

Redescription of type specimens of three *Bregmaceros* species (Gadiformes: Bregmacerotidae): *B. bathymaster*, *B. rarisquamosus*, and *B. cayorum*

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Abstract

This paper redescribes the type specimens of three nominal *Bregmaceros* species in the family Bregmacerotidae (*B. bathymaster* Jordan and Bollman, *B. rarisquamosus* Munro, and *B. cayorum* Nichols), compares them with past published descriptions, and comments on their validity based on comparisons with earlier-described species. Incomplete observations in the original descriptions are updated, and some new characters are described. Except for the pigmentation, which is difficult to interpret in the original description, *B. bathymaster* is nearly identical in all of the published accounts and considered valid. *B. rarisquamosus* has not been recorded with certainty since the original description. Most of the body proportions are significantly different between the original and our observations. *B. rarisquamosus* is most similar to *B. nectabanus*, among the seven earlier-described valid species, but differs mainly in having 14 principal caudal fin rays as opposed to 13, and is judged valid. *B. cayorum* also has not been recorded since the original description. It is most similar to *B. bathymaster*, among the eight earlier-described valid species, but differs in the shape of the opercle, and accordingly is considered valid. *B. longipes* Garman is considered a junior synonym of *B. bathymaster*.

There are 16 nominal species in the genus *Bregmaceros*, the only extant, valid genus in the family Bregmacerotidae (see Eschmeyer¹⁾, for a listing of nominal species). However, the validity of those species has been very uncertain. For example, Belyanina²⁾ regarded *Bregmaceros japonicus* Tanaka, 1908 as a form of *B. atlanticus* Goode and Bean, 1886, and Masuda et al.³⁾ indicated that *B. maclellandi* of D'Ancona and Cavinato⁴⁾ and Belyanina²⁾ is distinct from that originally described by Thompson⁵⁾, and that *B. lanceolatus* Shen, 1960 is valid. Those problems remain to be solved^{6, 7)}. To examine the issue of validity and diagnostic characters of all those species, reexamination of type specimens is required, since most of them were poorly described originally or improperly redescribed subsequently. In this paper we redescribe the

type specimens of three species (*Bregmaceros bathymaster* Jordan and Bollman, *B. rarisquamosus* Munro, and *B. cayorum* Nichols), compare our results with past descriptions, and comment on the validity of those species based on comparisons with earlier-described species.

Materials and Methods

The holotypes of *B. bathymaster* (USNM 41137), *B. rarisquamosus* (CSIRO B3425), and *B. cayorum* (AMNH 19539), and three paratypes of *B. bathymaster* (SU 427) were examined. Methods for counts and measurements and general terminology follow D'Ancona and Cavinato⁴⁾ and Torii et al.⁷⁾ Longitudinal and transverse scales, and short inner rays of pelvic fin were impossible to count

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exactly. Unpaired fin rays and vertebrae were counted and observed on radiographs. Shape of the opercle was observable externally. Length of the opercle was measured along a line running through the middle of its long axis (opercle line) from the dorsal to the ventral margin, and that of the opercle shaft along a line running through the middle of its long axis (shaft line) from its intersection with the opercle line to its posterior tip. Institutional abbreviations follow Eschmeyer⁸⁾.

***Bregmaceros bathymaster* Jordan and Bollman, 1890⁹⁾**
(Figs. 1A, 2A, 3A, 4A, 5A, Table 1)

Bregmaceros bathymaster Jordan and Bollman, 1890⁹⁾: 173-174 [type locality: Gulf of Panama]; D'Ancona and Cavinato, 1965⁴⁾: 43-46 (Gulf of Panama); Belyanina, 1974²⁾: 173-175 (a part of the specimens in D'Ancona and Cavinato⁴⁾).

Bregmaceros maclellandii [sic] (not of Thompson): Jordan and Evermann, 1898¹⁰⁾: 2526-2527 (two type specimens of *B. bathymaster* described in Jordan and Bollman⁹⁾).

Bregmaceros longipes Garman, 1899¹¹⁾: 191-192, plate XLIII, figs. 6-9 (Pacific coast of Mexico: 16° 47'30"

N, 99° 59'20"W).

Holotype. USNM 41137, ca. 35 mm SL, 30 March 1888, Gulf of Panama, Albatross St. 2804, (8° 16'30"N, 78° 37'4 5"W), 47 fms (86 m), large beam trawl, sex unknown.

Paratypes. SU 427, 3 specimens (SU427a of 33.3 mm SL, SU427b of 35.6, and SU427c of 41.0: letter suffixes added herein to distinguish the specimens), Albatross St. 2804, collected with holotype, sex unknown.

Diagnosis. Chromatophores limited dorsally on head and body except for indistinct ones on posterior half of caudal peduncle or a longitudinal row above anal fin base; dorsal fin dotted lightly with chromatophores; other fins except for caudal fin base colorless; no scales on cheek; opercle slender with a tape-like shaft extending posteriorly; length of opercle nearly equal to that of shaft.

Description. Type specimens not in a good condition: caudal and pectoral fins, and snout damaged greatly; scales mostly lost; body uniformly pale yellow, bleached, but chromatophores recognizable.

