. It is usually triangular in shape, and meets the mesethmoid dorsally and each prefrontal dorso-laterally. The posterior part of this bone gradually becomes narrower, extending backward beneath the anterior part of the parasphenoid.

On the ocular side, most species have the bone the dorsal portion of which is connected with the mesethmoid by suture anteriorly and by the cartilaginous component posteriorly. The fishes of the genus *Psettodes* have the vomer which dorsally joints with the mesethmoid by the suture alone (Fig. 96, A1). On the contrary, the fishes of the genera *Citharoides, Paralichthys* and *Pseudorhombus* have the vomer which dorsally joints with the mesethmoid by the cartilaginous component alone (Fig. 96, B1, D1, E1).

On the blind side, the bone of most of the members of Japanese flounders is generally connected with the mesethmoid by the suture anteriorly and by the cartilaginous component posteriorly (Figs. 96-99).

The teeth of the vomer are entirely absent in all the members of Japanese flounders, with the only exception of *Psettodes erumei,* which has a small patch of teeth on the anterior narrow area of the median shaft.

The mesethomoid is rather small and unpaired bone, and is generally inserted between the prefrontals and rests on the vomer. In most of the species, it bears on its dorsal surface a median longitudinal keel, forming the mesethmoid-vomerine keel together with the elevations of the vomer. But in *Psettodes erumei* it has no keel of this kind (Fig. 96, A1, A2). The dorsal region of the keel is provided with a short bony process*. Some different features present among the genera in the relations between lateral sides of the mesethmoid and the other elements composed of the cranium. The bone is classified into the four types according to the connections with other bones. In the first type represented by the fishes of the genera *Psettodes, Citharoides* and *Lepidoblepharon,* the bone is in contact posteriorly with the prefrontal on the blind side and with the frontal** on the same side, the latter of which is extended forward far along the inner side of the interobital bone. The mesethmoid does not form the anterior area of the upper orbital cavity (Fig. 96, A1-C1, A2-C2; Fig. 101, A1-C1; Fig. 104, A, B). The second type, which comprises the fishes of the genera *Paralichthys, Pseudorhombus* and *Tarphops* has the mesethmoid, the ocular side of which is connected with the interorbital process dorso-laterally, and the blind side of the same bone is connected with the prefrontal on the blind side. The mesethmoid forms the anterior portion of the upper orbital cavity (Fig. 96, D1-F1, D2-F2;

*This short bony process is called mesethmoid process.
**This bone is called the interorbital process.

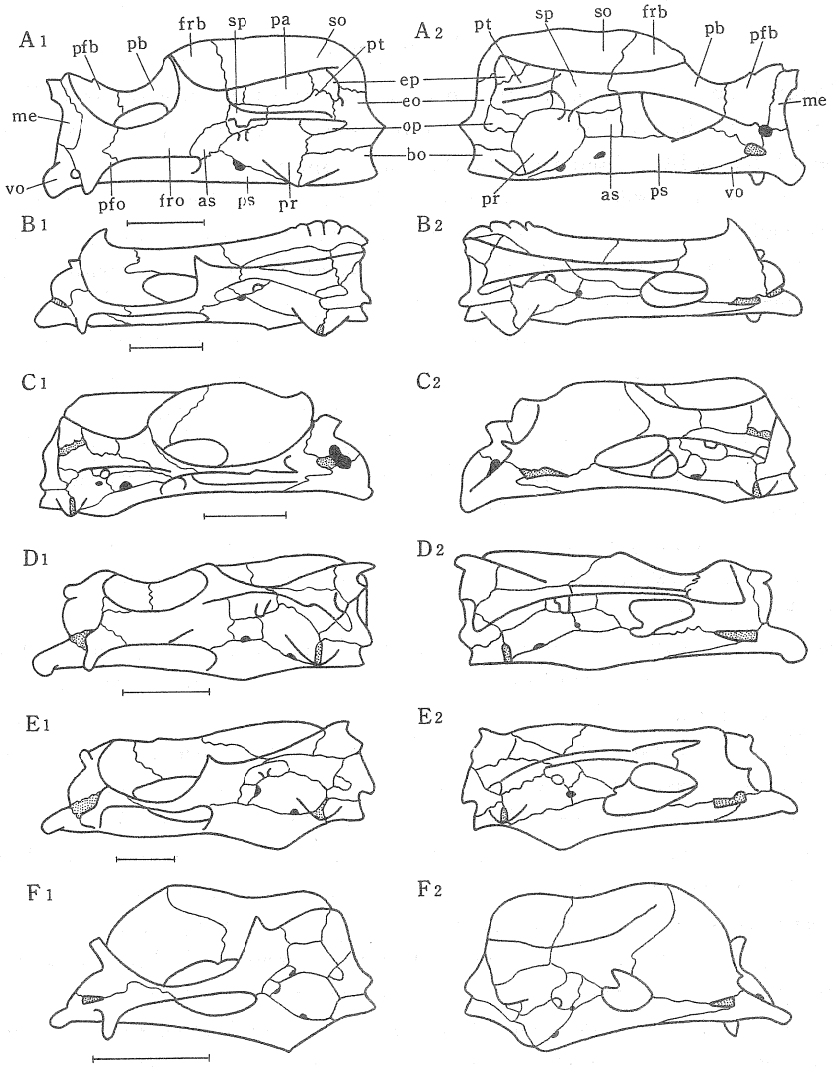

Fig. 96. Outline of lateral (A1 to F1 on ocular side; A2 to F2 on blind side) aspect of the cranium in six species. A1 • A2, *Psettodes erumei;* B1 • B2, *Citharoides macrolepidotus;* C1 • C2, *Lepidoblepharon ophthalmolepis;* D1 • D2, *Paralichthys olivaceus;* E1 • E2, *Pseudorhombus cinnamoneus;* F1 • F2, *Tarphops oligolepis.* bo, basioccipital; eo, exoccipital; ep, epiotic; fro, frontal on ocular side; frb, frontal on blind side; pb, pseudomesial bar; pfo, prefrontal on ocular side; pfb, prefrontal on blind side; me, mesethmoid; op, opisthotic; ps, parasphenoid; pa, parietal; pr, prootic; pt, pterotic; sp, sphenotic; so, supraoccipital; as, alisphenoid; vo, vomer. Scales indicate 10 mm.

Fig. 101, D1; Fig. 102, A1; Fig. 104, C). In the fishes of the genera *Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta* each side of the bone is connected with the prefrontal on each side, and constitutes the anterior portion of the upper orbital cavity (Fig. 99, A1-E1, A2-E2; Fig. 100, A1-E1, A2-E2; Fig. 102, C1; Fig. 104, D). In the fourth type, including the *Taeniopsetta, Engyprosopon, Crossorhombus, Tosarhombus, Parabothus* and *Bothus* the bone is inserted so as to wedge off the prefrontals on both sides and is completely surrounded by the these bones. The

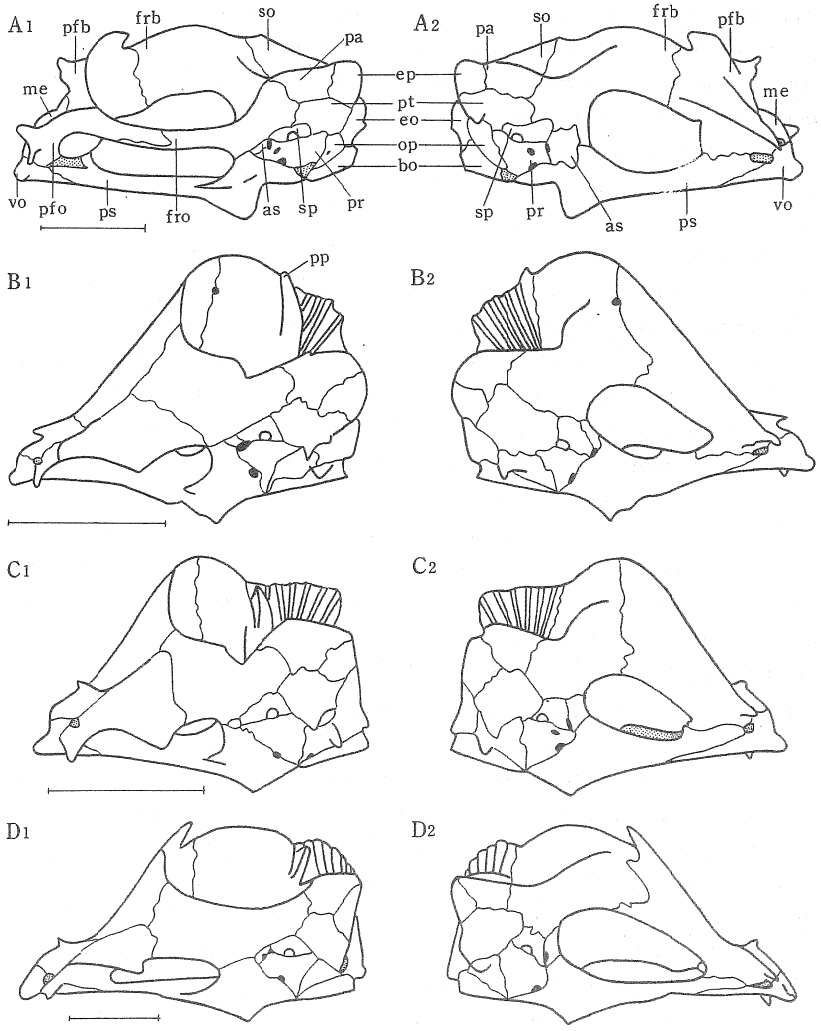

Fig. 97. Outline of lateral (A1 to D1 on ocular side; A2 to D2 on blind side) aspect of the cranium in four species. A1 • A2, *Taeniopsetta ocellata;* B1 • B2, *Engyprosopon grandisquama;* C1 • C2, *E. multisquama;* D1 • D2, *Tosarhombus octoculatus.* pp, postorbital process. Other abbreviations as in Fig. 96. Scales indicate 10 mm.

mesethmoid does not form the antero-dorsal portion of the upper orbital cavity (Fig. 97, A1-D1, A2-D2; Fig. 98, A1-D1, A2-D2; Fig. 102, B1, D1; Fig. 103, A1-C1; Fig. 104; E, F, G).

The prefrontals are paired, asymmetrical bones, lying on both sides of the mesethmoid, and the bone on the ocular side is much smaller than that on the blind side. Each of them is generally articulated anteriorly with the vomer and posteriorly with the corresponding frontal. Ventrally they are connected with the anterior area of the parasphenoid usually by the cartilaginous component or by the suture, but frequently by both.

On the ocular side, the bone forms the anterior or the antero-dorsal portion of the orbital cavity of the lower eye. The dorsal shape of the bone shows the different features among the genera. In the fishes of the genera *Psettodes, Lepidoblepharon, Citharoides, Paralichthys, Pseudorhombus, Tarphops, Arnoglossus, Psettina, Asterorhombus, Taeniopsetta, Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta*, it is barlike in shape, supporting the antero-dorsal surface of the lower eye (Fig. 96, A1-F1; Fig. 97, A1; Fig. 99, A1-E1; Fig. 100, A1-E1). All the members of the genera *Parabothus, Engyprosopon, Crossorhombus, Tosarhombus* and *Bothus* have a platelike prefrontal, supporting the entire dorsal surface of the lower eye (Fig. 97, B1-D1; Fig. 98, A1-D1). The bone is also differently connected dorsally with other elements of the cranium among the genera. In the fishes of the genera, *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus* and *Tarphops*, it is in narrow contact with the outer surface of the interorbital process (Fig. 96, A1-F1; Fig. 101, A1-D1; Fig. 102, A1; Fig. 104, A-C). In the fishes of the 10 genera, *Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Laeops, Neolaeops, Kamoharaia, Chascanopsetta, Bothus* and *Crossorhombus* the bone is connected anteriorly with the lateral side of the mesethmoid by suture alone (Fig. 98, A1, C1, D1; Fig. 99, A1-E1; Fig. 100, A1-E1; Fig. 102, C1; Fig. 103, B1, C1; Fig. 104, D, G). In the fishes of the four genera, *Taeniopsetta, Engyprosopon, Tosarhombus* and *Parabothus* it is widely connected anteriorly with the mesethmoid and dorsally with the prefrontal on the opposite side which anteriorly extends to the ocular side far beyond the median line of the cranium (Fig. 97, A1-D1; Fig. 98, B1; Fig. 102, B1-D1; Fig. 103, A1; Fig. 104, E, F).

On the blind side, the bone is generally platelike in shape, lying on the anterior or the dorso-anterior corner of the upper orbital cavity. The dorsal surface of the bone bears the several anterior interneural spines together with the fronto-supraoccipital keel. The marked difference in the prefrontal on the blind side is in the mode of connection with other bones. In the fishes of the families Psettodidae and Citharidae the bone is connected with the anterior part of the interorbital process antero-laterally, and these bones are also in contact with the posterior surface of the mesethmoid (Fig. 96, A1-C1, A2-C2; Fig. 101, A1-C1; Fig. 104, A, B). While in the fishes of the genera *Paralichthys, Pseudorhombus, Tarphops, Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Neolaeops, Laeops, Kamoharaia* and *Chascanopsetta* it is articulated with the lateral side of the mesethmoid alone (Fig. 96, D1-F1, D2-F2; Fig. 99, A1-E1, A2-E2; Fig. 100, A1-E1, A2-E2; Fig. 101, D1; Fig. 102, C1; Fig. 104, C, D). In the fishes of the genera *Taeniopsetta* and *Parabothus*, the prefrontal of the blind side extends to the ocular side on the mesethmoid far beyond the median line of the cranium and is connected with that on the opposite side (Fig.

97, A1, A2; Fig. 98, B1, B2; Fig. 104, E). In the fishes of the four genera *Engyprosopon, Tosarhombus, Crossorhombus* and *Bothus,* the bone is greatly expanded upward, reaching the ocular side far beyond the median line of the cranium, where in the first two of these genera it is widely connected with the prefrontal on the ocular side and with the frontal on the ocular side (Fig. 97, B1, C1, D1, B2, C2, D2; Fig. 104, F), but in the succeeding two it is connected with the frontal on the ocular side alone (Fig. 98, A1, C1, D1, A2, C2, D2; Fig. 104, G).

The frontals are paired bones, covering the median part of posterior and dorsal regions of each orbital cavity. They are also greatly asymmetrical both in position and shape.

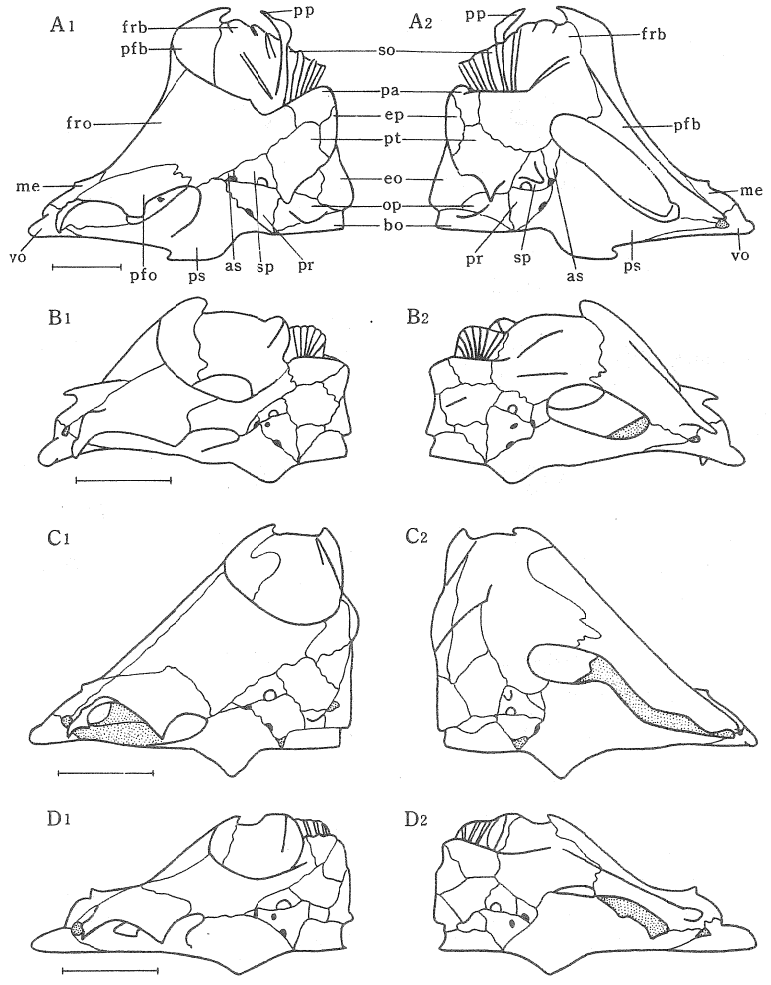

Fig. 98. Outline of lateral (A1 to D1 on ocular side; A2 to D2 on blind side) aspect of the cranium in four species. A1 • A2, *Crossorhombus kobensis;* B1 • B2, *Parabothus kiensis;* C1 • C2, *Bothus myriaster;* D1 • D2, *B. mancus.* Abbreviations as in Figs. 96 and 97. Scales indicate 10 mm.

On the ocular side, it is well expanded forward so as to form the interorbital area. In the fishes of the families Psettodidae, Citharidae and Paralichthyidae the bone is a barlike in shape and is in contact with the posterior part of the corresponding prefrontal and also with the outer side of interorbital process (Fig. 96, A1-F1; Fig. 104, A-C). In the fishes of the family Bothidae, however, the inner side of the bone is not connected with the interorbital process for lacking it. In the fishes of genera *Taeniopsetta, Parabothus, Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta* belonging to this family, the bone is rather barlike in shape, and connected anteriorly with the corresponding prefrontal bone alone (Fig. 97, A1; Fig. 98, B1; Fig. 99, A1-E1; Fig. 100, A1-E1; Fig. 104, D, E). But the fishes of the genera *Engyprosopon, Tosarhombus, Crossorhombus* and *Bothus* have the platelike frontal which is much expanded

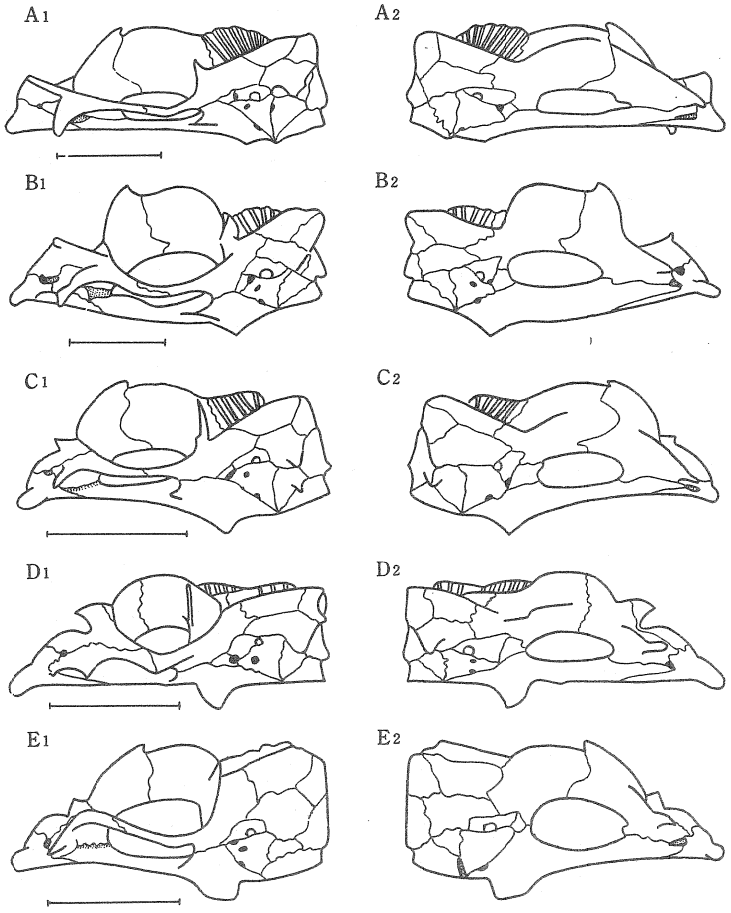

Fig. 99. Outline of lateral (A1 to E1 on ocular side; A2 to E2 on blind side) aspect of the cranium in five species. A1 • A2, *Arnoglossus oxyrhynchus;* B1 • B2, *A. polyspilus;* C1 • C2, *Psettina gigantea;* D1 • D2, *Asterorhombus intermedius;* E1 • E2, *Japonolaeops dentatus.* Scales indicate 10 mm.

upward and forward, and is widely connected with the prefrontal on the ocular side ventrally or antero-ventrally, and with the prefrontal on the blind side anteriorly (Fig. 97, B1-D1; Fig. 98, A1, C1, D1; Fig. 104, F, G). In most species of Japanese flounders the posterior region of the frontal bone is bordered by five bones, such as parasphenoid, sphenotic, pterotic, parietal and supraoccipital, and also by alisphenoid, if present. In *Psettodes erumei,* it is widely separated from the pterotic owing to the intervention of the sphenotic (Fig. 96, A1). In *Psettodes erumei* and *Lepidoblepharon ophthalmolepis* the ventral border of the frontal is not connected with the parasphenoid by the insertion of the alisphenoid (Fig. 96, A1, C1). In *Laeops kitaharae, Kamoharaia megastoma* and *Chascanopsetta lugubris* it is narrowly bordered by the dorso-anterior corner of the prootic (Fig. 100, A1, D1, E1). The fishes of the eight genera, *Taeniopsetta, Parabothus, Bothus, Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta* it is not connected with the supraoccipital owing to the insersion of the frontal on the blind side (Fig. 97, A1; Fig. 98, B1-D1; Fig. 99, E1; Fig. 100, A1-E1).

On the blind side, the most marked difference in the bone occurs in the anterior region. Japanese flounders can be divided into three types according to the shape of the bone and the connections of it with other bones. In the first type, represented by the fishes of the families Psettodidae and Citharidae the frontal is bifurcated anteriorly (Fig. 101, A1-C1; Fig. 104, A, B). One bony process called the interorbital process, is well extended forward along the inner side of the frontal on the ocular side and on the prefrontal on the ocular side, and the process is connected with the posterior surface of the mesethmoid and with antero-lateral portion of the corresponding prefrontal. The other process, which forms the dorso-posterior region of the orbital cavity on the upper eye, and which is connected anteriorly with the prefrontal on the blind side, is called the pseudomesial bar. In *Psettodes erumei,* however, the pseudomesial bar is jointed to the frontal on the blind side and forms the independent bone completely (Fig. 96, A2; Fig. 101, A1; Fig. 104, A). In the second type, represented by the members of the family Paralichthyidae the interorbital process is essentially the same with that of the members of the first type in the shape, but it is not connected with the corresponding prefrontal. The pseudomesial bar is completely united with the frontal on the blind side (Fig. 101, D1; Fig. 102, A1; Fig. 104, C). In the third type which includes the fishes of the family Bothidae, the interorbital process disappears, which is noteworthy features of the members of this type; the frontal on the blind side is merely connected with the counterpart of the opposite side on the posterior wall of the orbital cavity of the upper eye. The bar is perfectly united with the frontal on the blind side posteriorly, and connected with the corresponding prefrontal anteriorly (Fig. 102, B1-D1; Fig. 103, A1-C1; Fig. 104, D-G). On the posterior region, most species of the Japanese flounders have the frontal which is bordered by the five bones, the parasphenoid, the sphenotic, the pterotic, the parietal and the supraoccipital, and also by the alisphenoid, if present. In *Psettodes erumei* the posterior border of the frontal is not connected with the pterotic (Fig. 96, A2). In the fishes of the genera, *Citharoides, Lepidoblepharon, Pseudorhombus, Tarphops, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Psettina, Asterorhombus* and *Chascanopsetta,* and in *Laeops nigromaculatus* and *Arnoglossus polyspilus,* the bone is separated from the parasphenoid by the intervention

of the alisphenoid (Fig. 96, B2, C2, E2, F2; Fig. 97, B2-D2; Fig. 98, A2-B2; Fig. 99, B2-D2; Fig. 100, B2, E2). In *Laeops kitaharae* it is narrowly connected with the dorso-anterior corner of the prootic immediately in front of the sphenotic (Fig. 100, A2).

The frontal on the blind side is highly keeled along the midline, constituting, together with the median keel of the supraoccipital, the fronto-supraoccipital keel. The most remarkable characteristic of the flounders is in having a process, which generally extends upward and slightly backward from the frontal keel toward the ocular side of the cranium so as to support the posterior area of the upper eye. It is termed postorbital process. The degree of development of this process varies greatly according to families, subfamilies and genera. In the fishes of the families Psettodidae, Citharidae and Paralichthyidae the process which reaches to the ocular lateral side of the cranium is composed of the frontals on both sides in contact with each other by suture. In the fishes of the family Bothidae it is usually not extended to the ocular lateral side of the cranium, and is composed of the frontal on the blind side alone. In most fishes of the flounders the postorbital process is usually platelike and roughly triangular in shape, and is rather low. But in the members of the genera, *Engyprosopon, Tosarhombus, Parabothus* and *Bothus* it is highly projected upward (Fig. 97, B1-D1; Fig. 98, B1-D1). The fishes of the genus *Crossorhombus* have the process which is very slender and sticklelike in shape, curving forward at the tip, and being very much elongated vertically (Fig. 98, A1).

The parasphenoid is an unpaired and elongated bone, which runs along the midline of the ventral surface of the cranium. The anterior half of this bone, greatly extending upward on the blind side, forms the greater part of the ventral edge of the orbital cavity, while its posterior half occupies the mid-ventral surface of the brain case. The anterior part of the parasphenoid articulates ventrally with the vomer and dorsally with the prefrontals. The dorsal surface of the posterior part shows difference among the genera and the species in its connections with other bones.

Regarding the ocular side, the fishes of the first type, represented by those of the genera *Psettodes* and *Lepidoblepharon* has the parasphenoid which is articulated dorsally, from the front in order, with the alisphenoid, the prootic and the basioccipital (Fig. 96, A1, C1). In the second type, including the fishes of 13 genera, *Citharoides, Paralichthys, Pseudorhombus, Tarphops, Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Bothus, Arnoglossus, Asterorhombus* and *Psettina* the bone is connected with three bones, as is the case with the preceding type, but it is in contact with the ventral expansion of the frontal before the alisphenoid (Fig. 96, C1-F1; Fig. 97, A1-D1; Fig. 98, A1-D1; Fig. 99, A1-D1). The third type, which is lacking the alisphenoid, can be subdivided into two subtypes. In the subtype 3a represented by the fishes of the *Japonolaeops, Neolaeops* and *Laeops nigromaculatus* this bone is connected with the frontal, the prootic and the basioccipital, and particularly with the anterior part of the sphenotic extending forward between the frontal and the prootic (Fig. 99, E1; Fig. 100, E1, C1), while in the subtype 3b represented by the fishes of *Kamoharaia* and *Chascanopsetta,* and *Laeops kitaharae* it is not connected with the sphenotic owing to the insertion of the antero-dorsal corner of the prootic (Fig. 100, A1, D1, E1).

Regarding the blind side, in the members of the first type, represented by those of the

genera *Citharoides, Lepidoblepharon, Pseudorhombus, Tarphops, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Psettina, Asterorhombus* and *Chascanopsetta,* and *Arnoglossus polyspilus* and *Laeops nigromaculatus,* the parasphenoid has the same connection with other bones as that of the first type on the ocular side (Fig. 96, B2, C2, E2, F2; Fig. 97, B2-D2; Fig. 98, A2, B2; Fig. 99, B2-D2; Fig. 100, B2-E2). In the fishes of the second type, which comprises those of the genera *Psettodes, Paralichthys, Taeniopsetta, Japonolaeops* and *Kamoharaia,* and *Bothus mancus, B. pantherinus, Arnoglossus oxyrhynchus* and *A. japonicus,* the parasphenoid also has the same connection with other bones as that of the second type on the ocular side (Fig. 96, A2, D2; Fig. 97, A2; Fig. 98, D2;

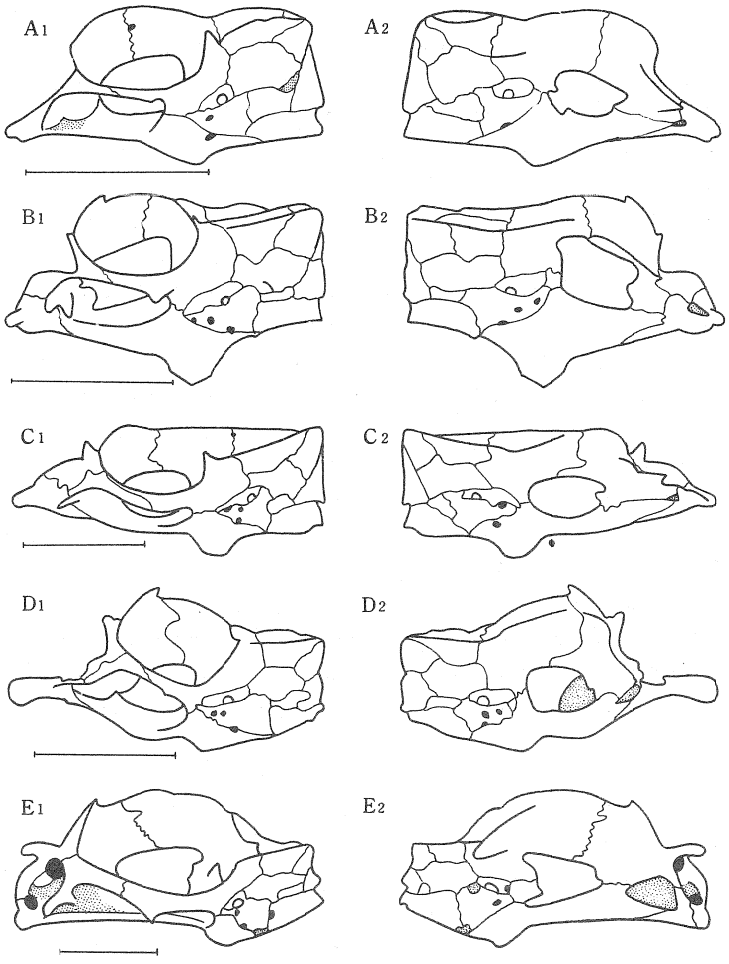

Fig. 100. Outline of lateral (A1 to E1 on ocular side; A2 to E2 on blind side) aspect of the cranium in five species. A1 • A2, *Laeops kitaharae;* B1 • B2, *L. nigromaculatus;* C1 • C2, *Neolaeops microphthalmus;* D1 • D2, *Kamoharaia megastoma;* E1 • E2, *Chascanopsetta lugubris.* Scales indicate 10 mm.

Fig. 99, A2, E2; Fig. 100, D2). The subtype 3a, represented by *Neolaeops* and the subtype 3b, represented by *Laeops kitaharae* also shows the same connections with other bones as the subtypes 3a and 3b on the ocular side respectively (Fig. 100, A2, C2). The fourth type, represented by *Bothus myriaster* alone, has the bone which comes in touch with the frontal, the prootic and the alisphenoid, and particularly with the anterior end of the sphenotic extending forward between the alisphenoid and the prootic (Fig. 98, C2).

The supraoccipital, is the bone lying along the median portion, and covers the dorso-posterior surface of the cranium. It is highly keeled along the midline, constituting, together with median keel of the frontal on the blind side, the fronto-supraoccipital keel. In the fishes of the families Psettodidae, Citharidae and Paralichtyidae the keel is so well extended backward along the median line of the cranium as to join the posterior tip of the supra-occipital (Fig. 96, A1-F1, A2-F2; Fig. 101, A2-D2; Fig. 102, A2). In the fishes of the family Bothidae the keel slightly extends backward, but it is widely apart from the posterior tip of the supraoccipital (Fig. 97, A1-D1, A2-D2; Fig. 98, A1-D1, A2-D2; Fig. 99, A1-E1, A2-E2; Fig. 100, A1-E1, A2-E2; Fig. 102, B2-D2; Fig. 103, A2-C2). Anteriorly the bone is generally inserted into the two frontals. However, in the fishes of the genera, *Taeniopsetta, Parabothus, Bothus, Japonolaeops, Neolaeops, Laeops, Kamoharaia* and *Chascanopsetta,* it is not connected with the frontal on the ocular side but with that on the blind side alone. The supraoccipital is generally connected with the parietals laterally and with the epiotics laterally or postero-laterally. In all the members of the families Psettodidae, Citharidae and Paralichthyidae it is in contact with the exoccipitals posteriorly. Among these families the fishes of the genus *Psettodes* have the supraoccipital which is widely articulated with the exoccipitals (Fig. 101, A1, A2), and in the fishes of the genus *Lepidoblepharon* it is somewhat less widely articulated with them (Fig. 101, C2); while in the remaining genera the posterior end of the bone extends to the suture of the median line of the exoccipitals (Fig. 101, B2, D2; Fig. 102, A2). On the contrary, in the fishes of the family Bothidae the bone is in contact with the epiotics on either side, but it is denied contact with the exoccipitals (Fig. 102, B2-D2; Fig. 103, A2-C2).

The parietals, which are paired, are interposed between the frontal and the epiotic on each side. Without meeting on the median line, they are widely separated from each other owing to the intervention of the supraoccipital. In most members of Japanese flounders each of them is articulated laterally to the pterotic alone. The fishes of the family Psettodidae, however, have the parietal which is connected antero-laterally with dorsal area of the sphenotic and postero-laterally with the pterotic (Fig. 96, A1, A2). In the fishes of the families Psettodidae, Citharidae and Paralichthyidae each bone, which occupies a larger dorsal part of the brain case, is much elongated, but it is not extended to the dorso-posterior corner of the cranium (Fig. 96, A1-F1, A2-F2; Fig. 101, A1-D1; Fig. 102, A1), while in the fishes of the family Bothidae the bones are rather short. In the fishes of the genera *Engyprosopon, Tosarhombus, Crossorhombus* and *Bothus* of this family, the posterior portion of the bone is extended to the dorso-posterior corner of the cranium (Fig. 97, B1-D1, B2-D2; Fig. 98, A1, C1, E1, A2, C2, E2; Fig. 103, A1-C1). In the remaining genera, it extends barely to the dorso-posterior corner of the cranium (Fig. 97, A1, A2; Fig. 98, B1, B2; Fig. 99, A1-E1, A2-E2; Fig. 100, A1-E1, A2-E2; Fig. 102, B1-D1).

The epiotics are lying on the dorso-posterior corner or posterior part of the cranium. On the ventral sides, each of the bones is connected with the pterotic ventrally or antero-ventrally and with the parietal anteriorly. Regarding the posterior arrangement of the bones, Japanese flounders can be clearly classified into two types according to whether or not they are connected with each other along the dorsal median line, and also to their position. In the first type, represented by the fishes of the families Psettodidae, Citharidae

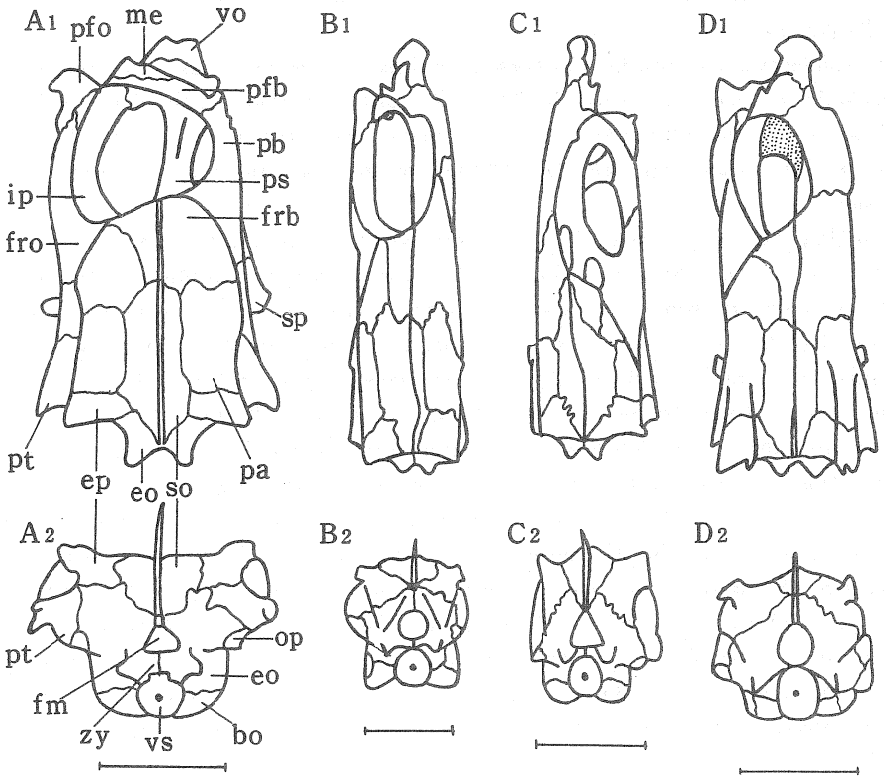

Fig. 101. Outline of dorsal (A1 to D1) and back (A2 to D2) aspects of the cranium in four species. A1 • A2, *Psettodes erumei;* B1 • B2, *Citharoides macrolepidotus;* C1 • C2, *Lepidoblepharon ophthalmolepis;* D1 • D2, *Paralichthys olivaceus.* ip, interorbital process; zy, zygapophysis of exoccipital; fm, foramen magnum; vs, socket for first vertebra. Other abbreviations as in Figs. 96, 97 and 98. Scales indicate 10 mm.

and Paralichthyidae the bones are separated from each other along the cranial median line by the intervention of the posterior area of the supraoccipital. Each of them is strongly bent downward at the hind end so as to join the exoccipitals, and forms the dorso-posterior area of the cranium (Fig. 101, A2-D2; Fig. 102, A2). Among this type, the fishes of the genera *Psettodes* and *Lepidoblepharon* have the epiotics which are widely or somewhat less widely separated from each other, and connected with the lateral sides of the supraoccipital

and with the dorsal surface of the exoccipitals (Fig. 101, A2, C2). But in remaining genera, the bones which are narrowly separated from each other by the posterior end of the supraoccipital are bounded on the posterior surface of the supraoccipital and on the dorsal surface of the exoccipitals (Fig. 101, B2, D2; Fig. 102, A2). The second type, represented by the fishes of the family Bothidae has the epiotics which, while being connected with each other by a suture along the median line of the cranium, are also connected with the supraoccipital dorsally and with the exoccipitals ventrally. Each of them is either slightly bent downward or almost vertical, and covers the posterior surface of the cranium (Fig. 102, B2-D2; Fig. 103, A2-C2).

The sphenotics, constituting the dorso-lateral part of the brain case and being surrounded by many bones, are rather small in size. The relative position of the bones differs among the families, the subfamilies and even the genera. By this feature Japanese flounders can be classified into three types and two subtypes on the ocular side and into three types on the blind side.

Regarding the ocular side, the first type which includes the members of the family Psettodidae, has the sphenotic which forms sutures with the frontal and the alisphenoid anteriorly, with the prootic ventrally, with the pterotic posteriorly and with the parietal dorsally (Fig. 96, A1). In the second type, represented by all the members of families Citharidae and Paralichthyidae, and of the nine genera among family Bothidae, *Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Bothus, Arnoglossus, Psettina* and *Asterorhombus,* the sphenotic is separated from the parietal by the pterotic extending forward (Fig. 96, B1-F1; Fig. 97, A1-D1; Fig. 98, A1-D1; Fig. 99, A1-D1). The third type, in which the sphenotic is not connected with the parietal in the same manner as preceding types, is lacking the alisphenoid. This type can be further divided into two subtypes on the basis of the difference in the arrangement of the sphenotic. In the subtype 3a, represented by the members of the genera *Japonolaeops* and *Neolaeops,* and *Laeops nigromaculatus,* the bone is so well extended forward as to join the parasphenoid (Fig. 99, E1; Fig. 100, B1, C1), while in the subtype 3b including the fishes of *Kamoharaia* and *Chascanopsetta,* and *Laeops kitaharae* it is not in touch with the parasphenoid (Fig. 100, A1, D1, E1).

