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Early development of the double-lined mackerel, *Grammatorcynus bicarinatus* (QUOY and GAIMARD), from the western tropical Pacific

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Abstract

Sixty-two postlarval and juvenile specimens referable to the double-lined mackerel, *Grammatorcynus bicarinatus*, mostly collected from the Papua New-Guinea waters are examined. Their meristic and morphological features are described, especially on the proportion of body, the pigmentation on body, the digestive tract and the structure of the caudal skeleton.

Postlarvae and juveniles of *G. bicarinatus* are distinguished from those of the morphologically similar species of *Rastrelliger* and *Scomber* by having the characteristic pigment blotches on the body and the preopercular spines. They are, however, much closer to the larvae of the primitive mackerel, *Rastrelliger* and *Scomber* in the structure of the caudal skeleton than to the *Scomberomorus* that is placed in the same scombrid tribe Scomberomorini (COLLETTE and CHAO, 1975). In addition, it is pointed out that, in juvenile double-lined mackerel, the caudal fin rays are supported indirectly by the last three vertebrae, while in a juvenile *Scomberomorus* sp., by the last five vertebrae.

Introduction

The double-lined mackerel, the monotypic *Grammatorcynus bicarinatus* (QUOY and GAIMARD), is a member of the scombrid tribe Scomberomorini and is mainly distributed in the coastal regions of the tropical and subtropical waters of the Indo-Pacific Oceans (COLLETTE and GIBBS, 1963; SILAS, 1963). However, it is not caught on commercial scale in these areas (WADE, 1951; JONES and KUMARAN, 1964), and little is known about the early stages of its life history.

The early development of *G. bicarinatus* has been described only by WADE (1951), who examined eight specimens (8.5 mm–17.5 mm in fork length) collected from the Sulu and Celebes Seas. A series of larval and juvenile specimens collected from the Papua New-Guinea waters and used in this study includes specimens in wider size range than those by WADE.

This paper intends to supplement previous information on the double-lined mackerel in its early developmental stages, with more detailed descriptions on the general body plans and the structure of the caudal skeleton.

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Materials and methods

Most of the specimens used in this study were collected from the Bismarck and Solomon Seas by the R/V Shunyo Maru of the Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, during the survey cruises in the Papua New-Guinea area from 1968 to 1970. They were obtained by dip-net and stick-held lift-net, except for the smallest two taken by larval net tows (Table 1).

Table 1. Capture records of the larval *G. bicarinatus*.

Date	Locality Lat.	Long.	No. of specimens	Size range (mm in SL)	Collecting methods	Collecting vessels
1964, Nov. 4	11°-20′ S	162°-23′ E	1	4.80	Larva-net	Shunyo Maru
1968, Nov. 5	Kollepine Harbour		1	25.52	Dip-net	Shunyo Maru
1968, Nov. 8	2°-20′ S	150°-18′ E	1	13.10	Stick-held lift-net	Shunyo Maru
1968, Nov. 16	5°-21′ S	150°-30′ E	9	7.50-15.42	Stick-held lift-net	Shunyo Maru
1968, Nov. 18	6°-33′ S	147°-51′ E	33	10.00-17.99	Stick-held lift-net	Shunyo Maru
1968, Nov. 23	7°-31′ S	147°-21′ E	1	16.67	Stick-held lift-net	Shunyo Maru
1968, Nov. 28	5°-11′ S	146°-36′ E	1	4.75	Larva-net	Shunyo Maru
1969, Nov. 3	Queen Carala Harbour		3	15.22-18.93	Stick-held lift-net	Shunyo Maru
1969, Nov. 5	Empress Augusta Bay		7	18.78-30.70	Stick-held lift-net	Shunyo Maru
1972, Aug. 9	West Harbour		4	27.64-32.63	Unknown	Unknown
1972, Nov. 28	Unknown		1	56.90	Unknown	Unknown

All specimens were preserved in 10% formalin and then transferred to 70% alcohol for later examination. Measurements were made on the following body parts with the dial reading caliper for large specimens and with micrometer under a binocular microscope for small specimens; standard length, snout length, orbit length, body depth, distance from snout to dorsal fin origin, and distance from snout to anus. Measurements and counts were made according to NISHIKAWA and NAKAMURA (1978).

The larval and juvenile double-lined mackerel ranged from 4.75 mm to 56.90 mm in standard length. Of a total of 62 larvae, 18 were cleared in 4% solution of potassium hydroxide and stained with alizarin red by the Holister's technique modified by CLOTHIER (1950) for counting the teeth, branchiostegals, preopercular and fin spines, and for observing detailed structure of the caudal skeleton. Seven larvae were dissected for examination of the digestive tract.

Description of early stages

Four postlarval and juvenile specimens selected to represent typical developmental stages are described in detail. Measurements on these specimens are given in Table 2.

Table 2. Measurements of the larval *G. bicarinatus* described.