Proportional measurements and meristic counts are shown in Table 1. Body moderately elongate and slightly compressed. Snout round, mouth oblique and

Table 1 Comparison of meristic counts and body proportions of *Bregmaceros bathymaster* as enumerated by different authors

Author	The present authors Jordan and Bollman (1889)		The present authors			D'Ancona and Cavinato (1965)	Belyanina (1974)
Specimens	Holotype USNM 41137		Paratypes SU427a SU427b SU427c			Non-type specimens 3 adults & 258 others	Non-type specimens ^a 2 adults & 16 others
Standard length(mm)	ca.35.0	50.8	33.3	35.6	41.0	~47.0	10.4-48.0
Meristic counts							
Dorsal fin rays	46	(ca.50) ^b	46	46	50	46-50	44-49
Anal fin rays	46	(ca.50) ^b	49	47	50	47-50	45-52
Pectoral fin rays	17	-	18	17	17	17-19	15-20
Caudal fin rays	-	-	33	33	-	29-36	-
Principal caudal fin rays	-	-	14	14	14	-	-
Transverse scales	-	(14) ^b	ca.14	-	-	11	-
Longitudinal scales	-	ca.50(58) ^b	ca.56	-	-	56-61	-
Abdominal vertebrae	14	-	14	13	14	-	-
Caudal vertebrae	36	-	35	35	35	-	-
Total vertebrae	50	-	49	48	49	48-51	-
Proportional measurements							
In % of standard length							
Head length	18.4	18.5	15.6	18.5	18.0	18.9-19.6 ^c	16.1-17.3 ^c
Body depth	14.0	15.6	14.4	14.3	13.4	13.5-14.7 ^c	13.2-15.0 ^c
Occipital ray length	16.0	ca.24.7	23.1	21.1	24.4	17.5-22.2 ^c	16.1-21.2 ^c
Pre-anal length	40.9	ca.40	40.8	39.3	42.7	-	16.1-21.2 ^c
Pre-dorsal length	38.9	ca.40	40.8	39.6	43.9	-	34.0-35.5 ^c
Longest pelvic length	36.9	ca.50	49.5	44.4	48.8	45.5-50.0 ^c	35.8-37.0 ^c
Caudal peduncle depth	5.1	-	6.6	6.2	5.6	-	39.4-43.9 ^c
Pectoral length	-	-	14.4	12.9	-	-	5.4-5.7 ^c
In % of head length							
Eye diameter	27.9	33.3	32.7	30.3	27.0	26.3-30.3 ^c	-
Interorbital width	23.3	ca.33.3	19.2	19.7	14.9	-	24.5-25.3 ^c
Snout length	24.8	-	23.1	16.7	21.6	-	22.0-28.0 ^c
Upper jaw length	45.0	45.5	48.1	36.4	44.6	38.5-41.7 ^c	22.9-24.5 ^c
In % of pre-anal length							
Pre-dorsal length	95.1	-	100	97.8	92.9	-	41.0-42.3 ^c

^a A rent of D'Ancona and Cavinato's (1965) specimens

^b Data from Jordan and Evermann (1898) (refer to text)

^c Proportions based on only adult specimens

subterminal. Interorbital smoothly convex. Eye covered dorsally with adipose eyelid; two nostrils just before eye. Upper jaw slightly longer than the lower; its tip ending posteriorly below area between center of eye and posterior margin of pupil. Medium-sized conical teeth in a band arranged relatively regularly in an outer row and irregularly in an inner row on upper jaw. An inner row of large conical teeth and an outer row of minute conical teeth on lower jaw. Vomer with a few minute conical teeth. Gill rakers reduced to small, conical tooth-like projections. A pair of medially deflected dermal flaps along ventral contour from insertion of pelvic fin to posterior end of anterior anal-fin lobe; the ventral groove anterior to anus rather deep, flat, and scaleless except for a pair of hollows just behind insertion of pelvic fin; and a low, median longitudinal ridge running between pelvic fin bases and anus. A rather deep dorsal groove along dorsum anterior to dorsal fin that receives a depressed occipital ray, with two scales before origin of dorsal fin in the holotype, one scale in two paratypes SU 427a and b, but none in c. Opercle small, slender, slightly curving

posteriorly and along upper edge of posterior margin, with a long, tapered, spine-like shaft curving upward posteriorly (Fig. 2A): ratio of length of shaft to that of opercle 0.99 in SU427b and 0.96 in c (indeterminate in the holotype due to damage). Axillary flap attached to the shoulder girdle above pectoral fin crescent-shaped with a shallow indentation in lower posterior margin (Fig. 3A). A slender occipital fin ray present, its depressed tip reaching just before origin of dorsal fin. Origin of anal fin at vertical between first and second dorsal fin rays. Dorsal and anal fins long-based and nearly identical in shape, each

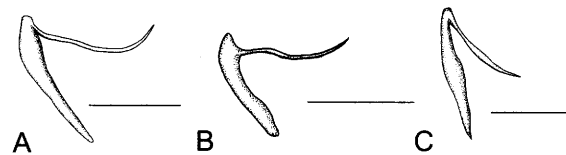


Fig. 2 Left side view of opercle: A, *Bregmaceros bathymaster*, 35.6 mm SL (SU 427b), B, *B. rarisquamosus*, 26.3 mm (CSIRO B3427), and C, *B. cayorum*, 44.5 mm (AMNH 19539). Bars 1 mm.