Regarding the blind side, the first type comprising the fishes of the family Psettodidae has the sphenotic which is connected with the alisphenoid, the frontal, the pterotic and the prootic, and moreover, is bounded on the parietal (Fig. 96, A2). In the second type which involves many members of the families Citharidae and Paralichthidae and of the genera *Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Bothus, Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Kamoharaia* and *Chascanopsetta,* and *Laeops nigromaculatus,* the bone is not in the least bounded on the parietal (Fig. 96, B2-F2; Fig. 97, A2-D2; Fig. 98, A2-D2; Fig. 99, A2-E2; Fig. 100, B2, D2, E2). The two species among this type, *Engyprosopon grandisquama* and *Bothus myriaster,* are especial in having the sphenotic connecting with the parasphenoid anteriorly (Fig. 97, B2; Fig. 98, C2). The third type, represented by the fishes of *Neolaeops,* and *Laeops kitaharae,* which is lacking the alisphenoid, has the sphenotic which meets the frontal anteriorly and dorsally, the prootic ventrally, and the pterotic posteriorly and dorsally (Fig. 100, A2, C2). In the

genus *Neolaeops* among this type, the bone is so well extended forward as to connect with the parasphenoid.

In some species, the antero-lateral wall of the brain case is composed of a paired alisphenoid. This bone particularly disappears on the ocular side in the five genera, *Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta* (Fig. 99, E1; Fig. 100, A1-E1), and on the blind side in two species, *Laeops kitaharae* and *Neolaeops microphthalmus* (Fig. 100, A2-C2). The alisphenoids, if present, are asymmetrical, rather complex in form among species, and different in arrangement among genera and species, but they are generally small in size.

Regarding the ocular side, the alisphenoid can be classified into three types according to the difference in the arrangement in relation to other bones of the cranium. In the first type, represented by the fishes of the genera *Psettodes* and *Lepidoblepharon,* anterior part of the bone forming the posterior wall of the orbital cavity, and the bone is bounded on the frontal dorsally, on the sphenotic posteriorly, on the parasphenoid antero-laterally and on the prootic postero-ventrally (Fig. 96, A1, C1). In the second type comprising the fishes of the genera *Citharoides, Paralichthys, Pseudorhombus, Tarphops, Taeniopsetta, Tosarhombus, Arnoglossus* and *Asterorhombus,* and *Engyprosopon multisquama,* the bone is not so well extended to the orbital cavity as to separate the frontal from the parasphenoid (Fig. 96, B1, D1, E1, F1; Fig. 97, A1, C1, D1; Fig. 99, A1, B1, D1). In the third type, which is represented by the fishes of *Crossorhombus, Parabothus, Bothus* and *Psettina,* and *Engyprosopon grandisquama,* the alisphenoid meets the parasphenoid, the frontal and the sphenotic, and takes part ventrally or posteriorly in the formation of the myodome together with the prootic (Fig. 97, B1; Fig. 98, A1-D1; Fig. 99, C1).

Regarding the blind side, the bone as well as that on the ocular side has some generic or specific variations in its arrangement. The Japanese flounders can be divided into four types by the characteristic of the bone. In the first type, which involves the fishes of the genera *Lepidoblepharon, Pseudorhombus, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Psettina, Asterorhombus* and *Chascanopsetta,* and *Arnoglossus polyspilus* and *Laeops nigromaculatus,* the bone shows the same connections as in the first type on the ocular side (Fig. 96, C2, E2; Fig. 97, B2-D2; Fig. 98, A2, B2; Fig. 99, B2-D2; Fig. 100, B2, E2). In the second type comprising the members of *Psettodes, Paralichthys, Taeniopsetta, Japonolaeops* and *Kamoharaia,* and *Bothus mancus, B. pantherinus, Arnoglossus oxyrhynchus, A. tenuis* and *A. japonicus,* the bone presents the same osteological features in arrangement as is shown in the second type on the ocular side (Fig. 96, A2, D2; Fig. 97, A2; Fig. 99, A2, E2; Fig. 100, D2). The third type which is represented by the fishes of two genera, *Citharoides* and *Tarphops* has the alisphenoid, the anterior part of which forms the posterior wall of the orbital cavity, and the bone also connecting with the three bones, the parasphenoid, the frontal and the sphenotic, but it is separated from the anterior corner of the prootic by the presence of the myodome (Fig. 96, B2, F2). In the fourth type, which involves the two species, *Engyprosopon grandisquama* and *Bothus myriaster,* the posterior border of this bone is not connected with the prootic, but is bounded on the whole anterior margin of the sphenotic which is so well extended forward as to separate the alisphenoid from the prootic (Fig. 97, B2; Fig. 98, C2). In the former

species, the bone forms the posterior wall of the orbital cavity, but in the latter species, it is not extended to the orbital cavity.

The pterotics, constituting most of the dorso-lateral part of the brain case are usually well developed. The bones are different in form and in connection among families and subfamilies. In the fishes of the family Psettodidae each of them, which is much elongated is bounded on the parietal and the epiotic dorsally, on the exoccipital posteriorly, on the opisthotic and the prootic ventrally and on the sphenotic anteriorly, but it is not connected

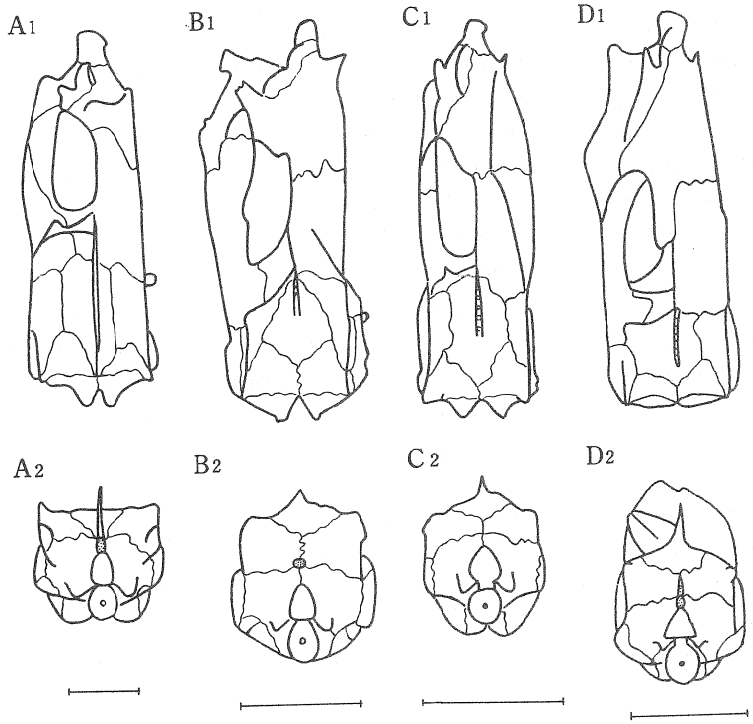

Fig. 102. Outline of dorsal (A1 to D1) and back (A2 to D2) aspects of the cranium in four species. A1 • A2, *Pseudorhombus cinnamoneus;* B1 • B2, *Taeniopsetta ocellata;* C1 • C2, *Arnoglossus japonicus;* D1 • D2, *Parabothus kiensis.* Scales indicate 10 mm.

with the frontal (Fig. 96, A1, A2). In the fishes of the families Citharidae, Paralichthyidae and Bothidae the anterior border of the bone is extended forward on the sphenotic, and is connected with the frontal. Among these families, the fishes of the families Citharidae and Bothidae generally have the bone which is bounded on the sphenotic, the prootic and the opisthotic ventrally, on the epiotic and the exoccipital posteriorly and the parietal dorsally. The fishes of the family Paralichthyidae and a genus *Chascanopsetta,* however, show different features. In the former, it is not connected with the opisthotic ventrally but posteriorly it is (Fig. 96, D1-F1, D2-F2). In the latter, it is extended downward far

between the prootic and the opisthotic, and narrowly connected with the dorso-anterior surface of the basioccipital (Fig. 100, E1, E2). Generally, the fishes of the genera *Citharoides, Lepidoblepharon, Paralichthys* and *Pseudorhombus* have the pterotic which is much elongated, and tapering (Fig. 96, B1-E1, B2-E2), while the remaining genera have very high pterotic.

The opisthotics are paired, and lie on the postero-lateral or the ventro-lateral portion of the cranium. The shape, the size and the arrangement of this bone relating to other bones show great variations among families, subfamilies and even genera. In the characteristics of the bone Japanese flounders may be divided into six types. In the first type which comprises all the members of the two families, Psettodidae and Citharidae, the bone is elliptical in shape and moderate in size, and articulates to prootic anteriorly, to the pterotic dorsally and to the exoccipital posteriorly and ventrally, and the ventral surface of this bone is widely separated from the basioccipital by the extension of the anterior area of the exoccipital (Fig. 96, A1-C1, A2-C2). In the second type which comprises all the members of the family Paralichthyidae, the bone is elliptical in shape and particularly small in size, articulating to the pterotic anteriorly and surrounded by the exoccipital dorsally, ventrally and posteriorly. Accordingly it is not connected with the basioccipital (Fig. 96, D1-F1, D2-F2). In the third type which is represented by the fishes of seven genera, *Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Arnoglossus, Psettina* and *Asterorhombus,* the bone, which is triangular in shape and rather large in size, is obliquely inserted so as to wedge off between the prootic and the basioccipital, and its anterior tip extends to the anterior tip of basioccipital (Fig. 97, B1-D1, B2-D2; Fig. 98, A1-B1, A2-B2; Fig. 99, A1-D1, A2-D2). On the posterior surface, the bone meets the pterotic dorsally and the exoccipital posteriorly. In the fourth type including the fishes of the genus *Taeniopsetta,* the articulation to other bones resembles the preceding type, but its anterior tip does not extend to the tip of the basioccipital (Fig. 97, A1, A2). The fifth type which comprises the fishes of the genera, *Bothus, Laeops, Japonolaeops, Neolaeops* and *Kamoharaia,* the bone is generally moderate in size and square in form. The bone is articulated to the prootic anteriorly, to the pterotic dorsally, to the exoccipital posteriorly and to the basioccipital ventrally, and the anterior tip does not extend to the anterior tip of the basioccipital (Fig. 98, C1-D1, C2-D2; Fig. 99, E1, E2; Fig. 100, A1-D1, A2-D2). In the sixth type, the sole representative of which is the fish of the genus *Chascanopsetta,* the bone is square in shape and moderate in size. It is adjoin the pterotic anteriorly and dorsally, the basioccipital ventrally and the exoccipital posteriorly, and is not connected with the prootic (Fig. 100, E1, E2).

The prootic is one of the skeletal elements forming a wide midlateral surface of the brain case. The bone, which is surrounded by many bones, is different in arrangement according to families, subfamilies and genera, and also even sides of the body. The Japanese flounders can be divided into seven types on the ocular side and six types on the blind side on the basis of the differences in mode of connection of the bone with other bones.

With respect to the ocular side, the first type represented by the fishes of the two families Psettodidae and Citharidae has the prootic which is connected with seven bones, the parasphenoid, the alisphenoid, the sphenotic, the pterotic, the opisthotic, the exoccipital

and the basioccipital (Fig. 96, A1-C1). In the second type, which is represented by the fishes of the family Paralichthyidae, the bone is connected with six bones, except for the opisthotic which is remarkably reduced in size and extends upward near to the posterior surface of the pterotic (Fig. 96, D1-F1). In the third type including the eight genera of the family Bothidae, *Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Arnoglossus, Psettina* and *Asterorhombus,* the posterior border of this bone is not connected with the exoccipital, but is bounded on the entire anterior margin of the opisthotic so as to separate the prootic from the basioccipital (Fig. 97, A1-D1; Fig. 98, A1-B1; Fig. 99, A1-D1). In the fourth type, the sole representative of which is the fish of the genus *Bothus,* the posterior surface of the bone is not connected with the exoccipital, as is the case with the preceding type, but is widely bounded on the basioccipital posteriorly (Fig. 98, C1, D1). The fifth type, in which the bone is not connected with the exoccipital and the alisphenoid is lacking, can be further subdivided into three subtypes. In the subtype 5a, represented by the fishes of the genera *Japonolaeops* and *Neolaeops,* and *Laeops nigromaculatus,* the anterior margin of the bone is not connected with the frontal (Fig. 99, E1; Fig. 100, B1, C1). In the subtype 5b including *Laeops kitaharae* and the fishes of the genus *Kamoharaia* the antero-dorsal corner of this bone forms a narrow area in order to contact with the frontal (Fig. 101, A1, D1), while in the subtype 5c represented by *Chascanopsetta* alone, the bone is connected with the frontal, but does not touch the opisthotic which is separated from the prootic by the antero-ventral area of the pterotic (Fig. 96, E1).

With respect to the blind side, is most of the Japanese flounders the bone shows usually the same mode of arrangement as is the case with the ocular side. In the first type represented by the two families Psettodidae and Citharidae, the bone is connected with seven other bones, the parasphenoid, the alisphenoid, the sphenotic, the pterotic, the opisthotic, the exoccipital and the basioccipital (Fig. 96, A2-C2). The second type which includes the fishes of the family Paralichthyidae has the prootic which meets six other bones excepting the opisthotic (Fig. 96, D2-F2). The third type represented by eight genera, *Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Arnoglossus, Psettina* and *Asterorhombus* has the prootic which comes in contact with the exoccipital and the basioccipital (Fig. 97, A2-D2; Fig. 98, A2, B2; Fig. 99, A2-D2), but in *Engyprosopon grandisquama* it is separated from the alisphenoid owing to the extension of the sphenotic (Fig. 97, B2). In the fourth type including the fishes of *Bothus, Kamoharaia,* and *Laeops nigromaculatus* the bone is articulated to six other bones excepting the exoccipital (Fig. 98, C2-E2; Fig. 100, B2, D2), but in *Bothus myriaster* it is separated from the alisphenoid by the extension of the anterior margin of the sphenotic (Fig. 98, C2). The fifth type has such character as the prootic is connected neither with the exoccipital nor with the alisphenoid which has disappeared completely. This type can be further subdivided into two subtypes according to whether or not the bone is connected with the frontal dorso-anteriorly. In the subtype 5a represented by *Neolaeops* the bone is not connected with the frontal (Fig. 100, C2), but in the subtype 5b including *Laeops kitaharae* (Fig. 100, A2), it has such connection. In the sixth type represented by *Chascanopsetta* alone, the bone is connected with the pterotic dorso-posteriorly and with the basioccipital

posteriorly, but not bounded on either of the bones, the exoccipital and the opisthotic (Fig. 100, E2).

The exoccipitals form parts of both postero-lateral and posterior surfaces of the cranium. On the lateral side, the bone shows a variety in the arrangement. In all the members of the families Psettodidae, Citharidae and Paralichthyidae, the bone is articulated anteriorly to the prootic in narrow area, extending forward between the dorsal surface of the

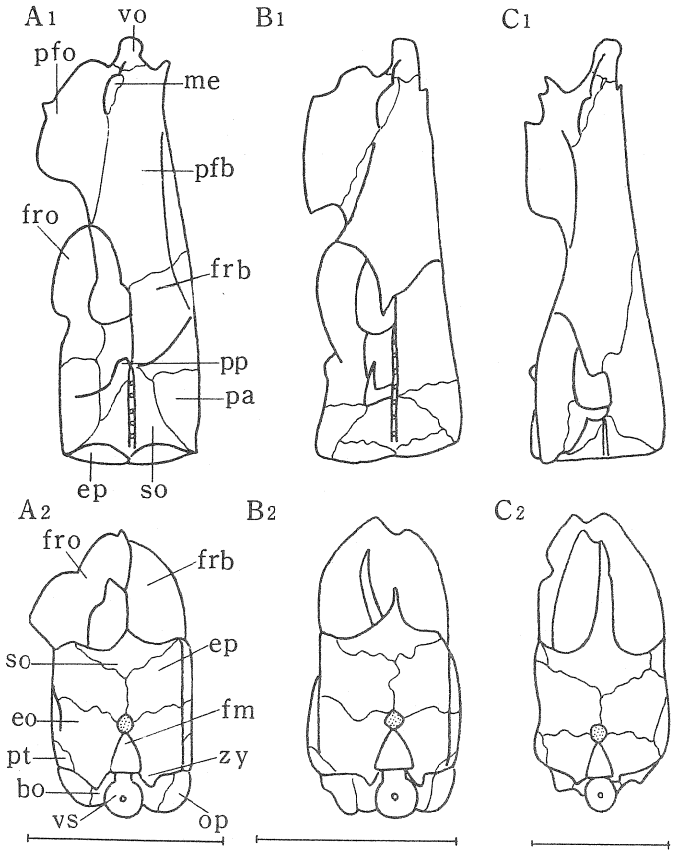

Fig. 103. Outline of dorsal (A1 to C1) and back (A2 to C2) aspects of the cranium in three species. A1 • A2, *Engyprosopon grandisquama;* B1 • B2, *Crossorhombus kobensis;* C1 • C2, *Bothus myriaster.* Abbreviations as in Figs. 96, 97, 98 and 101. Scales indicate 10 mm.

basioccipital and the ventral surface of the opisthotic, and it is bounded on the opisthotic and the pterotic anteriorly, on the epiotic dorsally and on the basioccipital ventrally (Fig. 96, A1-F1, A2-F2). On the contrary, in the fishes of the family Bothidae the bone is bounded on the pterotic anteriorly, on the epiotic dorsally and on the basioccipital ventrally, but is separated from the prootic by the insertion of the opisthotic (Figs. 97-100).

On the posterior surface of the cranium, each exoccipital shows two different features in its connection. In all the members of the families Psettodidae, Citharidae and Paralichthyidae the bone is connected with the supraoccipital dorso-medially, and with both the epiotic and the pterotic dorsally. Among these families, the genera *Psettodes* and *Lepidoblepharon* have the exoccipital which is widely or somewhat less widely bounded on the supraoccipital dorso-medially (Fig. 101, A2, C2), but in the remaining genera it is connected narrowly with it (Fig. 101, B2, D2; Fig. 102, A2). On the contrary, in all the members of the family Bothidae the bone is connected with the epiotic and the pterotic dorsally, but is separated from the supraoccipital, so that the epiotics articulate to each other along the median line (Fig. 102, B2-D2; Fig. 103, A2-C2). Each exoccipital articulates to the counterpart of the opposite side on the median line of the posterior surface by cartilaginous component or suture. Inferior to the median counterpart, the proximal parts of the exoccipitals form the foramen magnum. There are flat, oblique zygapophysis for the articulation of the atlas beneath the foramen magnum. The exoccipital may be divided into three types by the situation of each zygapophysis. In all the members of the families Psettodidae and Citharidae, the zygapophysis is broadly jointed to the fellow of the opposite side (Fig. 101, A2-C2). In all the members of the family Paralichthyidae, the zygapophysis is separated from each other by a short distance (Fig. 101, D2; Fig. 102, A2), while in the fishes of the family Bothidae, each is far apart from the fellow on the opposite side and lies on the same level with the tip of the basioccipital (Fig. 102, B2-D2; Fig. 103, A2-C2).

The basioccipital is an unpaired bone, broadly extending laterally on the posteriormost ventral surface of the cranium. The bone can be classified into four types according to the differences in shape and arrangement. In the first type, represented by the fishes of the families Psettodidae, Citharidae and Paralichthyidae the basioccipital, which is usually square in form when viewed laterally, is connected with the prootics anteriorly, with the parasphenoid ventrally and with the exoccipitals dorsally, but it is widely separated from the opisthotic owing to the expansion of the anterior portion of the exoccipital (Fig. 96, A1-F1, A2-F2). In the second type, represented by the fishes of the genera, *Taeniopsetta, Engyprosopon, Tosarhombus, Crossorhombus, Parabothus, Arnoglossus, Psettina* and *Asterorhombus,* the bone is triangular in shape when viewed laterally and gradually tapers, and is widely articulated to the opisthotic antero-dorsally, to the exoccipitals dorsally, and to the parasphenoid ventrally, but it is separated from the prootic by the insertion of the opisthotic (Fig. 97, A1-D1, A2-D2; Fig. 98, A1-B1, A2-B2; Fig. 99, A1-D1, A2-D2). In the third type, represented by the fishes of the genera *Bothus, Japonolaeops, Laeops, Neolaeops* and *Kamoharaia,* it is roughly rectangular in shape, and is articulated to the prootic anteriorly, to the parasphenoid ventrally, and to the opisthotic and the exoccipital dorsally (Fig. 98, C1-D1, C2-D2; Fig. 99, E1, E2; Fig. 100, A1-D1, A2-D2). In the fourth type, represented by the genus *Chascanopsetta,* it is bounded on the prootic anteriorly, on the parasphenoid ventrally, and the dorsal surface of this bone is connected with the three bones, the exoccipital, the opisthotic and the pterotic, the last of which extends downward before the opisthotic (Fig. 100, E1, E2).

The posterior part of the bone, which is articulated to the atlas, forms the floor of

the foramen magnum in all the members of the families, Paralichthyidae and Bothidae (Fig. 101, D2; Fig. 102, A2-D2; Fig. 103, A2-C2), but it is not related to form the foramen magnum in the fishes of the two families Psettodidae and Citharidae (Fig. 101, A2-C2).

Discussion: Although the cranical studies of the Heterosomata have already been carried on by many ichthyologists (Cole and Johnstone, 1901; Kyle, 1921; Wu, 1932; Gregory, 1933; Norman, 1934; Hikita, 1934), their anatomical researches are meager so far as the sinistral flounders are concerned, and are insufficient for making out something of phyletic and systematic significance.

By a comparative study of the cranium of the Japanese flounders it has been found that the following features may serve for the taxonomy of this group: 1) presence or absence of vomerine teeth; 2) condition of articulation of mesethmoid to the vomer; 3) presence or absence of mesethmoid-vomerine keel; 4) relation among the bones of mesethmoid, prefrontal, frontal and pseudomesial bar; 5) shape of prefrontal and frontal on ocular side; 6) either meeting or separation of the frontal on ocular side from supraoccipital; 7) degree of development and shape of postorbital process; 8) relation among the bones of frontal, pterotic, sphenotic and parietal; 9) degree of development of the fronto-supraoccipital keel; 10) relation among the bones of supraoccipital, epiotics and exoccipitals; 11) degree of development of parietals; 12) relation among the bones of prootic, sphenotic, alisphenoid, parasphenoid and frontal; 13) presence or absence, and if present, size and degree of development of alisphenoid; 14) relation among the bones of pterotic, exoccipital, basioccipital, prootic and opisthotic; 15) relation among the bones of prootic, exoccipital, alisphenoid, opisthotic, basioccipital and frontal; 16) shape and size of opisthotic; 17) contiguity of zygapophysis of exoccipital for reception of atlas; 18) shape of basioccipital.

As was already mentioned, the manner in which the specialization of the cranium of the flounders took place is rather complex, but some of the characters particularly furnish us with a sound ground for the consideration of the phyletic significance. To indicate such characters and their divergences briefly the present author gives Table 5.

Presence or absence of the vomerine teeth: The vomerine teeth are lacking in most species of Japanese flounders. But these teeth, although remarkably reduced in size, are found in the fishes of the type 1 alone. As was indicated by Hubbs (1945), the presence of vomerine teeth is obviously a primitive character. Thus, it is confirmed that the type 1 is more primitive than any other types so far as the vomerine teeth are concerned.

Relation or the three bones, supraoccipital, epiotic and exoccipital: The Japanese flounders may be grouped into four types according to the features of the connection of these bones. In the first type, the supraoccipital which is enlarged backward is widely connected with the exoccipital posteriorly, so that the epiotics are widely separated from each other. In the second type, the posterior margin of the supraoccipital is connected with the exoccipitals at the narrow patch or at the tip so as to narrowly separate the epiotics. In the third type, posterior tip of the supraoccipital is connected with the exoccipitals, so that the epiotics are slightly separated from each other. In the fourth type, the supraoccipital does not meet the exoccipitals, but is connected with each of the epiotics with a suture.

Throughout the percid fishes, the supraoccipital is usually well developed backward and is widely connected with the exoccipitals so as to widely divide into each of the epiotics. Thus, it appears that the first type is more generalized than the other types, and then comes the second and the third in order, and that the fourth type is most specialized.

Table 5. Nine types of the cranium in Japanese flounders. For abbreviated letters, see text.

Types	Characters			
	Vomerine teeth	Relation of SO, EP and EO	Zygapophysis of EO	AS on ocular side
1	present	SO widely connected with EO; EP widely separated from each other	widely adjoining	present, large, extending to orbital cavity
2	absent	SO connected with EO by a narrow patch or at the tip; EP separated from each other		present, large or moderate in size, extending to orbital cavity or not extending to it.
3		SO connected with EO at the tip; EP narrowly separated from each other	slightly apart	present, large or moderate in size, not extending to orbital cavity
4		SO not connected with EO; EP connected with each other	widely apart	present, very small or rudimentary, not extending to orbital cavity
5				
6				
7				
8				absent
9				

Contiguity of the zygapophysis of the exoccipital for the articulation of the atlas: The Japanese flounders can be classified into three types according to the articulation of the zygapophysis of the exoccipital for the reception of the atlas. In the first type, the zygapophysis is broadly joined to the fellow of the opposite side. In the second type, each zygapophysis is separated from the other by a short distance. In the third type, the zygapophysis is far apart from the fellow of the opposite side.

Starks (1904) reported in the osteological study of the berycoid fishes that the exoccipitals which broadly joins each other differ from those of the percoid fishes. Katayama (1959) for the serranid fishes and Suzuki (1962) for the carangid fishes lay much stress on this character in deducing the phylogenetical relationships of fishes on the basis of the cranium.

Table 5. (continued)

Relation of ME, PF, FR and PB	Relation of PT, EO, BO, PR and OP	Genera
A	A	*Psettodes*
B		*Lepidoblepharon* *Citharoides*
C	B	*Paralichthys* *Pseudorhombus* *Tarphops*
E	C	*Taeniopsetta*
E, F or G	D	*Parabothus, Engyprosopon* *Tosarhombus, Crossorhombus*
G	E	*Bothus*
D	D	*Arnoglossus, Psettina* *Asterorhombus*
	E	*Japonolaeops, Laeops* *Kamoharaia, Neolaeops*
	F	*Chascanopsetta*

They are of the opinion that the type which has the zygapophysis broadly jointed to the fellow on the opposite side is more primitive than the types which have the zygapophysis far apart from the fellow of the opposite side. In the case of the flounders, it is very justifiable, therefore, to consider that the first type is more primitive than the other types, and the third type is more specialized than other types.

Presence or absence, and if present, size and degree of development of the alisphenoid

on the ocular side: The Japanese flounders can be classified into five types with respect to the presence or absence of the alisphenoid, and if present, its size and position. In the first type, the alisphenoid is rather large, lying before the sphenotic, and the anterior margin extending to the posterior wall of the orbital cavity. In the second type, the bone is rather large or moderate in size, its anterior margin extending to the orbital cavity by narrow patch or not extending to it owing to the suture between the parasphenoid and the frontal. The third type has the alisphenoid which is rather large or moderate in size, and far apart from the orbital cavity. In the fourth type, the bone is very small or reduced in size, no portion of its anterior margin extending to the orbital cavity by being surrounded by the prootic, the frontal and the sphenotic. In the fifth type, the bone disappears completely.

In the percid fishes, the alisphenoid is rather large and is connected with the prootic, the frontal and the sphenotic, its anterior portion forming the dorso-posterior margin of the orbital cavity. Throughout the Japanese flounders, it is a general tendency that the alisphenoid extends downward and backward in the orbital cavity, and becomes reduced in size. Generally the degree of the development of the alisphenoid may be negatively correlated with that of the parasphenoid and of the frontal. If such correlation is correct, it is very reasonable to consider that the degeneration of the alisphenoid is a result of the specialization toward diminution which is followed by the development of the parasphenoid and the frontal. Thus, it appears that the first type is more generalized than the other types and then come the second, the third and the fourth in order, and the fifth type is most specialized.

Relation of the five bones on the ocular side, pterotic, exoccipital, basioccipital, prootic and opisthotic, and the shape of the basioccipital and the opisthotic: The Japanese flounders may be grouped into six types (A to F) according to the features of the connection of these bones, and the form of the opisthotic and the basioccipital. In the type A, the opisthotic is elliptical in shape and moderate in size, and is connected with the pterotic dorsally, with the exoccipital ventrally and posteriorly, but is separated from the basioccipital by the intervension of the exoccipital. The prootic is articulated to the pterotic, and the posterior margin is connected with the opisthotic, the exoccipital and the basioccipital (Fig. 96, A1-C1). In the type B, the opisthotic is elliptical in shape and very small in size, being surrounded by the exoccipital dorsally, posteriorly and ventrally, and the anterior part is connected narrowly with the pterotic. The prootic is articulated to the pterotic dorsally, and the posterior margin is connected with the two bones, exoccipital and basioccipital, but not with the opisthotic. The basioccipital is square in shape (Fig. 96, D1-F1). In the type C, the opisthotic is spearlike in shape, and moderate in size, being connected with the pterotic dorsally, with the exoccipital posteriorly and with the basioccipital ventrally. The prootic is articulated to the pterotic dorsally and to the opisthotic posteriorly, but is widely separated from the exoccipital and the basioccipital, owing to the insertion of the opisthotic (Fig. 97, A1). In the type D, the opisthotic has the same connection as is the case with the preceding type, but it is large, triangular in shape and the tip extends to the triangular basioccipital (Fig. 97, B1-D1; Fig. 98, A1, B1; Fig. 99, A1-D1). In the type E, the opisthotic is square in shape and moderate in size, and

is connected with the pterotic dorsally, with the exoccipital posteriorly and with the basioccipital ventrally. The prootic is connected posteriorly with the three bones, the pterotic, the opisthotic and the basioccipital. The basioccipital is roughly rectangular in shape (Fig. 98, C1, D1; Fig. 99, E1; Fig. 100, A1-D1). In the type F, the opisthotic is square in shape and moderate in size, and connected with the pterotic anteriorly and dorsally, with the exoccipital posteriorly and with the basioccipital ventrally. The prootic is connected with the pterotic dorsally and the basioccipital posteriorly, but is separated from the opisthotic by the intervention of the pterotic (Fig. 100, E1).

So far as the writer's knowledge is concerned, the relation of the five bones, the pterotic, the exoccipital, the basioccipital, the prootic and the opisthotic and the form of the opisthotic and the basioccipital agree well with those of the type A throughout the percid fishes. The type A, having such characters may, therefore, be reasonably interpreted to be more generalized than the other types. The type B resembles the preceding type in having the exoccipital nearly extends to the anterior margin of the basioccipital and also connected with the prootic anteriorly, but is a little more advanced than it, since the opisthotic becomes very small, lying at the back of the pterotic so as to be separated from the prootic. The types C, D, E and F are presumably much more advanced than the preceding types in having the exoccipital apart from the prootic by the intervention of the opisthotic. The differentiation among these types has led to yield two large groups. In the types C and D, the opisthotic is so much enlarged as to wedge off between the prootic and the basioccipital. The type C is more primitive than the type D in that the opisthotic of the former is not extended to the tip of the basioccipital. On the other hand, in the types E and F, the opisthotic is square in shape and much reduced in size, so that the prootic keeps in touch with the basioccipital. The type F is much more specialized than the type E, in having the basioccipital connected with the pterotic.

Relation among the bones of the mesethmoid, the prefrontal, the frontal and the pseudomesial bar: The Japanese flounders may be grouped into seven types (A to G) according to the features of the connections of these bones, and the shapes of the prefrontal and the frontal. The type A has the barlike interorbital bone constituted by the connection of the interorbital process and the interorbital bar, the former bone coming in contact anteriorly with the prefrontal on the blind side, and the latter being connected anteriorly with the prefrontal on the ocular side. The pseudomesial bar which is placed at the dorsal portion of the upper eye between the prefrontal on the blind side and the frontal on the same side is not united with the latter bone (Fig. 104, A). The type B closely resembles the preceding type in the relation of the three bones, the mesethmoid, the prefrontal and the frontal, but is different in possession of a character that the pseudomesial bar is completely fused with the frontal on the blind side (Fig. 104, B). The type C has a close resemblance to the types A and B in the general constitution of the interorbital bone, but is peculiar in having a character that separates the interorbital process from the prefrontal on the blind side, owing to the intervention of the mesethmoid (Fig. 104, C). In the type D, the interorbital bone is barlike in shape, being composed of the interorbital bar and the prefrontal on the ocular side, while the interorbital process is completely lacking. The prefrontals are widely separated from each other by the intervention of the

mesethmoid (Fig. 104, D). The type E resembles the preceding type in having the barlike interorbital bone composed of interorbital bar and the prefrontal on the ocular side, but is distinct from it by the fact that the prefrontals are in contact with each other above the mesethmoid (Fig. 104, E). The type F is more modified than types D and E, since the interorbital bone which is constituted by the interorbital bar and the prefrontal on the ocular side is more greatly expanded, and each of them is connected with the prefrontal on the blind side (Fig. 104, F). The type G resembles the preceding type in the general

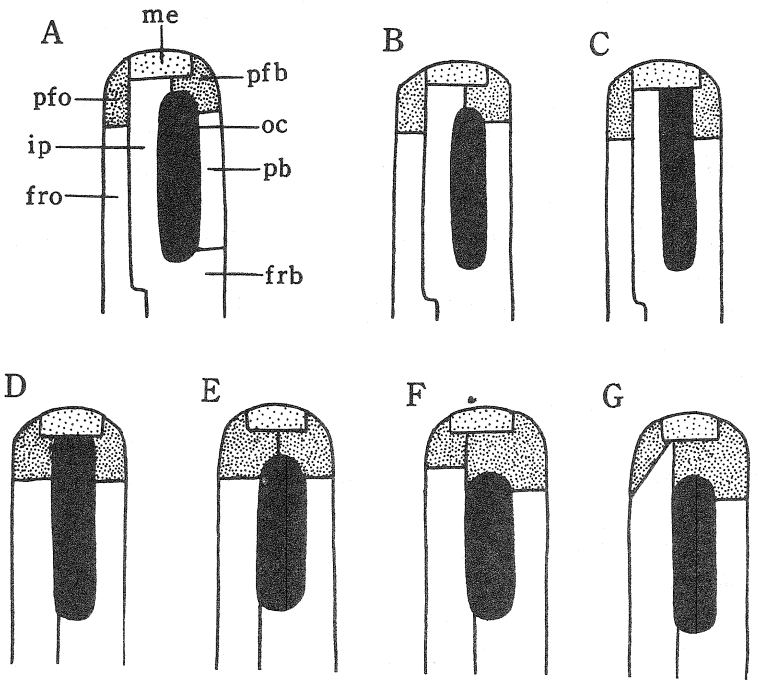

Fig. 104. Schematic representation of seven types of dorsal aspect of anterior part of the cranium in Japanese flounders and related flatfishes. A, *Psettodes;* B, *Lepidoblepharon* and *Citharoides*; C, *Paralichthys, Pseudorhombus* and *Tarphops;* D, *Arnoglossus, Psettina, Asterorhombus, Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta*; E, *Taeniopsetta* and *Parabothus;* F, *Engyprosopon* and *Tosarhombus;* G, *Bothus* and *Crossorhombus*. me, mesethmoid; pfo, prefrontal on ocular side; pfb, prefrontal on blind side; ip, interorbital process; pb, pseudomesial bar; fro, frontal on ocular side; frb, frontal on blind side; oc, orbital cavity.

features of the cranium, but is different from it in having the prefrontal on the ocular side separated from that on the blind side (Fig. 104, G).

As has been mentioned above, the cranium of the flounders is characterized by having peculiar features of the orbital region. Of the differentiation of the orbital region of the cranium treated here, the first attention may be directed to the presence of both eyes on the one side of the head. Traquair (1865) suggested that the two eyes are on the one side

as the result of the twisting of the orbital region of cranium, and that the pseudomesial bar which forms the area of the frontal of the upper eye is necessary to maintain the requiste stability of the cranium. NORMAN (1934) judging from the embryological work on the metamorphosis of flatfishes, pointed out that the peculiar development of the cranium provides no evidence in support of TRAQUAIR's view of the twisting of the orbital region of the cranium, and that the pseudomesial bar in view of its having the same position and the same relations as it would have if the cranium were symmetrical is not a new formation. As NORMAN has pointed out, it is wrong to say that the torsion of the orbital part of the cranium was certainly caused by the migration of the eye. In the type A to C, however, the interorbital bone which is developed after the migration of the eye is composed of the frontals on either side connected with each corresponding prefrontal. In view of this fact, it seems highly probable that since the interorbital bone of the flatfish is homologous with that of all other fishes, the pseudomesial bar representes a new and special formation. On the contrary, in the types D to G, the interorbital bone is composed of the frontal on the ocular side alone, and the interorbital process disappears. It may be presumed that the upper orbital cavity forms between the two frontals. In such a case, the pseudomesial bar is not a new formation, but homologous with the frontal of all the other fishes. It may not be able to apparently prove which of the two assumptions is true. In the type A, however, the pseudomesial bar is not a process which the frontal on the blind side sends forward, but is a wholly independent bone as a new formation, though NORMAN (1934) identified it with a part of the frontal on the blind side. If such a judgement be correct, it seems reasonable to suppose that the former assumption ought to be taken into consideration. Thus, the type A which is characterized by the following points is most primitive: the interorbital bone is composed of the two frontals, each of which is connected with the corresponding prefrontal; the pseudomesial bar is not connected with the frontal on the blind side. The type B is more advanced than the preceding type, since the pseudomesial bar is completely fused with the frontal. The type C resembles the types A and B in having the interorbital bone which is composed of the interorbital bar and the interorbital process, but is more advanced than these types, since the latter bone is not articulated to the prefrontal on the blind side by the intervention of the mesethmoid. The type D bears a relatively close resemblance to the type C in the connections of the other cranial elements, though the interorbital process is absent. It may be presumed that the process secondarily disappears. The type E is more advanced than the type D in having the two prefrontals connected with each other. This type probably comes before the types F to G which have the expanded interorbital bone. The type F is more specialized than the preceding types, since the frontal on the ocular side which is expanded platelike in shape is connected with the prefrontal on the blind side. The type G is most highly specialized in having each prefrontal separated from each other, owing to the insertion of the frontal on the ocular side which is highly expanded.

2. Orbital bones

Description: The orbital bones which consist of the preorbital and suborbitals are peculiarly asymmetrical in number and in shape. None of suborbital bones are provided with the suborbital shelf.

The preorbital bone, if present, is usually larger in size than any of the suborbital bones, and its dorsal or postero-dorsal surface is rigidly attached to the lateral process of the prefrontal by a ligament.

On the ocular side all the members of the Japanese flounders have one prefrontal bone which is triangular and sicklelike in shape, although there are some specific variations in the general shape. The bone is so thin that the sensory canal it contains is fairly distinct (Fig. 104).

On the blind side the fishes of the families Psettodidae, Citharidae and Paralichthyidae have always a well developed bone (Fig. 106, A-F; Fig. 107, A-C). On the contrary, in the flounders of the family Bothidae it is entirely absent (Fig. 107, D-G; Fig. 108, A-E). It, if present, is rhombic, quardangular or ovoital in shape. The bone in which the sensory canals are contained is thin in most species.

The suborbital bones which are penetrated by the sensory canal are a series of laminalike bones.

Regarding the ocular side, the Japanese flounders can be classified into three types according to the presence or absence of the suborbital bones and, if present, the developmental degree of them. In the first type which is represented by the family Psettodidae, four suborbital bones which are reduced slender tubular ossifications surround the lower margin of the lower eye (Fig. 109, A). In the second type to which the families Citharidae and Paralichthyidae belong, there are scaly nodules on the surface of the lower margin of the lower eye, and they appear probably to be vestigial suborbital bones in which the sensory canal is contained (Fig. 109, B). In the third type, including all the members of the family Bothidae, the bones are entirely lacking.