Measurements (mm) \ Sp. No.	3	23	2	1
Standard length	4.80	11.50	25.52	56.90
Head length	2.15	4.50	8.81	16.78
Snout length	0.62	1.40	2.70	5.40
Orbit length	1.00	1.90	3.00	4.98
Body depth	1.70	3.15	5.87	11.35
Snout to dorsal	—	5.20	10.11	20.51
Snout to anus	2.70	7.50	17.04	36.06

1. 4.80 mm in standard length, specimen No. 3 (Fig. 1)

Body deep and compressed. Head relatively large, about 45% of standard length. Dorsal profile of head gently arched from above eye to tip of snout. Mouth moderately large, and slightly oblique. End of upper jaw reaching below middle of eye. Eye large and rounded, with a small pit on its anteroventral part. Supraorbital crest poorly developed with no serration or spines on its outer edge. Nostril single and located midway between tip of snout and anterior margin of eye. Five teeth on each side of upper jaw and 6 on lower jaw. Six rather short spines on hind margin of preopercle with longest spine at its posterior lower angle. No spines on other part of head. Abdominal sac triangular in shape, similar to that of tuna larvae. Anus located slightly posterior to middle of body. All fins just to be developed. Pelvic fin very small as fleshy bud. Nine first dorsal spines and 15 dorsal and 19 anal fin rays discernible. Posterior 6 fin rays just to form fin-lets. First fin-let of dorsal and anal fins still attached to preceding fin ray by membrane and also so connected each fin-let. Caudal fin rounded posteriorly and 20 rays discernible.

Body and head poorly pigmented, except for brain and eye. Conspicuous chromatophores on dorso-lateral peritoneum, posterior part of brain, symphysis of pectoral girdle, and around eye. A row of black pigments along bases of dorsal and anal fins. Mid-lateral part of caudal

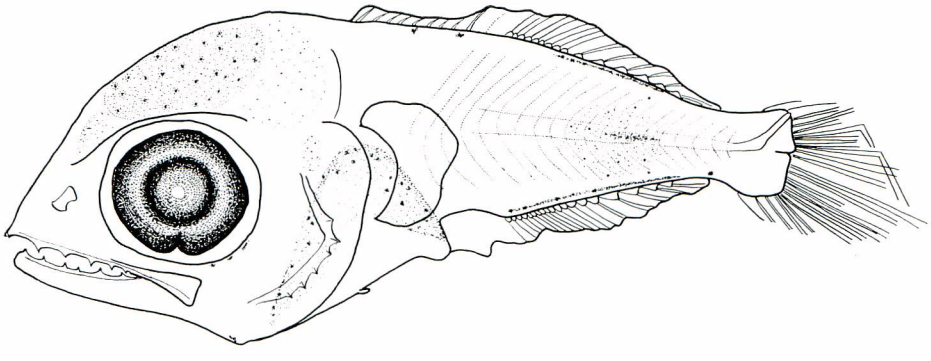

Fig. 1. Postlarval specimen, 4.80 mm in standard length, specimen No. 3.

region characteristically pigmented. In a specimen of similar size (4.75 mm SL), no such pigments on this part.

2. 11.50 mm in standard length, specimen No. 23 (Fig. 2)

Number of all fin rays in full adult complement. First dorsal fin relatively low, with longest second spine. First and second dorsal fins continuous. Second dorsal and anal fin-lets nearly formed and well branched distally. Two spines in anal fin. First anal spine shorter and apparently free, though connected to second spine at base. Two nostrils. Anterior nostril nearly rounded and rather small, and situated midway between tip of snout and anterior margin of eye. Posterior nostril slit-like in shape, and just ahead of eye. Caudal fin just to fork.

Body and head more pigmented. A large pigment patch on caudal fin base. Both dorsal and ventral areas of caudal peduncle characteristically lacking pigments. Scattered black pigments in head region, especially, in snout, behind maxillary and on opercle. A row of black pigments on dorsal side and on lateral side of lower jaw.

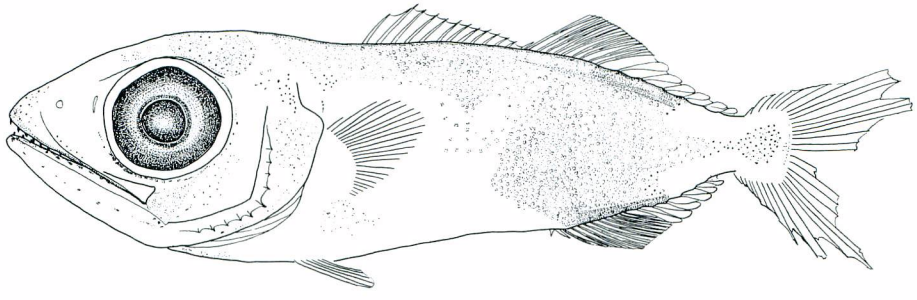

Fig. 2. Postlarval specimen, 11.50 mm in standard length, specimen No. 23.

3. 25.52 mm in standard length, specimen No. 2 (Fig. 3)

Body more elongate and slender. Body depth about 23% of body length. Cephalic sensory canal developed. Preopercular spines reduced in size.