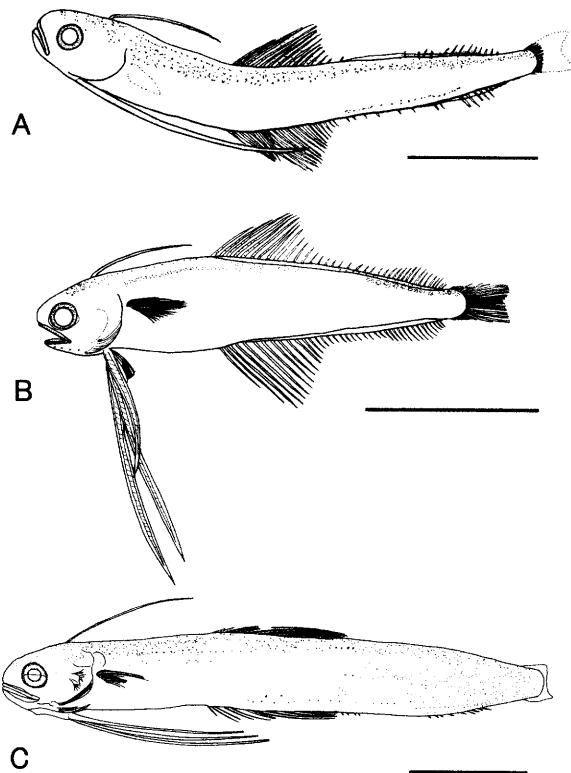


Fig. 1 A, *Bregmaceros bathymaster*, 41.0 mm SL (SU 427c); B, *B. rarisquamosus*, 26.3 mm (CSIRO B3427); and C, *B. cayorum*, 44.5 mm (AMNH 19539). Bars 10 mm.

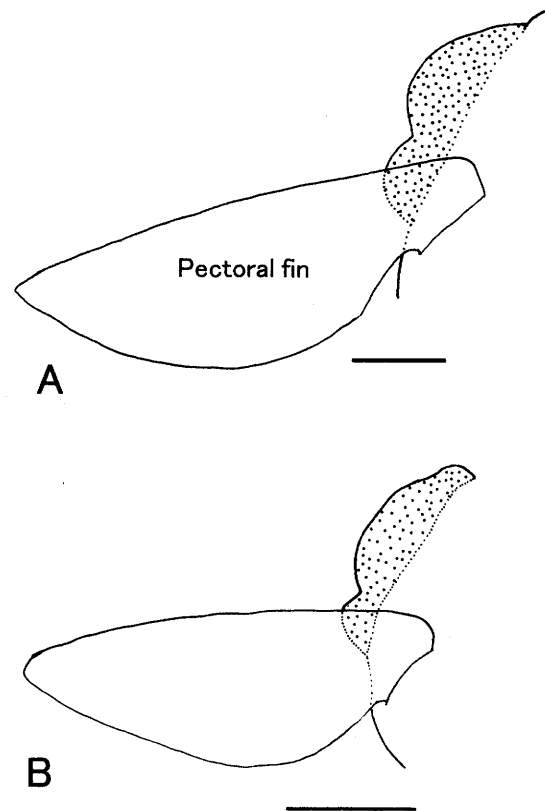


Fig. 3 Right side view of axillary flap (dotted part): A, *Bregmaceros bathymaster*, 35.6 mm SL (SU 427b) and B, *B. rarisquamosus*, 26.3 mm (CSIRO B3427). Bars 1 mm.

divided obscurely into three parts: anterior lobe highest and triangular, middle portion low and consisting of rudimentary rays, and posterior lobe of moderate height. Pectoral fin base slightly below lateral mid-line; in SU427b, its posterior margin slightly pointed and the lowest four rays branched. Pelvic fin jugular in position, tip of longest ray reaching to about posterior end of anterior anal fin lobe; lateral three rays greatly elongate, their tips not branched; the inner rays short (their number not possible to determine), complexly branched. Caudal fin slightly forked in SU427b; among 12 branched rays, eight are supported by a bony plate composed of fused terminal vertebrae and hypurals. No scales on head. Lateral line beginning near mid-point between dorsal edge of gill cover and insertion of occipital fin ray, running along dorsum from above dorsal edge of gill cover to about beginning of posterior dorsal fin lobe, and declining diagonally, ending shortly behind the declining point. Scales under pectoral fin nearly square, small, cycloid and deciduous, with circuli concentric around focus on exposed part and longitudinally straight and truncated along anterior border on concealed portion (Fig. 4A). Parapophysis of abdominal vertebrae short in base, canine-like, curving posteriorly in lateral view (Fig. 5A). Posterior neural zygapophysis unrecognizable on radiographs, possibly due to decalcification.

Ground color of specimens pale yellow. Occiput,

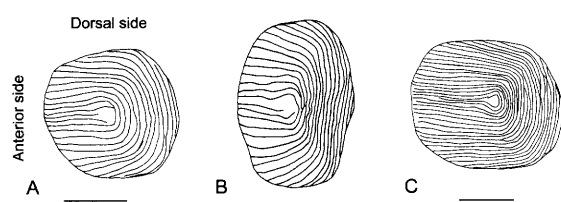


Fig. 4 Scales under pectoral fin: A, *Bregmaceros bathymaster*, 41.0 mm SL (SU 427c); B, *B. varisquamosus*, 26.3 mm (CSIRO B3427); and C, *B. cayorum* (AMNH 19539). Bars 0.5 mm.

anterior to insertion of occipital fin ray, covered by a wide, nearly circular area of pale brown pigment; all chromatophores in this area small and punctate. Irregularly distributed chromatophores dorsally from snout to caudal peduncle. Chromatophores on tail indistinct and variable among the specimens: in SU 427a, chromatophores irregularly and widely scattered on posterior half of caudal peduncle; in SU 427b an indistinct