On the blind side, the bones are present in most species of the Japanese flounders, but only in *Psettodes erumei* they are completely lacking. A suborbital series beginning near the lateral process of prefrontal extend backward almost horizontally along the ventrolateral edge of the prefrontal, that is, along the upper margin of the orbital cavity, and the last bone is rigidly attached to the upper margin of the frontal part of the orbital cavity (Fig. 110, A, C). But especially in *Taeniopsetta ocellata* the first bone is widely separated from the lateral process of the prefrontal (Fig. 110, B).

The number of bones in the suborbital series remarkably varies among the species: there are seven bones in *Pseudorhombus pentophthalmus* (Fig. 107, B), six bones in *P. arsius, P. oligodon, P. oculocirris, Tarphops oligolepis* and *T. elegans* (Fig. 106, F; Fig. 107, A, C), five bones in *P. cinnamoneus, P. levisquamis, Paralichthys olivaceus, Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis* and *Taeniopsetta ocellata* (Fig. 106, B-E; Fig. 107, D), four bones in the fishes of the genera *Bothus* and *Chascanopsetta* (Fig. 107, E-G) and three bones in the remaining species of family Bothidae except for the fishes of the two genera mentioned above (Fig. 108, A-E).

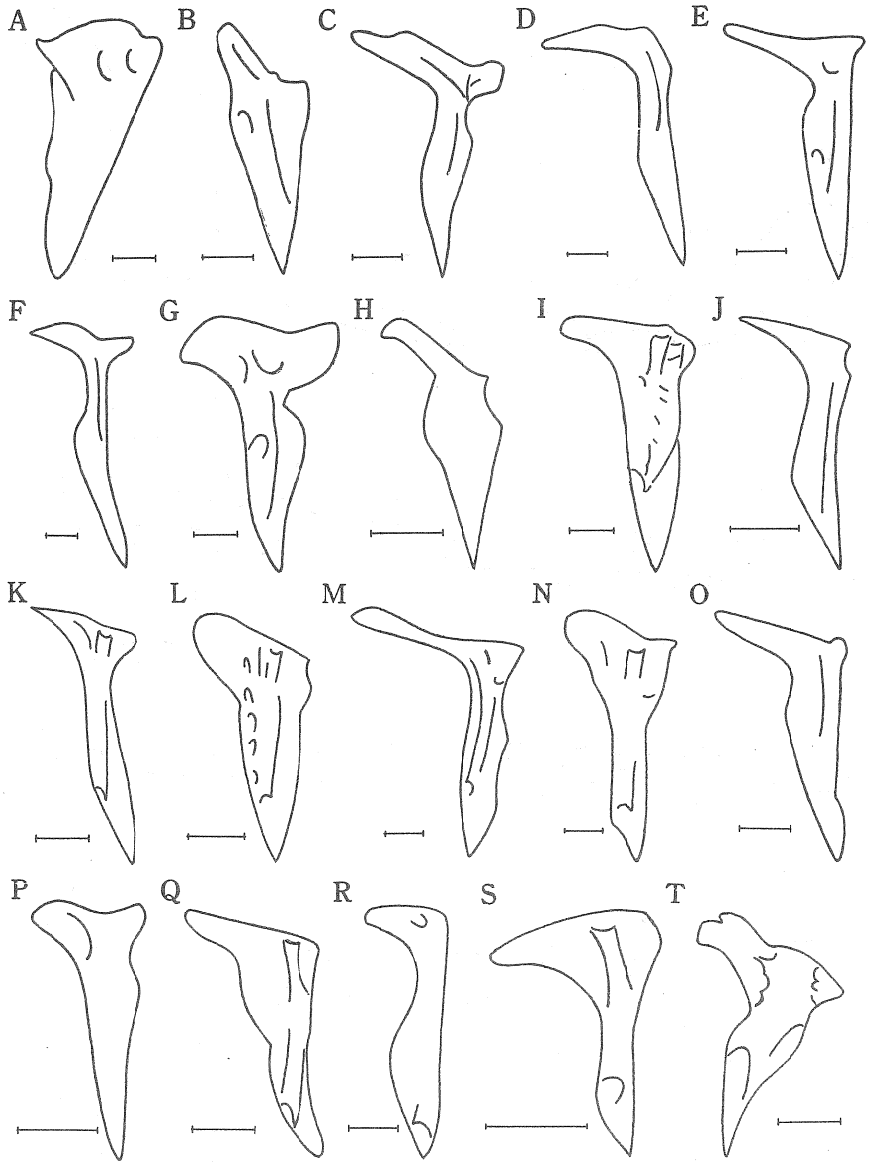

Fig. 105. Lateral aspect of the preorbital bone on the ocular side in 20 species. A, *Lepidoblepharon ophthalmolepis;* B, *Citharoides macrolepidotus;* C, *Pseudorhombus cinnamoneus;* D, *P. oligodon;* E, *P. arsius;* F, *P. pentophthalmus;* G, *P. levisquamis;* H, *Tarphops oligolepis;* I, *Taeniopsetta ocellata;* J, *Arnoglossus tenuis;* K, *Psettina gigantea;* L, *Arnoglossus japonicus;* M, *A. polyspilus;* N, *A. oxyrhynchus;* O, *Psettina tosana;* P, *P. iijimae;* Q, *Engyprosopon grandisquama;* R, *Bothus mancus;* S, *Japonolaeops dentatus;* T, *Chascanopsetta lugubris.* Scales indicate 1 mm.

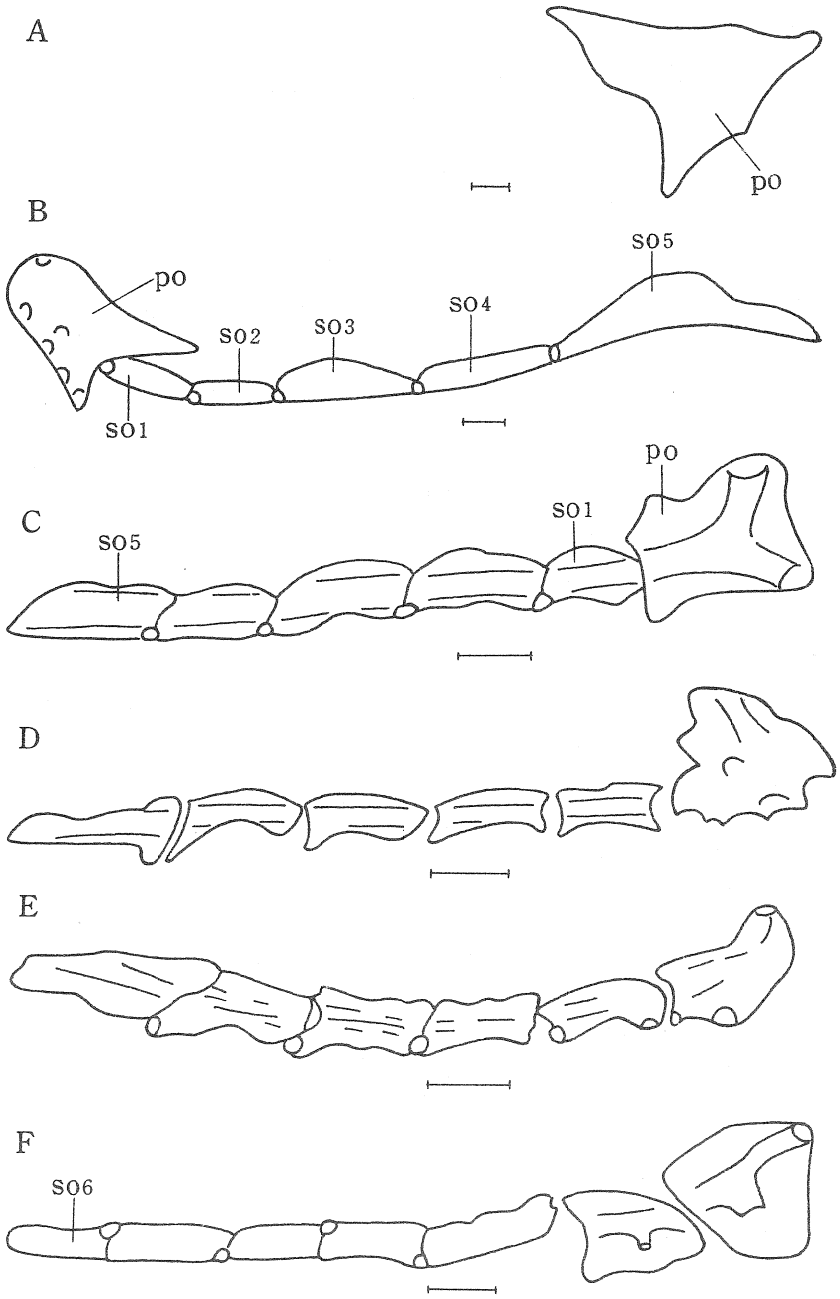

Fig. 106. Lateral aspect of the orbital bones on the blind side in six species. A, *Psettodes erumei*; B, *Lepidoblepharon ophthalmolepis*; C, *Citharoides macrolepidotus*; D, *Paralichthys olivaceus*; E, *Pseudorhombus levisquamis*; F, *P. oligodon*. po, preorbital; sol, first suborbital; so2, second suborbital; so3, third suborbital; so4, fourth suborbital; so5, fifth suborbital; so6, sixth suborbital. Scales indicate 1 mm.

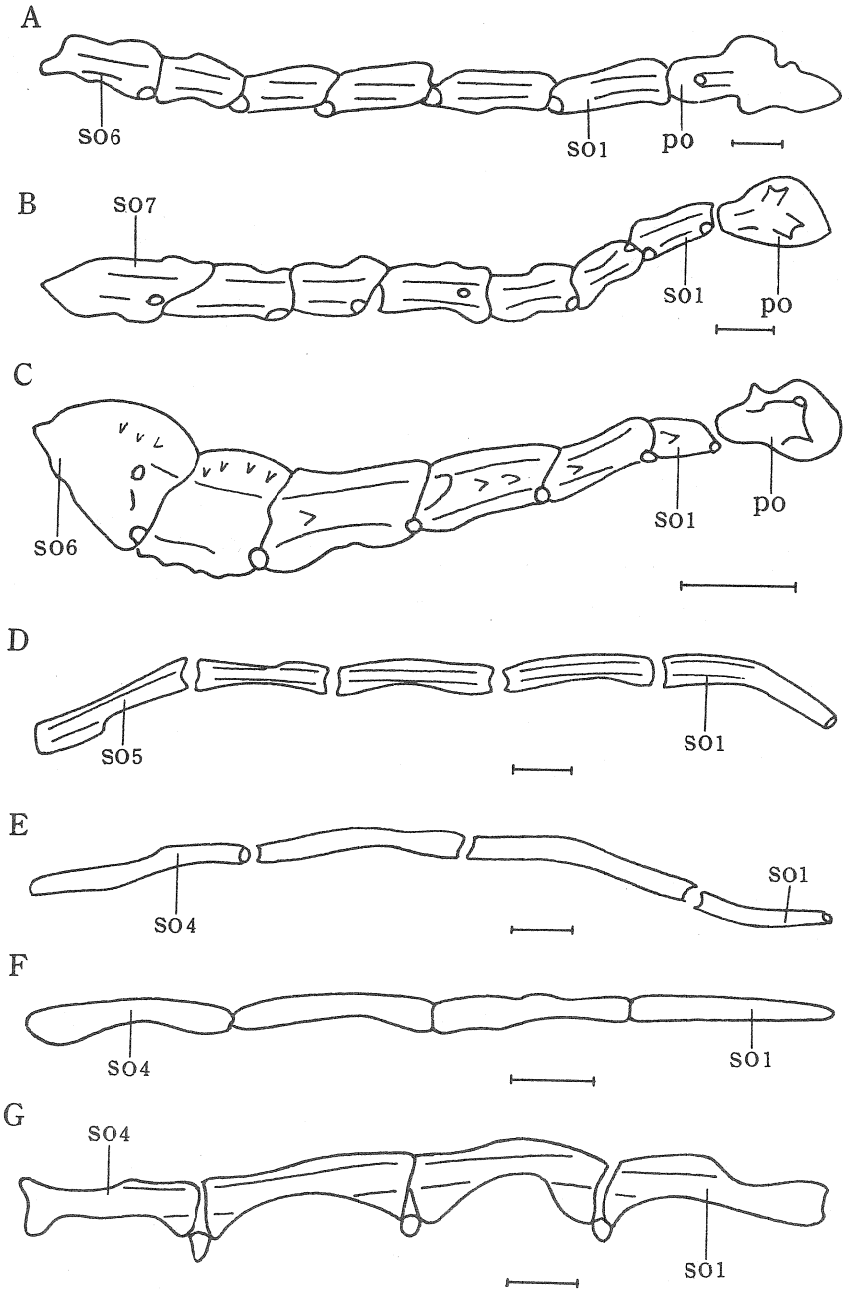

Fig. 107. Lateral aspect of the orbital bones on the blind side in seven species. A, *Pseudorhombus oculocirris*; B, *P. pentophthalmus*; C, *Tarphops oligolepis*; D, *Taeniopsetta ocellata*; E, *Bothus myriaster*; F, *B. pantherinus*; G, *Chascanopsetta lugubris*. so7, seventh suborbital. Other abbreviations as in Fig. 106. Scales indicate 1 mm.

With respect to the general shape and length of these bones, generally speaking, in most species having more than five suborbital bones, each bone is usually short, platelike in shape (Fig. 106, B-F; Fig. 107, A-C), while in the other species there are generally elongated and slender tubular bones (Fig. 107, D-G; Fig. 108, A-E).

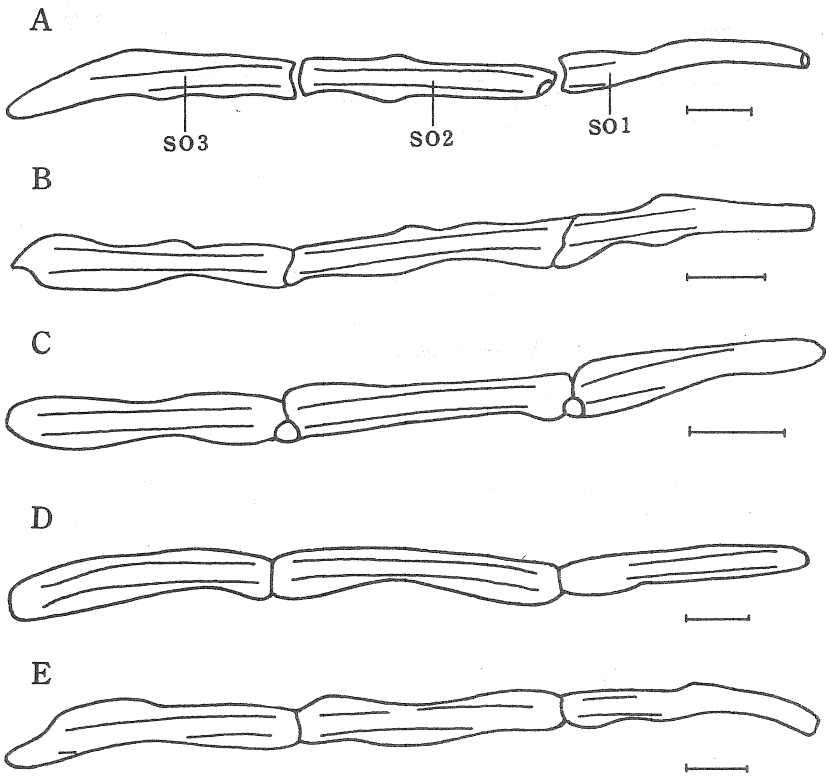

Fig. 108. Lateral aspect of the orbital bones on the blind side in five species. A, *Arnoglossus polyspilus*; B, *A. oxyrhynchus*; C, *Psettina tosana*; D, *Engyprosopon grandisquama*; E, *Parabothus kiensis*. Abbreviations as in Fig. 106. Scales indicate 1 mm.

Discussion: None of the flounders have hitherto been know to have a suborbital series except a more reduced prefrontal bone which they retain only (SMITH and BAILEY, 1962). By a detailed study of the Japanese flounders it has been found that in most species the suborbital bones on the ocular side are either entirely lacking or occasionally remaining of the scaly nodules on the surface of the head, but these are apparently present on the blind side, though very reduced.

Hitherto the anatomical differences of the orbital bones have never been applied to the flounders for taxonomical purposes. But in the present study the writer has been able to find evidence that the bones offer great importance to the classification of the families,

subfamilies, genera and even species. These are: general shape of preorbital bone on ocular side; presence or absence of suborbital bones on ocular side; presence or absence of preorbital bone on blind side; general shape of suborbital bones, and length and number of suborbital bones. On the other hand, the features essential for the right understanding of the phylogeny are: presence or absence of preorbital bone and suborbital bones on

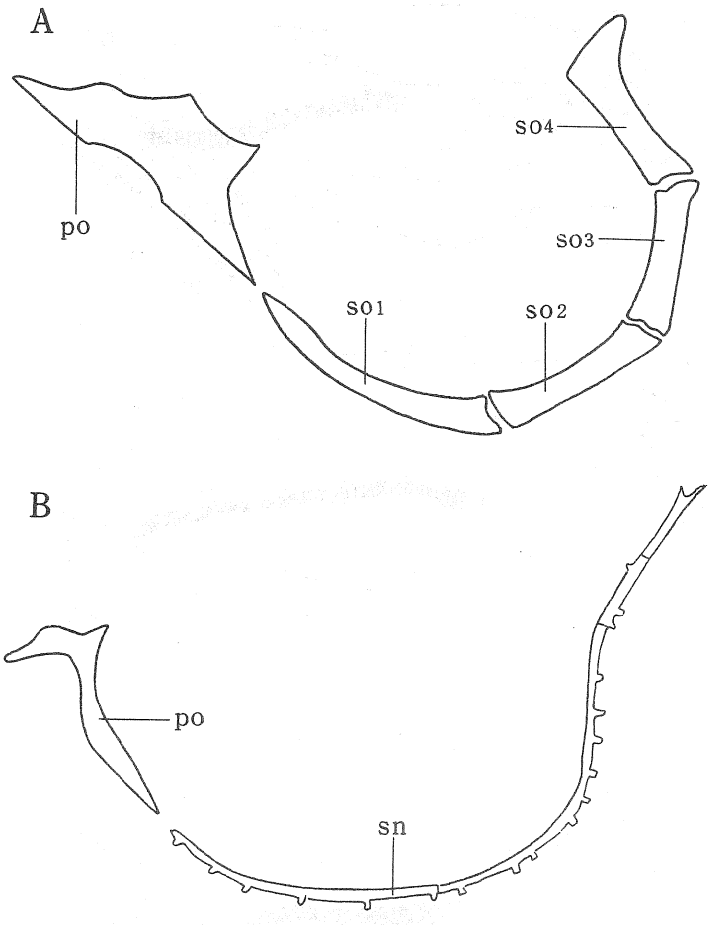

Fig. 109. Lateral aspect of the orbital bones (A) and the preorbital bone and the scaly nodules (B) on the ocular side in two species. A, *Psettodes erumei*; B, *Pseudorhombus pentophthalmus*. sn, scaly nodule. Other abbreviations as in Fig. 106.

ocular side; presence or absence of preorbital bone on blind side, and length and number of suborbital bones on blind side. Based on the these features, the orbital bones of the Japanese flounders can reasonably be classified into three types and six subtypes (Table 6). The first type comprising the fishes of the family Psettodidae has one preorbital bone on the blind side and four suborbital bones on the ocular side, but the suborbital bone

completely disappears on the blind side. In the second type which includes the fishes of the families Citharidae and Paralichthyidae, the suborbital bones are scaly nodules on the ocular side, but there is a pair of preorbital bones and five to seven suborbital bones on the blind side. This type can be subdivided further into three subtypes on the basis of the number of suborbital bones. There are five bones in the subtype 2a, represented by

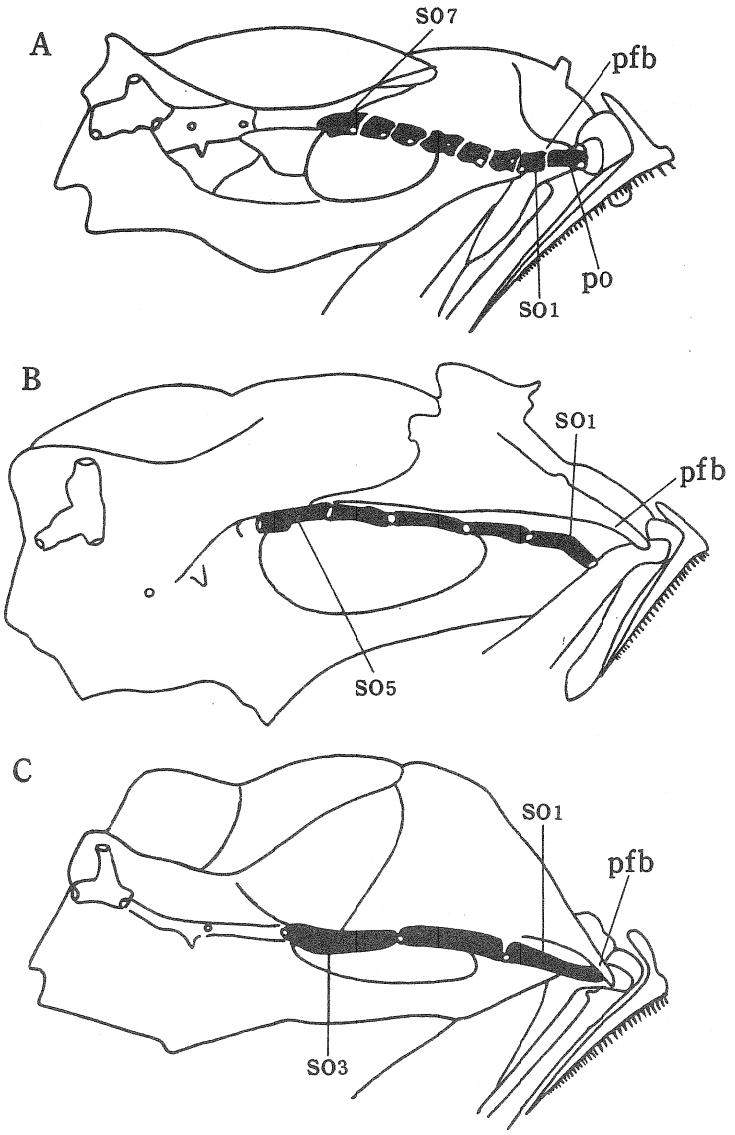

Fig. 110. Features of the attachment of the orbital bones on the blind side in three species. A, *Pseudorhombus pentophthalmus*; B, *Taeniopsetta ocellata*; C, *Arnoglossus japonicus*. pfb, prefrontal on the blind side. Other abbreviations as in Fig. 106.

Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Paralichthys olivaceus, Pseudorhombus cinnamoneus and *P. levisquamis*, six bones in the subtype 2b, represented by *P. arsius, P. oligodon, P. oculocirris, Tarphops oligolepis* and *T. elegans*, and seven bones in the subtype 2c, represented by *P. pentophthalmus*. In the third type which includes the fishes of family Bothidae the preorbital bone on the blind side is entirely lacking. The suborbital bones are absent on the ocular side, but on the blind side, three to five are to be found. This type can be subdivided further into three subtypes on the basis of the number of the suborbital bones. There are five bones in the subtype 3a represented by the fishes of the genus *Taeniopsetta*, four bones in the subtype 3b, represented by the fishes of the genera *Bothus* and *Chascanopsetta*, and three bones in the subtype 3c including the remaining genera.

Table 6. Three types and six subtypes of the orbital bones in Japanese flounders.

Types	Sub-types	Characters		Genera and species
		Suborbitals (ocular side)	Preorbital + Suborbitals (blind side)	
1	—	4	1 + 0	*Psettodes*
2	a	scaly nodules	1 + 5	*Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus cinnamoneus, P. levisquamis*
	b		1 + 6	*Pseudorhombus arsius, P. oligodon, P. oculocirris Tarphops oligolepis T. elegans*
	c		1 + 7	*Pseudorhombus pentophthalmus*
3	a	absent	0 + 5	*Taeniopsetta*
	b		0 + 4	*Bothus, Chascanopsetta*
	c		0 + 3	*Engyprosopon, Crossorhombus, Tosarhombus, Asterorhombus, Arnoglossus, Psettina, Parabothus, Japonolaeops, Laeops, Neolaeops, Kamoharaia*

The study of such fishes as Scorpaenidae (Matsubara, 1943), Platycephalidae (Matsubara and Ochiai, 1955), Serranidae (Katayama, 1959), Carangidae (Suzuki, 1962), Sparidae (Akazaki, 1962) and Lutjanidae (Shinohara, 1963) has attached much importance to the orbital bones, in conjecturing the phylogenetical relationships among genera, subfamilies and families. Matsubara (1943) states that the suborbitals consisting of a large number of

the bones which protect a wider part of the eye may possibly be considered as more generalized than those with a smaller number, and also that this hypothesis may probably be supported by the fact that in primitive teleosts such as salmonoids and cyprinoids the eye is usually surrounded by both the suborbital and supraorbital bones. He is of opinion that the reduction of the bones may be due either to fusion or merely retrogression. As was pointed out by Smith and Bailey (1962), at least among teleosts the number of bones in the suborbital series is remarkably constant; usually there are six including one preorbital bone, although in some fishes the bone have undergone reduction, and in a few, one or more of them have divided, thus increasing the total number of the elements. If one applies their way of thinking to the present case, it naturally follows that in the course of evolution of the flounders there have been two prominent trends in the orbital bones on the blind side. In the type 2 which has the preorbital bone on the blind side and scaly nodules on the ocular side, there is a tendency to the increase of the suborbital bones, while in the type 3, which lacks the preorbital bone on the blind side and the suborbital bones on the ocular side, there is a tendency to the decrease. In such a case, the subtype 2a, in having 1 + 5 bones, ought to be regarded as more generalized than the others, and 2b and 2c follow in order. Among the type 3, the subtype 3a is nearest to the subtype 2a, and 3b and 3c follow in order. The type 1, is so peculiar that it may be considered as most primitive, in that it has the suborbital bones on the ocular side, but as most specialized, in lacking them on the blind side. Such being the case, so far as the type 1 is concerned, it seems difficult to give a definite conclusion.

On the other hand, the increase or decrease of the orbital bones may possibly be considered as divided or fused, although the lacking of the preorbital bone may be probably loss. This hypothesis may be justified by the fact that in the type having a larger number of orbital bones the length of each bone is very short, while in the type having a smaller number of them, it is rather elongated.

3. Gill-rakers

Description: The gill-arch is composed of two parts; the upper-limb supported by the epibranchial, and the lower-limb supported by the ceratobranchial and hypobranchial bones. The branchial arch is generally armed with the gill-rakers and with tubercles, though the latters occur only in a several genera. The gill-rakers are the skeletal process somewhat regularly arranged along the anterior margin of the arch. The tubercles consisting of skeletal element vary in shape, and are present irregularly on the outer and inner surfaces of arch.

The gill-rakers on the first branchial arch markedly vary in number (Table 7) and in general shape.

With respect to the gill-rakers, the Japanese flounders may be classified into two groups according as the upper-limb is provided with them or not. One group possesses 1 to 14 gill-rakers on the upper limb, all the members of the families Psettodidae, Citharidae and Paralichthyidae, and *Arnoglossus polyspilus, Crossorhombus kanekonis, Japonolaeops dentatus, Laeops kitaharae, L. nigromaculatus, Psettina iijimae, Neolaeops microphthalmus* and

Kamoharaia megastoma of the family Bothidae being included in the group (Fig. 111, A1-D1; Fig. 112, A, D, E).

The other has no gill-rakers on the upper-limb, all the other members of the family Bothidae being included in it (Fig. 112, B, C, F).

Regarding the shape of the gill-rakers, the Japanese flounders can be classified into two groups as to whether they possess the spines or not the dorsal surface. One group is provided with many spines, the fishes of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus* and *Asterorhombus,* and *Arnoglossus japonicus, A. oxyrhynchus, A. polyspilus* and *Engyprosopon longipelvis* being included in the group (Fig. 111,

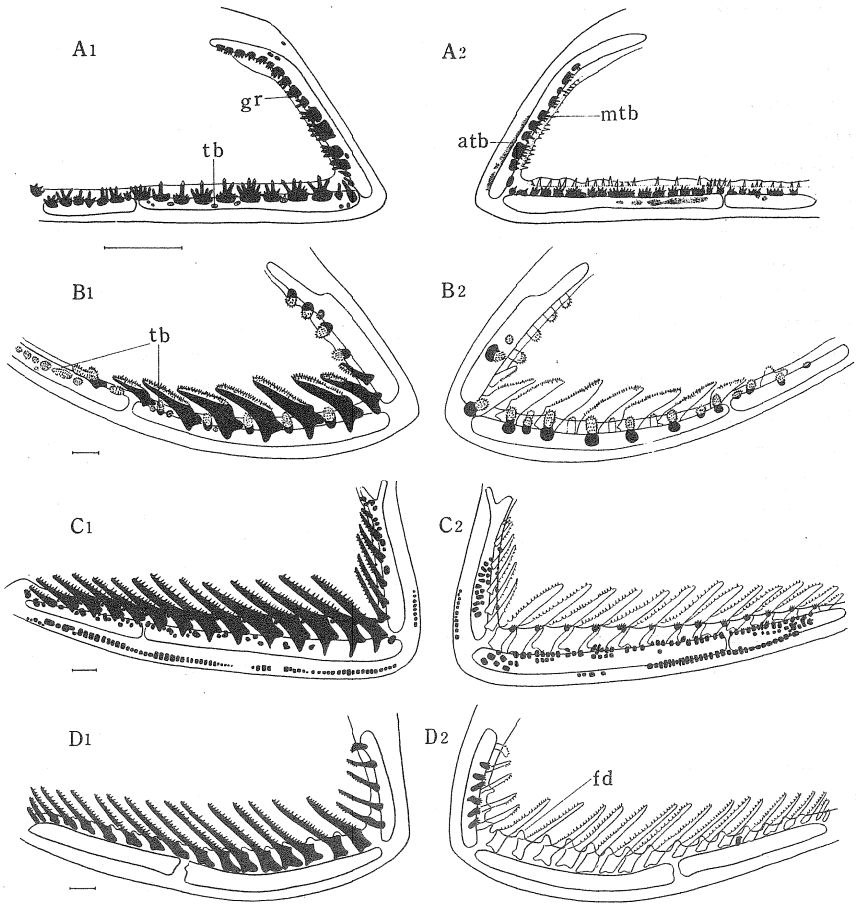

Fig. 111. Lateral (A1 to D1, outer side; A2 to D2, inner side) aspect of the first gill-arch on the ocular side in four species. A1 • A2, *Psettodes erumei*; B1 • B2, *Citharoides macrolepidotus*; C1 • C2, *Paralichthys olivaceus*; D1 • D2, *Pseudorhombus pentophthalmus*. gr, gill-raker; tb, tubercle; mtb, main tubercle; atb, accessory tubercle; fd, fold. Scales indicate 1 mm.

Table 7. Frequency distribution in counts of the gill-rakers on the lower limb of the first branchial arch in Japanese flounders.

Species	3	4	5	6	7	8	9	10	11
Psettodes erumei	—	—	—	—	—	—	—	—	—
Citharoides macrolepidotus	—	—	—	—	—	1	10	—	—
Lepidoblepharon ophthalmolepis	—	—	—	—	—	—	—	1	18
Paralichthys olivaceus	—	—	—	—	—	—	—	—	—
Pseudorhombus dupliciocellatus	—	—	—	—	—	—	1	—	—
P. oligodon	—	—	—	—	—	10	1	—	—
P. oculocirris	—	—	—	—	—	—	—	—	—
P. pentophthalmus	—	—	—	—	—	—	—	—	—
P. arsius	—	—	—	—	—	1	1	2	9
P. cinnamoneus	—	—	—	—	—	—	—	7	9
P. levisquamis	—	—	—	—	—	7	21	5	—
Tarphops oligolepis	—	—	—	—	—	—	—	—	—
T. elegans	—	—	—	—	—	—	—	—	—
Taeniopsetta ocellata	—	4	32	13	—	—	—	—	—
Parabothus coarctatus	—	—	—	—	—	8	12	1	—
P. kiensis	—	—	—	—	1	18	21	3	—
Tosarhombus octoculatus	—	—	—	2	15	8	—	—	—
Crossorhombus kobensis	—	—	3	23	23	—	—	—	—
C. kanekonis	—	—	—	18	43	6	—	—	—
Engyprosopon grandisquama	—	—	—	87	—	—	—	—	—
E. multisquama	—	—	1	70	8	1	—	—	—
E. macroptera	—	—	—	—	—	—	5	6	1
E. xystrias	—	—	—	—	—	—	—	—	—
E. longipelvis	—	—	—	1	3	—	—	—	—
Bothus myriaster	—	—	2	24	37	5	—	—	—
B. mancus	—	—	—	—	—	—	1	3	8
B. pantherinus	—	—	—	2	3	1	—	—	—
Asterorhombus intermedius	—	—	—	—	—	1	2	—	—
Psettina iijimae	—	2	31	14	1	—	—	—	—
P. gigantea	—	—	—	7	31	2	—	—	—
P. tosana	—	—	—	27	62	8	—	—	—
Arnoglossus tenuis	—	—	—	—	—	2	4	—	—
A. polyspilus	—	—	—	—	—	16	13	—	—
A. japonicus	—	—	—	—	8	9	5	—	—
A. oxyrhynchus	—	—	—	—	—	10	2	—	—
Japonolaeops dentatus	—	—	—	1	3	17	21	7	—
Neolaeops microphthalmus	—	—	—	—	—	3	—	—	—
Laeops nigromaculatus	—	—	—	2	1	—	—	—	—
L. kitaharae	—	—	2	15	23	3	—	—	—
Kamoharaia megastoma	—	—	—	—	—	1	2	—	—
Chascanopsetta lugubris	3	—	—	—	—	—	—	—	—

Table 7. (continued)

Characters													Specimens examined
12	13	14	15	16	17	18	19	20	21	22	23	24	
—	—	—	—	—	—	1	4	1	—	—	—	—	6
—	—	—	—	—	—	—	—	—	—	—	—	—	11
—	—	—	—	—	—	—	—	—	—	—	—	—	19
—	—	—	1	1	—	1	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	1
—	—	—	—	—	—	—	—	—	—	—	—	—	11
—	—	—	—	—	3	13	7	4	—	—	—	—	27
—	—	—	—	8	6	9	4	—	—	—	—	—	27
2	—	—	—	—	—	—	—	—	—	—	—	—	15
2	—	—	—	—	—	—	—	—	—	—	—	—	18
—	—	—	—	—	—	—	—	—	—	—	—	—	33
—	—	—	—	—	—	1	1	4	4	6	3	2	21
—	—	—	—	—	—	1	7	9	5	—	—	—	22
—	—	—	—	—	—	—	—	—	—	—	—	—	49
—	—	—	—	—	—	—	—	—	—	—	—	—	21
—	—	—	—	—	—	—	—	—	—	—	—	—	43
—	—	—	—	—	—	—	—	—	—	—	—	—	25
—	—	—	—	—	—	—	—	—	—	—	—	—	49
—	—	—	—	—	—	—	—	—	—	—	—	—	67
—	—	—	—	—	—	—	—	—	—	—	—	—	87
—	—	—	—	—	—	—	—	—	—	—	—	—	80
—	—	—	—	—	—	—	—	—	—	—	—	—	12
—	1	1	—	—	—	—	—	—	—	—	—	—	2
—	—	—	—	—	—	—	—	—	—	—	—	—	4
—	—	—	—	—	—	—	—	—	—	—	—	—	68
—	—	—	—	—	—	—	—	—	—	—	—	—	12
—	—	—	—	—	—	—	—	—	—	—	—	—	6
—	—	—	—	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	48
—	—	—	—	—	—	—	—	—	—	—	—	—	40
—	—	—	—	—	—	—	—	—	—	—	—	—	97
—	—	—	—	—	—	—	—	—	—	—	—	—	6
—	—	—	—	—	—	—	—	—	—	—	—	—	29
—	—	—	—	—	—	—	—	—	—	—	—	—	22
—	—	—	—	—	—	—	—	—	—	—	—	—	12
—	—	—	—	—	—	—	—	—	—	—	—	—	49
—	—	—	—	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	43
—	—	—	—	—	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	3

A1-D1; Fig. 112, C). The other group has no such spines, all the other members being included in it (Fig. 112, A, B, D, E, F).

The spines can be assorted into three distinct types in accordance with the shape, the arrangement and the number. In the first type, as represented by *Psettodes erumei*, the spines with barbed tips are remarkably elongate and stout, but such spines are not so much in number (Fig. 111, A1). In the second type, including *Citharoides macrolepidotus* and *Lepidoblepharon ophthalmolepis*, the spines are numerous and very feeble, and arranged irregularly in band (Fig. 111, B1). In the third type, which comprises *Pseudorhombus arsius, P. oligodon, P. dupliciocellatus, Asterorhombus intermedius, Arnoglossus japonicus, A. oxyrhynchus, A. polyspilus* and *Engyprosopon longipelvis*, the spines are exceedingly stout and comparatively small in number (Fig. 112, C). In the last type, which includes the other species, the spines are rather feeble and set in comblike fashion (Fig. 111, D1).

With reference to the shape of the bases of the gill-rakers, three distinct types are recognizable in the Japanese flounders. In the first type, which comprises *Psettodes erumei*, the gill-rakers have wide bases, the majority being attached to the gill-arch (Fig. 111, A1). In the second type, which is represented by the members of the families Citharidae and Paralichthyidae, each gill-raker is somewhat widely expanded on the base, and complex in shape (Fig. 111, B1, C1, D1; Fig. 112, A). In the last type, as exemplified by the other species, those bones are not well expanded, and simple in shape (Fig. 112, B, C, E, F).

The length and the shape of the gill-rakers show many variations between species. In this respect, roughly speaking, Japanese flounders can be divided into three types. In *Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Paralichthys olivaceus, Pseudorhombus cinnamoneus, P. arsius, P. levisquamis, P. pentophthalmus, P. oculocirris, Tarphops oligolepis, T. elegans* and *Arnoglossus tenuis*, the gill-rakers are generally elongate. Among these species, the first six species have the comparatively stout ones (Fig. 111, B1, C1), but the rest are the exceedingly slender (Fig. 111, D1; Fig. 112, A). In *Pseudorhombus oligodon, Arnoglossus japonicus, A. oxyrhynchus, A. polyspilus, Engyprosopon longipelvis, Crossorhombus kanekonis, Tosarhombus octoculatus, Japonolaeops dentatus, Psettina gigantea, P. tosana, Bothus mancus, B. pantherinus, Parabothus kiensis, P. coarctatus, Engyprosopon macroptera, E. multisquama, E. xystrias, Taeniopsetta ocellata, Neolaeops microphthalmus, Laeops nigromaculatus*, the gill-rakers are moderately long. In the first five species, they are rather strong, but in the rest slender and feeble (Fig. 112, B, D). In *Psettodes erumei, Pseudorhombus dupliciocellatus, Asterorhombus intermedius, Engyprosopon grandisquama, Crossorhombus kobensis, Bothus myriaster, Psettina iijimae, Kamoharaia megastoma* and *Laeops kitaharae*, they are very short. In the first three they are remarkably stout, palmate in shape and as broad as long (Fig. 111, A1; Fig. 112, C), while in the rest they are feeble, small and short (Fig. 112, E). In *Chascanopsetta lugubris* they are disklike in shape, and rudimentary (Fig. 112, F).

