

Five New Species of Skates in the Genus *Bathyraja* from the Western North Pacific, with Reference to Their Interspecific Relationships

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(Received May 13, 1977)

Abstract Five new species of skates, *Bathyraja caeluronigricans*, *B. notoroensis*, *B. maculata*, *B. lindbergi*, and *B. minispinosa* were described from the western North Pacific. *Bathyraja matsubarai* (Ishiyama, 1952) was revised and redescribed, not only because this species is closely related to the above species but because one of the paratypes of this species was newly erected as *B. notoroensis*. Relationships of the six species were discussed morphologically and zoogeographically.

Introduction

The skates, family Rajidae, occur world-wide in shallow to deep seas across the temperate and subpolar zones. This family is one of the largest groups of the order Rajiformes in number of species as well as in geographic range.

The family Rajidae was divided into six genera, *Dactylobatus*, *Raja*, *Cruriraja*, *Breviraja*, *Psammobatis*, and *Sympterygia* by Bigelow & Schroeder (1948). Later, the genus *Rhinoraja* was added to the family by Ishiyama (1952).

In 1968, the genus *Bathyraja* was proposed

by Ishiyama and Hubbs for the skates which are allied to *Breviraja* but distinct from it in the structure of the rostral cartilage and the clasper. The center of distribution of *Bathyraja* is the North Pacific; 11 species have been recorded from the western part of the region by many authors. The range of the genus has recently been extended to the eastern North Atlantic (Stehmann, 1970), South Africa (Hulley, 1970), Antarctica (Springer, 1971), and New Zealand (Garrick and Paul, 1974).

Recent investigations of the western North Pacific by the Tokyo University of Fisheries and Fisheries Agency, Japan, yielded sizable collections of skates, in which a number of

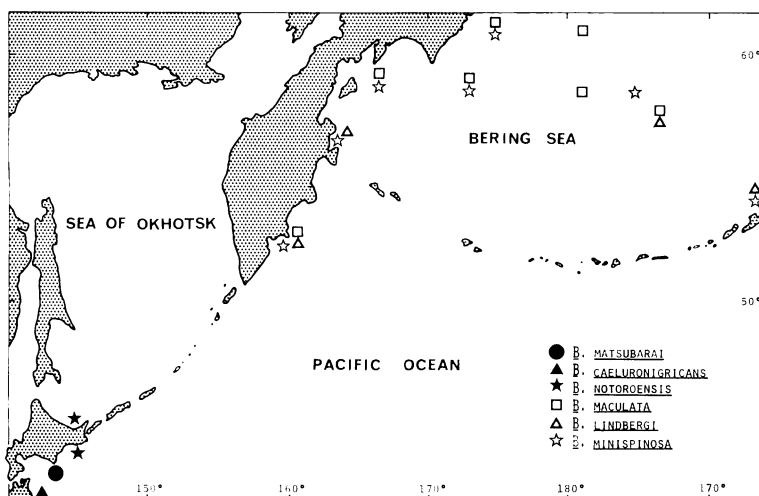


Fig. 1. Map of the western North Pacific showing collecting localities for the six species of *Bathyraja*.

specimens with unusual characters were contained. Subsequent study has revealed that these unusual specimens represent five undescribed species, though they are closely related to *Bathyraja matsubarai*, which was originally described as *Breviraja matsubarai* by Ishiyama (1952) from Hokkaido.

In this paper the western North Pacific refers to the area from Kyushu north to the Bering Sea and east to 160°W, and whole part of the Sea of Okhotsk and the Sea of Japan (Fig. 1).

Methods

Counts and measurements were generally made according to the methods proposed by Hubbs and Ishiyama (1968). Those which were not adopted in their work but employed in the present study were the number of pseudobranchial folds in the spiracles (Fig. 2), length of the electric organs, and proportions of the parts of the clasper (Fig. 3, A). Counts and measurements for bilateral parts, when different, were averaged. The nomenclature of the parts of the clasper and of the cartilage used in the present study were mainly in accordance with that of Leigh-Sharpe (1920~1926), Ishiyama (1958b), Stehmann (1970), and Hulley (1972), and that of the egg capsule followed Ishiyama (1958a). The methods of measurements of the egg capsule are shown in Fig. 4. Young specimens were used only for counting characters.