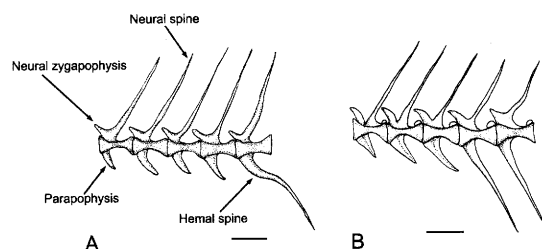


Fig. 5 Vertebrae of A, *Bregmaceros bathymaster*, 41.0 mm SL (SU 427c) and B, *B. cayorum* (AMNH 19539). Bars 1 mm.

short ventral row above base of middle portion of anal fin; in SU 427c (Fig. 1A) a rather long ventral row from above middle portion of anal fin base to above base of middle part of posterior anal lobe; and in the holotype a few scattered chromatophores. Dorsal fin entirely but lightly covered with chromatophores; caudal fin base with a few or several chromatophores in SU 427b and c (Fig. 1A), but none in a and not observable in the holotype (caudal fin and terminal vertebra missing); other fins colorless. Inner surface of gill cover, first gill arch, and mouth cavity unpigmented.

Comparison with past descriptions and validity. All specimens described as *B. bathymaster*, except those from Costa Rica for which Bussing and Lopez¹²⁾ provided a simple line drawing and short diagnosis, were collected in and around the Gulf of Panama, suggesting they probably belong to the same species. Compared with our observations each of the past descriptions can be criticized as follows: the original description⁹⁾ was poor on meristic characters (Table 1), and an illustration of the type was not provided; several meristic values (Table 1) were added by Jordan and Evermann¹⁰⁾ but the species was synonymized with *B. maclellandi*; the description of D'Ancona and Cavinato⁴⁾ was poor except with regard to body proportions, meristics, and distribution of chromatophores; Belyanina's²⁾ description, referring to some of the specimens in D'Ancona and Cavinato⁴⁾, was diverse in content but brief. Characters comparable among those descriptions are mainly meristics, body proportions, and distribution of chromatophores.

There appears to be no significant difference in body shape as indicated in the descriptions and shown in the proportional measurements in Table 1, with the exception of the larger interorbital width/HL given by Jordan and

Bollman⁹⁾ (ca. 33.3 % vs. 14.9-23.3 % in this study). This inconsistency may be due to incomplete observation or differences in technique. The accounts vary as to the position of the pectoral fins: it is high in Jordan and Bollman⁹⁾, mid-lateral in D'Ancona and Cavinato⁴⁾ and Belyanina²⁾, and slightly below mid-lateral in our study. Taking into account differences in terminology and points of reference, the pectoral fins are at or slightly below the lateral mid-line. The teeth descriptions differ between the original⁹⁾ and our descriptions. For example, teeth are reported to be in a single series on both jaws in the original description, but in two rows in our description, seemingly due to incomplete observation in the original description. The descriptions of chromatophores are essentially the same among all authors, except for the reported presence of a narrow white cross-bar at the caudal fin base and the dark markings on the dorsum in the original description⁹⁾. The description of those characters could not be a result of incomplete observation, since they are stated very clearly in Jordan and Bollman⁹⁾. Why the cross-bar was not observed by other authors is a difficult question to answer. Since our description is based on specimens that have been stored for a long period in alcohol, fading could be a factor in our inability to observe this or other features of pigmentation. The following features reported by D'Ancona and Cavinato⁴⁾, based on non-type material from the Gulf of Panama, are regarded here as characteristic of the species: homogeneous, thick, brown chromatophores on the dorsal region of head and behind eyes; few chromatophores in the interorbital region; some longitudinal series of brown chromatophores on the dorsal part of trunk; the sides do not have brown chromatophores except for the distal part of the tail; at the middle of tail, one or two little longitudinal series are present on the ventral region; the anterior lobe of the dorsal fin bears chromatophores on the rays (this description should be revised as dorsal fin entirely covered with chromatophores, according to our observations); some chromatophores are also present on the caudal fin; the other fins are colorless. Compared with our values, the meristic counts of Jordan and Evermann¹⁰⁾ seem comparable (Table 1), but counts of transverse and longitudinal scales by those authors cannot be evaluated since those scales are now missing in the types. There are some doubtful counts in D'Ancona and Cavinato⁴⁾: 11 TS,

compared with 14 in Jordan and Evermann¹⁰⁾, and ca. 14 in our counts (Table 1). All three meristic counts of Belyanina²⁾ show wider ranges than those in our study and in D'Ancona and Cavinato⁴⁾, probably a result of incorrect counts because of her inclusion of small specimens (10.4-16 mm SL).

Our comparisons indicate that all specimens collected from nearly the same locality (Gulf of Panama) and described under the name *B. bathymaster* belong to the same species, and the differences among the descriptions seem due to incomplete or incorrect observations, except for the mysterious pigmentation in Jordan and Bollman's⁹⁾ description and some anomalous meristic character values.