The tubercles which are found on outer and inner sides of the gill-arch are some specific variations in their general shape, in number and in the location. The species having the tubercles on outer side are *Psettodes erumei, Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Paralichthys olivaceus, Pseudorhombus levisquamis* and *P. cinnamoneus*. In *Psettodes erumei* the tubercles are greatly small disks and covered with poorly developed

prickles, they are arranged irregularly on the hypobranchial bone and on the ceratobranchial bone constituting the lower limb and a small disk is also on the upper posterior margin of the upper limb (Fig. 111, A1). In *Citharoides macrolepidotus*, the tubercles are arranged on the upper and lower limbs somewhat irregularly, and thickly covered with many spinules except at the base. Ones on the upper limb are strongly protruded, wartlike in appearance, but ones on the lower limb are wartlike in shape and arranged more or less regularly between gill-rakers on the ceratobranchial, and disklike in shape arranged

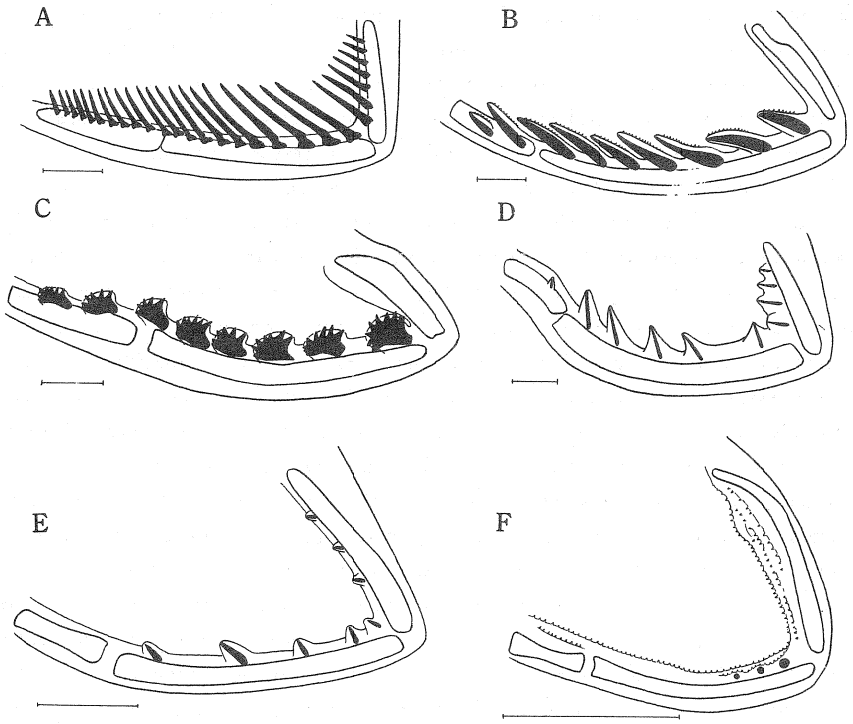

Fig. 112. Lateral aspect of outer side of the first gill-arch on the ocular side in six species. A, *Tarphops elegans*; B, *Engyprosopon macroptera*; C, *Asterorhombus intermedius*; D, *Laeops nigromaculatus*; E, *Psettina iijimae*; F, *Chascanopsetta lugubris*. Scales indicate 1 mm.

throughout its entire length on the hypobranchial (Fig. 111, B1). *Lepidoblepharon ophthalmolepis* has disklike tubercles, which is thickly covered with more or less equal-sized spinules, and they are arranged somewhat regularly between the gill-rakers. In *Paralichthys olivaceus* the gill-arch has numerous small tubercles extensively varied in shape, they are present along the anterior and posterior margins of the upper and lower limbs throughout its entire length, on which they are arranged somewhat irregularly (Fig. 111, C1). *Pseudorhombus levisquamis* possesses two wartlike tubercles on the upper limb and the disklike

ones which are frequently found between the gill-rakers on the upper and lower limbs, and each tubercle is covered with somewhat equal-sized spinules. In *P. cinnamoneus,* small tubercles which are thickly covered with many prickles are disklike in shape, and set somewhat regularly between gill-rakers.

When viewed from the inner side, the tubercles are found in following species; *Psettodes erumei, Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Paralichthys olivaceus, Pseudorhombus dupliciocellatus, P. arsius, P. oligodon, P. pentophthalmus, P. levisquamis, P. oculocirris* and *P. cinnamoneus.* There are some specific variations of them in number, in location and in degree of development. In *Psettodes erumei,* the tubercles which will be called main tubercle are palmate in shape with a small number of spines, and arranged in a single regular row extending throughout the entire length of the anterior margin. In addition to those tubercles, numerous prickles cover the lower half of the posterior margin of the upper limb, and sparsely the ceratobranchial and the hypobranchial bones. These smaller ones will conveniently be called the accessory tubercle (Fig. 111, A2). In *Citharoides macrolepidotus,* the main tubercles are strongly protruded into the prominent wart and overlapped the inner side of each gill-raker of the lower limb, and thickly covered with the spinules except for basal margin, which are comparatively strong and more or less equal in size. The accessory tubercles are large in size, either disklike or somewhat wartlike in shape and armed with many spinules at their tips, and located on the middle of the upper limb and entire length of the lower limb (Fig. 111, B2). *Lepidoblepharon ophthalmolepis* possesses more or less small disklike tubercles armed with many equal-sized spinules. The tubercles are set somewhat regularly between the each gill-raker throughout the upper and lower limbs. It is difficult to distinguish whether the tubercles are the main or the accessory ones. In *Paralichthys olivaceus* the main tubercles are small disks coated with several spinules at their tips and arranged regularly between the gill-rakers along inner side of the arch of the upper and lower limbs, but are not attached to the axis of the gill-arch. Besides them, the numerous accessory ones with or without spinules are scattered irregularly on the inner side of the arch nearly throughout its entire length (Fig. 111, C2). In *Pseudorhombus arsius* the tubercles being somewhat disklike in shape, lie three armed with very minute spinules on the upper limb, one on the upper edge of the ceratobranchial and one on the middle of the hypobranchial. *Pseudorhombus pentophthalmus, P. oculocirris* and *P. levisquamis* possess several tubercles on the upper limb and also on the hypobranchial of the lower limb. In the first species the tubercles are slender, wartlike in shape and scarcely covered with some spinules at their tips (Fig. 111, D2). In the latter two, tubercles on the both limbs are almost disklike in shape, though covered with the sparse and very minute spinules in the former of the two, and with the numerous prickles in the latter. In *Pseudorhombus dupliciocellatus* and *P. oligodon,* the disklike tubercles are found only on the upper limb, but they are covered with several prickles in the former and with a few spinules in the latter. In *P. cinnamoneus,* the tubercles are disklike in shape, set only on the hypobranchial and covered with many prickles. The main tubercle is indistinguishable from the accessory one in this genus.

In addition to those tubercles, in all the members of the genus *Pseudorhombus,* the membrane which covers the bases of the gill-rakers possesses many well developed folds

on the inner side of the gill-arch, and protrudes forward near each gill-raker (Fig. 111, B2).

Discussion: The number and general shape of the gill-rakers have heretofore been applied to the taxonomy of flounders, especially for identifying the species by many ichthyologists. The fact to be deduced from this detailed examination also made above results in disclosing the features valuable for the specific identification of flounders. There are as follow: presence or absence of the gill-rakers on the upper limb, general form of the bases of the gill-rakers, presence or absence of the spines on the gill-rakers, shape and number of the spines, presence or absence of the tubercles and, if present, shape of them, presence or absence of the fold and number of the gill-rakers.

On the other hand, in the case of flounders, the features of the gill-rakers and of the tubercles on the first branchial arch are hardly given us with ground of their availability for the phylogeny. When viewed from general tendency, however, it may be fairly subservient to the purpose of clarifying of the relationships of Japanese flounders. Generally, the following characters, at least, may reasonably be thought as showing the primitiveness in the flounders. 1) presence of gill-rakers on upper limb of the arch, 2) presence of spines on each gill-raker, 3) presence of expanded bases of gill-rakers, 4) elongation of gill-rakers and 5) presence of tubercles on the outer and inner sides.

Such being the case, all the members of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys* and *Pseudorhombus* having all the characters aforementioned may be considered as more primitive than the other genera. Among those genera, the fishes of the genus *Psettodes* which have peculiar spines with the barbed tip may probably represent a rather early split from the ancestral form. The fishes of the genera *Citharoides* and *Lepidoblepharon* in which spines on the gill-rakers occur with the toothed band are thought to be slightly more primitive nearest the ancestral form. The fishes of the genus *Tarphops* which lacks the characters of number 2) and 5) as aforementioned are more advanced than the preceding genera. All the members of the family Bothidae may be characterized in having the simple bases of the gill-rakers and the rather moderate or short gill-rakers, and in lacking any tubercles on both outer and inner sides of the arch. In addition to those characters, the majority of these members have neither the gill-rakers on the upper limb nor the spines on the gill-rakers. Considering from this fact, it may well be said that these members are more advanced than the others.

It was well reported that the shape and number of the gill-rakers may be related to the feeding habits (Suehiro, 1942). Suzuki (1962) pointed out that largeness and smallness in the number of gill-rakers in the Carangidae may have a certain relation to their feeding habits and the swiftness of their movement. In the flatfishes it is said that the gill-rakers are closely related to the feeding habits and the maxillary length (Kitamori, 1963). In the Japanese flounders the stomach contents of the most fishes indicate that they eat the benthic fishes, shrimp, crabs, lobworms (polychaeta) and so on, and the feeding habits are not to be clearly distinguished between species. When viewed from general tendency, the features of the gill-rakers may be fairly related to the feeding habits and the mouth length. The members of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys* and *Asterorhombus,* and *Arnoglossus japonicus, A. oxyrhynchus* and *A. polyspilus* which

possess a large mouth eat greedily large benthic animals. They have generally well developed gill-rakers and are armed with many spinules on their dorsal surface. On the other hand, the members of family Bothidae except for *Arnoglossus japonicus, A. oxyrhynchus* and *Asterorhombus intermedius* which possess a rather small mouth eat mainly small benthic animals, especially polychaeta, and have moderate or short gill-rakers without the spinules on their dorsal surface.

The gill-rakers are the bony structure having developed for the prevention of dangers of injuries which food fragments introduced into the branchial cavity may inflict upon gill-lamellae (Suzuki, 1962). In such a speculation, it may be interpretable that the structure of the gill-rakers has a certain relations to the feeding habits and size of the mouth. But the two species, *Kamoharaia megastoma* and *Chascanopsetta lugubris* have the short or rudimentary gill-rakers in spite of a peculiar large mouth, and eat mainly fishes. It is impossible for us to determine what factor has to do with such a fact, except living in greatly deep waters.

With regard to the tubercles, as were pointed out by Suzuki (1962), role of the main tubercles appear to lie in assisting the function of the gill-rakers. If this point is taken into consideration, it may reasonably be thought that the members of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys* and *Pseudorhombus*, which possess a large mouth and feed mainly large animals, have tubercles on the outer and inner sides, though they are considerably varied in number and in shape among species.

In the flounders, when we summarize the foregoing consideration, the group, which has a large mouth and well developed gill-rakers and eats greedily the large animals, yet retains many primitivenesses, while the other group, which has the small mouth and short and feeble gill-rakers and feeds mainly small animals and polychaeta is rather advanced form.

4. Branchial apparatus

Description: Branchial apparatus is a group of bones bearing the gill, the upper and lower pharyngeal bones, and is composed of three basibranchial bones, three pairs of hypobranchial bones, four pairs of ceratobranchial bones, four pairs of epibranchial bones, a pair of lower pharyngeal bones and four pairs of upper pharygeal bones. Here, the apparatus comprises a glossohyal bone, a bone of the hyoid arch.

Basibranchial bones consist of three bones lying in a median series on the floor of pharynx; posteriorly these constitute the interspaced cartilages which connect with each bone. In *Psettodes erumei, Lepidoblepharon ophthalmolepis, Pseudorhombus arsius, Bothus myriaster, B. mancus, Parabothus coarctatus, Arnoglossus japonicus, A. polyspilus, Asterorhombus intermedius, Japonolaeops dentatus, Chascanopsetta lugubris* and *Engyprosopon multisquama* there is a suture between the first and the second basibranchial bones, and between the second and the third as well (Fig. 113, A, C, E, G, H, I, L; Fig. 114, A, B, D, H, L). In *Paralichthys olivaceus, Tarphops oligolepis, Tosarhombus octoculatus, Crossorhombus kobensis, Psettina gigantea, Laeops kitaharae, L. nigromaculatus, Neolaeops*

microphthalmus and *Kamoharaia megastoma* a suture is formed only between the first and the second basibranchial bones, but not between the second and the third (Fig. 113, D, F, J; Fig. 114, C, E, F, G, J, K). In *Citharoides macrolepidotus, Taeniopsetta ocellata* and *C. kanekonis* there is no such suture (Fig. 113, B, K; Fig. 114, J).

The first bone, which is the smallest of the three, is triangular and gourdlike in shape; anteriorly it is attached to the ventral surface of the glossohyal bone, posteriorly it is attached to the second basibranchial bone and lies between the hypohyal bones.

The second bone is nearly as long as the third one, and it is elongate in the members of the families Psettodidae, Citharidae and Paralichthyidae, while it is widely expanded laterally in the members of the family Bothidae. The second bone which varies in shape between the genera can be assorted into some distinct types. In the type A represented by *Psettodes erumei,* it is rectangular in shape and slightly expanded posteriorly (Fig. 113, A). In the type B, which comprises *Citharoides macrolepidotus* and *Lepidoblepharon ophthalmolepis,* it is gourdlike in shape, greatly concaved on both sides of the middle part (Fig. 113, B, C). Characteristic of the type C consists in that the bone has the great concavity on both sides of the anterior part. This type can be classified into two subtypes in accordance with the developmental degree of the posterior part. In the subtype Ca, represented by *Paralichthys olivaceus, Pseudorhombus arsius, Tarphops oligolepis, Arnoglossus polyspilus, A. japonicus, Asterorhombus intermedius, Psettina gigantea, Parabothus coarctatus, Bothus myriaster, B. mancus, Tosarhombus octoculatus, Japonolaeops dentatus* and *Engyprosopon multisquama,* it has usually a gourdlike shape, which is slightly developed in the posterior part (Fig. 113, D-J, L; Fig. 114, A, B, C, D, H). In the subtype Cb, represented by *Taeniopsetta ocellata, Laeops kitaharae, L. nigromaculatus, Neolaeops microphthalmus, Kamoharaia megastoma, Crossorhombus kanekonis* and *C. kobensis,* it is gourdlike in shape and exceedingly expanded in the posterior part (Fig. 113, K; Fig. 114, E-G, L-K). In the type C which is represented by a single species *Chascanopsetta lugubris* it is exceedingly expanded in the posterior half, and is extremely reduced in the anterior half (Fig. 114, L).

The third basibranchial bone as well as the second bone shows the distinct features between the genera. In the type A, which includes *Psettodes erumei, Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Paralichthys olivaceus, Pseudorhombus arsius* and *Tarphops oligolepis,* the bone is generally elongate and spearlike in shape, concaved on both sides at anterior part (Fig. 113, A-F). The type B has one to three projections on both sides, which are widely expanded posteriorly. On the basis of these characters, this type is divided further into five subtypes. In the subtype Ba which comprises *Arnoglossus polyspilus, A. japonicus, Asterorhombus intermedius, Psettina gigantea, Taeniopsetta ocellata, Parabothus coarctatus, Bothus myriaster, B. mancus, Tosarhombus octoculatus* and *Japonolaeops dentatus* the bone is posteriorly gourdlike form, well developed on the posterior half (Fig. 113, G-L; Fig. 114, A-D). In the subtype Bb which is represented by *Laeops* and *Neolaeops* the bone is posteriorly gourdlike in shape (Fig. 114, E-G). In the subtype Bc which contains *Engyprosopon* and *Crossorhombus* the bone has a pair of wings, of which the posterior part is exceedingly well developed (Fig. 114, H-J). The subtype Bd as represented by *Kamoharaia* comparatively resembles the subtype Ba in the

general appearance, but differs in having no anterior projection (Fig. 114, K). In the type C which includes only *Chascanopsetta* the posterior part of this bone is not widely expanded, and a pair of short wings is found to exist on the anterior concave portions (Fig. 114, L).

The great circular or elliptical cartilage which bears the third hypobranchial bone, the fourth ceratobranchial bone and the lower pharyngeal bone is attached to the third basibranchial bone posteriorly.

The hypobranchial is three pairs' bones lying between the basibranchial and the ceratobranchial, and bears gill-rakers on their dorsal surface. The first hypobranchial is articulated to the anterior cartilaginous bridges, anteriorly of antero-lateral second basibranchial and

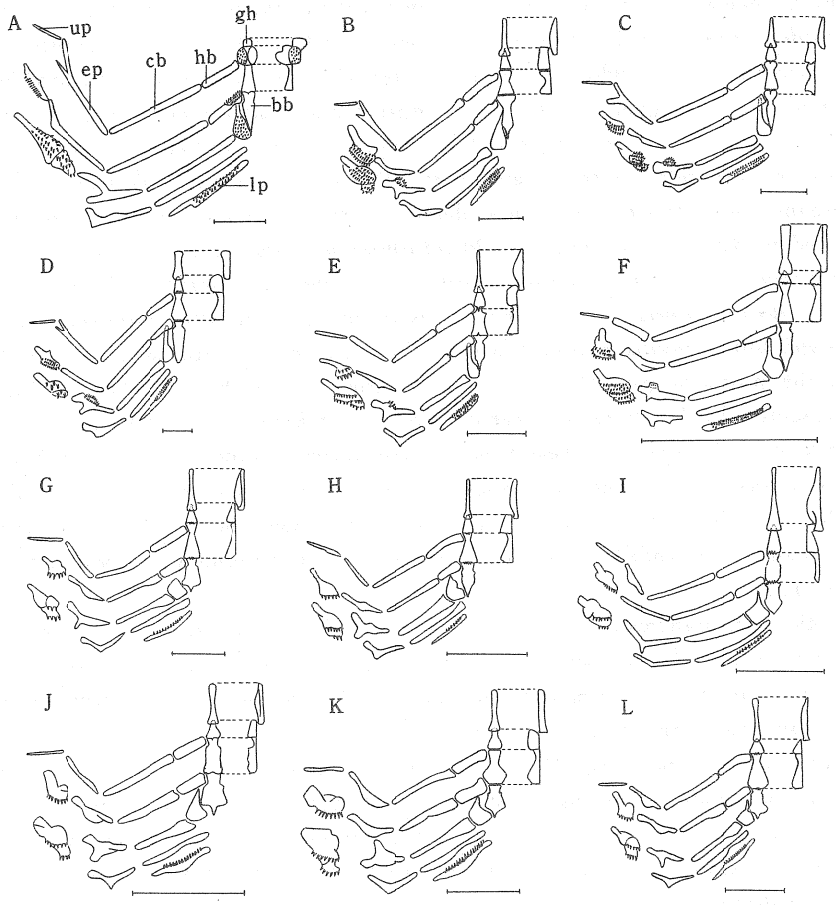

Fig. 113. Dorsal and lateral aspects of the branchial apparatus on the left side in 12 species. A, *Psettodes erumei*; B, *Citharoides macrolepidotus*; C, *Lepidoblepharon ophthalmolepis*; D, *Paralichthys olivaceus*; E, *Pseudorhombus arsius*; F, *Tarphops oligolepis*; G, *Arnoglossus polyspilus*; H, *A. japonicus*; I, *Asterorhombus intermedius*; J, *Psettina gigantea*; K, *Taeniopsetta ocellata*; L, *Parabothus coarctatus*. bb, basibranchial; cb, ceratobranchial; eb, epibranchial; gh, glossohyal; hb, hypobranchial; lp, lower pharyngeal; up, upper pharyngeal. Scales indicate 10 mm.

posteriorly of the first ceratobranchial. It is usually rectangular in shape.

The second hypobranchial is articulated anteriorly to the cartilaginous bridge between the second and the third basibranchials, posteriorly to the anterior cartilaginous bridge of the second ceratobranchial. In *Psettodes erumei* this bone has particularly a toothed plate on the dorsal surface (Fig. 113, A), but this disappears in other members (Fig. 113, B-L; Fig. 114, A-L). The shape of the second hypobranchial varies between genera or species. In the members of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus, Tarphops, Arnoglossus, Asterorhombus* and *Parabothus* it is usually

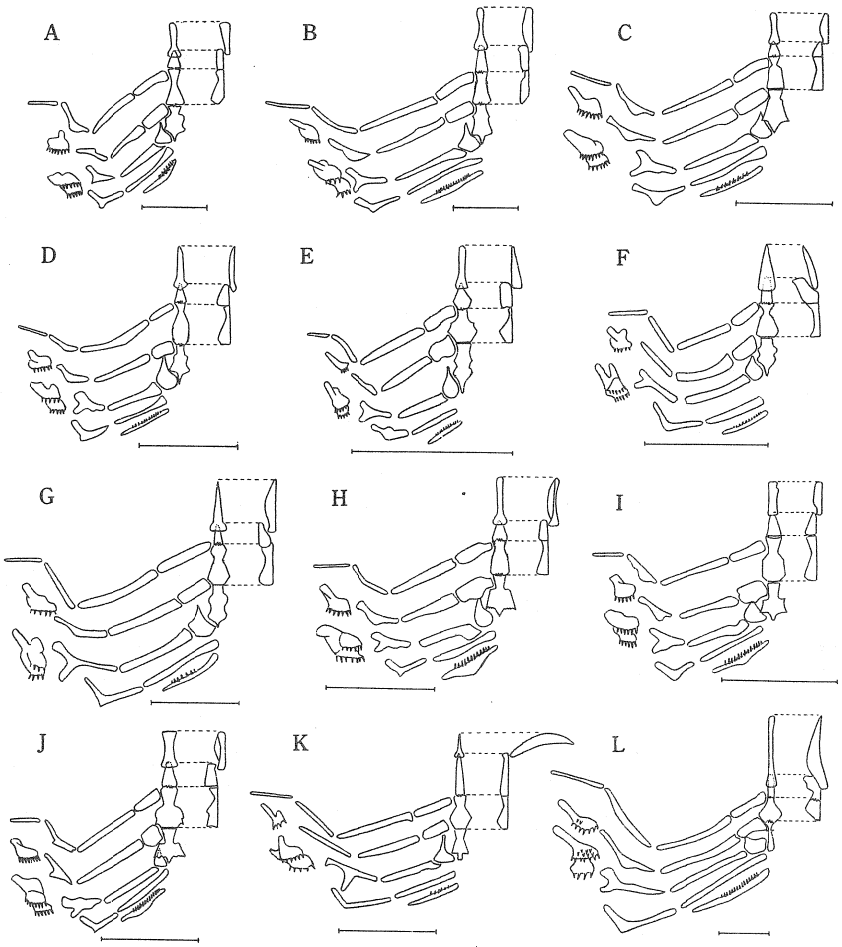

Fig. 114. Dorsal and lateral aspects of the branchial apparatus on the left side in 12 species. A, *Bothus myriaster*; B, *B. mancus*; C, *Tosarhombus octoculatus*; D, *Japonolaeops dentatus*; E, *Laeops kitaharae*; F, *L. nigromaculatus*; G, *Neolaeops microphthalmus*; H, *Engyprosopon multisquama*; I, *Crossorhombus kanekonis*; J, *C. kobensis*; K, *Kamoharaia megastoma*; L, *Chascanopsetta lugubris*. Scales indicate 10 mm.

rectangular in shape (Fig. 113, A-I, L). The fishes of the genera *Taeniopsetta, Bothus, Psettina, Tosarhombus, Japonolaeops, Neolaeops, Kamoharaia* and *Chascanopsetta* have nearly elliptical second hypobranchial (Fig. 113, J, K; Fig. 114, A-D, G, K, L), but in the fishes of the genera *Laeops, Engyprosopon* and *Crossorhombus* it is about circular in shape (Fig. 114, E, F, H, I, J).

The third hypobranchial has a process expanded below the second hypobranchial. It is articulated to cartilaginous bridges, anteriorly of the postero-lateral half of the third basibranchial, posteriorly of the anterior edge of the third ceratobranchial. In *Psettodes erumei,* the posterior half of this bone has a toothed plate on the dorsal surface (Fig. 113, A), but in other members it is not covered by such a toothed plate (Fig. 113, B-L; Fig. 114, A-L). This bone has the two different types in shape among families. In the first type as represented by all the members of the families Psettodidae, Citharidae and Paralichthyidae, it is elliptical in shape and elongated below the second hypobranchial (Fig. 113, A-F). In the second type which includes all the members of the family Bothidae, it is not elongate, but its posterior part is almost circular in shape (Fig. 113, G-L; Fig. 114, A-L).

There are four pairs of ceratobranchial bones. They are the longest bones of the branchial apparatus, and bear gill-rakers on their dorsal surface. The first, second and third ceratobranchials are articulated to the cartilaginous bridges, anteriorly of its own hypobranchials, posteriorly of its own epibranchials. In *Psettodes erumei* these four pairs of bones are very elongate (Fig. 113, A), but in other members these bones are moderate in size or rather short (Fig. 113, B-L; Fig. 114, A-L).

There are four pairs of epibranchials which form the upper limbs of the branchial arch, each bone bears gill-rakers on its dorsal surface. These bones are articulated anteriorly to cartilaginous bridges of the ceratobranchials, posteriorly they bear the upper pharyngeal bones. The first epibranchial can be classified into two types in accordance with its shape. In the first type which is represented by the members of the families Psettodidae and Citharidae, and *Paralichthys olivaceus* referable to the family Paralichthyidae, the bone is bifurcate in shape at the upper tip (Fig. 113, A-D), whereas in the second type, in which the rest of species belong it is not bifurcate (Fig. 113, E-L; Fig. 114, A-L). The second epibranchial is barlike in shape and curved or expanded on middle portion. The shape of this bone varies somewhat among species. The third epibranchial bears a well developed posterior process, and it is referable to two types in the flounders, one being characterized by the possession of the teeth cutting partly on its upper surface, and the other by no having them. Those teeth in the first type are formed in the members of the families Citharidae and Paralichthyidae (Fig. 113, B-F). The fourth epibranchial is a laterally compressed plate and usually V-like in shape.

The first bone which is invariably slenderer than any of the upper pharyngeal bones, is anteriorly attached to the epibranchial bone, posteriorly to the ventral surface of the parasphenoid. Only the first bone in the series has not the pharyngeal teeth. The second bone is contacted with its own epibranchial on the lower surface, and has a broad lateral base that is in contact with the third upper pharyngeal bone. The third bone, which is the largest of the upper pharyngeal bones, is contacted broadly upper-laterally with the

second bone, lower-laterally with the fourth bone and ventrally with the third epibranchial. The fourth upper pharyngeal bone is very small; it is contacted upper-laterally with the third bone, lower-laterally with its own epibranchial. The second, third and fourth upper pharyngeal bones can be assorted with five distinct types in accordance with the feature of teeth cutting on its surface. In the first type, as represented by the members of the families Psettodidae and Citharidae, many teeth cut densely in the irregular band on broad surface (Fig. 113, A-C). In the second type which comprises *Paralichthys olivaceus,* the second bone has dense teeth on its surface as is the case with the preceding type, but the third and the fourth bones possess teeth cutting in one or two rows on the surface of somewhat compressed bones (Fig. 113, D). In the third type as represented by *Pseudorhombus* and *Tarphops,* the three bones bear the teeth of two or three rows (Fig. 113, E, F). In the fourth type, the second, third and fourth upper pharyngeal bones have a comparatively small number of teeth cutting a single row on the surface of very compressed bones. This type comprises all the members of the family Bothidae, with the exception of *Chascanopsetta* (Fig. 113, G-L; Fig. 114, A-K). In the fifth type, represented by *Chascanopsetta,* these bones have a small number of teeth of two rows in the second, of two to three rows in the third and of a single row in the fourth (Fig. 114, L).

A pair of lower pharyngeal bones, which are elongate and rodlike or platelike in shape, is arranged in parallel with the fourth ceratobranchial, and anteriorly it connects with the posterior cartilage of the third basibranchial, posteriorly with the fourth epibranchial by the ligament. Most of the upper surface except for both anterior and posterior edges bears many teeth. It can be classified into two types in accordance with the shape of the bone and mode of the arrangement of the teeth. In the first type which is represented by the members of the families Psettodidae, Citharidae and Paralichthyidae the bone is rodlike in shape and armed with many teeth cutting densely on the broad upper surface (Fig. 113, A-F), whereas in the second type to which all the members of the family Bothidae belong it is a laterally compressed plate with the teeth of one or two rows on its narrow surface (Fig. 113, G-L; Fig. 114, A-L).

The median glossohyal bone which forms the base of tongue lies on the first basibranchial. In the dorsal view the bone is usually spearlike or rectangular in shape and concaved at the lateral sides of the middle portion. In *Psettodes erumei* the glossohyal bone bearing basally a pair of toothed plate, but not fused, is the smallest in the flounders, and its most portion overlaps the first basibranchial (Fig. 113, A). In other species this bone is not covered by such plates (Fig. 113, B-L; Fig. 114, A-L). In *Chascanopsetta lugubris* the bone is the longest, and about as long as the total length of all the basibranchial bones connected (Fig. 114, L). The glossohyal bone of *Kamoharaia megastoma* being rather elongate extends upward on the first basibranchial. In this feature this fish is quite different from the other members of this group (Fig. 114, K).

Discussion: The comparative study of the branchial apparatus which is sufficient for making out something of phylogenetical significance has hitherto never been successfully made on the fishes, though a few characters in the series such as the upper and lower pharyngeal bones furnish us with the feature valuable for the taxonomy. So far as

Japanese flounders are concerned, the branchial apparatus may give us fully the features to indicate the suggested phylogenetic significance.

Of a number of characters, which the branchial apparatus exhibits, much importance ought to be attached above all things to the feature of the lower and upper pharyngeal toothed bands, to the feature of the first epibranchial bone, to the presence or absence of teeth on the third epibranchial, to the length of the ceratobranchial bone and of the glossohyal bone and to the general shapes of the hypobranchial and of the basibranchial bones. If these points are taken into consideration, the constitution of the apparatus can reasonably be classified into seven types, and the fifth type is further divisible into three subtypes, which are indicated in Table 8.

Table 8. Seven types and three subtypes of the branchial apparatus in Japanese flounders.

<table>
<tr><th rowspan="3">Types and subtypes</th><th colspan="5">Characters</th></tr>
<tr><th rowspan="2">Lower pharyngeal bone</th><th colspan="3">Upper pharyngeal bone</th><th colspan="2">Epibranchial</th><th rowspan="2">Ceratobranchial</th></tr>
<tr><th>2nd</th><th>3rd</th><th>4th</th><th>1st</th><th>3rd</th></tr>
<tr><td>1</td><td rowspan="4">barlike in shape, toothed plate</td><td rowspan="2">toothed band</td><td colspan="2" rowspan="2">toothed band</td><td rowspan="3">bifurcate</td><td>not toothed band</td><td>elongate</td></tr>
<tr><td>2</td><td rowspan="3">toothed band</td><td rowspan="4">moderate or rather short</td></tr>
<tr><td>3</td><td colspan="2" rowspan="2">2-3 rows</td></tr>
<tr><td>4</td><td>2-3 rows</td><td rowspan="5">not bifurcate</td></tr>
<tr><td>5a</td><td rowspan="5">compressed platelike in shape, toothed in 1 or 2 rows</td><td colspan="2" rowspan="4">1 row</td><td rowspan="4">1 row</td><td rowspan="4">not toothed band</td></tr>
<tr><td>5b</td></tr>
<tr><td>5c</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td>2 rows</td><td>2-3 rows</td></tr>
</table>

The branchial apparatus shows two different groups in respects to the general shape and the teeth of the lower pharyngeal bone. In the types 1 to 4, this is barlike in shape and armed with a toothed patch cutting densely on the broad upper surface, whereas in the types 5 to 7 it is laterally compressed, platelike in shape and has teeth of one or two rows on its narrow surface. In general, it may possibly be considered as generalized form in which the lower pharyngeal bone is barlike in shape and armed with many dense teeth on its surface. The form with one or two rows' teeth on a narrow surface of the bone may, therefore, reasonably be regarded as a more specialized form.

On the upper pharyngeal bones, all species of flounders are provided with teeth, though the teeth are rather complex in arrangement. The second bone has the toothed patch

Table 8. (continued)

Hypobranchial		Basibranchial		Glossohyal	Genera
2nd	3rd	2nd	3rd		
elongate rectangular in shape with toothed plate	elliptical in shape without toothed plate	A	A	very short	*Psettodes*
rectangular in shape without toothed plate	elliptical in shape without toothed plate	B		moderate in length	*Citharoides* *Lepidoblepharon*
		C1 or C2			*Paralichthys*
					Pseudorhombus *Tarphops*
rectangular or elliptical in shape without toothed plate	circular in shape without toothed plate		Ba		*Arnoglossus, Bothus* *Parabothus, Psettina* *Tosarhombus* *Asterorhombus* *Japonolaeops, Taeniopsetta*
elliptical or circular in shape without toothed plate		C2 or C1	Bb		*Laeops* *Neolaeops*
circular in shape without toothed plate			Bc		*Engyprosopon* *Crossorhombus*
elliptical in shape without toothed plate			Bd	elongate peculiar feature	*Kamoharaia*
		D	C	elongate	*Chascanopsetta*

cutting densely many teeth in the types 1 to 3, but it cuts thinly two or three rows teeth in the type 4. In the types 5 and 6, however, it is arranged a single row. The type 7 closely resembles the type 4 in the arrangement of the teeth on the second upper pharygeal bone, but differs from the latter in having rather strong teeth. On the other hand, the third and fourth bones are provided with many irregularly arranged dense teeth in the fishes of the types 1 and 2, with two or three rows of teeth in the types 3 and 4 and with a single row of teeth in those of the types 5 to 6. The type 7 differs from other types in such characters as are provided with two or three rows of the teeth in the third bone, although the fourth has teeth which is arranged in a single row. It is an apparent fact that the upper pharyngeal bones which are armed with a patch of many dense teeth are probably generalized form, while those which have a single row teeth are specialized form, as far as the feature of teeth of the lower pharyngeal bone is concerned. It appears, therefore, that the types 3, 4 and 7 are the transitional form.

With respect to the epibranchial bone, the shape of the first bone can be divided into two patterns. In the types 1, 2 and 3 the bone is bifurcate at the tip, whereas in the types 4, 5,6 and 7 it is not so. AKAZAKI (1962) reported in his study on the phylogenetic relationship of spariform fishes on the basis of branchial apparatus that the fishes of such subfamilies as Benticinae and Monotaxinae have the bifurcate epibranchial bone. But he does not lay much discussion on its character. The most bifurcate form of the epibranchial bone, as described and figured by NORDEN (1961), is shown in primitive teleost, such as salmoid fishes. In such a case, the fish having a bifurcate epibranchial may, therefore, reasonably be regarded as primitive one. On the other hand, the third epibranchial bone can be classified in another way into two patterns. In the types 2, 3 and 4 the third bone is partly provided with toothed patch on its dorsal surface, but in the rest it entirely disappears. So far as the present author is aware, the presence of the teeth on the third epibranchial is of so peculiar that it may be more specialized to turn aside main line of evolution of flounders so far as matter is concerned with the character of the toothed patch on the third epibranchial bone.

Concerning the ceratobranchial bone, in the type 1 the bone is very elongated, but in the other types it is moderate or rather short. The type 1 presents a very peculiar condition.

The glossohyal bone may be divided into three groups in accordance with the length and presence or absence of toothed plate. In the type 1 it is the shortest bone with a pair of toothed plates, but in the types 2, 3, 4 and 5 as represented by the most members, it is of moderate in size and devoid of such toothed plate. In the types 6 and 7, however, the glossohyal bone is well elongated, having no toothed plate. Such general tendency to the elongation of the glossohyal bone seems to be related to the length of the mouth. Notwithstanding the glossohyal bone is short in the members of type 1, the mouth is large, and additionally it has a pair of the toothed plates. At all events, such feature as seen in this type may probably be considered as the peculiar. The glossohyal bone of the type 6 which extends upward on the first basibranchial bone shows a sharp contrast to the bone of the other types. It is probably interpreted that the peculiar feature of glossohyal bone has resulted from the fact that the anterior part of the vertebrae considerably curve to the ventral side so that the head and the associated organs may be also directed to the

ventral side.

Regarding the hypobranchial bones, the second bone is elongate and rectangular in shape, the anterior part has a toothed plate armed with many teeth in the type 1, but it is rectangular in shape without such a plate in the types 2, 3 and 4. In the members of the type 5 the bone is so remarkably diversified as to be divided into three subtypes. It is rectangular or elliptical in shape in the subtype 5a, elliptical or circular in shape in the subtype 5b and circular in shape in the subtype 5c. The types 6 and 7 are similar to the subtype 5b in general appearance. It is recognized as general tendency that the circularity of the second hypobranchial bone appears in more advanced form. On the other hand, the type 1 is peculiar in having such a character as toothed plate, undiscoverable in any other members, it is too difficult to determine which of presence or absence of toothed plate is more primitive.

The third hypobranchial bone can be also classified into two groups with respect to the shape. In the types 1 to 4, it is elliptical in shape, but in the types 5, 6 and 7 it is circular in shape, and additionally the bone in the type 1 bears a toothed plate on the dorsal surface.

It may be probably shown that the evolutional trend in the third hypobranchial bone as feature of the second hypobranchial bone is also from the elliptical shape toward the circular. The toothed plate which appears only in the type 1 seems to be the peculiar in the fishes of this group.

With regard to the basibranchial bone, the second bone yields a more differentiation in its shape. In the members of the type 1 this bone is rectangular in shape and wider posteriorly; in the type 2 it is rectangular in shape and concaved laterally at the middle part; in the types 3, 4 and the subtype 5a it is rectangular in shape and concaved deeply in both sides of the anterior part; in the subtypes 5b and 5c and the type 6 it is considerably expanded laterally in the posterior half of the bone, but it is very small in the anterior half. In the members of the type 7 it is exceedingly expanded in the posterior half of the bone, and is extremely reduced in the anterior half. There is usually the tendency that the second basibranchial bone transforms from the rectangular shape which is slightly wider in the posterior part toward the gourdlike with concave portions at the middle part, and at last, the posterior half of the gourdlike portion becomes exceedingly developed. The third basibranchial bone is spearlike in shape, and is concave antero-laterally in the types 1 to 4, but in the rest, except the type 7, the bone which exceedingly expands in the posterior portion is transformed into various forms. The type 7 is peculiar in having the shape undiscoverable in any other types, namely it has a pair of short wings on the anterior concave portions. It is apparent that the type 1 having a simple spearlike shape shows a primitive feature. Through modification of posterior part, the bone has been diversified to various types. The developmental degree of the bone may serve as an indicator of relationship and differentiation. The type 7 may show more specialized feature than the rest of the types and the subtypes.

When we summarize the foregoing consideration, we may reach the conclusion following: The type 1 represents the most primitive form with regard to many important characters, though it seems difficult to give a definite conclusion as to which is generalized form of the

two case; presence or absence of toothed plate on the second and the third hypobranchial bones and on the glossohyal bone. The types 2, 3 and 4 follow in due order, but these types bearing the toothed plate on the third epibranchial bone seem to proceed in other direction. The types 5, 6 and 7 are more advanced forms than the preceding types in respect of many characters. Among these types, the type 5 has proceeded probably along the main course of the evolution within flounders and yielded many diverse forms. The type 6 is closely related to the subtypes 5a and 5b regarding a few important characters, but many points show rather specialized form. However, the type 7 which has the both comparatively primitive and rather specialized characters seems to be specialized toward peculiar direction, after the types 2, 3 and 4 have diverged from the main course.