Body pigmentation more advanced. Conspicuous chromatophores scattered on snout, on lower jaw, on posterior part of mouth, on brain, and on postorbital region. A new pigment mass on isthmus. Three large saddle-shaped pigment blotches on trunk. Pigment patch on

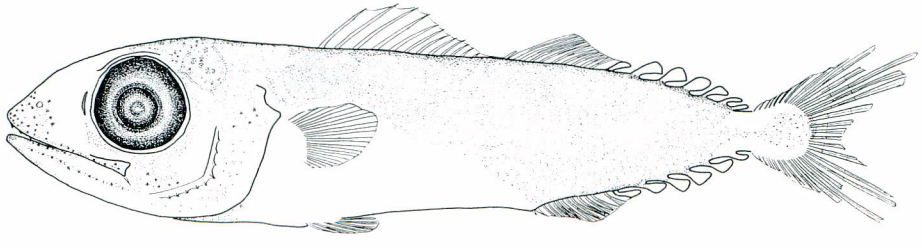

Fig. 3. Juvenile specimen, 25.52 mm in standard length, specimen No. 2.

caudal fin base extending more posteriorly.

4. 56.90 mm in standard length, specimen No. 1 (Fig. 4)

Body more elongate into adult form. Body depth about 20% of body length. Head length about 30% of body length. Preopercular spines reduced remarkably, with only two small spines remaining on its lower margin. First dorsal fin slightly high anteriorly and gradually low posteriorly. All dorsal spines moderately strong. Pelvic fin rather small, and situated below middle of pectoral fin base. Pectoral fin relatively short rounded distally. Scales on body already discernible. Upper lateral line starting above upper corner of gill opening and terminating at caudal peduncle along entire dorsal part of body. A short descending lateral line discernible, branched off from upper one below 4th dorsal spine.

Pigmentation more advanced. Six saddle-shaped pigment blotches over dorsal part of body. Pigment patch on caudal fin base still extending posteriorly to its fin rays. Faint pigments in dorsal fin membrane between 5th and 12th spines. Rest of fins not yet pigmented.

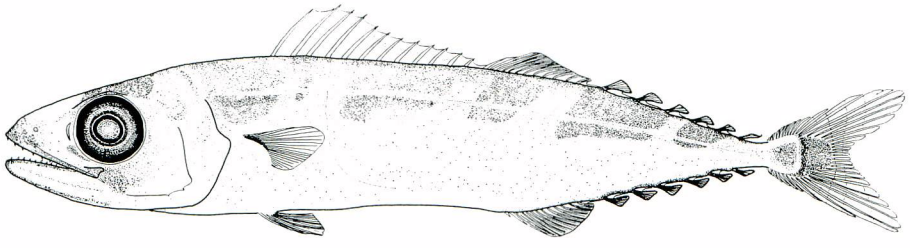

Fig. 4. Juvenile specimen, 56.90 mm in standard length, specimen No. 1.

Identification

Fishes of genera *Grammatorcynus*, *Rastrelliger* and *Scomber* have a total of 31 vertebrae (FRASER-BRUNNER, 1950), of which the former two have 13 precaudal and 18 caudal vertebrae (SILAS, 1963; MATSUI, 1967). According to MATSUI (1967), however, the *Scomber* differs from these two genera by having 14 precaudal and 17 caudal vertebrae except for an Atlantic species, *S. scombrus*, which shows a formula of 13+18 vertebrae. It is, therefore, rather difficult to identify species of the above three genera at their early stages so far as the vertebral counts are concerned. It is, on the other hand, relatively easy to distinguish postlarval and juvenile double-lined mackerel from other members of this family due to their characteristic pattern of body pigmentation (WADE, 1951).

According to present study, this pattern on the body is formed in specimens larger than 9.50 mm SL, so little confusion does occur in separating the double-lined mackerel from the *Rastrelliger* and *Scomber* after this size was attained. For three specimens smaller than this size (4.75 mm, 4.80 mm and 7.50 mm SL), a question arises whether or not they are identical and regarded as the double-lined mackerel, since for these specimens the characteristic pigment pattern on the body is not developed as yet, although similar in their external

appearance. Of these, a stained specimen 7.50 mm SL displays a total of 31 vertebrae, 13 precaudal and 18 caudal. The meristic counts made on its fin rays and spines indicate that they are for the *Grammatorcynus* rather than for the *Rastrelliger* or *Scomber* which differs in these counts (Table 3). For the remaining two, the smallest of the specimens examined, the myomere count can not be made properly. These two specimens, however, differ from the larvae of higher scombrids, the *Thunnus, Katsuwonus, Euthynnus* and *Auxis* (WADE, 1951; MATSUMOTO, 1958, 1959; YABE *et al.*, 1966; UEYANAGI, 1969) in the following points; 1) the stubby shape, 2) the large head and eye, 3) the obtuse snout, 4) the blunted preopercular spines, 5) a row of black pigments along the bases of the dorsal and anal fins, and 6) relatively densly pigments on the mid-lateral part of the caudal region. By having the preopercular spines, they are distinguished also from the *Rastrelliger* and *Scomber* which have been known to have no such spines throughout the larval and juvenile stages (UCHIDA *et al.*, 1958; PETER, 1969; BERRIEN, 1978). From the points mentioned above, the author identified the three early postlarval specimens as well as other larger ones as *G. bicarinatus.*

Changes of characters with growth

1. Meristic character

The meristic counts given in Table 3 were made on 18 specimens longer than 7.50 mm SL after they were cleared and stained. All of these postlarval and juvenile specimens have a total of 31 vertebrae, 13 precaudal and 18 caudal. In a specimen 7.50 mm SL, the number of fin rays and spines except for the pectoral and caudal fins shows full adult complement. As seen in Table 3, the size at which both pectoral and caudal fin rays attain to full complement is approximately 15 mm SL. The meristic counts for specimens above this size fall within the ranges reported for the adult previously (SILAS, 1963). Seven branchiostegals, the full adult complement, are discernible without exception in all stained specimens, even in the smallest one (4.75 mm SL).