B. bathymaster was the fifth species described in the family Bregmacerotidae¹⁾. It was poorly characterized as "very close to the Chinese *B. maclellandi*. It seems, however, to have larger scales and rather shorter ventrals". To determine its validity, we compare *B. bathymaster* with the four species that preceded it. The first, *B. maclellandi* Thompson, and the third, *B. atripinnis* (Tickell), are undoubtedly different from *B. bathymaster* in having all the fins except the pelvics heavily pigmented with dark brown to black⁷⁾. The second, *B. mirum* (Richardson), is valid and different from *B. bathymaster* in uniquely having scales on the cheek^{7,13)}. The fourth species, *B. atlanticus* Goode and Bean, is different from *B. bathymaster* in having the following characters: dense pigmentation covering much of body and chromatophores scattered on all fins except the anal fin, which is nearly unpigmented⁷⁾. Thus, it can be concluded that *B. bathymaster* is valid.

Concerning *B. longipes* Garman, 1899, we consider that nominal species to be a junior synonym of *B. bathymaster*, as did Belyanina²⁾. The *B. longipes* types are nearly identical to the *B. bathymaster* types with respect to the characters examined. In addition, the types of both nominal species were collected in the eastern Pacific, *B. longipes* off Mexico and *B. bathymaster* in the Gulf of Panama.

Comparative material examined. *Bregmaceros longipes*: MCZ 28603; USNM 120248.

Bregmaceros rarisquamosus Munro, 1950⁽⁴⁾

(Figs. 1B, 2B, 3B, 4B, 6, Table 2)

Holotype. CSIRO B3425, 33.3 mm SL (?), Bostrem Bay (Sek Harbour), north coast of New Guinea.

Diagnosis. Dorsal fin dotted lightly with chromatophores; other fins colorless; no scales on cheek; body chromatophores limited to dorsal part; PC 14; mandibular canal organs distinct and tubular; scales under pectoral fins elliptical; body depth/SL 21.3 % or /TL 16.4-20.0 %.

Description. Specimen in fairly good condition, although skeleton possibly decalcified. Proportional measurements and meristic counts are shown in Table 2. Body slightly compressed and apparently deeper than those of other bregmacerotids (e.g., compare with *B. bathymaster* and *B. cayorum*, redescribed herein): Body depth/SL 21.3% (Table 2) vs. 13.4-14.4% in *B. bathymaster* (Table 1) and 14.4% in *B. cayorum* (Table 3). Snout round, mouth oblique and subterminal. Eye partially covered dorsally with adipose eyelid; two nostrils just before eye. Interorbital smoothly convex. Upper jaw slightly longer than the lower; its tip ending posteriorly below area between the center of eye and posterior margin of pupil. One row of medium-sized conical teeth on upper jaw. Lower jaw with an inner row of large conical teeth and an outer row of minute conical teeth. A few minute conical teeth on vomer and palatine. Tongue rather large. Gill rakers reduced to small, conical, tooth-like projections distributed sparsely on gill arch. A pair of rather elongate, medially bent dermal flaps along ventral contour from insertion of pelvic fin to posterior end of anterior lobe of anal fin. A relatively deep scaleless groove between pelvic fins and anus bordered by the flaps. Groove flat except for two short, low ridges along middle of the groove just after insertion of pelvic fin and just before anus. Rather deep dorsal groove, which houses a depressed occipital fin, along dorsal contour from insertion of occipital fin to origin of dorsal fin; no scales in groove. Opercle small, slender, slightly curving posteriorly. On upper half of posterior margin, a long, tapered shaft ending in a point posteriorly (Fig. 2B). Axillary flap attached to shoulder girdle above pectoral fin distinct, nearly crescent-shaped with a small indentation at the lower half of posterior margin (Fig. 3B). A slender occipital fin ray above

posterior margin of eye, its tip reaching just before the origin of dorsal fin. Origin of anal fin below the second dorsal fin ray. Dorsal and anal fins long in base and nearly identical in shape, both divided obscurely into three parts: the anterior high and triangular, the middle low and consisting of rudimentary rays, and the posterior of moderate height. Pectoral fin base mid-lateral, its posterior margin a little pointed and the lowest three rays branched. Pelvic fins jugular in position, tip of longest ray reaching just behind anterior part of anal fin base; the outer three rays thickened and greatly elongate, their tips not branched; the inner rays short, complexly branched and impossible to count precisely. Caudal fin slightly forked; among 12 branched rays with doubly bifurcated tips, eight rays are supported by a bony plate composed of fused terminal vertebrae and hypurals. No scales on head. Lateral line beginning slightly above mid-point between insertion of occipital fin ray and upper margin of gill cover, ascending nearly vertically to dorsum, then running posteriorly, ending at origin of posterior lobe of dorsal fin without a clear diagonal descent. Scales under pectoral fins transversally elliptical, small, cycloid, and deciduous with circuli transversally nearly straight on the exposed part and longitudinally nearly straight on the covered part (Fig. 4B). Base of caudal fin covered by nearly square scales distinctly smaller than those under pectoral fins. Four mandibular canal organs open through distinct, tubular projections (Fig. 6). Vertebrae unobservable on radiograph, likely due to decalcification.