5. Urohyal

Description: The urohyal is unpaired, flattened bone, locating between the hyoid arch and the isthmus, and connecting them.

In the fishes of the suborder Psettodina, the bone is about rectangular in shape, bearing on its lower border a pair of the lateral ridges extending horizontally (Fig. 115, A). The head of the bone is almost barlike in shape, being connected to the inner side of the hypohyal by a pair of ligaments. Posteriorly it is joined to the lower margin of the cleithrum by a thick ligament (Fig. 117, A). In all the members of Japanese flounders except for the fishes of the genus *Psettodes,* it is fishhook-like in shape, and consists of three parts, main part, sciatic part and cardiac apophysis*. The major part of the bone is a thin plate, but along the inner margin it has a pair of ridges on both sides. It will conveniently be termed inner ridge. The main part is surrounded by a thin membrane, connected anteriorly to the lower posterior part of hypohyal by a long ligament and dorsally attached to the ventral side of the basibranchial bones by membrane.

The cardiac apophysis locates just before ventral side of the cleithrum, and is connected to it by thin membrane.

The sciatic part is connected upper-posteriorly with the cleithrum by a narrow membrane, and its tip extends to the isthmus. In the fishes of the family Bothidae it generally bears the dorsal surface of the anterior cartilaginous portion which forms the pelvic bone on the ocular side (Fig. 117, E-G). The cardiac apophysis and the sciatic part are thickly surrounded by the muscle of the isthmus.

This bone varies in general shape and developmental degree in according to the genera and species.

In all the members of the family Citharidae, the main part is anteriorly barlike in shape, and the platelike bone is not extended to the tip. The cardiac apophysis is not developed largely. The sciatic part is truncated at the tip, very short and extending to posterior 1/3 of distance from the tip of the main part to the angular portion. The inner ridge is low, and is not distinguishable at the tip of the sciatic part (Fig. 115, B, C).

*CHABANAUD (1954) called the main part as branche paraortique, sciatic part as branche parischistique, cardiac apophysis as apophy cardiaque.

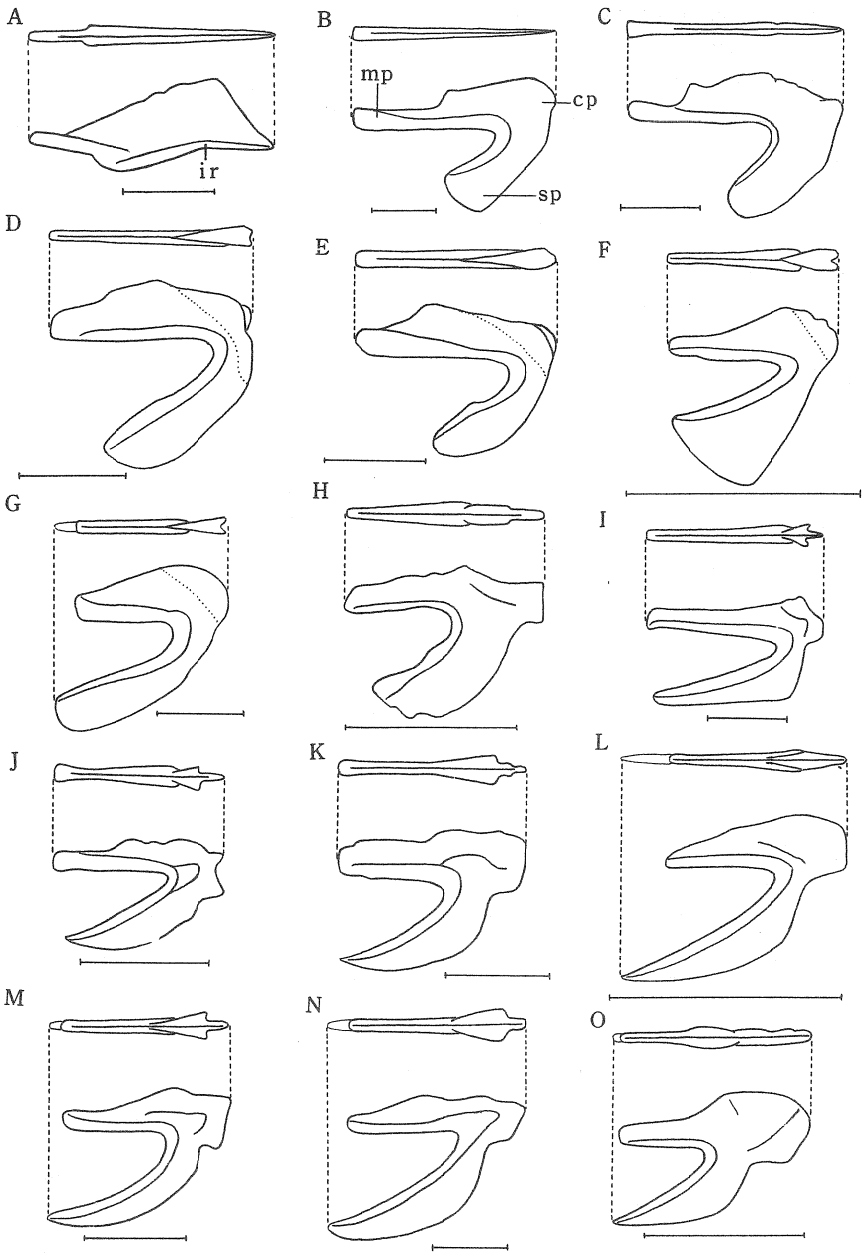

Fig. 115. Lateral aspect of the urohyal in 15 species. A, *Psettodes erumei*; B, *Lepidoblepharon ophthalmolepis*; C, *Citharoides macrolepidotus*; D, *Pseudorhombus levisquamis*; E, *Paralichthys olivaceus*; F, *Tarphops oligolepis*; G, *Pseudorhombus pentophthalmus*; H, *Taeniopsetta ocellata*; I, *Arnoglossus japonicus*; J, *A. tenuis*; K, *Psettina gigantea*; L, *Asterorhombus intermedius*; M, *Tosarhombus octoculatus*; N, *Parabothus coarctatus*; O, *Neolaeops microphthalmus*. mp, main part; cp, cardiac apophysis; sp, sciatic part; ir, inner ridge. Scales indicate 10 mm.

In the family Paralichthyidae, the cardiac apophysis is small and bifurcate at the posterior portion. The sciatic part is truncated at the tip. The inner ridge is comparatively high. In *Paralichthys olivaceus,* the main part is barlike in shape anteriorly, the sciatic part is short, extending to the midway from the tip of the main part to the angular portion of the bone (Fig. 115, E). In *Pseudorhombus arsius, P. levisquamis, P. cinnamoneus* the urohyal closely resembles that of preceding species in general shape, but it differs from the latter in not being barlike in shape at the tip of the main part (Fig. 115, D).

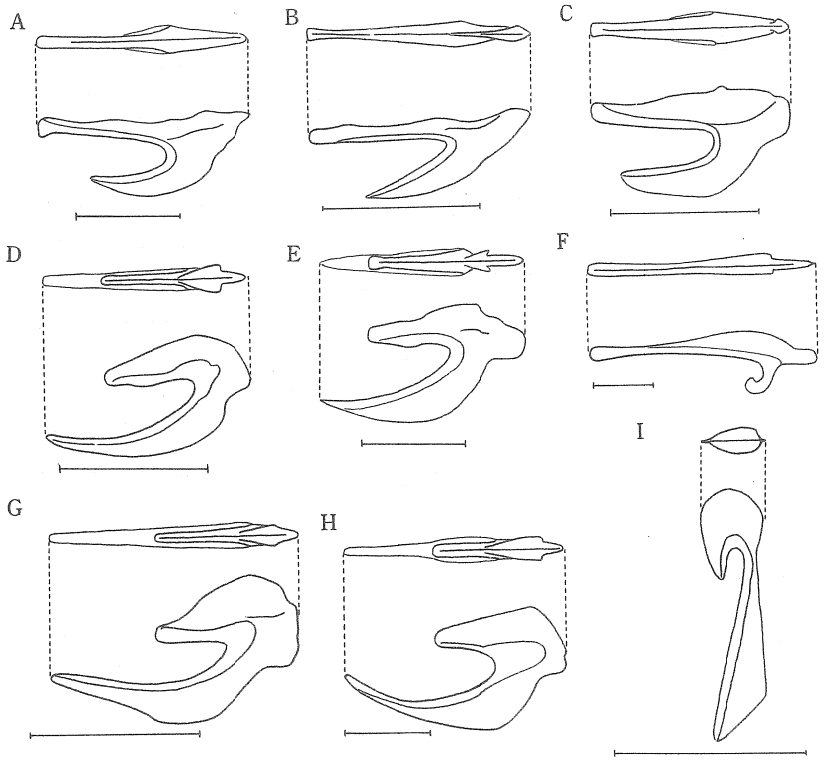

Fig. 116. Lateral aspect of the urohyal in nine species. A, *Laeops kitaharae*; B, *L. nigromaculatus*; C, *Japonolaeops dentatus*; D, *Engyprosopon multisquama*; E, *Crossorhombus kobensis*; F, *Chascanopsetta lugubris*; G, *Bothus myriaster*; H, *Crossorhombus kanekonis*; I, *Kamoharaia megastoma*. Scales indicate 10 mm.

In *Pseudorhombus oligodon, P. oculocirris, P. pentophthalmus* and *P. dupliciocellatus* the tip of the sciatic part is a little longer than that of main part (Fig. 115, G). In *Tarphops oligolepis* and *T. elegans* it nearly extends to the tip of the main part, and exceedingly becomes wider toward the tip (Fig. 115, F).

In the family Bothidae, the cardiac apophysis is generally large, expanded wenlike in shape, but it is not bifurcated. In the fishes of *Taeniopsetta,* the cardiac apophysis has a pair of low ridges on its middle part horizontally. The sciatic part is truncated at the tip,

extending to anterior 1/3 of distance from tip of the main part to the angular portion (Fig. 115, H).

In *Arnoglossus oxyrhynchus, A. tenuis, A. japonicus, Psettina tosana, P. gigantea, Tosarhombus octoculatus, Parabothus kiensis* and *P. coarctatus,* the urohyal is expanded at the cardiac apophysis like a pair of lateral large wings, the sciatic part is pointed at the tip, and the inner ridge is very high (Fig. 115, I, J, K, M, N). In the fishes of two genera *Psettina* and *Arnoglossus* the tip of the sciatic part extends to the vertical line through that of the main part, or slightly behind it. On the contrary, it extends slightly beyond the tip of the main part in the two genera *Tosarhombus* and *Parabothus*. In *Psettina iijimae* and *Asterorhombus intermedius,* the wings are scarcely expanded laterally, and it becomes a pair of ridges (Fig. 115, L).

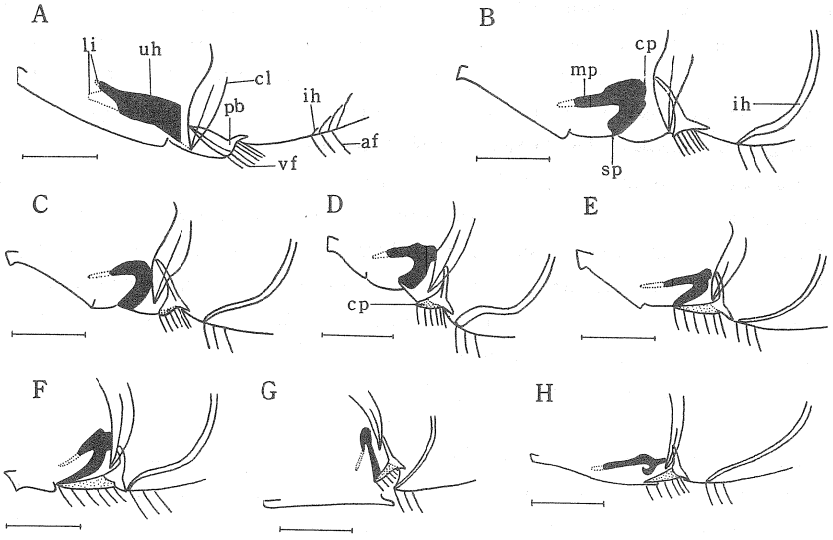

Fig. 117. Showing eight types of mode of attachment of the urohyal in Japanese flounders. A, *Psettodes erumei*; B, *Lepidoblepharon ophthalmolepis*; C, *Pseudorhombus arsius*; D, *Taeniopsetta ocellata*; E, *Arnoglossus polyspilus*; F, *Bothus myriaster*; G, *Kamoharaia megastoma*; H, *Chascanopsetta lugubris*. li, ligament; uh, urohyal; cl, cleithrum; pb, pelvic bone; ih, interhaemal spine; cp, anterior cartilage of pelvic bone; af, anal fin ray; vf, ventral fin ray; mp, main part; cp, cardiac apophysis; sp, sciatic part. Scales indicate 20 mm.

In *Neolaeops microphthalmus, Japonolaeops dentatus, Laeops kitaharae* and *L. nigromaculatus* the cardiac apophysis is exceedingly large, having a pair of lateral ridges on both sides. The tip of the sciatic part extends to anterior 1/3 of distance from the tip of the main part to the angular portion in the fishes of the genera *Laeops* and *Japonolaeops,* while in the fishes of the genus *Neolaeops* it extends to a vertical line through tip of the main part. In either species, the tip is pointed (Fig. 115, O; Fig. 116, A-C).

In the fishes of the genera *Engyprosopon, Crossorhombus* and *Bothus* the cardiac apophysis is well developed, with a process projecting backward, having a pair of lateral small wings on both sides. The sciatic part is exceedingly longer than the main part, projecting remarkably and is gradually tapering toward the front. Its tip is sharply pointed (Fig. 116, D, E, G, H). In the fishes of the genus *Kamoharaia,* the main part is short, curved sharply toward the ventral. The cardiac part projects largely upward, without the wings and ridges. The sciatic part is exceedingly elongate vertically, but scarcely gets beyond the tip of the main part. It is very narrow basally, becomes gradually wider toward the tip, and is pointed at the tip (Fig. 116, I).

In the fishes of the genus *Chascanopsetta,* the main part is very elongate, barlike in shape, without the wings and the ridges. The sciatic part is very short and the tip is turned upward (Fig. 116, F).

Discussion: To our knowledge, of all the members of pisces, the Heterosomata is peculiar, at least, in the possession of the urohyal transformed into fishhook-like in shape. Presence of such bone may probably represent one of the important characteristics of the Heterosomata, and the shape of this bone has used as a criterion for defining suborder, families and genera (Norman, 1934; Hubbs, 1945; Chabanaud, 1954).

In the Japanese flounders, so far as the urohyal bone is concerned, its anatomical features considerably furnish us with certain sound ground for its availability for assumption of the differentiation and relationship. The following characters may be subservient to the purpose of them. 1) general shape, 2) shape and developmental degree of cardiac apophysis, 3) relative position of tip of sciatic part, 4) shape of anterior portion of sciatic part. If these features are taken into consideration, the urohyal can reasonably be classified into eight types and four subtypes, which are shown in the Table 9.

The urohyal bone shows two different patterns in respect to the general shape.

In the type 1 comprising *Psettodes,* the urohyal is about rectangular in shape, slightly curved downward in the posterior portion. In the rest of the fishes, the bone is fishhook-like in shape and is divided into seven types and four subtypes in according to the developmental degree of the sciatic part. In the type 2, which comprises the fishes of the genera *Citharoides* and *Lepidoblepharon,* the sciatic part is very short, extending to posterior 1/3 of distance from the tip of the main part to the angular portion. The 3a subtype, including the fishes of the genus *Paralichthys* has the short sciatic part, which extends to the middle portion of the main part. In the subtype 3a and the types 4 and 5 including all the members of the genera, *Pseudorhombus, Tarphops, Taeniopsetta, Arnoglossus, Parabothus, Tosarhombus, Psettina, Asterorhombus, Neolaeops, Japonolaeops* and *Laeops,* the tip of the sciatic part extends to a vertical line through the main part or is slightly shorter or longer than it.

The sciatic part of the bone in the type 6, which is represented by the fishes of the genera *Engyprosopon, Crossorhombus* and *Bothus* is exceedingly elongate, and goes far beyond the main part.

In the type 7 to which the fishes of the genus *Kamoharaia* belongs only, the sciatic part is very elongate vertically, and its tip is not beyond that of the main part. In the type 8, including only the fishes of the genus *Chascanopsetta,* the sciatic part, which is particularly

short, extends to posterior 1/4 of distance from the tip of the main part to the angular portion.

So far as the present author is aware, the urohyal is usually about rectangular in shape throughout the percoid fishes. A rectangular urohyal may, therefore, reasonably be regarded as generalized one. The fishhooked urohyal may possibly be considered as transformed from rectangular one. This hypothesis may be justified by the fact, at least, that the inner ridges in the former corresponds to ones expanded on its ventral border in the latter, and also that the latter has the urohyal which is slightly concave posteriorly. If one applies this way of thinking to the present case, elongation of the sciatic part takes

Table 9. Eight types and four subtypes of the urohyal in Japanese flounders.

Types and subtypes	Characters					Genera
	General shape	Tip of sciatic part		Cardiac apophysis		
1	rectangular	—	—	—	—	*Psettodes*
2	fishhook	posterior 1/3 of main part	truncate	small	simple	*Citharoides* *Lepidoblepharon*
3a		middle of main part			bifurcate	*Paralichthys*
3b		as long as, or slightly longer or shorter than tip of main part				*Pseudorhombus* *Tarphops*
4				large	ridge	*Taeniopsetta*
5a			pointed forward	moderate	ridge or wing	*Psettina* *Arnoglossus* *Parabothus* *Tosarhombus* *Asterorhombus*
5b				large	ridge	*Neolaeops* *Japonolaeops* *Laeops*
6		exceedingly more advanced than tip of main part			wing	*Engyprosopon* *Crossorhombus*, *Bothus*
7		as long as tip of main part			simple	*Kamoharaia*
8		posterior 1/4 of main part	pointed upward	barlike		*Chascanopsetta*

place gradually and represents the advanced type.

Considering from such a case, the type 2 ought to be regarded as more primitive than the others, and 3a, 3b, 4, 5 and 6 follow in due order. The types 7 and 8 represent the most highly specialized forms toward other directions respectively.

The developmental degree of the sciatic part is closely related to the locations of the isthmus and the ventral fin. In the type 1, the ventral fins are on thorasic part, with pelvic bones located on more posterior part than the cleithrum and directly attached to it anteriorly (Fig. 117, A). In the type 2, the ventral fins are a little advanced, the pelvic bones which are well separated from the isthmus lie just behind the cleithrum (Fig. 117, B). In the type 3, the ventral fins are a little advanced than ones of the preceding type, the pelvic bones locate immediately below the cleithrum (Fig. 117, C). In the type 4, the ventral fin on the ocular side is a little elongated forward, the pelvic bone which draws near the isthmus is placed slightly in front of the cleithrum at the tip (Fig. 117, D).

In the types 5 and 6 the ventral fin on the ocular side is exceedingly elongated, extending forward to the isthmus, supported by a cartilaginous plate placed exceedingly in front of the cleithrum, and the urohyal is ventrally attached to the cartilaginous plate. The pelvic bone in the type 6 is in more anterior part than that of the type 5 (Fig. 117, E, F).

In the types 7 and 8, the cartilaginous plate is well elongated. In the former type, it extends particularly downward to the cleithrum, forming the isthmus attached to the tip of the urohyal, of which sciatic part is exceedingly elongated vertically (Fig. 117, G), while in the latter type, it is placed well in front of the cleithrum, but its tip is separated from the urohyal (Fig. 117, H). In these types, the specialty of the urohyal is represented by a peculiar condition of the mouth portion.

In such a case, it is highly probable that a developmental degree of the fishhook-like had resulted from the shifting of the pelvic bones forward.

The sciatic part can be divided again in another way into three patterns, namely on the basis of the shape of the sciatic part. In the fishes of the types 2, 3 and 4 it is wide and truncated at the tip, but in the types 5, 6 and 7 it is tapering gradually towards the pointed tip. In the type 8, it is very peculiar shape, being upward at the tip.

On the other hand, the shape of the sciatic part at the tip may probably be related to its bearing the pelvic bone. The truncated sciatic part has nothing to do with bearing the pelvic bone, while the slender and pointed one bears ventrally the anterior cartilaginous plate of the pelvic bone. In the type 8, the pelvic bone on the ocular side is drawn near the tip of the sciatic part, but it is not supported directly.

It is fully thought that the pointed sciatic part at the tip has transformed from the truncated one so as to serve as bearing the pelvic bone and play a role in protecting the elongate cartilaginous plate.

In such a case, it is far from unlikely that the truncated tip of the sciatic part represents more primitive form than those having the pointed one, and the type 8 is more highly specialized.

The cardiac part shown also in another way the five patterns with respect to the developmental degree of it. In the types 2 and 3, it is very small, while in the types 4 and 6 and the subtype 5b, it is exceedingly large with a weblike projection backward. The

cardiac part of the subtype 5a is moderate in size. The type 7 has the large projection upward in peculiar. In the type 8 it is barlike in shape, projected backward.

Generally speaking, the developmental degree of the cardiac part may have a certain relation to bearing pelvic bone as well as the shape of the sciatic part. None of majority of types with the small cardiac part bear the pelvic bone. A large cardiac part may, therefore, be regarded as to strengthen the urohyal for bearing the pelvic bone.

With respect to the shape of the cardiac part, there are three different patterns. In the types 2, 7 and 8, the shape is a simple plate, but in the other types, it has some specific variation in its shape. The type 3 has the cardiac part bifurcated toward the both lateral sides. In the type 4 and the subtypes 5a and 5b, a pair of lateral ridges is expanded on the cardiac part horizontally, while in the majority of the subtype 5a and the type 6, a pair of wings is broad and well-developed on both sides of the cardiac part.

Akazaki (1962) in his osteological study of the spariform, gave a brief conclusion on the urohyal. He is of the opinion that the simple platelike urohyal may be interpreted to be more generalized than the urohyal with a pair of wings on the dorsal or ventral margin. In the flounders, therefore, the simple platelike form may be more generalized so far as the matter is concerned with the shape of the cardiac part, and the advanced forms appear probably in two great directions. It appears that the shape of the cardiac part is bifurcate in one direction and is a pair of wings produced from the ridges in the other.

The transformation of the urohyal is observed in the carangid and sparid fishes (Suzuki, 1962; Akazaki, 1962). The author presumed that in the modified urohyal such projection as mentioned above may have function to attach the muscle. This interpretation explains the fact that the modified urohyal has resulted from the need for mechanical strengthening of the entire complex of structure in the isthmus rather than for simple support of the isthmus.

Summarizing the foregoing consideration, the type 1 is, as a whole, most primitive, and the type 2, from which the two great lines are differentiated, is a little advanced form. One line has two offshoots, the subtypes 3a and 3b, and the subtype 3a is more primitive than the subtype 3b. The other line has four offshoots, and among these, the type 6 represents the most highly advanced form and 5b, 5a, 4 follow in due order. The types 7 and 8 which seem to us to be highly specialized must be considered to have arisen earlier than, at least, the types 4, 5 and 6.

6. Vertebrae and their accessory bones

Description: The vertebral column of the flounders may be divided into two regions based on the presence or absence of the haemal spines. The anterior vertebrae lack haemal spines and are known as abdominal vertebrae; the remaining vertebrae possessing the spines are called caudal vertebrae. The abdominal vertebrae generally curve downward anteriorly. In the fishes of the genera *Kamoharaia* and *Neolaeops* there is a strong bend against a horizontal axial line (Fig. 122, B). The first three columns are very short, and the first one is shorter than half column of the middle portion; the succeeding abdominal

vertebrae becoming slightly larger posteriorly. Each centrum of the caudal vertebrae is generally about as long as that of the last abdominal vertebra.

The centrum is developed around the notochord and is pieced by an opening for the passage of the notochord. The centrum can be roughly assorted into three distinct types in accordance with the diameter of the opening for notochord. In the first type, as represented by the fishes of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys,*

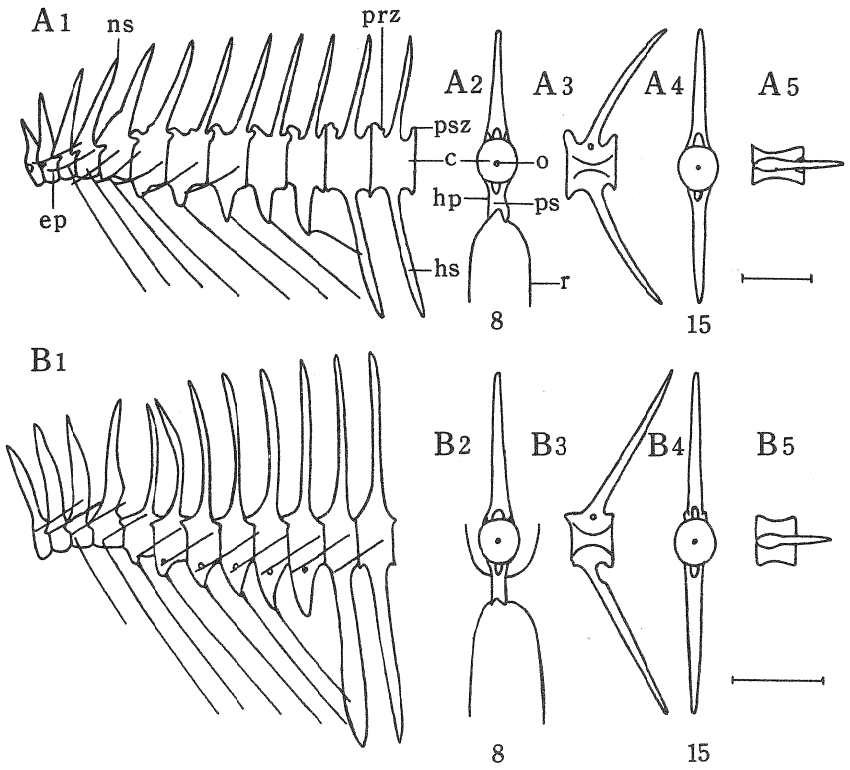

Fig. 118. Outline of lateral (A1 • A3 • B1 • B3), frontal (A2 • A4 • B2 • B4) and dorsal (A5 • B5) aspects of the abdominal and anterior caudal vertebrae and their accessory bones in two species. A1 to A5, *Psettodes erumei*; B1 to B5, *Lepidoblepharon ophthalmolepis*. ep, epipleural; r, rib; ns, neural spine; hs, haemal spine; hp, haemapophysis; ps, parapophysial stay; c, centrum; o, opening for notochord; prz, prezygapophysis; psz, postzygapophysis. The number put in each figure indicates the order counted from the first vertebra. Scales indicate 10 mm.

Pseudorhombus, Tarphops and *Taeniopsetta* the opening is peculiarly small (Fig. 118, A, B; Fig. 119, A, B; Fig. 120, A; Fig. 123, A, B). In the second type which comprises the members of the genera *Crossorhombus, Engyprosopon, Tosarhombus, Asterorhombus, Psettina, Arnoglossus, Parabothus, Bothus* and *Chascanopsetta,* the opening is moderately large (Fig. 120, B; Fig. 121, A, B; Fig. 122, B; Fig. 123, C, D, E). In the last type which

includes the members of the genera, *Laeops, Japonolaeops, Neolaeops* and *Kamoharaia,* the opening is very large, and the diameter being about half time as long as diameter of centrum (Fig. 122, A; Fig. 123, F).

The centrum of each vertebra is amphicoelous, concave both anteriorly and posteriorly, and is provided with an opening for the passage of the notochord on the middle deepest portion of both concavities. The degree of development of both concavities of the centrum and the position of the opening varies rather extensively among the genera. In the fishes of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus* and *Tarphops,* the centrum is equally deep in both anterior and posterior concavities; the opening lies on the middle portion of the centrum (Fig. 123, A). In the fishes of the genera *Taeniopsetta* and *Chascanopsetta,* the anterior concavity of the centrum is a little shallower than the posterior one, and the opening occupies slightly in front of the middle portion of the centrum (Fig. 123, B, C). In the remaining members, the anterior concavity of the centrum is shallower than the posterior one, and the opening is more advanced than the middle portion of the centrum (Fig. 123, D, E, F). Especially, in the members of the three genera, *Asterorhombus, Arnoglossus* and *Parabothus,* the opening is most advanced in position (Fig. 123, E).

The transverse apophysis is present in the fishes of the family Bothidae (Figs. 25-27), but is disappears in the other families (Figs. 118-119). The transverse apophysis, if present, consists of two pairs of processes; anterior transverse apophysis and posterior transverse apophysis. They are raised into prominent lateral wings horizontally extended from the anterior and posterior lateral portions of the centrum into horizontal myoceptum which separates the epaxial muscle from the hypaxial one, and generally pointed at the tip. In most species of the flounders, the anterior transverse apophysis occurs from the centrum of the second vertebra to that of the last caudal vertebra except for the urostyle (Fig. 120, A, B; Fig. 121, A, B), but in *Neolaeops, Kamoharaia* and *Chascanopsetta,* the apophysis begins with the fourth or the fifth vertebra (Fig. 122, A, B), and the bone is best-developed on the centra of anteriormost region of the caudal vertebrae, becoming progressively shorter both posteriorly and anteriorly. The posterior transverse apophysis smaller than the anterior one, usually occurs backward from the centrum of the seventh vertebra, and is well developed on the centra of the anteriormost region of the caudal vertebrae, becoming smaller to the last vertebra (Figs. 120-122). Especially, in *Taeniopsetta ocellata* both apophyses are well developed, the posterior transverse apophysis begins with the second vertebra (Fig. 120, A).

Laterally there are some concave portions on each centrum. The developmental degree of the concave portions varies among the genera. In the members of the genera, *Psettodes, Lepidoblepharon, Citharoides, Tarphops, Taeniopsetta, Paralichthys* and *Pseudorhombus,* the centrum is concave shallowly or deeply on the upper and lower portions, the concave becomes progressively deeper to mid-portion of the centrum (Fig. 118, A, B; Fig. 119, A, B; Fig. 120, A). In the members of the last two genera, there are one or two small elliptical concaves between the upper and lower large concave portions additionally (Fig. 119, A, B). In the fishes of the genera *Crossorhombus, Engyprosopon, Psettina, Arnoglossus, Parabothus, Japonolaeops, Bothus* and *Asterorhombus,* the centrum possesses a pair of

deep concaves, whose upper and lower deepest portions are more advanced than mid-portion of the centrum (Fig. 120, B; Fig. 121, A, B). The members of the genera *Laeops, Neolaeops* and *Kamoharaia* have some small concave portions (Fig. 122, A). In the fishes of the genus *Chascanopsetta,* there are a pair of elliptical concave portions on the lateral side of the centrum, being greatly deep (Fig. 122, B).

The neural arches occur all over the vertebrae. Each of them is perfectly united with its centrum and is held on it. The neural arches of the anterior vertebrae are generally well developed, and are about as high as the centrum to which they are attached.

The neural spine on the first vertebra is present in the fishes of families Psettodidae,

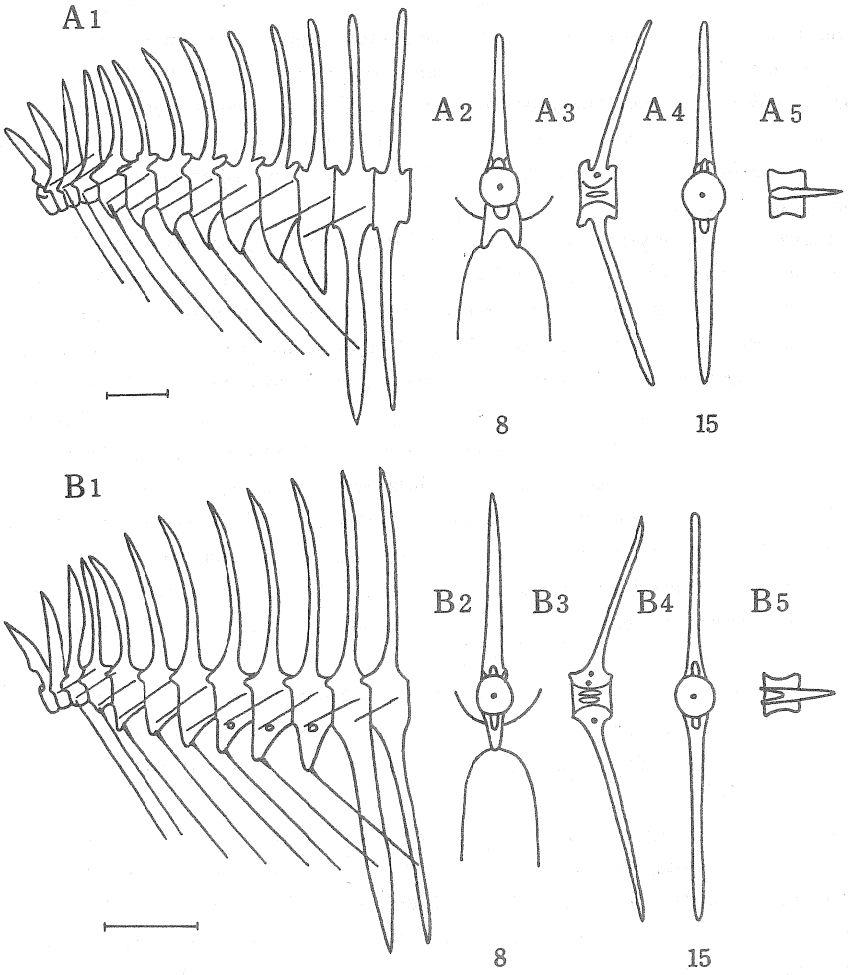

Fig. 119. Outline of lateral (A1 • A3 • B1 • B3), frontal (A2 • A4 • B2 • B4) and dorsal (A5 • B5) aspects of the abdominal and anterior caudal vertebrae and their accessory bones in two species. A1 to A5, *Paralichthys olivaceus*; B1 to B5, *Pseudorhombus oligodon*. Abbreviations as in Fig. 118. Scales indicate 10 mm.

Citharidae and Paralichthyidae (Fig. 124, A), but it disappears in the members of the family Bothidae (Fig. 124, B). The neural spines are of slender but moderately strong bones. Each neural spine of the anterior several vertebrae is generally not spinous in form, but is developed into the moderately broad plate. The platelike neural spines occur from the first to the sixth vertebrae in *Psettodes* (Fig. 118, A), from the first to the fourth vertebrae in *Citharoides, Lepidoblepharon* and *Paralichthys* (Fig. 118, B; Fig. 119, A), and from the first to the third vertebrae in the fishes of the genera *Pseudorhombus* and *Tarphops* (Fig. 119, B). In the members of the family Bothidae, the second and third vertebrae possess the platelike neural spines, though the anterior neural spines gradually become slenderer

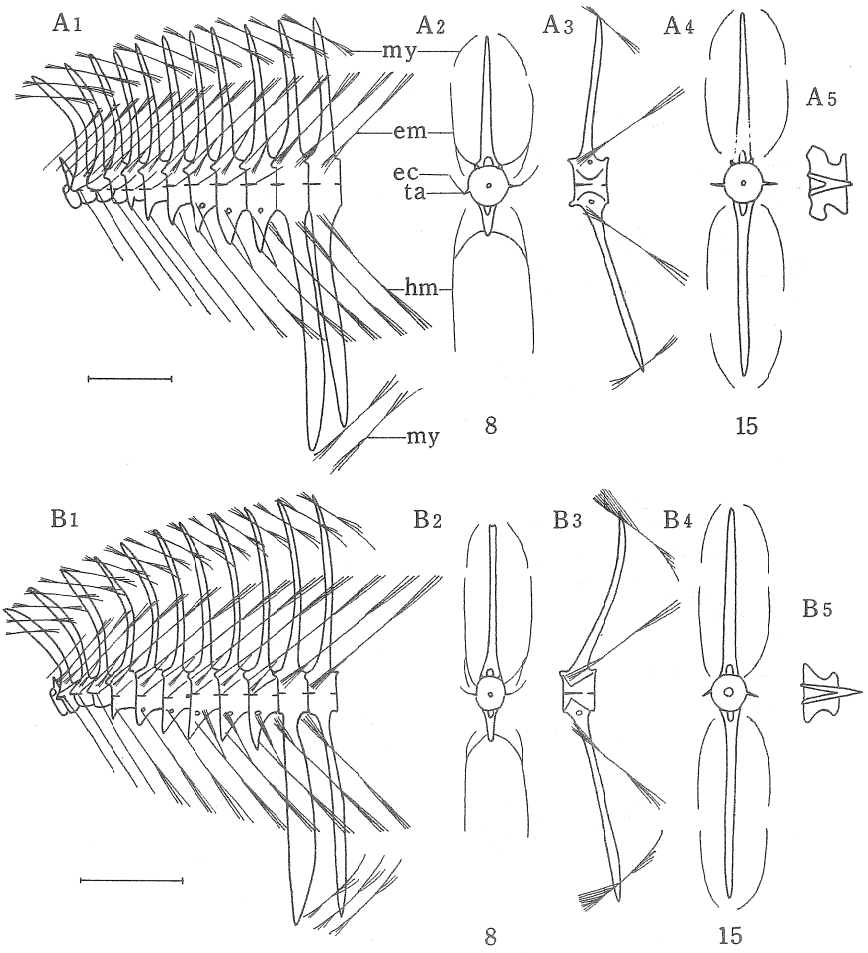

Fig. 120. Outline of lateral (A1 • A3 • B1 • B3), frontal (A2 • A4 • B2 • B4) and dorsal (A5 • B5) aspects of the abdominal and anterior caudal vertebrae and their accessory bones in two species. A1 to A5, *Taeniopsetta ocellata*; B1 to B5, *Crossorhombus kobensis*. my, myorhabdoi; em, epimeral; hm, hypomeral; ec, epicentrum; ta, transverse apophysis. Other abbreviations as in Fig. 118. Scales indicate 10 mm.

posteriorly (Figs. 120-122).

The haemal arches are of two kinds, those of the caudal vertebrae being complate, meeting below to form a tunnel and to unit with the haemal spine, while those in abdominal vertebrae are represented by the parapophysis or haemapophysis.