The average values of measurements made on several body parts are given in Appendix Table 1.

2. Body proportion

The percentage of the head length, orbit length, distance from snout to anus and body depth to the standard length was determined, and plotted against the standard length as shown in Fig. 5. Percentages of the head length, orbit length and body depth have equally a decreasing trend as growth proceeds (Fig. 5a, b and d). On the contrary, percentage of the distance from snout to anus increases with growth until about 10 mm SL, and after this size, maintains almost the same value up to at least 57 mm SL (Fig. 5c). The relatively rapid extension of peritoneal cavity up to about 10 mm SL takes place in connection with the similar growth of the digestive tract during this early stage of development, which will be mentioned later.

3. Pigmentation

As noted by WADE (1951), the pigmentation in the early stage of this species is distinc-

Table 3. Counts of some meristic characters of cleared and stained specimens of larval *G. bicarinatus*.

Size (mm SL)	Sp. No.	Dorsal	Anal	Pectoral	Pelvic	Caudal Pr	Caudal Se	Teeth in jaw Up	Teeth in jaw Lo	Palatine teeth	Branchiostegals	Preopercular spines	Vertebrae
7.50	56	XII, I, 10+6	II, 11+6	9	I, 5	17	7	7	9	3	7	8	13+18
9.10	54	XII, I, 10+6	II, 11+6	10	I, 5	17	14	10	10	—	7	9	13+18
10.00	45	XII, I, 10+6	II, 11+6	15	I, 5	17	17	12	12	5	7	10	13+18
10.43	52	XII, I, 10+6	II, 11+6	16	I, 5	17	18	14	13	5	7	9	13+18
10.50	49	XII, I, 10+6	II, 10+6	14	I, 5	17	17	15	13	6	7	8	13+18
11.25	48	XII, I, 10+6	II, 11+6	16	I, 5	17	20	15	10	5	7	11	13+18
11.36	33	XII, I, 10+6	II, 11+6	18	I, 5	17	20	13	15	—	7	11	13+18
12.03	31	XII, I, 10+6	II, 11+6	19	I, 5	17	22	14	13	3	7	10	13+18
12.50	44	XII, I, 10+6	II, 11+6	20	I, 5	17	21	14	14	—	7	9	13+18
14.06	28	XII, I, 10+6	II, 11+6	22	I, 5	17	22	15	14	5	7	12	13+18
14.08	41	XII, I, 10+6	II, 11+6	20	I, 5	17	23	16	21	5	7	10	13+18
15.42	51	XII, I, 10+6	II, 11+6	22	I, 5	17	23	16	16	5	7	11	13+18
15.77	25	XII, I, 10+6	II, 11+6	23	I, 5	17	23	17	18	6	7	11	13+18
17.55	19	XII, I, 10+6	II, 11+6	23	I, 5	17	24	19	22	5	7	10	13+18
20.80	16	XII, I, 10+6	II, 11+6	22	I, 5	17	24	19	21	6	7	11	13+18
21.82	6	XII, I, 10+6	II, 11+5	23	I, 5	17	25	24	24	5	7	10	13+18
29.92	13	XII, I, 10+6	II, 11+6	24	I, 5	17	23	22	25	8	7	10	13+18
32.63	4	XII, I, 10+6	II, 11+6	24	I, 5	17	22	26	28	9	7	9	13+18

Pr: principal caudal ray, Se: secondary caudal ray, Up: upper jaw, Lo: lower jaw

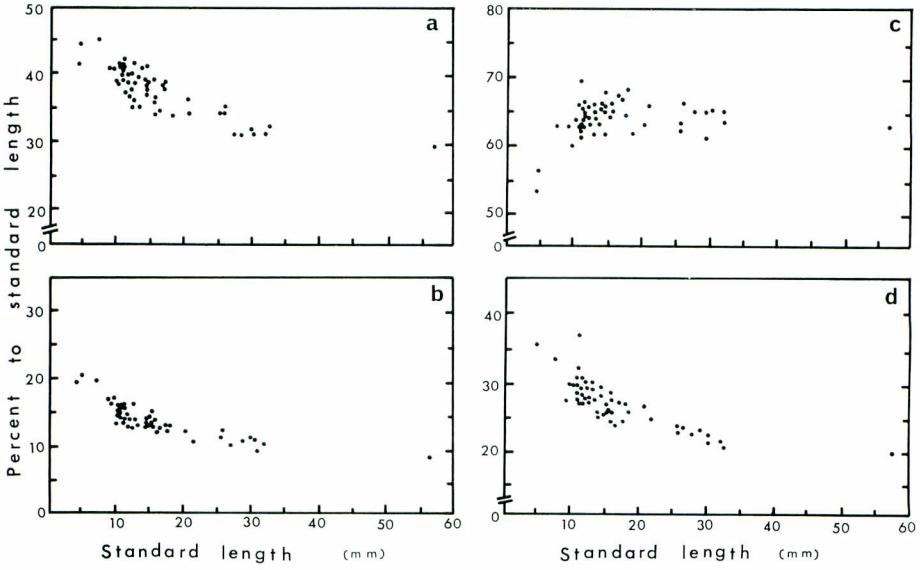

Fig. 5. Relative length for four body parts expressed as percent of standard length. a: head length, b: orbit length, c: distance from snout to anus, d: body depth.