Ground color of holotype red-brown. All chromatophores

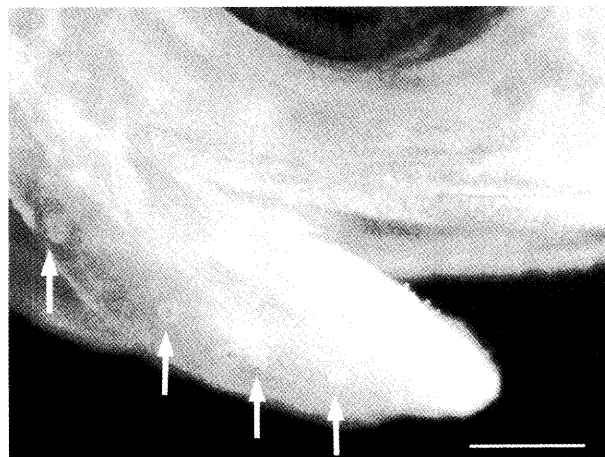


Fig. 6 Right side view of four mandibular canals indicated by arrows of *Bregmaceros rarisquamosus*, 26.3 mm SL (CSIRO B3427). Bar 0.5 mm.

bleached and contracted but fundamentally in the same pattern as reported in the original description¹⁴⁾. Dorsally on posterior portion of head between vertical through posterior margin of pupil and before occipital fin ray, a cluster of prominent chromatophores composed of a pair of extremely large chromatophores anteriorly and six or seven large, circular ones with darker circle at their center posteriorly. Light, sparsely scattered chromatophores along dorsal margin from insertion of occipital fin ray to posterior end of anterior dorsal fin base. A longitudinal band of medium-sized, punctate chromatophores on dorsal side from a little above mid-point between pectoral fin base and dorsum, posteriorly to about below middle of anterior dorsal fin lobe, scattered in that area. A band of large, light stellate chromatophores along dorsal contour from below base of posterior lobe of dorsal fin to proximal dorsal procurent caudal fin rays. Dotted small chromatophores over proximal half of anterior and posterior lobes of dorsal fin. Occipital, pectoral, pelvic, and anal fins entirely colorless. Several internal chromatophores visible along ventral contour of abdomen. Inner surface of gill cover, first gill arch, and mouth cavity

unpigmented.

Comparison with past descriptions and validity. Munro's¹⁴⁾ original description and ours differ in body proportions and pigmentation. Most of the body proportions in our study (Table 2) are outside those reported in the original description¹⁴⁾; e.g., (our data first) head length / TL 16.5% vs. 17.9-19.6%, occipital ray length / head L. 148.0% vs. 110.0-120.0%. These discrepancies are caused by two factors: (1) shrinkage after 50 plus years in alcohol (for example, 33.3 mm TL of Munro¹⁴⁾ vs. 30.3 mm in our study); (2) incomplete observation by Munro¹⁴⁾.

Measurements of the specimen illustrated in fig. 10 of Munro¹⁴⁾ by us are more similar to those of our study than to Munro's, for example, head L./ TL ca. 16.6% vs. 16.5% (Table 2) vs. 19.6%¹⁴⁾, body depth / TL ca. 17.9% vs. 18.5% vs. 20.0% and occipital ray L./head L. >135% vs. 148.0% vs. 120.0%. As a result, body proportions of *B. rarisquamosus* are quite uncertain, and measurements of new specimens are required. The pigmentation pattern differs somewhat between that recorded by Munro¹⁴⁾ and what we saw; we found most of the chromatophores along the dorsal surface from above eye to caudal fin smaller than

Table 2. Comparison of meristic counts and body proportions of *Bregmaceros rarisquamosus* as enumerated by different authors

Specimens	Holotype CSIRO B3425		Nontype specimens (n=4)	Non-type specimens (n=9)	Non-type specimens (n=4) ^a
	Author	Munro(1950)	Munro(1950)	D'Ancona and Cavinato(1965)	Belyanina(1974)
Locality	Bostrem Bay		Bostrem Bay and Port Moresby	East coast of Australia to Arabian Sea ^b	North New Guinea to Arabian Sea ^c
Standard length(mm)	26.3(30.3) ^d	(33.3) ^d	(23.0-28.5) ^d	~25.0	20.0-30.0
Meristic counts					
Dorsal fin rays	38	38	36-39	34-41	34-39
Anal fin rays	39	39	38-40	36-43	38-43
Pectoral fin rays	16	-	-	13-15	12-15
Caudal fin rays	29	-	-	26-34	-
Principal caudal fin rays	14	-	-	-	-
Transverse scales	ca.11	10	10-12	9-11	-
Longitudinal scales	ca.48	44	43-50	40-52	-
Total vertebrae	-	-	-	43-48	43-46
Proportional measurements					
In % of standard length					
Head length	19.0 [16.5] ^e	[19.6] ^e	[17.9-19.2] ^e	16.9-19.2	16.1-18.6
Body depth	21.3 [18.5] ^e	[20.0] ^e	[16.4-17.5] ^e	11.4-12.5	12.5-15.0
Occipital ray length	28.1 [24.4] ^e	[23.5] ^e	[18.5-20.0] ^e	20.0-23.3	15.6-22.0
Pre-anal length	44.9	-	-	-	35.6-40.1
Pre-dorsal length	44.1	-	-	-	37.5-40.5
Longest pelvic length	55.9 [48.5] ^e	[45.5] ^e	[43.5-47.6] ^e	40.0-50.0	34.4-41.0
Caudal peduncle depth	7.2	-	-	-	4.3-6.0
Pectoral length	15.2 [13.2] ^e	[14.0] ^e	[11.4-12.8] ^e	-	9.8-11.2
In % of head length					
Pectoral length	80.0	71.4	62.5-66.6	-	-
Occipital ray length	148.0	120.0	100.0-110.0	-	-
Longest anal fin ray length	120.0	100.0	90.9-111.0	-	-
Eye diameter	34.0	37.0	28.6-34.5	21.3-23.3	-
Interorbital width	44.0	48.1	37.1-51.5	-	-
Snout length	20.0	24.7	20.2-22.8	-	-
Upper jaw length	44.0	52.6	47.6-50.0	40.0-50.0	-
In % of pre-anal length					
Pre-dorsal length	98.3	-	-	-	-

^a Larger specimens in table 1 of Belyanina (1974)

^b For details, refer to fig.35 of D'Ancona and Cavinato (1965)

^c For details, refer to fig.2 of Belyanina (1974)

^d Total length in mm

^e % of TL

described by Munro (see fig. 10 of Munro¹⁴⁾ and Fig. 1B), probably due to shrinkage. Also, the chromatophores over the proximal half of the anterior and posterior dorsal fin lobes were not described by Munro¹⁴⁾ and possibly overlooked or ignored by him.