Vertebral counts were taken from radiographs. Proportional measurements for the cranium were made on adult and immature specimens. Coloration was observed on both fresh-caught and formalin specimens.

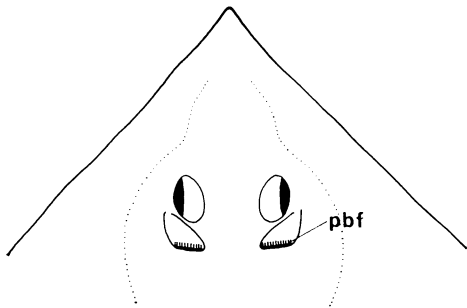


Fig. 2. General structure of the orbital region in *Bathyraja*. pbf, pseudobranchial folds.

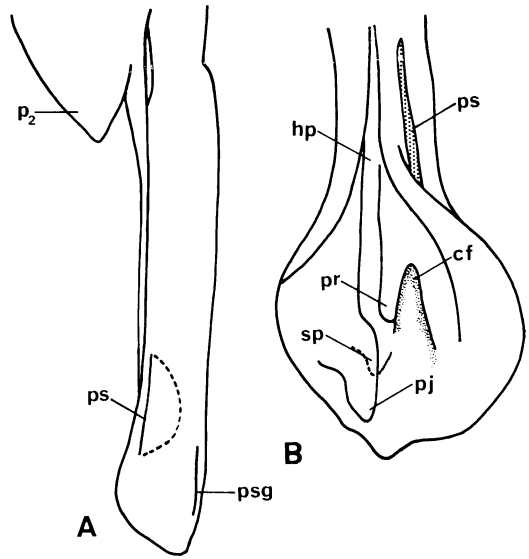


Fig. 3. General structure of clasper (left-side) in *Bathyraja*. A, clasper groove closed. B, clasper groove opened. cf, cleft; hp, hypopyle; p₂, pelvic fin; pj, projection; pr, pseudorhipidion; ps, pseudosiphon; psg, pseudosiphon-like groove; sp, spur.

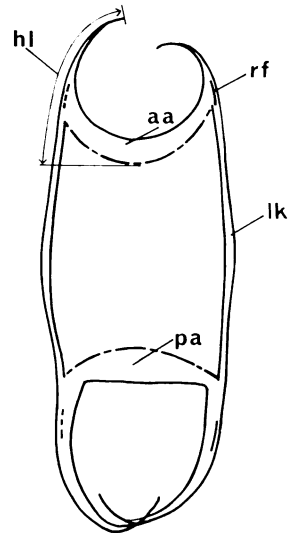


Fig. 4. General shape, structure, and measurement of egg capsule in *Bathyraja*. aa, anterior apron; hl, horn length; lk, lateral keel; pa, posterior apron; rf, respiratory fissure.

Descriptions

Genus *Bathyraja* Ishiyama and Hubbs, 1968
Breviraja Ishiyama (not Bigelow & Schroeder, 1948), 1952: 7.

Bathyraja Ishiyama and Hubbs, 1968: 407
 (type species: *Raja isotrachys* Günther, 1887).

Diagnosis. Snout soft and flexible. Dorsal side of disk and tail with prickles and large spines in most species. Malar hooks not developed in both sexes but alar hooks well developed in male. Tail as long as or longer than disk length. Rostral cartilage weak and rod-like, extending to tip of snout; its basal part without segment. Rostral appendix fused basally with anterior part of rostral cartilage, its anterior margin with a shallow notch on each side, posterior portions hanging backward free from rostral cartilage. Tip of radial cartilages of pectoral fins close to lateral sides of rostral appendix (Fig. 5).