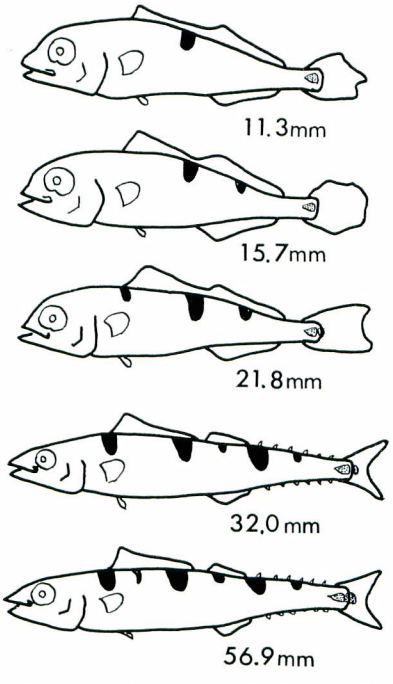

Fig. 6. Schematic sketch of the development of the saddle-shaped pigment blotches on the trunk and of pigment patch on the caudal fin base.

tive and differs markedly from that of other larval scombroid fishes. This characteristic pattern including the saddle-shaped pigment blotches on the body and the pigment patch on the caudal fin base is here described in more detail. Fig. 6 shows a schematic representation of the development of this body pattern associated with growth.

The saddle-shaped pigment blotches on the trunk comprise three larger and additional three smaller blotches, the anterior, central and posterior ones, respectively. The larger blotches appear in advance of the smaller ones. At about 11 mm SL, the central larger blotch appears first, followed by the posterior one at about 16 mm SL and the anterior one at about 22 mm SL. After these were found, then the central smaller blotch comes out between the two larger ones at about 29 mm SL, followed by the posterior one at about 32 mm SL and the anterior one at about 57 mm SL.

A pigment patch on the caudal fin base is well developed in a specimen 9.50 mm SL. The posterior portion of this patch extends gradually into the caudal fin rays as development proceeds.

The fins of larval double-lined mackerel are poorly pigmented in contrast with their advanced pigmentation of the body. The dorsal fin lacks pigments in all postlarval specimens up to about 32 mm SL. Only a juvenile specimen 57 mm SL has a faint longitudinal band of black pigments in the posterior half of the first dorsal fin. It can be said that the dorsal fin pigments appear late in this species even in comparison with the *S. japonicus* (WATANABE, 1970) and the *Restrelliger* sp., in which they first come out at 23.5 mm and 21 mm SL, respectively.

4. Head spination and lateral line

Head spination in the postlarval stage is relatively poor, with only several spines on the hind margin of propercle. The smallest specimen 4.75 mm SL has three such spines. They increase in number with growth up to the maximum of 12 in a specimen 14.06 mm SL, and then gradually reduce in number and size. In a specimen about 57 mm SL, they are only discernible as the two feeble processes at the lower margin of preopercle.

No spines are formed on the pterotic region. The supraorbital crest is very feeble and has no particular spines on its outer edge.

In a specimen about 32 mm SL, scales on the body become first discernible. The cephalic sensory canal is developed, with many small pores. A similar sensory canal on the head is known in juveniles of the carangids and gempylids (OKIYAMA, 1970; NISHIKAWA and NAKAMURA, 1978). The characteristic two lateral lines are discernible in specimen 56.90 mm SL.

5. Digestive tract

Fig. 7 shows the change in the external appearance of the digestive tract in the postlarval stages. It consists of a blind sac and a folded intestine and is similar in shape to the same organ in the larval yellowfin tuna and skipjack (UEYANAGI *et al.*, 1973; NISHIKAWA, 1975). A specimen 9.80 mm SL already has the well developed stomach and pyloric caeca. The stomach and intestine extend gradually backward with growth, and at about 26 mm SL, the posterior tip of the stomach reaches well beyond the end of pyloric caeca. A constriction of the intestine is not observed in all larval and juvenile specimens.