B. rarisquamosus was reported by D'Ancona and Cavinato⁴⁾ and later by Belyanina³⁾, who followed D'Ancona and Cavinato⁴⁾ in identification of her material. Many significant differences are recognized between Munro's data¹⁴⁾ and those of D'Ancona and Cavinato⁴⁾. The following are examples (Munro plus our study first: see Table 2 for body proportions): a black chromatophore on mandibular joint and a few others scattered on abdominal region absent (Munro's and our data) vs. present (D'Ancona and Cavinato⁴⁾); proportion of maximum depth of body to SL 21.3% (our study) or greater (16.4–20.0% to TL in Munro¹⁴⁾) vs. 11.4–12.5% (D'Ancona and Cavinato⁴⁾); eye diameter to HL 28.6–37.0% vs. 21.3–23.3 %. In addition, the specimens of D'Ancona and Cavinato⁴⁾ are probably a mixture of two different species based on the presence or absence of the black chromatophore on the joint of mandible in their material (Torii and Ozawa, unpublished). Thus, since the original description¹⁴⁾, the species has not been recorded again with certainty.

B. rarisquamosus was the ninth species described in the family Bregmacerotidae¹⁾. In the original description, Munro¹⁴⁾ referred to five earlier-described species and characterized *B. rarisquamosus* as closest to *B. nectabanus* Whitley in coloration, but different in having fewer dorsal and anal rays, considerably fewer horizontal and vertical tracts of scales, larger eye and shorter ventral fins. Munro¹⁴⁾ synonymized *B. mirum* and *B. atripinnis* with *B. maclellandi*, and *B. longipes* Garman with *B. bathymaster*. Since at least *B. mirum* is valid⁷⁾, the comparison by Munro¹⁴⁾ was incomplete.

B. rarisquamosus differs from the earliest four species, *B. maclellandi*, *B. mirum*, *B. atripinnis*, and *B. atlanticus*, by the same characters used to validate *B. bathymaster*: fins dotted lightly with chromatophores or colorless; no scales on cheek; body chromatophores limited to dorsal part. *B. japonicus* Tanaka is distinct from *B. rarisquamosus* in having pigmentation distributed entirely over the body as well as on dorsal, pectoral, and caudal fins^{15,16)}. *B. bathymaster* (our study) inclusive of a junior synonym *B. longipes* (see above), has a longitudinal row of chromatophores above the anal fin base that is absent in *B. nectabanus*^{16,17)} and

B. rarisquamosus. These results are the same as Munro¹⁴⁾ in that *B. rarisquamosus* is closest to *B. nectabanus*, and according to our observations, they can be differentiated with the same characters as in Munro¹⁴⁾, as well as by the number of principal caudal fin rays [13 in *B. nectabanus*³⁾ vs. 14 in *B. rarisquamosus* (Table 2)]. Therefore, we conclude that *B. rarisquamosus* is valid.

Comparative material examined. *Bregmaceros rarisquamosus*: a part of Dana samples [ZMUC-P 372749 (12 specimens), 372750 (18), 372751 (33), 372755 (1), 372756 (5), 372762 (1), 372820 (1), and 372825 (2)] in D'Ancona and Cavinato (1965).

Bregmaceros cayorum Nichols, 1952¹⁸⁾

(Figs. 1C, 2C, 4C, 5B, Table 3)

Holotype. AMNH 19539, 46.0 mm SL, Straits of Florida, "west of Cay Sal," 325 fathoms, July 12, 1949.

Diagnosis. No chromatophores on abdominal part of trunk; dotted chromatophores scattered widely over the latter half of tail; no scales on cheek; shaft of opercle directed downward and distinctly shorter than opercle; mandibular canal organs indistinct.

Description. The holotype and only known specimen in very poor condition: all fins damaged greatly; scales mostly lost; body partly bleached, but chromatophores recognizable.

Proportional measurements and meristic counts are Table 3. Meristic counts and body proportions of the holotype (AMNH 19359) of *Bregmaceros cayorum*

Author	The present authors	Nichols (1952)
Standard length(mm)	44.5	46.0
Meristic counts		
Dorsal fin rays	48	34?(52) ^a
Anal fin rays	50	45?(54) ^a
Pectoral fin rays	17	-
Longitudinal scales	-	<70
Anal fin rays	14	-
Caudal vertebrae	37	-
Total vertebrae	51	50
Proportional measurements		
In % of standard length		
Head length	17.5	17.2
Body depth	14.4	15.2
Occipital ray length	24.9	28.7
Pre-anal length	38.2	-
Pre-dorsal length	38.2	-
Longest pelvic length	-	58.8
Caudal peduncle depth	5.4	-
In % of head length		
Eye diameter	29.1	27.0
Inter-orbital width	25.3	25.0
Snout length	17.7	21.3
Upper jaw length	45.6	50.0
In % of pre-anal length		
Pre-dorsal length	100	-