Clasper cylindrical, simple in structure, with-

out shield and rhipidion (Fig. 3, B). Pseudosiphon present or not. Egg capsule rectangular, usually about 7 cm or more in long axis excluding horns, middle part more or less swollen. The capsule consisting of two layers, outer thick layer with densely distributed minute prickles; whip-like horn on each of the four corners of capsule; posterior horns longer than anterior ones; respiratory fissures in middle or distal portions of horns, but not on their tips (Fig. 4). Caudal vertebrae 60~91 from 1st caudal vertebra to origin of 1st dorsal fin. Electric organs made up of cup-form elements, situated in posterior half of tail.

Bathyraja matsubarai (Ishiyama)

(Japanese name: Matsubara-ei)

Fig. 6

Breviraja matsubarai Ishiyama, 1952: 10 (in part).

Holotype: FAKU (Faculty of Agriculture,

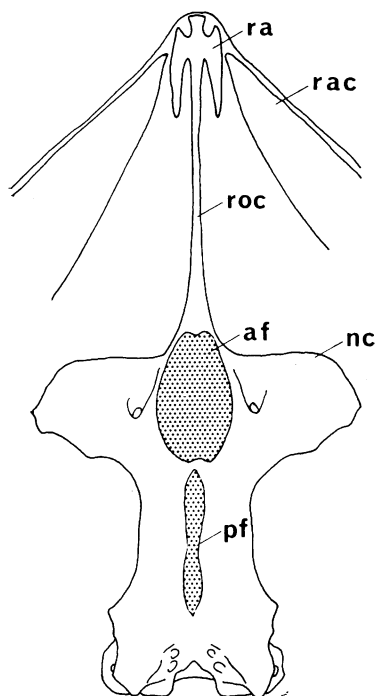


Fig. 5. Structure of cranium of *Bathyraja* (dorsal view, snout top). af, anterior fontanelle; nc, nasal capsule; pf, posterior fontanelle; ra, rostral appendix; rac, radial cartilage; roc, rostral cartilage.

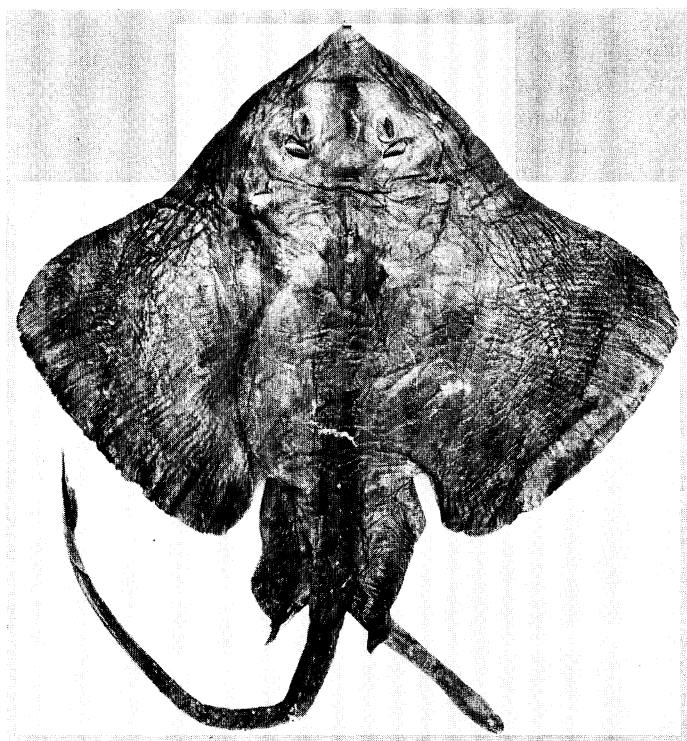


Fig. 6. *Bathyraja matsubarai*, holotype, FAKU 49458, male; 633 mm in disk width.

Kyoto University) 49458 (Ishiyama's Fish Collection No. 16701), adult male, 633 mm in disk width, collected off Erimo Peninsula (41°30'N, 143°15'E), Hokkaido, at a depth of about 800 m, on May 20, 1951.