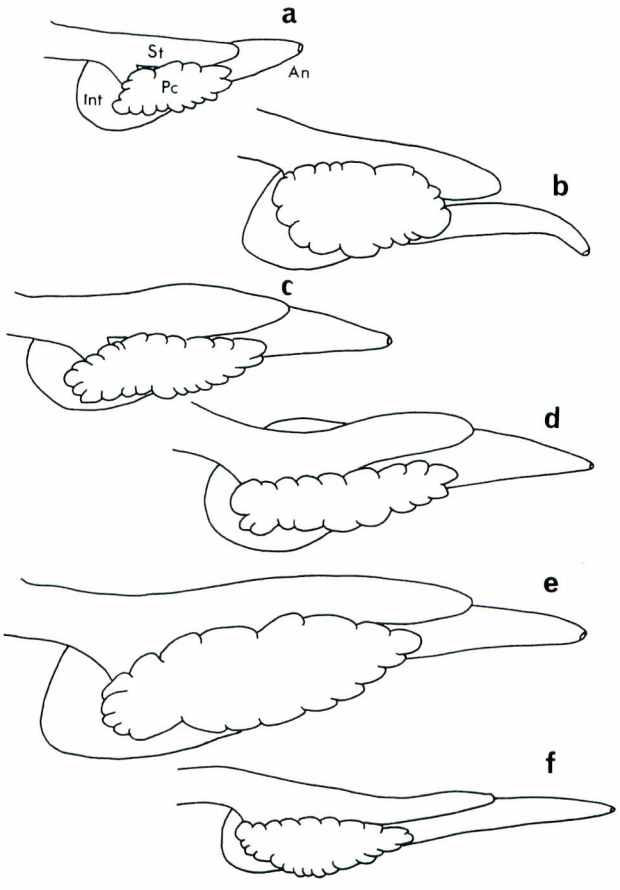

Fig. 7. The development of digestive tract of larval and juvenile *G. bicarinatus*. St: stomach, Pc: pyloric ceaca, Int: intenstine, An: anus., a: 9.8 mm SL, b: 12.85 mm SL, c: 14.48 mm SL, d: 15.22 mm SL, e: 18.78 mm SL, f: 26.05 mm SL.

6. Caudal skeleton

The development of the caudal skeleton is illustrated in Fig. 8, based on four postlarvae and juveniles selected from 18 cleared and stained specimens. The terminology used in this study for the caudal skeleton follows POTTHOFF (1975).

Ossification of various bony elements in the caudal region of *G. bicarinatus* is relatively fast. At about 9.10 mm SL (Fig. 8a), the last four vertebrae (urostyle and preural centra two to four), the neural spines of preural centra four (Pu 4) and three (Pu 3), and the haemal spines of preural centra two (Pu 2) to four are already ossified. The epurals, the neural arch, the uroneural and the posterior part of the urostyle, parhypural and hypurals are not yet stained in this specimen. Hypurals "one and two" and hypurals "three and four" are fused with each other in distal part. Fusion is not observed between hypurals "one and two" and hypural three at this stage. Ossification of the hypurals goes backward, and the fusion