The haemal spines attach to the lower side of haemal arches, each of those spines sitting opposite to respective neural spine of the caudal vertebrae. Each of the anterior caudal vertebrae is more elongate than the respective corresponding neural spine. Especially, the first spine is generally very strong plate for supporting the elongated first interhaemal spine, as compared with other spines. But particularly in the fishes of the genus *Psettodes*, it is as slender as other haemal spines (Fig. 118, A). On the other hand, in the fishes of

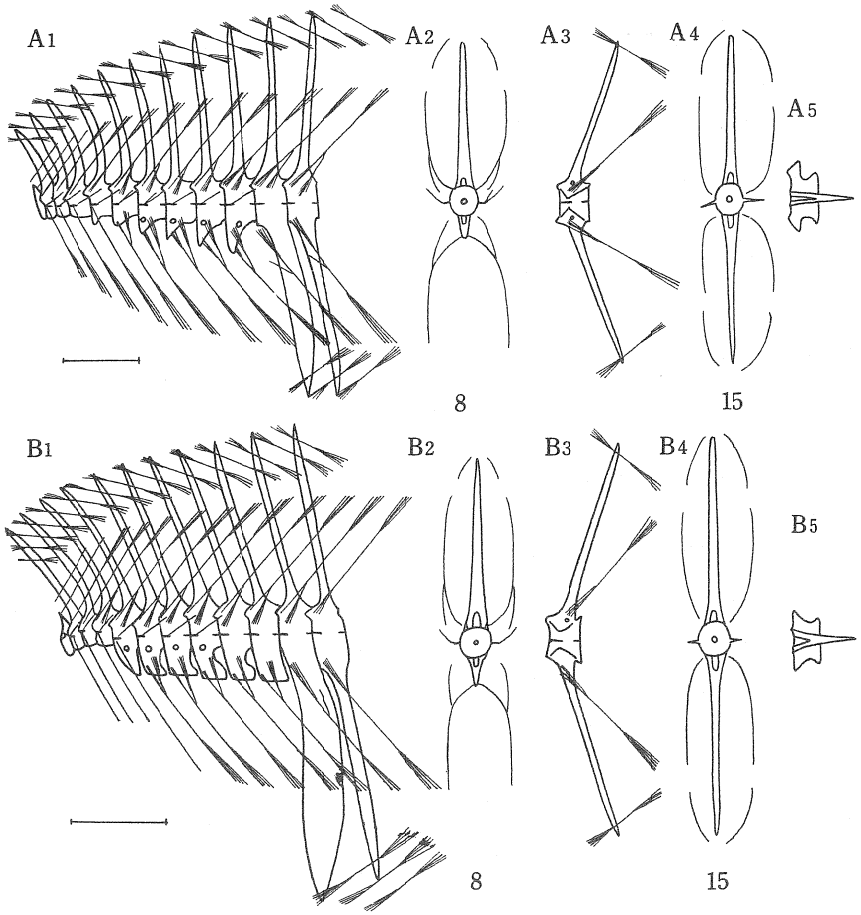

Fig. 121. Outline of lateral (A1 • A3 • B1 • B3), frontal (A2 • A4 • B2 • B4) and dorsal (A5 • B5) aspects of the abdominal and anterior caudal vertebrae and their accessory bones in two species. A1 to A5, *Parabothus kiensis*; B1 to B5, *Bothus myriaster*. Abbreviations as in Figs. 118 and 120. Scales indicate 10 mm.

the genus *Bothus* the bone is extremely heavy (Fig. 121, B).

The parapophyses are developed into plates over the abdominal vertebrae. Each parapophysis projects downward as a short process from ventral portion of the centrum, growing progressively larger to the last one. In most species of the Japanese flounders, the first parapophysis occurs in the fifth abdominal vertebra. In the members of the three genera *Psettodes, Neolaeops* and *Kamoharaia* the sixth vertebra has the first pair of parapophysis (Fig. 118, A; Fig. 122, A). In the posterior abdominal vertebrae, the parapophyses on

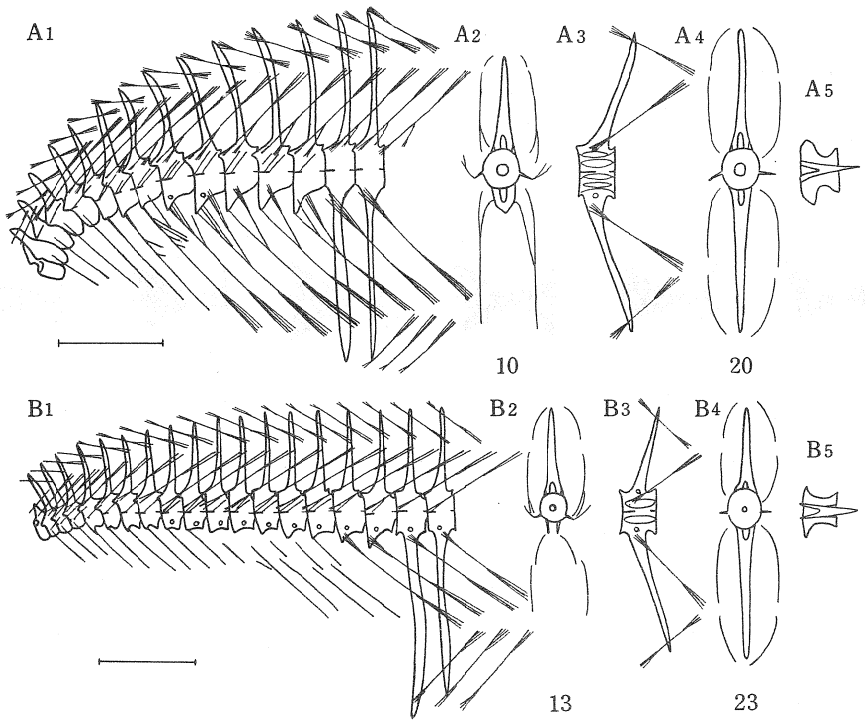

Fig. 122. Outline of lateral (A1 • A3 • B1 • B3), frontal (A2 • A4 • B2 • B4) and dorsal (A5 • B5) aspects of the abdominal and anterior caudal vertebrae and their accessory bones in two species. A1 to A5, *Kamoharaia megastoma*; B1 to B5, *Chascanopsetta lugubris*. Abbreviations as in Figs. 118 to 120. Scales indicate 10 mm.

both sides meet as a horizontal bridge, leaving a haemal arch above. They are known as the haemapophysis. The haemapophysis can be seen between the seventh and the last abdominal vertebrae in *Psettodes erumei, Citharoides macrolepidotus, Lepidoblepharon ophthalmolepis, Asterorhombus intermedius, Parabothus kiensis* and *Neolaeops microphthalmus* (Fig. 118, A, B; Fig. 121, A), between the eighth and the last abdominal vertebrae in *Paralichthys olivaceus, Pseudorhombus cinnamoneus, Arnoglossus polyspilus,* between the sixth and the last abdominal vertebrae in *Taeniopsetta ocellata, Crossorhombus kanekonis,*

C. kobensis, Engyprosopon multisquama, Tosarhombus octoculatus, Psettina gigantea, Bothus myriaster, B. pantherinus, Japonolaeops dentatus, Laeops nigromaculatus (Fig. 120, A, B; Fig. 121, B), between the ninth and the last vertebrae in *Kamoharaia megastoma* (Fig. 122, A), and between the fourteenth and the last abdominal vertebrae in *Chascanopsetta lugubris* (Fig. 122, B). The tips of the several haemapophyses diverge to form condyle for the articulation of the ribs in the fishes of families Psettodidae, Citharidae and Paralichthyidae, forming parapophysial stay (Fig. 118, A, B; Fig. 119, A). In the fishes of the genera *Psettodes* and *Paralichthys* it can be seen between the first and the last haemapophyses, and the first or the first to the second ones in the remaining genera, whilst the tips of haemapophyses completely joint each other for the articulation of the hypomerals in the members of the family Bothidae. The haemapophysis is generally triangular in shape, and tapering in most flounders in lateral view. In the fishes of the genus *Bothus,* however, especially it is well expanded backward at the tip so as to almost extend to the next haemapophysis (Fig. 121, B).

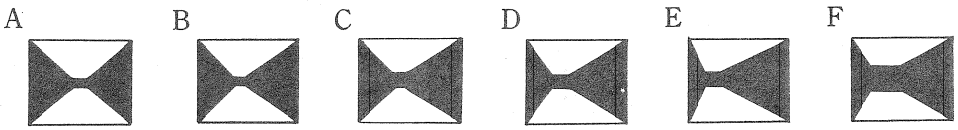

Fig. 123. Diagrammatic feature of longitudinal section of centrum. Showing six types of position and size of the opening for passage of the notochord in Japanese flounders and their related flatfishes. A, *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus* and *Tarphops*; B, *Taeniopsetta*; C, *Chascanopsetta*; D, *Engyprosopon, Crossorhombus, Tosarhombus, Bothus* and *Psettina*; E, *Arnoglossus, Asterorhombus* and *Parabothus*; F, *Kamoharaia, Laeops, Neolaeops* and *Japonolaeops*.

At the upper and lower edges of a centrum, there is paired, horizontal or vertical articular projection termed zygapophysis. On the dorsal side there are the neural prezygapophyses and postzygapophyses, and on the ventral side the haemal prezygapophyses and postzygapophyses. The neural pre- and postzygapophyses are developed in all the vertebrae of all members of the Japanese flounders. In the abdominal vertebrae and the anterior caudal ones the neural pre- and postzygapophyses are tightly interlocked with each other, but in the remaining vertebrae, they are slightly articulated, or free with each other. In the fishes of the genus *Psettodes,* the both zygapophyses are well developed, the prezygapophyses are overlapped on the postzygapophyses between the first and the tenth vertebrae (Fig. 118, A), whilst in *Citharoides.* and *Lepidoblepharon,* such zygapophyses are found to exist between the eighth and the tenth vertebrae (Fig. 118, B). In all the members of the families Paralichthyidae and Bothidae, all postzygapophyses are inserted on the prezygapophyses (Fig. 119, A, B; Fig. 120, A, B; Fig. 121, A, B; Fig. 122, A, B).

The haemal pre- and postzygapophyses are present only on posterior abdominal vertebrae and on caudal ones, and are generally less developed than the neural ones. They are not articulated, but are prefectly free.

The rib is present in the fishes of the families Psettodidae, Citharidae and Paralichthyidae (Figs. 118-119), but disappears completely in the fishes of the family Bothidae (Figs. 120-121). The rib, if present, is rodlike in shape, running backward and downward between the muscle and the peritoneum. The rib can be seen between the third and the tenth vertebrae in the fishes of the genera *Psettodes, Paralichthys, Pseudorhombus* and *Tarphops* (Fig. 118, A; Fig. 119, A, B), between the third and the ninth in *Lepidoblepharon* (Fig. 118, B), and between the third and the eighth in *Citharoides*. In most species, the first two ribs are attached directly to the antero-lateral side of the centrum, but in the fishes of the genus *Psettodes*, there are the first three ones (Fig. 118, A). The other ribs are expanded at the tip for the articulation of the tip of the parapophysis or the haemapophysis.

The epipleural is well developed in the fishes of the families Psettodidae, Citharidae and Paralichthyidae, as is the case with the ribs, but it is absent in the fishes of the family Bothidae (Figs. 120-122). The epipleural, if present, horizontally extends into the horizontal myoseptum which separated the epaxial muscle from the hypaxial one. Epipleural has the specific variation in number; it can be seen between the first and the sixth vertebrae in *Psettodes erumei* (Fig. 118, A), between the first and the tenth vertebrae in *Citharoides macrolepidotus*, between the first and the eleventh vertebrae in *Lepidoblepharon ophthalmolepis* (Fig. 118, B), whilst there are between the second and the eleventh vertebrae in *Paralichthys olivaceus* and *Pseudorhombus cinnamoneus* (Fig. 119, A, B), and between the second and the tenth vertebrae in *Tarphops oligolepis*. The epipleurals which are directly attached to the antero-lateral side of the centrum occur in the first two ones in the fishes of the genus *Psettodes* (Fig. 118, A), in the first four ones in the fishes of two genera, *Citharoides* and *Lepidoblepharon* (Fig. 118, B) and in the first three ones in the remaining members (Fig. 119, A, B). The remaining epipleurals are generally attached to the proximal portions of the parapophyses and haemapophyses, but in the fishes of the genus *Psettodes* they are connected with the basal portions of the ribs between the third and the fifth ones, and with the distal portions of the haemapophyses on the last two ones (Fig. 118, A).

In all the members of the family Bothidae, which are not provided with the ribs and epipleurals, there are four other series of rodlike bones (Fig. 125). These are grouped according to position into epicentra, epimerals, hypomerals and myorhabdois.

The epicentra, occuring outward and backward in the horizontal septum, which separates the epaxial muscle from the hypaxial one, as is the case with the epipleurals, are attached directly to the posterior edges of the anterior transverse apophyses originated from the centra anteriorly, and are free at the distal end. But in the members of the genera, *Neolaeops, Kamoharaia* and *Chascanopsetta*, the first two or three epicentra are attached directly to lateral sides of the centra for the undevelopment of the anterior transverse apophyses (Fig. 122, A, B). Each epicentrum, beginning with the second vertebra, is restricted within the abdominal vertebrae in most members of the Japanese flounders, but peculiarly in the fishes of the genera *Kamoharaia* and *Neolaeops*, the first one occurs in the third vertebra, so far as the writer's examinations go (Fig. 122, A). Occasionally it is developed on the first caudal vertebra, or disappears in the posterior abdominal vertebrae. The epicentrum is generally the simple rodlike bones, but occasionally it is branched at the distal part, or two or three ones on an anterior transverse apophysis.

The epimeral stands outward, upward and backward on the dorsal myoseptum for most of the bodily part of the fish. Except for the anterior abdominal vertebrae and the posterior caudal vertebrae, each epimeral bifurcates at the proximal end on the same myoseptum. The anterior end of the upper branch of the bone, being brushlike in shape at the distal part, is free from either axial skeleton at the tip. The lower one, being simple in shape in the majority of portions, but slightly branching in a few cases, is attached to the antero-lateral portion of the neural arch or the centrum by a ligament. The epimerals of the anterior vertebrae are not bifurcated anteriorly. Each bone of the anterior vertebrae is connected loosely with the antero-lateral portion of the neural arch by a ligament, or is free anteriorly, and the first epimeral of both sides of the body is articulated to the posterior surface of epiotics (Fig. 125). On the other hand, the epimerals of the posterior caudal vertebrae are brushlike in shape at the proximal and become free from the axial skeleton. Most of the epimerals which are brushlike in shape at the distal end, are extended near the bodily surface and free from either axial skeleton (Figs. 120-122; Fig. 125).

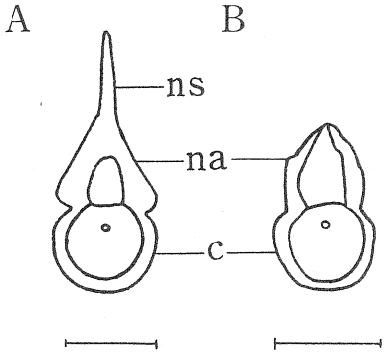

Fig. 124. Showing two types of frontal aspect of the first vertebra. A, *Citharoides macrolepidotus*; B, *Taeniopsetta ocellata*. ns, neural spine; na, neural arch; c, centrum. Scales indicate 5 mm.

The hypomeral runs outward, downward and backward on the myoseptum of the ventral side of body and confronts its self with the epimeral of its own vertebra. It does not occur on the first vertebra, but is present in all other vertebrae. Except for the anterior several abdominal vertebrae and the caudal ones, each hypomeral is forked anteriorly, as is case with the epimeral. The anterior end of the lower branch of the forked hypomeral, being usually simple in shape rarely with a expanded tip or slightly branched tip, is loosely connected with the haemapophysis or parapophysis by a ligament. That of the upper branch, being brushlike in shape, extends to form the symmetry to the epimeral with it free from either axial skeleton. In the several anterior abdominal vertebrae the bones are simple in shape at the proximal end, and attached directly to the basal regions of the anterior transverse apophyses. In the caudal vertebrae, those are brushlike in shape at the proximal end, and extend into the similar myoseptum with it free from either axial skeleton. The distal ends of the hypomerals which are brushlike in shape with the exception of those of the anterior caudal vertebrae, extend over the bodily surface (Figs. 120-122; Fig. 125). Peculiarly in the fishes of the genus *Chascanopsetta* the hypomerals on the abdominal vertebrae are not forked, but some of them are cut off the two portions, and extend into similar myoseptum (Fig. 122, B). The distal end is simple in shape in majority of the abdominal vertebrae. Additionally, in the fishes of the genus *Kamoharaia* the several rodlike ossicles are attached to the hypomerals of the several abdominal vertebrae (Fig. 122, A).

The myorhabdoi runs on the uppermost and the lowermost myoseptum on both sides of the body. Most of these bones are brushlike in shape anteriorly and posteriorly, and extend over the bodily surface (Figs. 120-122; Fig. 125).

The vertebrae of the Japanese flounders remarkably vary in number with the species (Table 10); *Chascanopsetta lugubris*, which has its vertebral count of 57 is the largest in number among the Japanese flounders, and *Psettodes erumei* with its 24 vertebrae is the smallest in number.

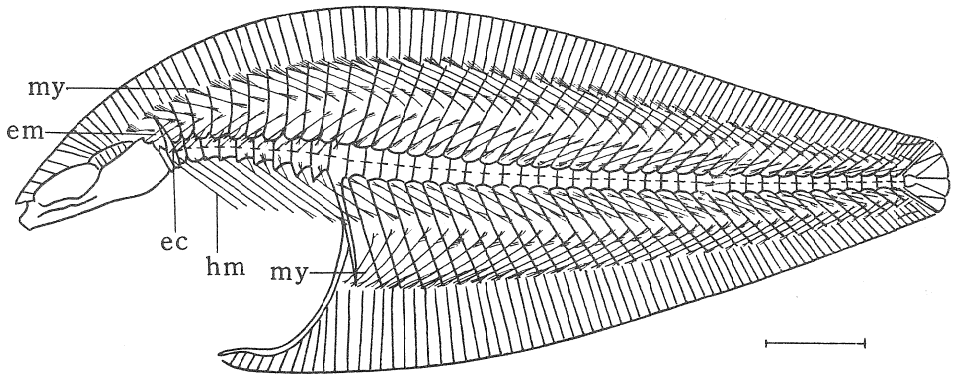

Fig. 125. Lateral aspect of the vertebrae and the accessory bones (myorhabdoi, epimeral, hypomeral and epicentrum) in *Arnoglossus oxyrhynchus*. my, myorhabdoi; em, epimeral; hm, hypomeral; ec, epicentrum. Scale indicates 20 mm.

With regard to the abdominal vertebrae, the majority of species of the Japanese flounders has 10 vertebrae, but the specific variation exists in some species. The abdominal vertebrae are constantly 11 in number in *Paralichthys olivaceus, Arnoglossus oxyrhynchus,* and *Japonolaeops dentatus,* 12 in *Laeops nigromaculatus* and *Laeops kitaharae,* 13 in *Neolaeops microphthalmus,* 14 in *Kamoharaia megastoma* and 16 to 17 in *Chascanopsetta lugubris.* The individual variation is not present in the abdominal vertebrae except for the last one species, so far as the examined Japanese flounders are concerned. On the other hand, each species of the flounders considerably shows individual variation in caudal vertebral count, extending to the range of four in the most variable species, such as *Chascanopsetta lugubris.* But in most species which have the variable count, it ranges to three, and the majority of specimens occupies the count situated at the middle of its range. The caudal vertebrae of the Japanese flounders are roughly divided into four types on the basis of the counts. The first type represented by the fishes of the genus *Psettodes* has its vertebral counts, being 14 of the smallest number. The second type including the fishes of the genera *Lepidoblepharon* and *Citharoides* has their vertebral counts from 20 to 22. The third type involves the fishes of the 12 genera *Paralichthys, Pseudorhombus, Tarphops, Taeniopsetta, Engyprosopon, Crossorhombus, Tosarhombus, Bothus, Psettina, Asterorhombus, Arnoglossus, Parabothus* which have their caudal vertebral counts from 23 to 35. The fourth

Table 10. Frequency distribution in counts of the abdominal and caudal vertebrae (including hypural) in Japanese flounders.

Species \ Number of vertebrae	Abdominal vertebrae													
	10	11	12	13	14	15	16	17	14	15	16	17	18	19
Psettodes erumei	5	—	—	—	—	—	—	—	5	—	—	—	—	—
Lepidoblepharon ophthalmolepis	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Citharoides macrolepidotus	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Paralichthys olivaceus	—	4	—	—	—	—	—	—	—	—	—	—	—	—
Pseudorhombus dupliciocellatus	1	—	—	—	—	—	—	—	—	—	—	—	—	—
P. oligodon	3	—	—	—	—	—	—	—	—	—	—	—	—	—
P. oculocirris	6	—	—	—	—	—	—	—	—	—	—	—	—	—
P. pentophthalmus	9	—	—	—	—	—	—	—	—	—	—	—	—	—
P. arsius	3	—	—	—	—	—	—	—	—	—	—	—	—	—
P. cinnamoneus	5	—	—	—	—	—	—	—	—	—	—	—	—	—
P. levisquamis	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Tarphops oligolepis	9	—	—	—	—	—	—	—	—	—	—	—	—	—
T. elegans	12	—	—	—	—	—	—	—	—	—	—	—	—	—
Taeniopsetta ocellata	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Parabothus coarctatus	4	—	—	—	—	—	—	—	—	—	—	—	—	—
P. kiensis	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Tosarhombus octoculatus	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Crossorhombus kobensis	34	—	—	—	—	—	—	—	—	—	—	—	—	—
C. kanekonis	34	—	—	—	—	—	—	—	—	—	—	—	—	—
Engyprosopon grandisquama	65	—	—	—	—	—	—	—	—	—	—	—	—	—
E. multisquama	53	—	—	—	—	—	—	—	—	—	—	—	—	—
E. macroptera	3	—	—	—	—	—	—	—	—	—	—	—	—	—
E. xystrias	2	—	—	—	—	—	—	—	—	—	—	—	—	—
E. longipelvis	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Bothus myriaster	64	—	—	—	—	—	—	—	—	—	—	—	—	—
B. mancus	3	—	—	—	—	—	—	—	—	—	—	—	—	—
B. pantherinus	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Asterorhombus intermedius	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Psettina iijimae	35	—	—	—	—	—	—	—	—	—	—	—	—	—
P. gigantea	27	—	—	—	—	—	—	—	—	—	—	—	—	—
P. tosana	79	—	—	—	—	—	—	—	—	—	—	—	—	—
Arnoglossus tenuis	2	—	—	—	—	—	—	—	—	—	—	—	—	—
A. polyspilus	7	—	—	—	—	—	—	—	—	—	—	—	—	—
A. japonicus	7	—	—	—	—	—	—	—	—	—	—	—	—	—
A. oxyrhynchus	—	3	—	—	—	—	—	—	—	—	—	—	—	—
Japonolaeops dentatus	—	13	—	—	—	—	—	—	—	—	—	—	—	—
Laeops nigromaculatus	—	—	1	—	—	—	—	—	—	—	—	—	—	—
L. kitaharae	—	—	12	—	—	—	—	—	—	—	—	—	—	—
Neolaeops microphthalmus	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Kamoharaia megastoma	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Chascanopsetta lugubris	—	—	—	—	—	—	10	4	—	—	—	—	—	—

Table 10. (continued)

Caudal vertebrae																						
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	4	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	1	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1	6	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	1	7	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	5	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	1	7	1	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	1	8	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1	11	1	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	4	28	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	7	26	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	3	57	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	13	39	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	11	48	5	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	3	29	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	4	18	5	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	24	51	4	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	1	5	1	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	2	5	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	7	4	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	6	2	—	—

type represented by the fishes of the genera *Japonolaeops, Laeops, Neolaeops, Kamoharaia* and *Chascanopsetta* has their caudal vertebral counts from 37 to 42.

Discussion: So far as the vertebrae are concerned, their structural difference have, up to the present, provided us with no sound basis for the classifying the flounders, though NORMAN (1934) used the feature of transverse apophysis for classifying the subfamilies of the family Bothidae.

The present study indicates that the following characters are subservient to the classification of the flounders: presence or absence of first neural spine; number of platelike neural spine; developmental degree of first haemal spine; presence or absence of parapophysial stay; shape of haemapophysis; relation between neural pre- and postzygapophysis; presence

Table 11. Nine types of the vertebrae and their accessory bones in Japanese flounders.

Types	Characters				
	First neural spine	Number of plate-like neural spines	Developmental degree of first haemal spine	Parapophysial stay	Shape of haemapophysis
1	present	first to sixth	moderate	present	triangular
2		first to fourth	expanded		
3		first to fourth or first to third			
4	absent	second or second to third		absent	
5					
6			particularly expanded		expanded at tip
7			expanded		triangular
8					
9					

or absence of epipleural, if present, number of epipleurals; presence or absence of rib; number of abdominal vertebrae and caudal ones; size of opening for passage of notochord; position of opening of notochord; feature of concavity of lateral side of centrum; presence or absence of transverse apophysis; presence or absence of a series of bones, epicentrum, epimeral, hypomeral and myorhabdoi.

In view of aforementioned fact, the vertebrae in Japanese flounders appear to be divisible together with respect to their osteological feature and their number into nine types as shown in Tables 11 and 12.

With regard to the neural spine, the Japanese flounders can be strikingly classified into two groups. The first group (Types 1, 2 and 3) is provided with the neural spine which is a little shorter than the second one. The second group (Types 4 to 9) has no such character-

Table 11. (continued)

Number of neural postzygapophyses beneath prezygapophyses	Rib	Epipleural	Number of caudal vertebrae	Genera
first to tenth	present	beginning with first vertebra	14	*Psettodes*
eighth to tenth			20 to 22	*Lepidoblepharon* *Citharoides*
absent		beginning with second vertebra	23 to 35	*Paralichthys* *Pseudorhombus* *Tarphops*
	absent	absent		*Taeniopsetta*
				Crossorhombus, Psettina *Engyprosopon, Arnoglossus* *Tosarhombus, Parabothus* *Asterorhombus*
				Bothus
			37 to 42	*Japonolaeops* *Laeops*
				Neolaeops *Kamoharaia*
				Chascanopsetta

istics, but is provided with the neural arch joining each other.

This feature is so peculiar that the disappearance of this spine has not been observed in any groups of fishes of the teleosteans, so far as the author's knowledge is concerned, certainly, therefore, the second group may be greatly diversified.

The platelike neural spine can be classified into four groups in number. Such spines can be seen on the first to the sixth vertebrae in the first group (Type 1), on the first to the fourth vertebrae in the second group (Type 2), and on the first to the third vertebrae in the third group (Type 3), but exceptionally they are on the first to the fourth vertebrae in the fishes of the genus *Paralichthys*. In the fourth group (Types 4 to 9) they are on

Table 12. Nine types of the vertebrae and their accessory bones in Japanese flounders.

<table>
<tr><th rowspan="2">Types</th><th colspan="5">Characters</th><th rowspan="2">Genera</th></tr>
<tr><th>Size of opening for notochord</th><th>Position of opening</th><th>Feature of concavity of centrum</th><th>Anterior transverse apophysis</th><th>Epicentrum Epimeral Hypomeral Myorhabdoi</th></tr>
<tr><td>1</td><td rowspan="4">very small</td><td rowspan="3">middle</td><td rowspan="4">A</td><td rowspan="3">absent</td><td rowspan="4">absent</td><td>Psettodes</td></tr>
<tr><td>2</td><td>Lepidoblepharon
Citharoides</td></tr>
<tr><td>3</td><td>Paralichthys
Pseudorhombus
Tarphops</td></tr>
<tr><td>4</td><td>slightly advanced</td><td rowspan="4">beginning with second vertebra</td><td rowspan="5">present</td><td>Taeniopsetta</td></tr>
<tr><td>5</td><td rowspan="3">moderate</td><td rowspan="4">more advanced</td><td rowspan="2">B</td><td>Crossorhombus
Engyprosopon
Tosarhombus
Asterorhombus
Psettina
Arnoglossus
Parabothus</td></tr>
<tr><td>6</td><td>Bothus</td></tr>
<tr><td>7</td><td rowspan="2">large</td><td>C or B</td><td>Japonolaeops
Laeops</td></tr>
<tr><td>8</td><td>C</td><td rowspan="2">beginning with fourth or fifth vertebra</td><td>Neolaeops
Kamoharaia</td></tr>
<tr><td>9</td><td>moderate</td><td>slightly advanced</td><td>D</td><td>Chascanopsetta</td></tr>
</table>

the second or the second to the third vertebrae, though the neural spines progressively become slenderer backward.

Generally, in the perciform, each neural spine of the anterior several vertebrae is platelike in form, and stands backward. Throughout the flounders, there is a general tendency that such neural spines are gradually replaced by the slender ones from the rear, and stand forward. In such a case, the first group, in which many platelike spines are present, represents most generalized form, and the second and the third follow in due order. The fourth group is the most highly specialized. On the other hand, the appearance of the slender neural spines of the anterior vertebrae standing forward may be associate with the fact that the dorsal spines are replaced by the soft ray, and the fact that the dorsal ray extends particularly toward the head.

Regarding the developmental degree of the first haemal spine, the Japanese flounders are divided into the three groups. The first group (Type 1) has the slender first haemal spine as well as the others. In the second group (Types 2, 3, 4, 5, 7, 8, 9), it is strongly expanded and platelike in shape. The third group (Type 6) has particular heavy bone. The developmental degree of the first haemal spine seems to be essentially related to the forward extension of the anal fin. In the first group, the anal fin is not well extended forward, and the some interhaemal spines which set more advanced than the first haemal spine are attached to the distal end of the first haemal spine. In the second and the third groups, the anal fin is well extended forward, and many interhaemal spines which set more advanced than first haemal spine are supported by an extended and elongated first interhaemal spine whose proximal end is attached rigidly to the middle portion of the first haemal spine. Judging from this fact, it probably be assumed that such strengthened first haemal spine is certainly related to support the first interhaemal spine. The developmental degree of the first haemal spine in the first group agrees well with that of the entire groups of the perciform. The first group having such character, therefore, may be reasonably interpreted to be more generalized than other groups, whilst the third group is most highly specialized.

The parapophysis which joins with the fellow of the opposite side on the posterior abdominal vertebrae is called the haemapophysis. This term was introduced by CHABANAUD (1951) who calls such parapophysis the haemacantha.

The haemapophysis shows the two patterns in the developmental degree. One pattern is provided with the parapophysial stay. The other is lacking the parapophysial stay, but has the haemapophyses on the posterior abdominal vertebrae which are completely joined with each other at respective distal end.

The parapophysial stay is a transverse bony bridge which connects with each other the parapophysis on both sides in the abdominal vertebrae; the model has been shown by MAKUSHOK (1958) in blennid fishes. CHABANAUD (1951) designates them as ponts apophysaires or ponts transversales.

Regarding the haemapophysis, Japanese flounders can be classified into two groups as to whether or not they possess the parapophysial stay. In the first group (Types 1, 2 and 3), the haemapophyses provided with the parapophysial stays occur on some abdominal vertebrae, whilst in the second group (Types 4 to 9), the haemapophyses are coalesced with

each other at respective distal end, and completely lacking the stay.

The parapophysial stay is noted in *Sardinops caerulea* (PHILLIPS, 1942), in great many perciforms (FORD, 1937), in many pleuronectiforms (CHABANAUD, 1951) and in blennid fishes (MAKUSHOK, 1958). The first group having such character, therefore, may reasonably be interpreted to be more generalized than the second group which has the haemapophyses joined each other at respective distal end.

Regarding the haemapophysis coalesced at its end, CHABANAUD (1947) proposed to designate the canal formed by the parapophysis as the hemonephridial canal. MAKUSHOK (1958) calls the parapophysis of Pholidae (blennid fishes) which forms a closed canal in which the kidneys and blood vessels are included the hemonephrapophysis. In his work, MATSUBARA (1963) used this term for *Zeus faber*. In the flounders, however, the hemonephrapophysis is not a reasonable term, since a closed canal includes blood vesseles only with the kidney left out. Here it is called haemapophysis.

Regarding the shape of haemapophysis, Japanese flounders can be classified into two groups. In the first group it is triangular in shape, tapering at the tip, when viewed from lateral side. In the second group, it is so well expanded backward at the tip as to almost extend to the next one. In most case, the haemapophysis is triangular in shape and tapering. The second group may, therefore, reasonably be regarded as more specialized. On the other hand, it is interesting to note that the peculiar shape of the haemapophysis as the second group agrees closely well with that of *Zeus faber* figured by STARKS (1898). But it may appear independently in each of two orders.

A similar structure of such haemapophysis as coalesced at its end has already been reported in *Zeus faber* (STARKS, 1898), Soleina such as Achiridae, Soleidae and Symphrinae (CHABANAUD, 1951) and some species of blennid fishes (MAKUSHOK, 1958). HUBBS (1927) states that the appearance of the hemonephrapophysis in Pholidae is conjecturally assossiated with the strong lateral compression of the body. But according to CHABANAUD (1951), many fishes with strongly compressed bodies have not the haemapophysis coalesced at its distal end. So far as all members of the flounders, *Zebrias fasciatus* and *Zenopsis neblosa* are examined by the present author, the haemapophysis including only the blood vessel entirely differs in structure from that of Pholidae.

With respect to the neural prezygapophysis and postzygapophysis, Japanese flounders may be divided into two groups according to the interlocking feature. In the first group the neural prezygapophyses are interlocked on the postzygapophyses located on at least some abdominal vertebrae. The first group is further divisible into two subgroups. In the subgroup 1a they are found to exist between the first and the tenth vertebrae, whilst in the subgroup 1b they are found between the eighth and the tenth abdominal vertebrae. In the second group, the neural prezygapophyses are interlocked beneath the postzygapophyses all over the vertebrae. The zygapophysis of the caudal vertebrae in *Psettodes erumei* may probably be most primitive, because both zygapophyses extend vertically upward and never interlock with each other. It is highly probable that the two groups have originated from the group with such zygapophysis as is found in *Psettodes*. Generally speaking, in the majority of the fishes, the neural prezygapophyses are tightly interlocked on the neural postzygapophyses.

It appears, therefore, that the first group is more primitive than the other group.

According to presence or absence of two bones, the rib and the epipleural, Japanese flounders can split into two groups. The first group has the rib and the epipleural, whilst, in the second group they are lacking. The first group is further divisible into two subgroups as to whether the epipleural begins with the first or the second vertebra. So far as the writer's knowledge is concerned, the lacking of the epipleural and the rib is noted in suborder Soleina (Ochiai, 1959). It seems to me that the fishes belonging to the second group are philogenetically related to the fishes of Soleina. Makushok (1958) reported that the ribs are lacking in Pholidae (blennid fishes) which are considered to be highly specialized. On the other hand, those bones are usually well developed and the epipleural begins with the first vertebra as in the subgroup 1a throughout the teleosts. The subgroup 1a having such characters, therefore, may be reasonably interpreted to be more generalized than the subgroup 1b the epipleural starting with the second vertebra. The second group is most specialized, so far as these bones are concerned.

The number of the vertebrae of the Japanese flounders varies from species to species within a limit of 24 to 57. With regard to the abdominal vertebrae there are specific variations of 10 to 17 in number, but in most of Japanese flounders there are constantly 10 vertebrae. In the percid fishes, it seems to be basic and ancestral that there are 10 abdominal vertebrae (Hubbs, 1945). Thus, it appears that those having 10 abdominal vertebrae are most generalized, and that the more abdominal vertebrae increase in number, the more it does in specialization. On the other hand, regarding the caudal vertebrae, Japanese flounders may be roughly classified into four groups according to number. The caudal vertebrae numbers 14 in the first group. As pointed out by many ichthyologists (Norman, 1934; Hubbs, 1945), the 14 caudal vertebrae are said to be basic and ancestral throughout the percid fishes. The first group may, therefore, reasonably be regarded as more generalized. The second group has the intermediate 20 to 22 in number between the first group and the third group, as already pointed out by Hubbs (1945). The third group, having caudal vertebrae from 23 to 35 in number, may be well differentiated among the flounders. In the fourth group the caudal vertebrae are the largest number from 37 to 42.

In the Japanese flounders, it is highly probable that the vertebrae tend to increase in number as they are specialized. Thus, the first group represents the most primitive form, groups second and third follow in due order, and the fourth group is most highly specialized.

Regarding the developmental degree of the opening for the passage of the notochord, the Japanese flounders can be classified into three groups. In the first group (Types 1, 2, 3, 4) the opening is peculiarly small. The second group (Types 5, 6, 9) has the moderately large opening. In the third group (Types 7, 8) it is very large, about half time as large as the centrum in diameter.

Though the size of the opening aforementioned has never hitherto been discussed in the other fishes, the opening which is generally very small throughout perciform, agrees well with that of first group. Such a large opening as that of the third group is observed in a species of the family Melanostomiatidae, *Eustomias obscurus* (Regan and Trewavas, 1930) and in the fossil fishes, such as *Osteorhachias leedsi* (Goodrich, 1958).

Judging from such a fact mentioned above and from a process of development of the centrum, the author presumes that the group with such large opening indicates rather a primitiveness.

With regard to the position of the opening, the Japanese flounders are apparently divided into the three groups. The first group (Types 1, 2, 3) has the centrum concave with an equal depth anteriorly and posteriorly; the opening, therefore, lies at the middle portion of the centrum. In the second group (Types 4, 9) the anterior concave of the centrum is a little shallower than the posterior one; the opening, therefore, occupies slightly in front of the middle portion of centrum. In the third group (Types 5, 6, 7, 8) the anterior concave is shallower than the posterior one; the opening, therefore, is more advanced than the middle portion. CHABANAUD (1937) in his investigation of the Heterosomata and MAKUSHOK (1958) in his study of the blennid fishes respectively observed the two types of the amphicoelous centrum; the former author called them the isocone and the anisocone; the latter one the symmetrical vertebrae and the asymmetrical vertebrae respectively. In present study the first group agrees well with the isocone and symmetrical vertebrae, and the second and third groups agree well with the anisocone and asymmetrical vertebrae. Since the centrum, which is generally well-developed amphicoelous, forms the isocone throughout the teleostean fishes, the anisocone centrum is so peculiar. A similar structure in centrum is noted in some species of Heterosomata (CHABANAUD, 1937), in Pholidae, Asygopterinae, Xiphisterinae (*Xiphister* and *Phytichthys*) and Ptilichthyidae including the blennid fishes, and in Mastacembeldae and Zoaricidae (MAKUSHOK, 1958). MAKUSHOK (1958) reports in his study of the blennid fishes that the forward displacement of the vertebral constriction associates with certain peculiarities of movement and has evolved independently. In the flounders, however, the shift of the opening occurs uniformly in all members of the family Bothidae, whilst the opening lies on the middle portion of the centrum in the fishes of the families Psettodidae, Citharidae and Paralichthyidae, and those groups do not indicate a great difference in the habitat. Judging from this fact, it is probably thought that the anisocone centrum is not associated with movement of fishes, but rather related to the phylogenetic significance of fishes. On the other hand, the vertebrae of *Lepisosteus* are unique among fishes in being opisthocoelous, the centrum having a convex anterior face fitting into a concavity of the centrum in front (GOODRICH, 1958). Although this centrum differs from the anisocone one in having a convex anterior face, it comparatively resembles the fishes of the third group, which have the deepest concavity posteriorly. This fact may afford us a hypothesis; the first group having an isocone centrum is a generalized form, and the third group retaining a particular anisocone is most primitive.

The feature of the concavity of lateral side of the centrum shows great variety among species, but the feature is divided roughly into four types in Japanese flounders. In the type A the centrum is concave shallowly or deeply on the upper and lower portions, becoming progressively deeper to mid-portion of the bone. The type B has a pair of similar deep concaves, but the upper and lower deepest portions are more advanced than in those of the former. The type C has some small concave portions on the centrum. In the type D the centrum is provided with a pair of deep elliptical concavities on the upper and lower parts horizontally.

The feature of the lateral side of the centrum in the type A bears a resemblance to that of the percid fishes throughout. On the other hand, it is highly probable that the feature of the centrum like that of the type B has resulted from the anisocone. In the type C, however, the centrum has not particular pattern on the lateral side, though it is the anisocone. It may be probably correlated with the large opening for the notochord. The type D goes between the type A and the type B in general feature. From the above view-points, we may reach the conclusion that the type A is a more generalized form than others and follows in due order to the type D and B; the type C, however, is a primitive form, as position of the opening for the passage of the notochord.

The transverse apophysis is the lateral process which extends horizontally from the lateral portion of the centrum. This term was introduced by Norman (1934). Regan (1912) and Trewavas (1932) used the transverse process for classifying of the apodal fishes. Asano (1962) calls such process epicentrum in studing of the Japanese apodal fishes, but probably it may be the transverse apophysis. The Japanese flounders may be divided into two major groups whether the centrum is provided with transverse apophysis or not. The first group (Types 1, 2, 3) is completely lacking it, whilst the second group (Types 4 to 9) has well developed two pairs of the transverse apophyses on the centrum. The second group can be further classified in another way into two subgroups by the degree of development of the anterior transverse apophysis. In the subgroup 2a (Types 4 to 7), it starting with the second vertebra, whilst in the subgroup 2b (Types 8 to 9) it begins with the fourth or the fifth vertebra. So far as the author's knowledge is concerned, the transverse apophysis is noted in apodal fishes (Regan, 1912; Trewavas, 1932; Asano, 1962), but it is usually absent in all the members throughout percid group. Such a process may, therefore, reasonably be regarded as primitive apparatus. There is the secondary disappearance of the transverse apophyses of the anterior vertebrae in the second group. If such is the case, it may be reasonable to consider the first group as more generalized than the second group. In the second group, the subgroup 2a may be more primitive than the subgroup 2b.