Paratype: MTUF (Museum, Tokyo University of Fisheries) 21832, 1 young male, 447 mm, captured with the holotype.

Seventeen specimens were designated as paratypes in the original description of this species, but no catalogue number were given. In Ishiyama's personal list of specimens, his personal catalogue numbers, data on their size, and collecting localities are given. Of these one has been deposited in FAKU and six in MTUF. Other 10 paratypes were not available for this study. Five of the six MTUF specimens are of very young stage (less than 150 mm in disk width) and therefore of ambiguous specific identity. The remaining one specimen proved to be *B. matsubarai* and newly given catalogue number MTUF 21832 as indicated above. The single FAKU specimen, which was collected by K. Matsubara at Akkeshi Fish Market, Hokkaido, was identified as *B. noto-roensis* and designated as a paratype of the species, with catalogue No. FAKU 49459.

Diagnosis. *Bathyraja matsubarai* differs from other species of the genus *Bathyraja* in the combination of dark purplish brown both sides of body, eyeball as long as spiracle length, smooth interorbital space, and clasper with a deep cleft.

Description. Meristic counts and morphometric measurements of the holotype and paratype are shown in Table 1.

External features: Snout short, soft and broad; eyeball as long as spiracle; interorbital space flat and wide. Two dorsals large, equal in size, separated from each other by a short interspace. Tail longer than precaudal. Lateral folds developed on posterior half of tail. Dorsal side of disk rough with both large spines and prickles; scapular and interdorsal spines absent. A row of mid-dorsal spines running from before scapular arch to first dorsal; the row interrupted at middle of trunk. Lumbar spines, when present, followed by tail spines. Prickles developed on dorsal surface of disk, posterior pelvic lobes, two dorsals

and caudal, and absent at interorbital space, in central part of pectorals, on tip of snout and anterior pelvic lobes. Ventral side of body smooth. Skin covering eyes without prickles.

Coloration: Ground color of dorsal side dark purplish brown, ventral side lighter. Areas in front of mouth, immediately before gill slits and around cloaca, distal portion of anterior pelvic lobes, and sensory pores whitish.

Internal features: Cranium wide; rostral cartilage short, soft, poorly calcified, slightly undulated; rostral appendix elongate, extending to middle of rostral cartilage; anterior fontanelle oval-shaped, posterior margin flat, anterior margin extending to the line connecting front edge of nasal capsules; posterior fontanelle long, with a constriction in the middle (Fig. 7, A).

Clasper: Clasper long, extending to middle of tail, cylindrical, with a round tip; pseudosiphon large, located far from tip of clasper. Inner surface of dorsal lobe with a deep cleft and a pseudorhipidion. Posterior portion of inner surface of ventral lobe with a large projection and a small spur. Axial cartilage spatulated distally. Three dorsal terminals (1~3) more or less well developed. Dorsal terminal 1 elongate, pointed at anterior and posterior ends, middle portion swollen. Ventral terminal narrow anteriorly, gradually broadened toward posterior end like the leaf of ginkgo. Accessory terminal small, firmly connected to posterior edge of ventral marginal (Fig. 8, A).

Bathyraja caeluronigricans sp. nov.

(New Japanese name: Tsumura-kasube)

Figs. 9, A and B

Holotype: MTUF 21803, adult male, 744 mm in disk width, collected off Hachinohe (41°00'N, 142°00'E), at a depth from 200~400 m, on Oct. 23~26, 1975.

Paratypes: 2 adult males, MTUF 21804, 728 mm, MTUF 21805, 696 mm; 4 adult females, MTUF 21806, 722 mm, MTUF 21807, 700 mm, MTUF 21808, 677 mm, MTUF 21809, 674 mm; 4 young males, MTUF 21810, 579 mm, MTUF 21811, 484 mm, MTUF 21812, 458 mm, MTUF 21813, 445 mm; 3 young females, MTUF 21814, 600 mm, MTUF 21815, 386 mm, MTUF 21816, 377 mm; all the

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 Table 1. Counts and measurements of two species of *Bathyraja*. —, not examined; *, number of vertebrae counted up to the origin of second dorsal; **, from three specimens.