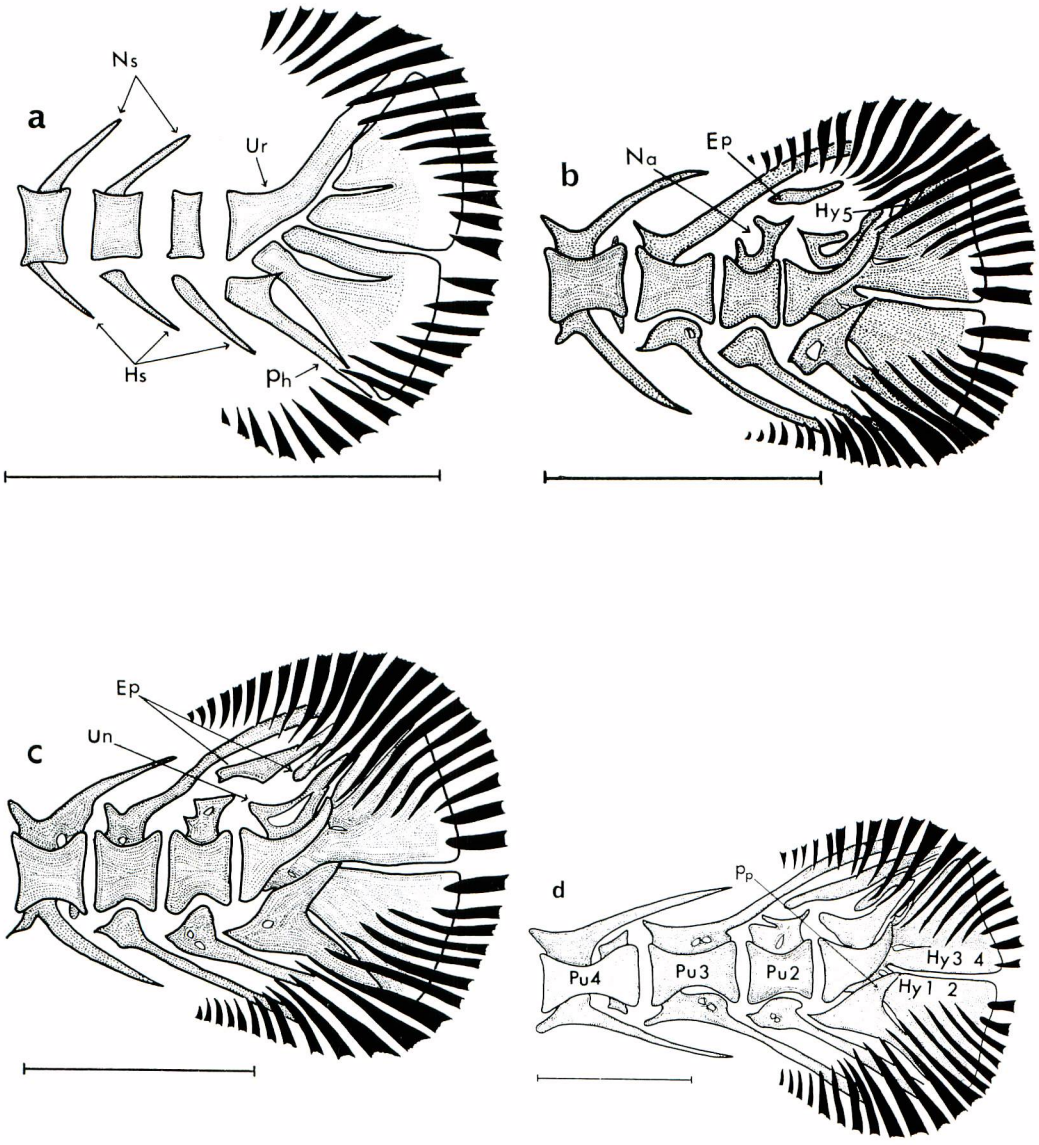

Fig. 8. The development of the caudal skeleton of *G. bicarinatus*.

Scales equal to 1 mm. Pu: preural centrum, Ur: urostyle, Ns: neural spine, Hs: haemal spine, Ep: epural, Na: neural arch, Un: uroneural, Ph: parhypural, Pp: parhypurapophysis, Hy: hypural., a: 9.10 mm SL, b: 15.77 mm SL, c: 21.82 mm SL, d: 32.63 mm SL.

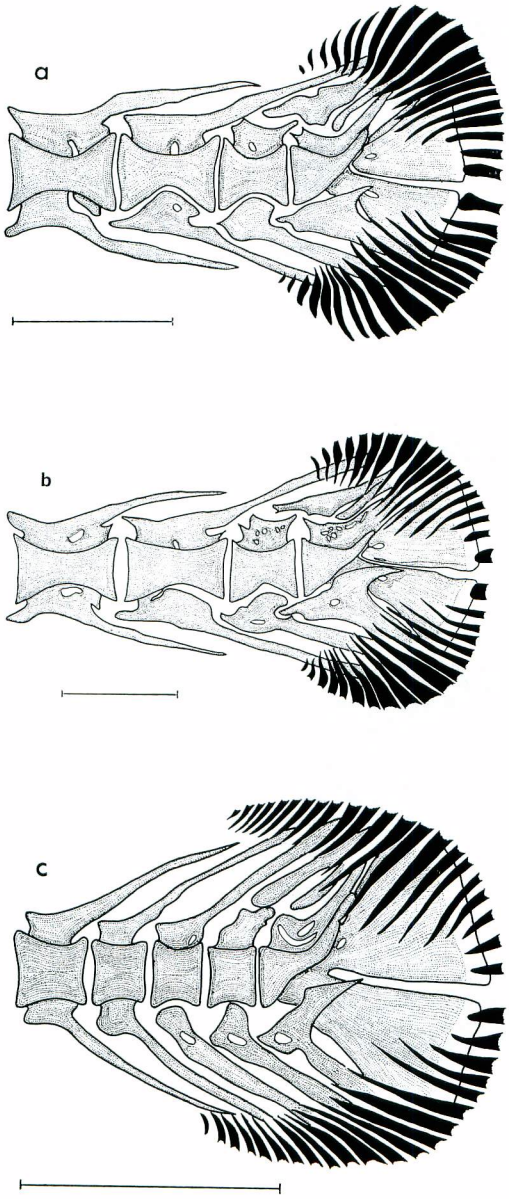

Fig. 9. Caudal skeleton for juveniles of *Rastrelliger*, *Scomber* and *Scomberomorus*. Scales equal to 1 mm. a: *Rastrelliger kanagurta*, 34.7 mm SL, b: *Scomber japonicus*, 44.0 mm SL, c: *Scomberomorus* sp., 30.74 mm SL.

of the hypurals to hypural plate proceeds forward gradually.

The principal rays of caudal fin, 9 on dorsal and 8 on ventral sides, are stained and a total of 14 secondary rays, 6 on dorsal and 8 on ventral, are discernible in this specimen. In a specimen 15.77 mm SL (Fig. 8b), the ossification is seen in the neural arch, uroneural, anterior epural and hypural five. The neural and haemal spines of preural centra two to four are more developed. The neural and haemal spines of the preural centrum three extend to the anterior 7th secondary ray on both dorsal and ventral sides of the caudal fin. The neural and haemal spines of preural centra two and three thicken posteriorly. Fusion of hypurals "one and two" and hypurals "three and four" partially takes place at their base. Number of caudal fin rays attains to full adult complement, with a total of 41 rays. The posterior epural is ossified in a specimen 21.82 mm SL (Fig. 8c). In this stage, ossification of all elements in the caudal skeleton is apparently completed except for the distal edge of hypurals. In a specimen 32.63 mm SL, a very narrow region along the distal edge of hypural still remains not ossified.