Of the four terms of rodlike bones, epicentrum, epimeral, hypomeral and myorhabdoi, the former three were introduced by Phillips (1942) in *Sardinops coerulea*. The epicentrum occuring outward and backward in the horizontal septum which separates the epaxial muscle from the hypaxial one agrees well with the epipleural in its position in other groups of fishes. The epicentrum, however, is originally distinguished from the latter without attaching to the rib, parapophysis and haemapophysis but to the anterior transverse apophysis, and occasionally bifurcating at the distal end and having two on an anterior transverse apophysis.

The epimeral stands outward, upward and backward into the dorsal myoseptum between the posterior surface of the cranium and the last vertebra. Some of them bifurcate at the proximal end into the same myoseptum.

The hypomeral runs outward, downward and backward into the myoseptum of the ventral side of the body between the second vertebra and the last one, and confronts its self with the epimeral of its own vertebra in position and in shape.

The myorhabdoi runs into the uppermost and lowermost myoseptum on both sides of the body. Most of these bones are brushlike in shape both anteriorly and posteriorly,

extending the bodily surface beneath the skin and free from the axial skeleton.

PHILLIPS (1942) takes the epimeral and the hypomeral together with the epineural and epipleural respectively. But the hypomeral is not identical with the epipleural in position, which occurs in the horizontal septum separated the epaxial muscle from the hypaxial one. Consequently it seems preferable to use independently the epimeral and the hypomeral respectively. So far as the epicentrum, the epimeral, the hypomeral and the myorhabdoi are concerned, Japanese flounders may be clearly classified into two groups whether the vertebrae are provided with four series bones or not. The first group (Types 1 to 3) is lacking the four bones, whilst the second group (Types 4 to 9) has such bones.

It has never been reported by any of the investigators that the flounders are provided with such bones. Throughout the teleosts such bones are usually well developed in the species of Clupeida and Anguillida. Consequently, the second group provided with the four series bones may be considered as a primitive form, so far as the present character is concerned, because the fishes provided with such bones are usually believed to be primitive.

As already mentioned, the manner of specialization in which the structure and number of vertebrae of the flounders took place is very complex, and differentiation of some of the characters are not necessarily correlated with that of other important features. The existance of such divergence is of convenience not only from a taxonomical view-point, but also from the point of suggested phyletic significance.

If we take the following characters into the consideration, we may reach the conclusion that type 1 represents the most primitive form, and 2, 3, 4, 5, 6, 7, 8 and 9 follow in due order. 1) presence or absence of first neural spine; 2) number of the platelike neural spine; 3) shape of first haemal spine; 4) presence or absence of parapophysial stay; 5) relation between neural prezygapophysis and neural postzygapophysis; 6) presence or absence of rib and epipleural; 7) shape of haemapophysis. On the other hand, when the following characters are taken particularly into consideration, we may reach the conclusion that the types 1 to 3 represent most generalized form, but the types 4 to 9 indicate a more primitive form. 1) size of opening of centrum; 2) position of opening of centrum; 3) presence or absence of epicentrum, epimeral, hypomeral and myorhabdoi; 4) presence or absence of transverse apophysis; 5) feature of concavity of centrum.

Here we may reach the conclusion that the types 1 to 3 are followed by a general rule, whereas that the types 4 to 9 which are highly specialized in several characteristics leave the most primitive feature in other respects.

7. Caudal rays

Description: The Japanese flounders have generally the caudal fin in the truncate and rounded forms. The fin is composed of the branched rays in most middle parts and the unbranched ones in both the uppermost and lowermost margins, the unbranched ones are distinguishable clearly in two kinds of rays, the segmental and unsegmental rays.

The total number of caudal rays which varies very frequently between families and

even genera; 24 in the fishes of the genus *Psettodes* (Psettodidae), 23 in the fishes of the genera *Citharoides* and *Lepidoblepharon* (Citharidae), 18 in the fishes of the genus *Paralichthys* (Paralichthyidae) and always 17 in other members of the families Paralichthyidae and Bothidae.

The branched rays number 15 in the fishes of the both families Psettodidae and Citharidae. In members of the families Paralichthyidae and Bothidae, the rays vary from 9 to 13 between species specifically or even in a species (Table 13).

The number of the simple rays also varies between families as is the case with the branched rays. The fishes of the family Psettodidae possess five and four simple rays in the upper and lower extremities respectively. In the fishes of the genera *Citharoides* and *Lepidoblepharon* representing the family Citharidae, these rays count four in the both upper and lower extremities. The rays markedly vary in members of the families Paralichthyidae and Bothidae (Table 13); among these families, *Paralichthys olivaceus* alone has three and two simple rays in the upper and lower extremities respectively, but in other species, the number of simple rays is closely related to that of the branched rays. The species with 13 branched rays have two simple rays in each extremity; the species with 12 branched rays have two and three in the upper and the lower, or *vice versa;* the species with 11 branched rays have three; the species with 10 branched rays have three (upper) and four (lower), or *vice versa;* and the species with the nine branched rays have four (Table 13).

The unbranched rays are generally composed of both segmented and unsegmented rays. The fishes of the families Psettodidae and Citharidae have three unsegmented rays on both extremities. Among the fishes of the families Paralichthyidae and Bothidae there are two (upper) and one (lower) in *Paralichthys olivaceus,* but one or none in both extremities in other species.

Discussion: The caudal rays of the flounders have previously been examined by some investigators. Regan (1910) and Hubbs (1945) already found that *Psettodes erumei* and *Citharoides macrolepidotus* have 17 principal rays, 15 branched rays, and pointed out that the caudal ray formula of the genera *Psettodes* and *Citharoides* shows some indication of primitiveness and of relationship between both families Psettodidae and Citharidae. All members of the families Paralichthyidae and Bothidae, as shown by Norman (1934) in figure and text, have fewer than 15 branched rays with the exception of a few species, and the number of the total rays shows variation extensively. So far as the Japanese flounders are concerned, the branched rays vary from 9 to 13, but the total rays have constantly 17 except for *Paralichthys olivaceus*.

The previous investigators did not appreciate the importance of the total number of caudal fin rays not only for the taxonomy but also for the suggestion of the phyletic relationships of the flounders, though the principal rays were examined in a few species. The writer, therefore, examined the total number of the caudal fin rays by means of X-ray, and recognized the significance in both taxonomy and phylogeny of flounders in this feature. The fishes of the family Psettodidae have the highest number, 24 in total rays, 15 in the branched rays, five in upper and four in lower unbranched rays. Regan (1910) pointed out that *Psettodes erumei* has the basic number of 17 principal and 15 branched rays,

Table 13. Frequency distribution of number of total caudal rays in Japanese flounders.

Species \ Caudal ray formulae	5+15+4 =24	4+15+4 =23	3+13+2 =18	2+13+2 =17
Psettodes erumei	2	—	—	—
Lepidoblepharon ophthalmolepis	—	2	—	—
Citharoides macrolepidotus	—	2	—	—
Paralichthys olivaceus	—	—	4	—
Pseudorhombus dupliciocellatus	—	—	—	2
P. oligodon	—	—	—	9
P. oculocirris	—	—	—	11
P. pentophthalmus	—	—	—	19
P. arsius	—	—	—	10
P. cinnamoneus	—	—	—	7
P. levisquamis	—	—	—	15
Tarphops oligolepis	—	—	—	—
T. elegans	—	—	—	—
Taeniopsetta ocellata	—	—	—	12
Parabothus coarctatus	—	—	—	21
P. kiensis	—	—	—	10
Tosarhombus octoculatus	—	—	—	19
Crossorhombus kobensis	—	—	—	—
C. kanekonis	—	—	—	25
Engyprosopon grandisquama	—	—	—	—
E. multisquama	—	—	—	—
E. macroptera	—	—	—	—
E. longipelvis	—	—	—	—
E. xystrias	—	—	—	—
Bothus myriaster	—	—	—	21
B. mancus	—	—	—	7
B. pantherinus	—	—	—	4
Asterorhombus intermedius	—	—	—	2
Psettina iijimae	—	—	—	23
P. gigantea	—	—	—	13
P. tosana	—	—	—	8
Arnoglossus tenuis	—	—	—	—
A. polyspilus	—	—	—	11
A. japonicus	—	—	—	—
A. oxyrhynchus	—	—	—	—
Japonolaeops dentatus	—	—	—	—
Laeops nigromaculatus	—	—	—	—
L. kitaharae	—	—	—	2
Neolaeops microphthalmus	—	—	—	—
Kamoharaia megastoma	—	—	—	—
Chascanopsetta lugubris	—	—	—	15

Table 13. (continued)

3+12+2 =17	2+12+3 =17	3+11+3 =17	3+10+4 =17	4+10+3 =17	4+9+4 =17	Specimens examined
—	—	—	—	—	—	2
—	—	—	—	—	—	2
—	—	—	—	—	—	2
—	—	—	—	—	—	4
—	—	—	—	—	—	2
—	—	—	—	—	—	9
—	—	—	—	—	—	11
—	—	—	—	—	—	19
—	—	—	—	—	—	10
—	—	—	—	—	—	7
—	—	—	—	—	—	15
2	—	13	—	—	—	15
—	—	10	—	1	—	11
2	3	5	—	—	—	22
—	—	—	—	—	—	21
—	—	—	—	—	—	10
—	—	—	—	—	—	19
—	—	26	—	—	—	26
—	—	—	—	—	—	25
—	—	26	—	1	—	27
—	—	10	—	—	—	10
—	—	17	—	—	—	17
—	—	11	—	—	—	11
—	—	2	—	—	—	2
8	—	8	—	—	—	37
—	1	—	—	—	—	8
1	—	—	—	—	—	5
—	—	—	—	—	—	2
—	—	—	—	—	—	23
—	—	—	—	—	—	13
2	—	—	—	—	—	10
1	—	17	—	—	—	18
2	—	—	—	—	—	13
—	—	11	—	—	—	11
—	—	10	—	—	—	10
—	—	22	1	—	—	23
—	—	—	—	—	1	1
10	—	10	—	—	—	22
—	—	1	—	—	—	1
—	—	—	—	—	2	2
—	—	—	—	—	—	15

and stressed this character as evidence that *Psettodes* is simply as asymmetrical percoid. Indeed, in the number of principal and branched rays *Psettodes erumei* agrees with the fishes of Serranidae in general, but when the total rays were also compared, they have extremely high number in the fishes of Serranidae (percoid), while they are reduced considerably in *Psettodes erumei*. Without doubt, however, *Psettodes erumei* in having the highest number of the total caudal rays and 15 branched rays shows most primitive feature in all the flounders. In the number of the branched rays *Citharoides macrolepidotus* and *Lepidoblepharon ophthalmolepis* belonging to the family Citharidae agree with *Psettodes*

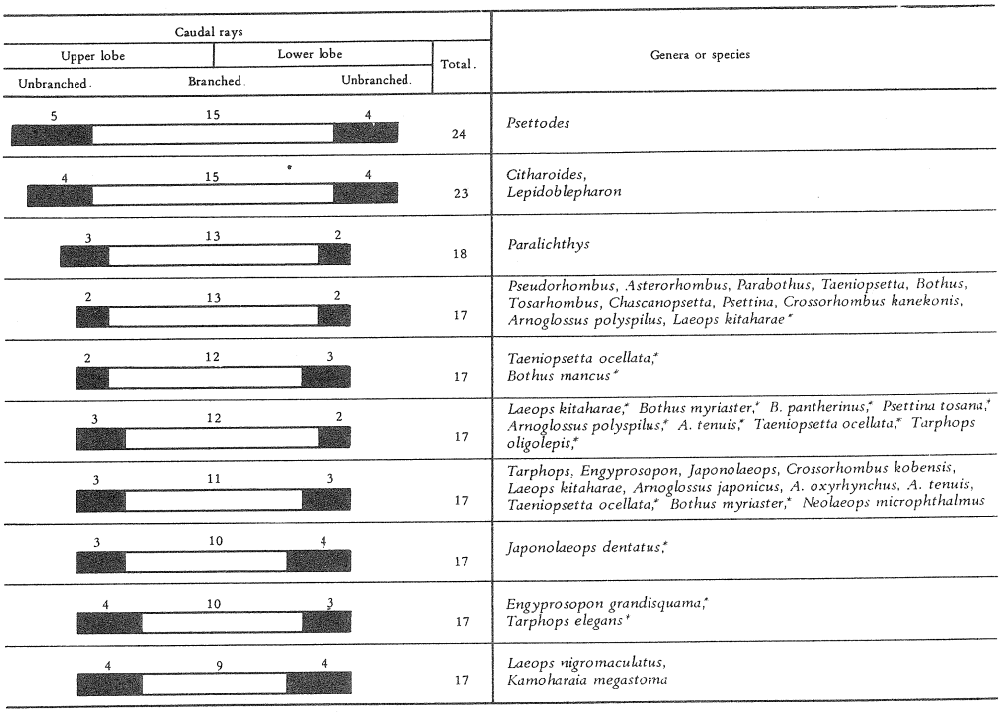

Fig. 126. Diagrammatic features of the reduction of the caudal rays in Japanese flounders. * The species occasionally shown by a few specimens; to see Table 13.

erumei belonging the family Psettodidae. On the basis of this character, it is indicated that both the families have the most close relationship (Hubbs, 1945). A distinctive feature of the family Citharidae, however, is of the total caudal rays reduced to 23. It may be inferred that one unbranched ray disappears on the upper extremity in the members of this family. The fishes of this family, therefore, may presumably be more progressive type than those of family Psettodidae. In *Paralichthys olivaceus* belonging to the family Paralichthyidae, the caudal fin rays number 18 in the total ones, 13 in the branched ones and three in upper and two in lower in the unbranched ones. On the lower half of the

caudal fin its count agrees well with that of the other members of this family, but the difference in number occurs in the upper lobe. In view of caudal fin ray count, it is concluded that there is far greater gap between this species and the fishes of the former two families, and that this species is rather near the other members of the families Paralichthyidae and Bothidae. In all the members of the families Paralichthyidae and Bothidae examined with the exception of *Paralichthys olivaceus* the total number of the caudal fin rays is constantly 17, but the branched rays vary from 9 to 13. The analysis shows that the difference in this ray counts is closely made related to the number of the unbranched rays. It seems to me to be highly probable that this group with 17 total rays is more advanced form than *Paralichthys olivaceus* with 18. Though among this group the number of branched rays occurs considerable variation within and between species, usually the number of the branched rays seems to reduce in advanced form.

From these fact, it finally is concluded that the trend in the evolution of the caudal fin rays of the flounders is reduced in number of both the total and branched rays. In spite of the unbranched rays decrease in number to the step of *Paralichthys olivaceus*, they appear to increase progressively in the members of families Paralichthyidae and Bothidae except for *Paralichthys olivaceus* (Fig. 126). Though the distinctive feature seems to be in conflict with the above conclution, perphaps the best explanation is as follows: among the families Psettodidae and Citharidae, and *Paralichthys olivaceus* belonging to the family Paralichthyidae, there has doubtlessly come about a progressive decrease in the number of the unbranched rays, but in all the other members of families Paralichthyidae and Bothidae in having only the principal rays, the branched rays are secondarily replaced by the unbranched rays (Fig. 126). On the other hand, it may also support apparently this fact that when the species in having two unbranched rays (*e. g. Pseudorhombus*, etc.) compared with those in having three (*e. g. Engyprosopon*, etc.) the caudal rays supported by each hypural bone and epural bone remain unchanged.

8. Caudal skeleton

Description: The caudal skeletons of Heterosomata have been reported hitherto in the certain species by several authors (Cole and Johnstone, 1901; Whitehouse, 1910; Barrington, 1910; Chabanaud, 1937; Wu, 1932; Ochiai, 1959), but no mention of each bone of the caudal elements has ever agreed with any of the investigator. The term of each bone may be decided to be based on its origin. In such an opinion, it is significant that the mention has been made by Barrington (1910) in his developmental study of *Pleuronectes platessa* (pleuronectid fishes). Such study of these elements has not been made in most flounders. Then, on the basis of a gradation in the caudal skeletons from form in which this structure is fairly primitive or generalized to form in which it is considerably fused, those origins of the bones were presumed. As to the terms of the caudal elements, it is made according to Hollister (1937) for the facility of a comparison between orders or within order.

The urostyle is divided into two different groups. In the first group represented by the fishes of the families Psettodidae and Citharidae, the bone is not fused with the hypural

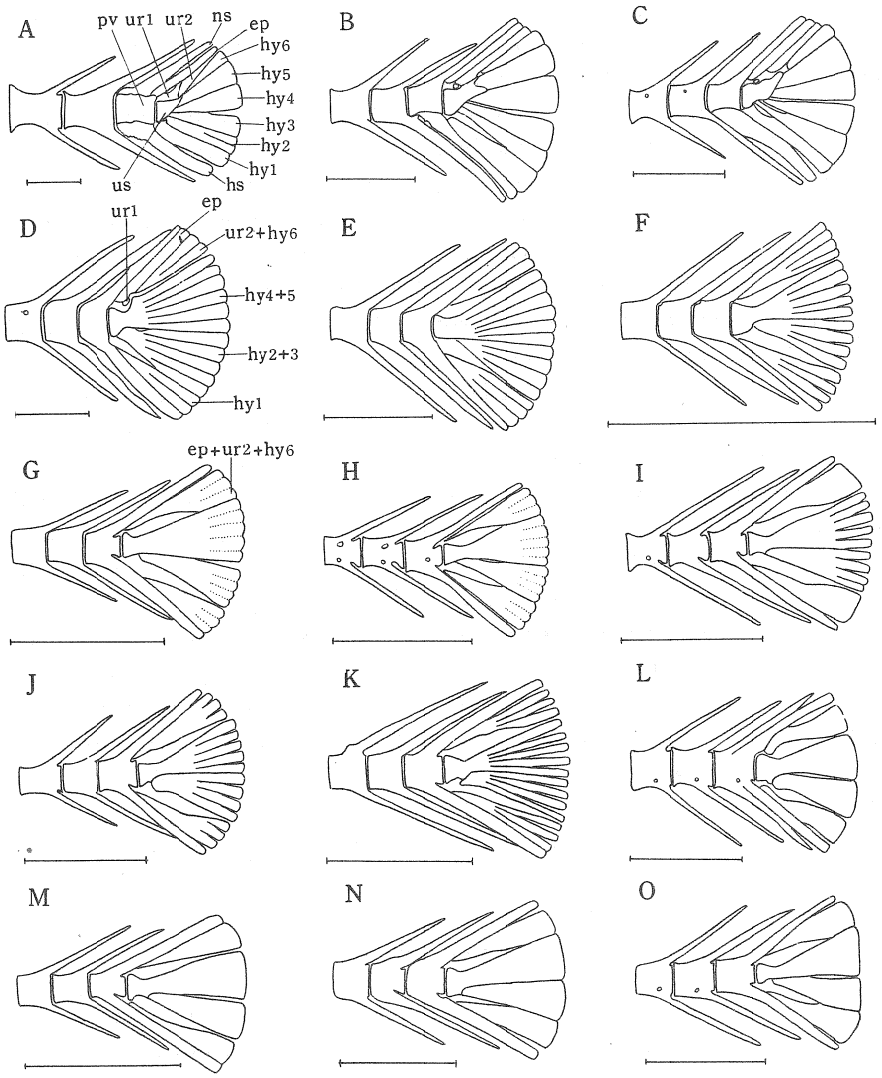

Fig. 127. Lateral aspect of the caudal skeleton in 15 species. A, *Psettodes erumei*; B, *Citharoides macrolepidotus*; C, *Lepidoblepharon ophthalmolepis*; D, *Paralichthys olivaceus*; E, *Pseudorhombus oculocirris*; F, *Tarphops oligolepis*; G, *Psettina gigantea*; H, *Crossorhombus kobensis*; I, *C. kanekonis*; J, *Engyprosopon grandisquama*; K, *Asterorhombus intermedius*; L, *Taeniopsetta ocellata*; M, *Tosarhombus octoculatus*; N, *Bothus mancus*; O, *B. myriaster*. ep, epural; hy1, first hypural; hy2 second hypural; hy3, third hypural; hy4, fourth hypural; hy5, fifth hypural; hy6, sixth hypural; url, uroneural 1; ur2, uroneural 2; pv, preterminal vertebra; ns, neural spine; hs, haemal spine; us, urostyle; hy2+3, a bone fused second hypural and third one; hy4+5, a bone fused fourth hypural and fifth one; ur2+hy6, a bone fused uroneural 2 and sixth hypural; ep+ur2+hy6, a bone fused epural, uroneural 2 and sixth hypural. Scales indicate 1 mm.

bone, but upturning and tapering. In the fishes of the genera *Psettodes* and *Lepidoblepharon* it is somewhat triangular in shape, attached to the first to the fifth hypurals ventrally, to the uroneural 1 and uroneural 2 dorsally, not to the sixth hypural dorsally (Fig. 127, A, C), while in the fishes of the genus *Citharoides* it is shallowly forked at the tip, and attached to the second to the fourth hypurals ventrally, to the uroneural 1 and 2 dorsally, but the fifth hypural is wedged in the fork of the urostyle (Fig. 127, B). In the second group, which is represented by the members of the families Paralichthyidae and Bothidae, the bone is completely fused with the hypural 4 + 5, forming an urostyle-hypural complex as a whole, though these components are not necessarily identifiable (Fig. 127, D-O; Fig. 128, A-H).

The uroneural 1 is comparatively small, the fishes of the genera *Psettodes, Citharoides, Lepidoblepharon* and *Paralichthys* have this bone. In the fishes of the genus *Psettodes* the bone is greatest in size, somewhat rhombic in shape, and is attached anteriorly to the upper part of the preterminal vertebra, posteriorly to the base of uroneural 2, antero-dorsally to the base of the epural and ventrally to all the upper surface of the urostyle (Fig. 127, A). In the members of the latter three genera, this bone is an ossicle reduced remarkably in size. In the fishes of the genus *Citharoides* it remains between the urostyle and the uroneural 2, in the fishes of the genus *Lepidoblepharon* on the urostyle, and in the fishes of the genus *Paralichthys* beneath the epural bone (Fig. 127, B, C, D). This bone disappears particularly in all the other members of Japanese flounders (Fig. 127, E-O; Fig. 128, A-H).

The uroneural 2, if present, which is rectangular or wedge-shaped is inserted between the epural and the uppermost hypural and is attached to those bones. The fishes of the three genera *Psettodes, Citharoides* and *Lepidoblepharon* have this bone (Fig. 127, A-C), forming a fanlike bone in shape, but in the members of the families Paralichthyidae and Bothidae there is a fusion with other bone. In the fishes of the genus *Paralichthys,* the bone fuses completely with the sixth hypural (Fig. 127, D), whereas in the other members it fuses dorsally with the epural and ventrally with the hypural (Fig. 127, B-O; Fig. 128, A-H).

The epural possessed by the fishes of the four genera *Psettodes, Citharoides, Lepidoblepharon* and *Paralichthys* is set between the neural spine related to the preterminal vertebra and either the uroneural 2 or uroneural 2 + hypural 6, and is rectangular in shape (Fig. 127, A-D), but in all the other members of the families Paralichthyidae and Bothidae except for the fishes of the genus *Paralichthys,* the bone fused with the uroneural 2 + hypural 6 is fanlike in shape (Fig. 127, B-O; Fig. 128, A-H). The fanlike shaped bone (ep + ur 2 + hy 6) of the family Paralichthyidae is divided into two or three parts posteriorly, but these parts are fused with each other basally (Fig. 127, E, F). Generally, in the members of the family Bothidae the bone is platelike in shape without being branched (Fig. 127, L-O; Fig. 128, A-H), but the fishes of the genera *Engyprosopon* and *Psettina,* and *Crossorhombus kobensis* have some divided bones at the tip or some grooved bones lengthways (Fig. 127, G-K).

The hypurals bearing the major parts of the caudal rays show two different patterns in number. In the fishes of the genera *Psettodes, Citharoides* and *Lepidoblepharon* the bones are six in number (Fig. 127, A-C). In the fishes of the two genera *Psettodes* and *Lepidoblepharon,* the first to the fifth hypurals are attached basally to the urostyle (Fig.

127, A, C), while in the fishes of the genus *Citharoides,* the first hypural is not attached to it (Fig. 127, B). The sixth hypural* is inserted between the fifth hypural and the uroneural 2, without attaching to the urostyle (Fig. 127, A-C). In all the members of the families Paralichthyidae and Bothidae, however, they are three in number with fusions between the second and the third hypurals (hypural 2 + 3), between the fourth and the fifth hypurals (hypural 4 + 5), and between the sixth hypural and the uroneural 2 or even the epural (hypural 6 + ur 2 or hypural 6 + ur 2 + ep); the hypural 4 + 5 completely is fused with the urostyle, the hypural 2 + 3 is attached to the basis of the urostyle + hypural 4 + 5 ventrally (Fig. 127, D-O; Fig. 128, A-H).

The first hypural** whose the ventral border is usually connected with the last haemal arch, but the base is attached to neither the urostyle nor the urostyle + hypural 4 + 5.

In all the members of the family Paralichthyidae the three hypurals and the hypural 6 + ur 2 + ep are divided into several parts from the tip to near the base. In the fishes of the family Bothidae with exception the fishes of the four genera *Engyprosopon, Crossorhombus, Psettina* and *Asterorhombus,* however, each bone is platelike shaped without being branched. In the fishes of the genera *Engyprosopon* and *Asterorhombus,* the three hypurals and the hypural 6 + ur 2 + ep are divided into some parts at the tip (Fig. 127, J, K), while in the fishes of the genus *Psettina* and *Crossorhombus kobensis* there are not divided bones but several grooves on the bones (Fig. 127, G, H). In *Crossorhombus kanekonis,* on the other hand, the hypural 2 + 3 and the hypural 4 + 5 are similar to those of *Engyprosopon,* but the other bones are platelike shaped without being branched (Fig. 127, I).

These hypurals and the hypural 6 + ur 2 + ep or hypural 6 + ur 2 show the three different patterns by the feature dividing the each bone. The first pattern is found in *Paralichthys olivaceus,* in which there is each division as two parts in the first hypural, five parts in the hypural 2 + 3, six parts in the hypural 4 + 5 and two parts in the hypural 6 + ur 2 (Fig. 127, D). In the second pattern as represented by *Pseudorhombus cinnamoneus, P. levisquamis, P. pentophthalmus* and *P. oculocirris,* the first hypural is divided into three parts, the hypural 2 + 3 into four parts, the hypural 4 + 5 into six parts, and the hypural 6 + ur 2 + ep into two parts (Fig. 127, E). The third pattern is found in the following species: *Pseudorhombus oligodon, P. arsius, P. dupliciocellatus, Tarphops oligolepis, T. elegans, Engyprosopon grandisquama, E. multisquama, E. macroptera, E. xystrias* and *Asterorhombus intermedius,* in which there is each division as three parts in the first hypural, four parts in the hypural 2 + 3, five parts in the hypural 4 + 5 and three parts in the hypural 6 + ur 2 + ep (Fig. 127, F, J, K). In *Crossorhombus kanekonis* the first hypural and the hypural 6 + ur 2 + ep is not divided, but the divisional feature of the other hypurals agrees with that of the last pattern (Fig. 127, I).

The neural and haemal spines related to the preterminal vertebra, which lie in front of the urostyle, have undergone so various transformation that these spines bear some caudal

*WU (1932) called the bone the radials dorsal.

**This bone is called the ventral radialis by WHITEHOUSE (1910) and BARRINGTON (1910) respectively, and the prohypural by CHABANAUD (1937).

rays. These spines* which are more or less platelike are more elongate to posterior margin of the caudal skeleton than the other ones. In *Taeniopsetta ocellata, Parabothus coarctatus* and *Laeops kitaharae* the tips of those spines are provided with the bifurcation even among the same species (Fig. 127, L; Fig. 128, A, D).

Psettodes erumei has a preterminal centrum articulated to both the neural and haemal spines (Fig. 127, A), but in *Citharoides macrolepidotus* and *Lepidoblepharon ophthalmolepis* the centrum is articulated to the haemal spine, but fused completely with the neural spine (Fig. 127, B, C). In all the members of the families Paralichthyidae and Bothidae

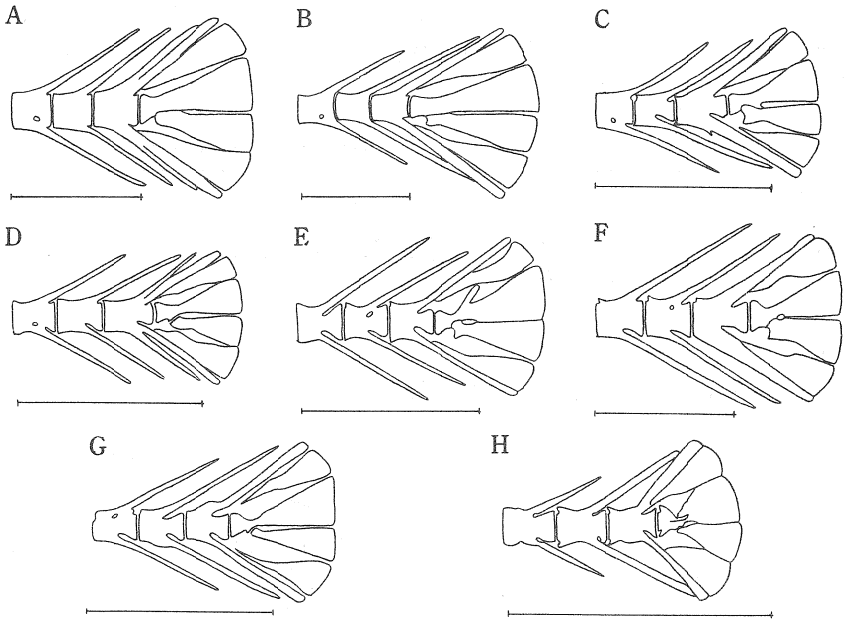

Fig. 128. Lateral aspect of the caudal skeleton in eight species. A, *Parabothus coarctatus*; B, *Arnoglossus polyspilus*; C, *Japonolaeops dentatus*; D, *Laeops kitaharae*; E, *L. nigromaculatus*; F, *Neolaeops microphthalmus*; G, *Kamoharaia megastoma*; H, *Chascanopsetta lugubris*. Scales indicate 1 mm.

the centrum is fused fully with the both spines (Fig. 127, D-O; Fig. 128, A-H). In the members of the family Bothidae, in general, the posterior margins of the bases of the neural and haemal spines related to the preterminal vertebra have a pair of slits directed toward middle parts of the centrum (Fig. 127, G-O; Fig. 128, A-H). Among the family Bothidae, the fishes of the five genera *Laeops, Chascanopsetta, Kamoharaia, Neolaeops* and *Japonolaeops* have the deepest slits not only on both bases of the neural and haemal spines of the preterminal vertebra, but also on both bases of one or two centra in front of the preterminal

*WHITEHOUSE and BARRINGTON called those spines the epural and hypural bones respectively.

vertebra (Fig. 128, C-H). On the other hand, in the fishes of the genera *Psettodes, Citharoides, Lepidoblepharon, Paralichthys, Pseudorhombus* and *Tarphops* the slits scarcely occur (Fig. 127, A-F).

Discussion: Although the osteology of the caudal skeleton in the flounders has already been investigated by Wu (1932) and CHABANAUD (1937), their knowledge on these relationships remain incomplete and meager. Through the more detailed comparative study with reference to Japanese flounders the present author could succeed in finding some relationships between genera, subfamilies and families viewed from the structure of the caudal skeleton. Interrelations among various forms of the caudal skeletons in the flounders will be considered from the phylogenetic point of view. In such a consideration it appears to be worthy to note following points particularly: presence or absence of the fusion

Table 14. Four types and seven subtypes of caudal skeleton in Japanese flounders.

<table>
<tr><th rowspan="2">Types or subtypes</th><th colspan="6">Characters</th></tr>
<tr><th>Urostyle</th><th>Last neural spine and centrum</th><th>Last haemal spine and centrum</th><th>Hypurals</th><th>Uroneural 1</th><th>Uroneural 2</th></tr>
<tr><td>1a</td><td rowspan="2">not fuse</td><td>not fuse</td><td rowspan="2">not fuse</td><td rowspan="2">not fuse, hy1 to hy6</td><td rowspan="3">present</td><td rowspan="2">not fuse</td></tr>
<tr><td>1b</td><td rowspan="8">fuse</td></tr>
<tr><td>2</td><td rowspan="7">fuse, urostyle + hy4+hy5</td><td rowspan="7">fuse</td><td>fuse, hy1 hy2+hy3 hy4+hy5 hy6+ur2</td><td>fuse, ur2+hy6</td></tr>
<tr><td>3</td><td rowspan="5">fuse, hy1 hy2+hy3 hy4+hy5 hy6+ur2+ep</td><td rowspan="5">absent</td><td rowspan="5">fuse, ur2+hy6+ep</td></tr>
<tr><td>4a</td></tr>
<tr><td>4b</td></tr>
<tr><td>4c</td></tr>
<tr><td>4d</td></tr>
<tr><td>4e</td><td></td></tr>
</table>

between the uroneural 1 or the uroneural 2 and other bones; whether the fusion is present or not between the urostyle and the hypural; the number of the hypural; the shape of the epural and the hypural; presence or absence of the slits on each base of the neural and haemal spines related to the preterminal vertebra.

As mentioned above, as to the structure of the caudal skeleton, Japanese flounders are conspicously grouped into four major types, the first and the last types are further divisible into the two and five subtypes respectively (Table 14).

The type 1 comprising the fishes of the three genera *Psettodes, Citharoides* and *Lepidoblepharon* seems to represent the primitive condition, because it has an uroneural 1, an uroneural 2 and six hypurals in number, and the urostyle is not fused with the hypural. The subtype 1a including the fishes of the genus *Psettodes* has more primitive structure than the subtype 1b, because it has the centrum articulated to each neural and haemal

Table 14. (continued)

Epural	Slits of neural and haemal spines	Features of hy and ep	Genera and species
not fuse	absent	six plates	*Psettodes*
			Citharoides *Lepidoblepharon*
		branched	*Paralichthys*
			Pseudorhombus *Tarphops*
fuse, ep+ur2−hy6	present	groove	*Psettina* *Crossorhombus kobensis*
		branched+plate	*Crossorhombus kanekonis*
		branched	*Engyprosopon* *Asterorhombus*
		three plates	*Bothus, Parabothus, Arnoglossus* *Taeniopsetta, Tosarhombus*
			Laeops, Japonolaeops, Neolaeops *Kamoharaia, Chascanopsetta*

spine, and the greatest uroneural 1. On the other hand, the subtype 1b, including two genera *Citharoides* and *Lepidoblepharon,* which have a fusion between the centrum of the preterminal vertebra and only the neural spine, and very small uroneural 1 ought to be regarded as more advanced than the subtype 1a.

In the type 2, including only the fishes of the genus *Paralichthys* fusions are found to occur between such bones as the second and the third hypurals, the fourth and the fifth hypurals, the sixth hypural and the uroneural 2 and additionally between the centrum and the last both spines. In such a case it may be reasonable to consider the type 2 as more advanced form than the type 1, though it remains the small uroneural 1.

The type 3 represented by the fishes of the genera *Pseudorhombus* and *Tarphops* is allied to the previous type; it has the centrum fused with the neural and haemal spines, and is not provided with a pair of slits at these bases, and the hypurals are divided into several parts at the tip. This type, however, has more specialized characters; the uroneural 1 disappears and the uroneural 2 and epural are fused with other bones.

The type 4 differs from the preceding types in having the slits at each base of the neural and haemal spines, which seem to be developed through the different linages. In the type 4 differentiation is so much diversified as to yield the five subtypes. In the subtype 4a which involves the fishes of the genus *Psettina,* and *Crossorhombus kobensis,* no three hypurals and hypural 6 + ur 2 + ep have several divisions, but obviously have several grooves on these parts. In the subtype 4b including *Crossorhombus kanekonis,* the hypural 2 + 3 and hypural 4 + 5 is divided into several parts at the tip, but the first hypural and the hypural 6 + ur 2 + ep are not so. The subtype 4c represented by the members of the fishes of the genera *Engyprosopon* and *Asterorhombus* has a character that three hypurals and the hypural 6 + ur 2 + ep are divided into several parts at the tip. The subtype 4d including the fishes of the genera *Bothus, Parabothus, Tosarhombus, Taeniopsetta* and *Arnoglossus,* and the subtype 4e including the fishes of the genera *Laeops, Neolaeops, Japonolaeops, Chascanopsetta* and *Kamoharaia* closely resembles the subtype 4a in having no several divisions of these bones, but differs from it in having complete smooth platelike bones. In the subtype 4d the slits being the posterior margin of the posteriormost neural and haemal spines are very shallow, and the caudal skeleton is relatively well ossified, while in the subtype 4e, the slits are extremely deep, formed at least in one or two centra in front of the preterminal vertebra, and the caudal skeleton is comparatively less ossified.

GOSLINE (1961), which has examined the caudal skeleton of the many lower teleostean fishes conclusively reported that within and between orders, the caudal elements are brought about by loss and fuse in more advanced form, and at last these will be a simple platelike caudal skeleton. The similarity occurs apparently among flounders. These facts suggest an inquiry into the possibility of phylogenetic relationship to the fishes of this group. The type 1, having many caudal elements, shows most primitive and generalized forms, from which types 2, 3 and 4 seems to evolve one after another with the fusion and reduction of the caudal elements. Such fact may represent the trend in the evolution within order of teleostean fishes, and is reported already on many fishes (GOSLINE, 1961; HOLLISTER, 1937).

On this point, it may be reasonable to consider that the subtypes 4d and 4e have evolved probably along the main course of evolution among flounders.

It is peculiar feature that the types 2 and 3 and the subtypes 4b and 4c have three hypurals and hypural 6 + ur 2 + ep divided into several parts at the tip. The aspect of such a caudal skeleton has been found in some pleuronectid fishes (Whitehouse, 1910). It is probably interpreted that after a main trend of evolution is brought about by fusions and losses of the caudal elements, these types and subtypes originate secondarily apart from the main stem of the evolution. This fact is discussed below.

Biological adaptation: The caudal skeletons of the flounders have the two peculiar features which seem to develope in response to a mode of life; the symmetrization in structure of the upper and lower lobes and secondary redivision in the caudal skeleton. As aforementioned, the type 1 has the sixth hypural expanded to far upper part, the small rectangular epural and uroneural bones on it, and the upturned urostyle. These features are entirely asymmetry. In the type 2, the hypural 4 + 5 is fused completely with the urostyle, the hypural 6 + ur 2 is almost fanlike in shape, and the hypural 6 + ur 2 plus the epural and the first hypural, as well as hypural 2 + 3 and hypural 4 + 5 are symmetry respectively. The caudal skeleton in the types 3 and 4 shows a rather stronger tendency toward the symmetry than that in previous types.

Now, it may be highly probable that the caudal elements of flounders develope in response to propelling the body by means of the upper and lower motions of the caudal fin.

In the primitive forms of flounders, the caudal skeleton remains asymmetrical form, but it is more symmetrized as it evolves.