^a Data from Milliken and Houde (1984)

shown in Table 3. Body moderately elongate and slightly compressed. Interorbital smoothly convex. Snout round, mouth oblique and subterminal. Eye covered dorsally with adipose eyelid; two nostrils just before eye. Upper jaw slightly longer than lower, its posterior tip between verticals at posterior margins of pupil and of eye. A band of irregularly arranged medium-sized conical teeth on upper jaw. An inner row of large and an outer row of minute conical teeth on lower jaw. Vomer with a few medium-sized conical teeth. Gill rakers reduced to transparent, small, conical tooth-like projections distributed sparsely on gill arches. Tongue rather large. Rather deep dorsal groove along dorsum between insertion of occipital fin and origin of dorsal fin, which receives a depressed occipital ray, with two scales before the origin of dorsal fin. A pair of rather slender, medially bent dermal flaps along ventral contour from insertion of pelvic fin to end of anterior lobe of anal fin base; the ventral groove bordered by the flaps before anus rather deep with a low, longitudinal ridge entirely along the middle of the groove, and scaleless. Opercle bamboo-leaf in shape and on its upper edge of posterior margin, with a long, tapered shaft descending and reaching a point posteriorly (Fig. 2C); length of shaft to that of opercle 0.72. Shape of axillary flap on shoulder girdle unknown due to damage to its lower half. A slender ray on occiput, its depressed tip reaching just before origin of dorsal fin. Origin of anal fin directly ventral to origin of second dorsal fin; both fins heavily damaged in the holotype; relative sizes and shapes therefore indeterminate. Pectoral fin mid-lateral, its shape and distribution of branched rays unknown due to damage. Pelvic fins jugular in position, tips of longest rays broken; outer three rays greatly elongated and unbranched; the inner rays short, complexly branched, fin ray counts therefore indeterminate. Caudal fin damaged, impossible to determine shape and fin ray count. Lateral line beginning at about mid-point between upper edge of gill cover and insertion of occipital ray, running along the dorsum from above upper edge of gill cover to about beginning of posterior dorsal fin lobe, declining diagonally, ending shortly behind the declining point. Scales under the pectoral fin nearly circular, small, cycloid and deciduous with circuli concentric around focus on exposed part and longitudinally straight and truncated along anterior border on covered portion (Fig. 4C). Four mandibular canal

organs indistinct. Parapophysis of abdominal vertebrae short-based, canine-like, straight or slightly curved posteriorly in lateral view (Fig. 5B).

Ground color of the holotype pale brown. All chromatophores small and nearly dot-like. Chromatophores scattered on snout, above eye, behind interorbital, and around upper edge of gill cover. Body above lateral mid-line covered entirely by small chromatophores, with a longitudinal row of slightly larger ones from upper edge of gill cover to below anterior dorsal fin lobe. Posterior half of tail covered entirely by small punctate chromatophores with an indistinct longitudinal row of irregularly distributed ones along ventral contour posteriorly from the middle part of anterior anal fin lobe. Except for distal part, anterior dorsal fin lobe with punctate chromatophores. Anterior half of anal fin, pelvic fins, and pectoral fins unpigmented. Pigmentation of other parts of dorsal, anal, and caudal fins unknown due to damage. Inner surface of gill arches pigmented sparsely with pale chromatophores. Inner surface of gill cover and mouth cavity unpigmented.

Comparison with past descriptions and validity. The original description by Nichols¹⁸⁾ was not consistent with our observations in some respects, especially on meristics (Table 3), but is fundamentally the same with our findings in pigment pattern (see fig.1 of Nichols¹⁸⁾ and Fig. 1C), regardless of the discoloration from long-term preservation. Milliken and Houde¹⁹⁾ reexamined the holotype and cited only three meristic characters, D 52, A 54, and vertebrae 50, all of which are different from our counts (Table 3).

B. cayorum was the tenth species described in the family Bregmacerotidae¹⁾. In the original description¹⁸⁾, the species was briefly compared with four species, *B. mccllellandi*, *B. atlanticus*, *B. japonicus*, and *B. longipes* (a junior synonym of *B. bathymaster*, see above). The description agreed with *B. longipes* in color pattern, but it differed in many body proportions. Thus, in addition to the poor description, the comparisons were incomplete. Later, *B. cayorum* was questionably synonymized with *B. mccllellandi* by D'Ancona and Cavinato⁴⁾ and with *B. atlanticus* by Milliken and Houde¹⁹⁾. *B. cayorum* is distinct from *B. mccllellandi*, *B. mirum*, *B. atripinnis*, *B. atlanticus*, and *B. japonicus* in the same characters used to validate *B. bathymaster* and *B. rarisquamosus* (above), and from *B.*

nectabanus and *B. varisquamosus* in the presence of a longitudinal row of chromatophores above the anal fin base. *B. cayorum* is very similar to *B. bathymaster* in meristic characters and body proportions (Tables 1 and 3) and in pigmentation pattern (Figs. 1A and 1C). It differs in the shape of the shaft of the opercle, which is directed downward and distinctly shorter than the opercle (ratio of shaft length to opercle length 0.72) (Fig. 2C), compared with directed horizontally with upward curvature posteriorly and nearly equal to opercle length (0.96-0.99) in *B. bathymaster* (Fig. 2A).

The above comparisons with the earlier-described eight valid species indicate that *B. cayorum* is valid.

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