Fig. 9 shows the caudal skeleton of the juveniles of the *Rastrelliger kanagurta*, *Scomber japonicus* and *Scomberomorus* sp. to compare with *G. bicarinatus*. The structure of their caudal skeleton is almost identical with that of *G. bicarinatus*, except for the support of the caudal fin rays which will be mentioned later. The adult forms of the primitive mackerels, *Rastrelliger* and *Scomber*, and of Scomberomorini have a definite notch at the median part of the hind margin of hypural plate (COLLETTE and CHAO, 1975), and they are distinguished in this respect from other species of the family Scombridae with the exception of *Gymnosarda unicolor* where an only vestige remains. This difference is also found in juvenile stage as the difference in the degree of fusion of hypural elements. In the juveniles of the primitive mackerels and of Scomberomorini, the *Grammatorcynus* and *Scomberomorus* (Fig. 8d and Fig. 9), the fusion of hypurals progresses relatively at a slow pace. Especially, between hypurals "one and two" and hypural three, little fusion taken place with a rather broad gap. A similar gap between hypurals is also seen in a juvenile of *Gymnosarda unicolor* (OKIYAMA and UEYANAGI, 1977), although narrower than in the juveniles of the above groups. For the juveniles of the higher tunas, *Thunnus thynnus* (25 mm FL) and *T. atlanticus* (34.2 mm SL), these hypurals are already completely fused into a large hypural plate (WATSON, 1964; POTTHOFF, 1975).

According to the present observation, it should be worthy of note that, in a juvenile *Scomberomorus* 30.74 mm SL, the caudal fin rays are associated indirectly with the last five vertebrae, the urostyle and preural centra two to five (Fig. 9c), while in juveniles of the *Rastrelliger kanagurta*, *Scomber japonicus* (Fig. 9a and b) and *Grammatocynus bicarinatus* (Fig. 8d), with last three vertebrae, the urostyle and preural centra two and three. Further study will be made on this point in connection with the growth.

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西部熱帯太平洋から得られたニジョウサバ, *Grammatorcynus bicarinatus* (QUOY and GAIMARD) の仔稚魚について

西 川 康 夫

摘　　要

遠洋水産研究所所属調査船俊鷹丸によって西部熱帯太平洋，パプア・ニューギニア水域からニジョウサバ，*Grammatorcynus bicarinatus* (QUOY and GAIMARD) と思われる仔稚魚 62 個体が採集された。これら標本個体の計数計測形質，特に体形，色素形成，消化管，尾鰭骨格等の成長に伴なう形態変化について検討し記述した。検討の結果，これらの仔稚魚は *G. bicarinatus* と同定された。

ニジョウサバの仔稚魚は，形態的に類似しているグルクマ属 *Rastrelliger* およびサバ属 *Scomber* の仔稚魚とは体側の特長的な色素斑紋ならびに前鰓蓋骨後縁に小棘を有する点において明瞭に識別される。仔稚魚期における尾鰭骨格の構造において，ニジョウサバはグルクマーやサバと構造的によく類似しているが，しかし本種が同系とされているサワラ族 Scomberomorini (GOLLETTE and CHAO, 1975) の中のサワラ属 *Scomberomorus* とは尾鰭鰭条の支持形態において相違が認められた。

Appendix Table 1. Average values of body measurements of the larval *G. bicarinatus*.

Size range (mm SL)	Number of specimens	Standard length (average)	Average value of body measurements (as percent of the standard length)					
			Head length	Snout length	Orbit length	Body depth	Snout-dorsal	Snout-anus
4.00- 4.99	2	4.78	43.24	12.77	20.42	36.50	—	59.70
7.00- 7.99	1	7.50	45.33	12.00	20.00	33.60	56.13	63.33
9.00- 9.99	2	9.30	41.18	11.27	16.94	28.58	47.03	61.59
10.00-10.99	6	10.57	40.12	11.03	15.53	29.30	46.90	63.37
11.00-11.99	8	11.32	40.40	11.41	15.47	29.75	45.80	65.35
12.00-12.99	5	12.33	37.23	11.25	13.82	28.82	46.19	64.67
13.00-13.99	3	13.44	39.01	11.60	14.64	27.46	45.75	63.50
14.00-14.99	6	14.57	39.72	11.18	14.30	26.75	47.83	65.77
15.00-15.99	5	15.49	38.41	11.29	13.55	26.52	46.34	65.11
16.00-16.99	1	16.67	34.61	11.03	12.23	23.51	41.21	67.54
17.00-17.99	3	17.51	38.47	11.87	13.18	25.78	43.48	66.68
18.00-18.99	1	18.93	34.60	10.35	13.10	25.88	43.37	62.28
20.00-20.99	1	20.80	36.54	12.02	12.60	26.83	45.67	63.08
21.00-21.99	1	21.82	34.60	9.44	10.77	24.98	40.33	66.36
25.00-25.99	2	25.35	35.13	11.39	12.00	23.30	41.18	63.49
26.00-26.99	1	26.05	34.55	10.94	11.90	23.80	40.38	66.56
27.00-27.99	1	27.64	31.88	9.55	10.60	22.61	39.69	64.94
28.00-28.99	1	28.91	31.82	10.55	11.03	23.21	38.91	65.03
29.00-29.99	1	29.92	32.12	9.86	11.26	22.36	40.54	61.93
30.00-30.99	1	30.70	31.99	10.42	11.04	21.37	38.76	65.08
32.00-32.99	2	32.32	32.18	9.77	10.18	21.08	38.14	64.40
56.00-56.99	1	56.90	29.49	9.49	8.75	19.95	36.05	63.37