In the latter case, the first hypural, hypural 2 + 3, hypural 4 + 5, and hypural 6 + ur 2 represented by the type 2, the first hypural to hypural 4 + 5 and hypural 6 + ur 2 + ep represented by the type 3 and the subtypes 4a, 4b and 4c are divided into several parts or they are concave shallowly on these parts. Ochiai (1959) pointed out in his study of Soleina that the number of many divided parts is closely related to that of the caudal rays, and that these counts decrease in according with the degeneration of the caudal fin. In the flounders, however, since there are the divided 16 to 17 bony parts and constant 17 caudal rays, such relationship may not be recognizable. In the flounders it seems probable that there are some relationships between division of many parts in the caudal skeleton and depth of the caudal peduncle, and also between them and the depth of the habitat of the fish (Fig. 129).

In the members including the type 2, the type 3 and the subtypes 4a, 4b and 4c, the depth of the caudal peduncle is high, 8.2 to 9.8, 6.8 to 10.5 and 6.6 to 9.6 times in standard length respectively, and they live in the shallow water. On the other hand, in the members including the subtypes 4d and 4e the depth of the caudal peduncle is rather low, 8.8 to 12.3 and 13.7 to 19.1 times in standard length respectively, and they generally live in the rather deep water except for two species, *Bothus mancus* and *B. pantherinus*.

Now, it is highly possible that the depth of the caudal peduncle is related to swimming power. The member living in the shallow water seems to be required stronger swimming power to the feeding and the escaping than that living in the deep water. From these, it is concluded that the division of the caudal skeleton appears to be developed deviated from the main stem in response to strong swimming power, after the main course of

evolution is determined by losses and fusions of the bones.

Relation between other orders and flounders: As stated above, in the flounders there is a gradation in the caudal skeleton from primitive form to specialized form. The caudal skeleton of *Psettodes erumei* represented by primitive feature with regard to the number of caudal rays and the structure of the caudal skeleton is compared with that of other orders.

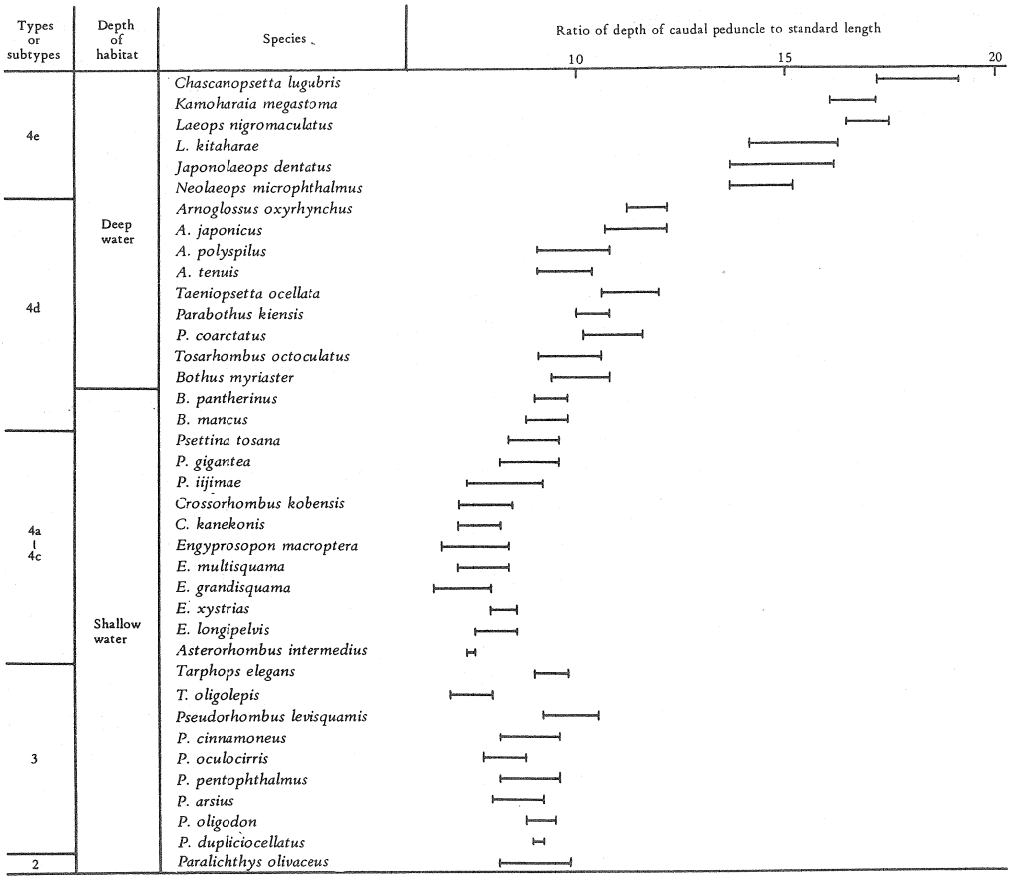

Fig. 129. Relationships between the depth of habitat and the ratio of the depth of caudal peduncle to standard length, and also between them and types or subtypes in Japanese flounders.

Whitehouse (1910) pointed out that the features of the urostyle and the hypural of *Solea lutea* (Soleina) and *Pleuronectes platessa* (pleuronectid) figured by Cole and Johnstone (1901) resemble essentially that of *Zeus* (Zeidae).

In four species of Japanese Zeidae, *Zeus japonicus, Zen itea, Zenion japonicum* and *Parazen pacificus* examined, all have the hypural fused with each other and the urostyle

completely fused with hypurals, the epurals are either two or three in number (Fig. 130, A-C). So far as number of the epurals is concerned, the species of Zeidae remain obviously more primitive feature than *Psettodes erumei,* but as to the hypural, the uroneural and the fusion of the centrum with the neural spine in the preterminal vertebra, the caudal skeleton of the Zeidae is considerably well specialized. On the other hand, with regard to the number of the caudal fin rays, the formula is 2 + 11 + 2 = 15 in *Zeus japonicus,* 10 + 9 + 9 = 28 in *Parazen pacificus,* 3 + 11 + 3 = 17 in *Zenion japonicum* and 4 + 11 + 4 = 19 in *Zen itea.* The most significant difference occurs in number of the branched rays and in the relation between the number of branched rays and that of the unbranched rays. So far as the caudal skeleton and the caudal rays are concerned, as the Japanese fishes of Zeidae are so specialized within order, the resemblance between the members of Zeidae and *Psettodes erumei* has obscured.

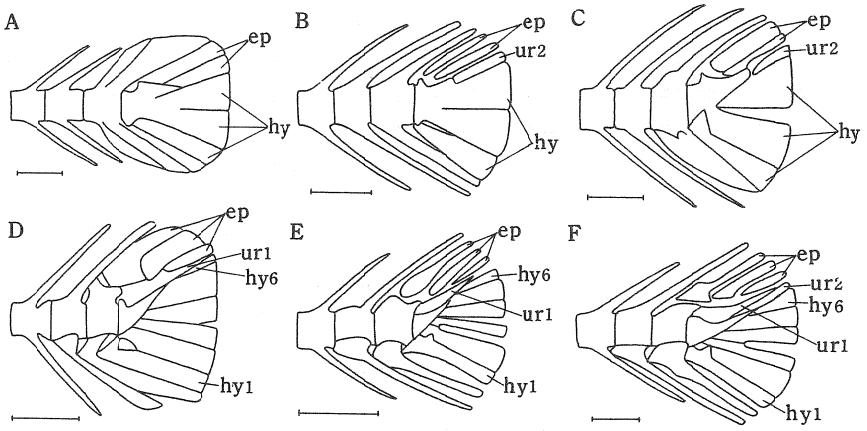

Fig. 130. Lateral aspect of caudal skeleton in six species. A, *Zeus japonicus*; B, *Zen itea*; C, *Parazen pacificus*; D, *Antigonia capros*; E, *Epinephelus epistictus*; F, *Lateolabrax japonicus.* Abbreviations as in Fig. 127. Scales indicate 1 mm.

When the specialized members of flounders are compared with the species of Zeidae, the fusion between the hypural and the urostyle is considerably different feature. From these, it is concluded that no relationships are found to be exist between the features of caudal skeleton and the number of caudal fin rays in zeiform fishes and those in flounders.

Gosline (1961) reported that among the zeiform, *Antigonia* is most primitive form, and its caudal skeleton bears a striking resemblance to that of perciform. As pointed out by Matsubara (1955), however, Antigonidae is not the member of zeiform, but that of perciform (Fig. 130, D).

Wu (1932), in his study of Heterosomata, emphasized the close relationships of *Psettodes erumei* to the member of the Serranidae. An examination of the caudal skeletons of *Epinephelus epistictus, Lateolabrax japonicus, Epinephelus bonaci* (Gosline, 1961) and *Serranus cobriela* (Whitehouse, 1910) indicates that those general features are closely related

to that of *Psettodes erumei* (Fig. 130, E, F). Among those perciform, the number of the uroneural of *Lateolabrax japonicus* agrees well with *Psettodes erumei*, but number of the epural is different; three in *L. japonicus*, one in *P. erumei*. This may be interpreted by the fact that the epural 1 and epural 2 + epural 3 in the former agree with the neural spines of preterminal vertebra and the epural in the latter respectively. Goslin (1961) reported that the caudal skeleton in pleuronectid form is considerably more fused than that in the basal percoid. However, the caudal skeleton of *Psettodes erumei* has as some basic structure as that of percoid.

As to the caudal fin rays, the formula is found to be 9 + 15 + 9 = 33 in *Epinephelus epistictus*, 13 + 15 + 12 = 40 in *Lateorabrax japonicus*, and the branched rays of both species agree well with that of *Psettodes erumei* (5 + 15 + 4 = 24). On the basis of this character, Regan (1910) already pointed out that *Psettodes erumei* is no more than asymmetrical percoid. But the low number of the unbranched rays in *Psettodes erumei* may represent somewhat specialized feature. From these, finally, it is concluded that *P. erumei* which is most primitive form among flounders is derived from percoid-like stock, and is a little more specialized form than living species of Serranidae. On the other hand, it is presumed that *P. erumei* may be related to the basal zeiform, but so far as living species of the zeiform is concerned, there is no close correlation between the flounders and the zeiform.

V. General consideration

1. Origin of the flatfishes

The flatfishes comprise various large groups, although they are distinguished from the others in having the two eyes on the one side of the head. As to relationship of the flatfishes, they have been considered to be related to Chaetodontidae and Scorpididae (Agassiz, 1842), to Taeniosomous fishes (Gill, 1887), to such deep-bodies fishes as *Platax*, *Dascyllus* or *Zeus* of Chaetodontidae and Zeidae (Holt, 1894), to Gadidae (Jordan and Evermann, 1898), to Zeidae (Boulenger, 1902; Thilo, 1902), to Percomorphi (Regan, 1910) and to Anacanthini and Allotriognathi (Jordan, 1923). All the authors so far mentioned appear to regard the flatfishes as the monophyletic group. Kyle (1921), however, concluded that the origin of the group was polyphyletic, and that each group of flatfishes have sprung from such different lines as Macrurids, Trachypterids, Psettidae, Storomateoides and so on. Norman (1934), having compared the osteology of *Psettodes*, which is the least specialized member and from which flatfishes are believed to be derived with that of a generalized Ganoid, Zeoid and Percoid respectively, pointed out that the resemblance is so striking that there can be doubtless about its relationship with Percoid in following important characters: 1) dorsal fin has first 10 spines and does not extend forward on to head; 2) caudal fin has 17 principal rays, 15 of which are branched; 3) ventral fin consists of a spine and five soft rays; 4) supplemental maxillary present; 5) form of mouth; 6) feature of

ventral fins; 7) form of pectoral arch; 8) attachment of ventral fins; 9) form of vertebral column; 10) number of vertebrae; 11) form of sagitta. With regard to origin of flatfishes, NORMAN (1934) was finally led to conclude "that *Psettodes* is the least specialized member of the Heterosomata, and all the available anatomical evidence supports the view that it has been derived from a generalized Percoid stock, and that the Heterosomata represent a homogenous group, although it is just possible that the Soleidae and Cynoglossidae may have arisen from another part of the Percoid stem." HUBBS (1945) additionally gave the following characters as primitive features of *Psettodes* which are considerably related to the Percoid: 1) optic chiasma; 2) shape of urohyal; 3) feature of branchiostegal membranes; 4) vomerine teeth; 5) teeth on palatine and glossohyal; 6) position of anus and genital papilla, stating that "it seems most in line with the available evidence to regard the Heterosomata as a natural group," although the polyphylety of the Heterosomata remains a possibility. Recently, MATSUBARA (1964) noted that *Psettodes* is closely related to a fossil form *Amphistium* which is considered as an ancestral form of Zeidae, at least in having the following points: 1) body is very deep; 2) body cavity is exceedingly small in size; 3) three to five spines on dorsal and anal fins, and spinous portion is connected with the soft ray portion; 4) each ventral fin is thorasic in position with a spine at anterior margin; 5) pelvic girdle is attached to clavicle; 6) arrangement of scales are imbrication; 7) 10 + 14 = 24 vertebrae, although he recognized that the *Psettodes* is descended from a typical Percoid pointed out by REGAN (1910), NORMAN (1934) and HUBBS (1945). Finally, the conclusion is reached that the Heterosomata is differentiated from an ancestral Percoid which has as many important characters as the Percoid.

In order to presume the origin of the flatfishes, the author has taken into consideration following primitive characters existing in the cranium, the orbital bones, the gill-rakers, the branchial apparatus, the urohyal, the vertebrae, the caudal rays and the caudal skeleton: 1) vomerine teeth are present; 2) supraoccipital is widely connected with exoccipital; 3) zygapophyses of exoccipitals are widely adjoining; 4) alisphenoid on ocular side is large, extending to orbital cavity; 5) relation of mesethmoid, prefrontal, frontal and pseudomesial bar is type A; 6) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is type A; 7) one preorbital and four suborbital bones; 8) first, second and third upper pharyngeal bones with toothed band; 9) first epibranchial is bifurcate; 10) ceratobranchial is elongate; 11) second hypobranchial is an elongated rectangular shape, with toothed plate; 12) third hypobranchial is elliptical in shape, with toothed band; 13) second basibranchial is type A; 14) glossohyal is very short; 15) urohyal is rectangular in shape; 16) gill-rakers are on upper limb; 17) tubercles are present on outer and inner sides of gill-arch; 18) first to sixth neural spines are platelike in shape; 19) first haemal spine is moderate in size; 20) opening for notochord is moderate or large in size; 21) opening of notochord is advanced; 22) transverse apophyses are present; 23) parapophysial stay is present; 24) feature of concavity of centrum is type C; 25) neural postzygapophyses beneath prezygapophyses are from first to tenth vertebrae; 26) epicentrum, epimeral, hypomeral and myorhabdoi are present; 27) caudal vertebrae are 14; 28) urostyle is not fused with hypural; 29) last neural and haemal spines are not fused with centrum; 30) there are six hypurals; 31) uroneural 1 and 2 are present; 32) epurals are present; 33) caudal rays are 5 + 15 + 4 = 24. Among

those characters, *Psettodes* is apparently most primitive in having 1) to 19), 25) and 27) to 33), which as a whole suggests a close relationship with the Percoid, as NORMAN (1934) and HUBBS (1945) already pointed out. As we already discussed, however, it is worthy of special mention that the family Bothidae (although NORMAN and HUBBS placed on the subfamily Bothinae) as a natural group are provided with very primitive characters 20), 21), 22), 24) and 26), which are apparently uncommon in other flounders which have been examined by the author or even in the osteologically-known species of the order Heterosomata. Especially, the last character is found in a clupeoid fish such as *Sardinops coerules* (PHILLIPS, 1942) and an apodal fish of *Anago anago* (ASANO, 1962). It is clearly impossible to consider as an adaptative character, since the family Bothidae as a natural group is provided with such characters and the rest (Psettodidae, Citharidae and Paralichthyidae) is entirely lacking them. Such being the case, those characters may also afford us a part of sound bases for considering the origin of the Heterosomata.

From these facts mentioned above, the Heterosomata is not a natural group derived from such a single stock as a generalized Percoid as NORMAN and HUBBS pointed out, but the writer considers that the Heterosomata has sprung off from different stocks among the ancestral Percoid much earlier than extending to Percoid.

2. Differentiation of the genera of the sinistral flounders and the related flatfishes

The relationship among the suborders, families and subfamilies has already been carried out by many ichthyologists (REGAN, 1910; KYLE, 1921; NORMAN, 1934; CHABANAUD, 1934-1937; HUBBS, 1963; MATSUBARA, 1963). In order to presume the relationship of suborders, families, subfamilies and genera among Japanese sinistral flounders and the related flatfishes, we have particularly taken those characters existing in the cranium, orbital bones, branchial apparatus, urohyal, vertebrae, caudal rays and caudal skeleton into consideration, and also important both external and internal characters already worked out. Having discussed in the preceding chapters the degree of differentiation of all the those characters, we may give a concise summary which indicates mainly genetic differentiation (Table 15).

In accordance with Table 15, Fig. 131 has been drawn as a presumable phylogenetic scheme of the sinistral flounders and the related flatfishes, mainly based on morphology of Japanese flounders. From this phylogenetical tree, it will be found that we have recognized four large genetic stems; *Psettodes*-stem (B), *Citharoides*-stem (D), *Paralichthys*-stem (E) and *Bothus*-stem (H). The differentiation of characters in which they are distinguished each other is so remarkable that the four stems should be better regarded as families Psettodidae, Citharidae, Paralichthyidae and Bothidae, the last two families are thought to be newly elevated to the rank of family.

Psettodes-stem (B) is represented only by the genus *Psettodes*. The characters of this stem which are apparently distinguished from those of the other stems are as follow: 1) vomerine teeth is present; 2) supraoccipital bone is widely connected on both sides with exoccipitals; epiotics are widely separated with each other; 3) alisphenoid on ocular side

is large, extending anteriorly to orbital cavity; 4) relation of mesethmoid, prefrontals, frontals and pseudomesial bar is shown by type A; 5) gill-rakers armed with barbed tip; 6) four suborbital bones are present on ocular side; 7) one preorbital bone is present, but suborbital bone is absent on blind side; 8) second epibranchial bone lacks toothed band; 9) ceratobranchials are elongate; 10) second and third hypobranchials armed with toothed plate; 11) second basibranchial is as shown by type A; 12) glossohyal is very short; 13) urohyal is rectangular in shape; 14) platelike neural spines are present on first to sixth vertebrae; 15) neural postzygapophyses beneath prezygapophyses are present on first to tenth vertebrae; 16) first haemal spine is moderate in size; 17) 14 caudal vertebrae are present; 18) last

Table 15. The characters of the various parts of the body in Japanese flounders. The characteristic of each type and subtype for each column, see text of the preceding chapters. Type 1 is usually more primitive or generalized than type 2 and so on, but in several characters as shown Table 12, types 4 to 9 are more primitive or generalized than types 1 to 3.

Genera	Cranium	Orbital bones	Branchial apparatus	Urohyal	Vertebrae	Caudal rays and its skeleton	Stems	Substems
Psettodes	1	1	1	1	1	1a	*Psettodes*	
Citharoides *Lepidoblepharon*	2	2	2	2	2	1b	*Citharoides*	—
Paralichthys	3	2	3	3a	3	2	*Paralichthys*	
Pseudorhombus *Tarphops*			4	3b		3		
Taeniopsetta	4	3a	5a	4	4	4a-4d	*Bothus*	*Taeniopsetta*
Engyprosopon *Crossorhombus*	5	3c	5c	6	5			*Engyprosopon*
Tosarhombus *Parabothus*			5a	5a				
Bothus	6	3b		6	6			*Bothus*
Asterorhombus *Psettina* *Arnoglossus*	7	3c		5a	5			*Arnoglossus*
Japonolaeops	8		5b	5b	7	4e		*Laeops*
Laeops *Neolaeops*					8			
Kamoharaia			6	7				
Chascanopsetta	9	3b	7	8	9			*Chascanopsetta*

neural spine is not fused with centrum; 19) caudal rays are composed of 5 + 15 + 4 = 24. As indicated by the type 1 in Table 15, the *Psettodes*-stem is apparently, as a whole, more primitive than the others.

Besides those characters, the following characters are also primitive as pointed out by NORMAN (1934) and HUBBS (1945): 1) dorsal fin has first 10 spines and does not extend forward on to head; 2) ventral fin consists of a spine and five soft rays; 3) supplemental maxillary is well-developed; 4) pelvic bone does not extend to shoulder girdle; 5) palatine and glossohyal are armed with teeth; 6) optic chiasma is dimorphic; 7) branchiostegal membranes are widely separated. REGAN (1910), NORMAN (1934) and HUBBS (1945) have pointed out that *Psettodes* branched off from near the base of the Heterosomata, since there can be observed characters of extreme primitiveness distinguishing *Psettodes* from other flatfishes. In agreement with them, it is also thought that the *Psettodes*-stem might be differentiated from an ancestral stem line at a considerably earlier stage in the course of flatfishes evolution, when the above-mentioned primitive and well differentiated characters are emphasized.

According to HUBBS' opinion, we ought to recognized that the *Psettodes*-stem should be better regarded as a suborder Psettodina.

Citharoides-stem (D) including the two genera, *Citharoides* and *Lepidoblepharon* of Japanese flounders is usually distinguished from the other stems in having the following characteristics: 1) supraoccipital bone is connected with exoccipitals by a narrow patch or at its tip; epiotics are separated from each other; 2) alisphenoid on ocular side is large or moderate in size, extending to orbital cavity or not; 3) relation of mesethmoid, prefrontals, frontals and pseudomesial bar is type B; 4) second basibranchial is type B; 5) tip of sciatic part is posterior 1/3 of main part; 6) cardiac apophysis is simple in shape; 7) platelike neural spines are on first to fourth vertebrae; 8) neural postzygapophyses beneath prezygapophyses are on eighth to tenth vertebrae; 9) caudal vertebrae are 20 to 22 in number; 10) caudal rays are 4 + 15 + 4 = 23. As indicated by the type 2 or subtype 1b in Table 15, it is presumed that this stem is slightly more specialized than the former stem.

In other respect, this stem seem to be more closely related to the *Psettodes*-stem in having the following characteristics: 1) zygapophyses of exoccipitals are widely adjoining; 2) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is type A; 3) second and third upper pharyngeal bones are armed with toothed band; 4) epipleural bone begins with first vertebra; 5) urostyle is not fused to any of the hypural; 6) last haemal spine is not fused to centrum; 7) hypurals are six plate bones; 8) uroneural 2 is present.

HUBBS (1945) already suggested that the members of the family Citharidae provided with the ventral fin of a spine and five soft rays, the wide separation of the branchiostegal membranes and so on, are closely related to the genus *Psettodes*, and that the family Citharidae may be regarded as transitional between the fishes of the family Psettodidae and the more typical members of the pleuronectid series. On the other hand, however, the present stem shares with the *Paralichthys*-stem (E), as discussed below, for having more specialized characters, but most of the generic characters of this stem may be sharply distinguished from the *Bothus*-stem. Judging from these features, the present author has come to a conclusion that this stem is presumably not on the *Bothus*-stem, but rather on

a lower branch set apart from the main line (C) of *Paralichthys*-stem.

The genus *Lepidoblepharon* having both eyes on the right side is provided with the large alisphenoid extending to the orbital cavity, 20 caudal vertebrae, the supraoccipital bone is connected with exoccipitals by a narrow patch, and the epiotics are widely separated from each other. The genus *Citharoides* having both eyes on the left side, is provided with rather small alisphenoid without extending to the orbital cavity, 22 caudal vertebrae, the supraoccipital is connected with exoccipitals at its tip, and the epiotics are narrowly separated from each other. These features may suggest that the members of the former genus are slightly more primitive than the members of the latter genus.

Paralichthys-stem (E) is apparently distinguished from the other stems in having following important characteristics: 1) supraoccipital is connected with exoccipitals, and epiotics are narrowly separated from each other; 2) zygapophyses of exoccipitals are slightly apart from each other; 3) alisphenoid is large or moderate in size, not extending to orbital cavity; 4) relation of mesethmoid, prefrontals, frontals and pseudomesial bar is type C; 5) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is type B; 6) second and third upper pharyngeal teeth are two to three rows; 7) cardiac apophysis of urohyal is bifurcate; 8) platelike neural spines are on first to third or first to fourth vertebrae; 9) epipleural begins with second vertebra.

As indicated by types 2, 3 or 4 in Table 15, these features are as a whole, apparently more specialized than those of the former stems.

The closed relationship between this stem and the former two stems is apparently further strengthened in having such characteristics as: 1) supraoccipital is connected with exoccipitals; 2) alisphenoid is large or moderate in size; 3) frontal on blind side forms inner side of interorbital bone; 4) preorbital bone is present on blind side; 5) lower pharyngeal bone is barlike in shape and armed with toothed band; 6) third basibranchial is type A; 7) first neural spine is present; 8) position of opening for notochord is present in middle portion of centrum; 9) parapophysial stay is present; 10) transverse apophysis is absent; 11) rib and epipleural are present; 12) epicentrum, epimeral, hypomeral and myorhabdoi are absent; 13) slits of last neural and haemal spines are absent. Moreover, this stem especially resembles the *Citharoides*-stem, in having five to seven suborbital bones on the blind side, scaly nodulelike suborbital bones on the ocular side, the second hypobranchial of rectangular shape, the third hypobranchial of elliptical shape, the third epibranchial with toothed band and a small cardiac apophysis.

On the basis of those features, it is very probable, therefore, that the present stem may has arisen from an ancestor not very unlike the members of the *Citharoides*-stem.

The present stem is naturally subdivided into two groups; the first group represented by *Paralichthys,* and the second group exemplified by *Pseudorhombus* and *Tarphops*. The first group is unquestionably most primitive at least in having following characteristics: 1) first upper pharyngeal bone is provided with toothed band; 2) first epibranchial bone is bifurcate; 3) epural is present; 4) tip of cardiac part is in middle of main part; 5) caudal rays are 3 + 13 + 2 = 18; 6) platelike neural spines are first to fourth vertebrae; 7) uroneural 1 is present. The second group as shown in Table 15 is apparently more specialized than the former group in having the following features: 1) first upper pharyngeal teeth are

arranged in two to three rows; 2) first epibranchial is not bifurcate; 3) uroneural 1 is absent; 4) epural is absent; 5) suborbital bones on blind side are more than five in number; 6) tip of sciatic part is more advanced than middle of the main part; 7) platelike neural spines are present on first to third vertebrae; 8) caudal rays are 17 in number.

Although there are a little osteological differences between *Pseudorhombus* and *Tarphops*, the latter genus may be slightly specialized than the former one in having the dwarf form.

On the basis of these features, a presumable phylogenetic position of two group is indicated in Fig. 131.

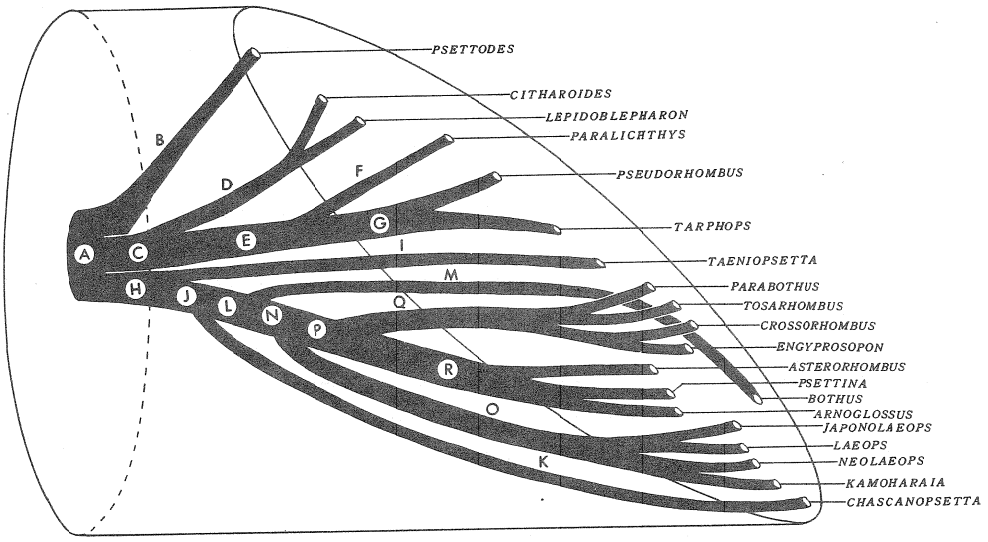

Fig. 131. A presumable phylogenetic tree of the genera of the Japanese sinistral flounders and related flatfishes.

Bothus-stem (H): most of the Japanese sinistral flounders' genera are indicated in this stem, though they may be subdivided into many groups. This stem is apparently distinguished from the former stems in having the following characters: 1) supraoccipital is not connected with exoccipitals; 2) zygapophyses of exoccipitals widely apart from each other; 3) alisphenoid on ocular side is either very small or absent; 4) relation of mesethmoid, prefrontals, frontals and pseudomesial bar is types D, E, F or G; frontal on blind side does not form interorbital bone; 5) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is types C, D, E or F; exoccipital is not connected with prootic; 6) suborbital bones on ocular side are entirely absent, and a preorbital bone is absent on blind side; 7) lower pharyngeal bone is compressed, platelike in shape and toothed in one or two rows; 8) upper pharyngeal bone is generally armed with one or two rows of teeth; 9) third basibranchial bone is type B or C; 10) cardiac apophysis is large or moderate in size; 11) first neural spine is entirely absent; 12) platelike neural spine is present in second, or

second to third vertebrae; 13) parapophysial stay is absent; 14) rib and epipleural are absent; 15) each base of ventral fins is well elongated, origin on ocular side is at least more advanced than that on blind side; 16) position of opening for notochord is more or slightly more advanced than in middle of centrum; 17) transverse apophyses are present; 18) epicentrum, epimeral, hypomeral and myorhabdoi are present. Among these characters, 1) to 15) are apparently most specialized, when compared with the former stems (Table 15). But such characters as 16) to 18) may apparently be most primitive, which may not be seen in the genera of the other stems, as already discussed in the preceding chapter.

Thus, the present stem presumably is not involved in the paralichthyid phyletic series, as assumed by many ichthyologists, but it is rather clear that this stem independently has been branched off from near the base of the main line (A) of the Heterosomata, when the *Psettodes*-stem is set apart from the main line simultaneously or afterward, and the members of the present stem may be apparently more specialized than those of any other stem maintaining the most primitive characters.

From Table 15 it will be found that we have recognized six large substems, *Taeniopsetta* substem (I), *Chascanopsetta* substem (K), *Bothus* substem (M), *Laeops* substem (O), *Engyprosopon* substem (Q) and *Arnoglossus* substem (R), though they are closely related with each other.

Taeniopsetta substem (I) represented by a single genus *Taeniopsetta* is rather peculiar to be included in the *Bothus*-stem, and this substem has the following characteristics: 1) ventral fin on ocular side is not advanced; 2) opening for notochord of centrum is very small in size; 3) sciatic part is truncated at its tip; 4) tip of sciatic part well apart from that of pelvic girdle, as seen in those genera of the other stems mentioned above. Except these features, this substem is provided with many important characters which undoubtedly have the basic form of *Bothus*-stem. This substem seems, as a whole, rather primitive for the members of the *Bothus*-stem, particularly the following characters are taken into consideration: 1) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is type C; 2) suborbital bones are five in number on blind side; 3) tip of sciatic part is shorter than that of main part; 4) tip of sciatic part is slightly more advanced than tip of shoulder girdle; 5) position of opening of centrum is slightly advanced.

On the basis of those features, a presumable phylogenetic position of this substem is indicated in Fig. 131. In other words, the substem may have descended earliest from the *Bothus*-stem, related to the members of the *Paralichthys*-stem (E).

Chascanopsetta substem (K) represented only by the genus *Chascanopsetta* is rather peculiar in having both characters of the following specialized (1 to 7) and primitive (8 to 11): 1) relation of pterotic, exoccipital, basioccipital, prootic and opisthotic is type F; 2) cardiac apophysis is barlike in shape; 3) feature of concavity of centrum is type D; 4) second basibranchial is type D; 5) third basibranchial is type C; 6) glossohyal is elongate; 7) position of opening for notochord of centrum is slightly advanced; 8) tip of sciatic part is very short, posterior 1/4 of main part; 9) cardiac apophysis is simple; 10) first and second upper pharyngeals are armed with two rows of teeth; 11) four suborbital bones are present on blind side. Excepting these features, however, most of the genetic characters of this substem are largely similar to those of the *Laeops* substem:

anterior transverse apophysis begins with fourth or fifth vertebra; alisphenoid is entirely absent on ocular side; relation of mesethmoid, prefrontals, frontals and pseudomesial bar is type D; caudal vertebrae are very large in number. Those features being taken into consideration, the phylogenetic position of this substem is presumed to be what is shown in Fig. 131. In other word, the present substem (K) is early set apart from the main line (G) of *Bothus*-stem, and is most specialized independently, closely related to the members of the *Laeops* substem.

The main line (L) of the *Bothus*-stem marked by the fact that the position of the opening for notochord is more advanced than in the middle of the centrum may be branched into the four substems, *Bothus, Laeops, Arnoglossus* and *Engyprosopon.*

Bothus-substem (M) represented by a single genus *Bothus* seems to be more specialized than most of the other substems of the *Bothus*-stem in having such characteristics as: first haemal spine is particularly expanded and the haemapophyses are particularly expanded backward at their tips so as to almost extend to the succeeding ones. On the other hand, this substem seems to be rather primitive, next to the *Taeniopsetta* substem as the members of the *Bothus*-stem in having suborbital bones composed of four bony elements. Excepting these characters, however, the members of this substem are closely related to those of the *Laeops* substem in having such a primitive character as the relation of pterotic, exoccipital, basioccipital, prootic and opisthotic represented by type E, and to the members of the *Engyprosopon* substem in having such specialized characters as the relation of mesethmoid, prefrontals, frontals and pseudomesial bar represented by type G and the tip of sciatic part far more advanced than that of the main part.

In such a case, though a presumable phylogenetic position of this substem is very complex, it is possible that the present substem is specialized independently apart from the main line (N) of the *Bothus*-stem, closely related to the *Engyprosopon* substem and the *Laeops* substem after the *Chascanopsetta* substem branched off from the main line (L). The main phylogenetical line (N) which is here considered to be splited into the *Engyprosopon* substem, the *Laeops* substem and the *Arnoglossus* substem is defined as having the suborbital bones composed of three elements, and is most specialized. Those substems are so familiar with each other that their phylogenetical positions are by no means so simple (Table 15).

The *Laeops* substem (O) is most primitive among these stems in having the large opening of the centrum for notochord and the feature of the concavity of the centrum represented by type C. In other respects, however, the members of this substem quite resemble those of the *Bothus* substem in having the relation of pterotic, exoccipital, basioccipital, prootic and opisthotic represented by type E, and also those of the *Arnoglossus* substem in having the relation of mesethmoid, prefrontals, frontals and pseudomesial bar represented by type D. Excepting those characters, this substem is closely related to the *Chascanopsetta* substem in having the following characters: 1) alisphenoid is entirely absent on ocular side; 2) caudal vertebrae are rather large in number; 3) anterior transverse apophysis begins with either fourth or fifth vertebra; 4) slits of neural and haemal spines are very deep. Therefore, we taking these characters as aforementioned, the present substem presumably has been descended from nearest the offshoots of the *Arnoglossus* and *Bothus* substems in remaining

the primitive characters, and an approach is made toward the *Chascanopsetta* substem as the present substem is specialized.

The present substem is naturally subdivided into two groups; the first group is represented by *Japonolaeops* and *Laeops*, and the second group involving *Neolaeops* and *Kamoharaia*. The first group is apparently marked by rather a small mouth. The genus *Japonolaeops* is most generalized among this substem in having the rectangular second hypobranchial, the third basibranchial represented by type B, the feature of the concavity of the centrum represented by type B, and 11 abdominal vertebrae, and the genus *Japonolaeops* is related to the members of the *Arnoglossus* substem. The genus *Laeops* is more specialized than the genus *Japonolaeops* in having extremely small and very asymmetrical mouth, no teeth on ocular side, and 12 abdominal vertebrae. The second group is unquestionably more specialized than the former group in having a large mouth, the anterior part of the abdominal vertebrae curved downward and more than 13 abdominal vertebrae. The genus *Neolaeops* is less specialized than the genus *Kamoharaia* in having rather large mouth and 13 abdominal vertebrae. The genus *Kamoharaia* is highly specialized among this substem in having the following features: the mouth is extremely large, the glossohyal is attached peculiarly to the first basibranchial, the third basibranchial is represented by type B4, the urohyal has a peculiar feature and the abdominal vertebrae are 14 in number. On the other hand, the members of this genus are closely related to the genus *Chascanopsetta* in having the large mouth and the abdominal vertebrae of rather large number.

The main ascending stem (P) of the *Engyprosopon* substem and the *Arnoglossus* substem is well differentiated in having such highly specialized character as the relation of pterotic, exoccipital, basioccipital, prootic and opisthotic represented by type D. Except this character, this stem (P) is less specialized among the *Bothus* stem at least in having the following characters: 1) alisphenoid is either very small or rudimentary; 2) size of opening for notochord of centrum is moderate in size; 3) feature of concavity is type B; 4) anterior transverse apophysis begins with second vertebra; 5) caudal vertebrae are common in number, and is related considerably well with the members of the *Bothus* substem and even those of the *Taeniopsetta* substem.

The *Engyprosopon* substem (Q) is closely related to the *Bothus* substem and even *Taeniopsetta* substem in having the most highly specialized character among the *Bothus*-stem such as the relation of mesethmoid, prefrontals, frontals and pseudomesial bar represented by types E, F or G.

This substem is represented by the genera *Engyprosopon, Crossorhombus, Tosarhombus* and *Parabothus*. The former two genera are considerably more specialized than the latter ones, in having the tip of the sciatic part far more advanced than that of the main part, the caudal skeleton furnished with many branched parts or grooves, the second hypobranchial of circular shape and the third basibranchial represented by type B3. The genus *Engyprosopon* is apparently less specialized than the genus *Crossorhombus* and may be distinguished from it by following features: the relation of the mesethmoid, prefrontals, frontals and pseudomesial bar is represented by type F and the projection of the frontal bone on the blind side is triangular in shape, as against the latter genus has the relation of those bones represented by type G, and the projection very slender and sticklelike in shape.

The genera *Tosarhombus* and *Parabothus* seem to be less specialized than above-mentioned two genera in having the following characteristics: 1) platelike caudal skeleton, 2) tip of sciatic part extends forward far beyond that of main part, 3) second hypobranchial is type B1. The genus *Tosarhombus* is closely related to the former two genera in having the relation of mesethmoid, prefrontals, frontals and pseudomesial bar represented by type F, while the genus *Parabothus* is less specialized than the genus *Tosarhombus* in having the relation of those bones represented by type E.

Arnoglossus substem (R) is closely related to the *Engyprosopon* substem mentioned above. In other respect, this substem closely resembles the *Laeops* and *Chascanopsetta* substems in having a rather primitive such feature as the relation of mesethmoid, prefrontals, frontals and pseudomesial bar is type D. Excepting those characters, it is possible that the present substem represents a form close to the main evolutionary line of the *Bothus* stem, since it shares, as a whole, many generalized characteristics.

This substem is represented by the genera *Asterorhombus, Psettina* and *Arnoglossus.*

The genus *Asterorhombus* is closely related to the genus *Engyprosopon* in having the interorbital bone concave slightly, the caudal skeleton with several branched parts, and 26 caudal vertebrae. An approach of the genus *Asterorhombus* is, therefore, made toward the *Engyprosopon* substem.

The genus *Psettina* is placed on a side branch of this substem rather than on direct line ascending the *Arnoglossus* in having the following features: the caudal skeleton is provided with several grooves, ctenoid scales have peculiar long hairlike spines, and vertebrae are 26 to 30 in number.

The genus *Arnoglossus* may be especially related to the members of the genus *Laeops* among this substem in having the platelike caudal skeleton, and the caudal vertebrae more than 30 in number. On the whole, however, it represents a form advanced along the main line of bothid evolution.

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