Characters	<i>B. matsubarae</i>			<i>B. caeluronigricans</i>		
	Holotype	Paratype N=1 (young 1)	Mean N=2	Holotype	Paratypes N=13(♂ 2, ♀ 4, young 7)	Mean N=14
1. Total length (mm.)	1037	—	—	1206	1104~1231	1172.7
2. Disk width (mm.)	633	—	—	744	674~744	705.9
3. Head length (mm.)	160	—	—	191	188~199	193.6
4. Tail length (mm.)	558	—	—	649	569~657	620.6
5. Precaudal vertebrae	38	36	37.0	36	36~38	36.6
6. Caudal vertebrae	72	72	72.0	73	69~75	71.9
7. Total vertebrae*	120	120	120.0	122	119~124	121.2
8. Nuchal spine	4	3	3.5	3	2~5	3.0
9. Lumbar spine	0	1	0.5	2	0~2	0.4
10. Tail spine	30	22	26.0	31	26~35	29.9
11. Alar hooks in longitudinal	23.5	—	—	22	21~23	22.0
12. Alar hooks in transverse	7.5	—	—	6	6~7	6.3
13. Spiral valves of the intestine	—	11	—	—	9~11	10.0
14. Tooth rows on upper jaw	25	21	23.0	29	25~30	27.1
15. Pseudobranchial folds	16	18	17.0	19	17~19.5	18.2
In % of disk width						
16. Total length	163.8	—	—	162.1	158.6~174.4	166.3
17. Disk length	79.0	—	—	79.3	80.4~85.5	82.3
18. Tail length	88.2	—	—	87.2	81.8~94.1	88.0
In % of head length						
19. Preocular length	54.6	—	—	64.9	61.4~66.0	64.2
20. Interorbital length	27.7	—	—	26.2	24.1~27.2	25.4
21. Eyeball length	18.2	—	—	14.4	12.5~15.4	14.1
22. Spiracle length	19.2	—	—	19.9	17.2~20.1	18.5
23. Over 1st gill slits (male)	127.0	—	—	123.6	117.5~128.5	123.2
24. Over 1st gill slits (female)	—	—	—	—	119.6~132.3	126.2
25. Clasper length (adult only)	154.0	—	—	161.8	151.9~158.8	157.4
26. $\frac{\text{Eyeball length}}{\text{Interorbital length}}$ (%)	65.7	—	—	55.0	49.5~55.4	54.0
27. $\frac{\text{Eyeball length}}{\text{Preocular length}}$ (%)	33.3	—	—	22.2	19.0~23.7	21.9
28. $\frac{\text{Eyeball length}}{\text{Spiracle length}}$ (%)	94.8	—	—	72.4	69.4~77.8	72.4
In % of tail length						
29. Precaudal length	85.3	—	—	86.7	85.7~94.1	89.4
30. Length of electric organ**	—	—	—	—	37.0~41.8	40.7
31. D ₁ origin to tail end	24.1	—	—	24.1	22.5~26.1	24.7
32. Post dorsal length	7.8	—	—	8.6	7.1~9.7	8.7
In % of cranium length**						
33. Cranium width	—	71.2	—	—	70.2~72.3	71.6
34. Rostral cartilage length	—	40.1	—	—	39.8~43.4	41.7
35. Prefontanelle length	36.3	36.6	36.5	—	36.1~39.1	37.7
36. Posterior fontanelle length	—	24.4	—	—	22.3~25.9	24.1
In % of clasper length						
37. Length of pseudosiphon	15.2	—	—	15.4	12.9~17.0	15.1
38. Posterior extremity of pseudosiphon to clasper tip	15.4	—	—	13.4	12.0~14.2	13.2

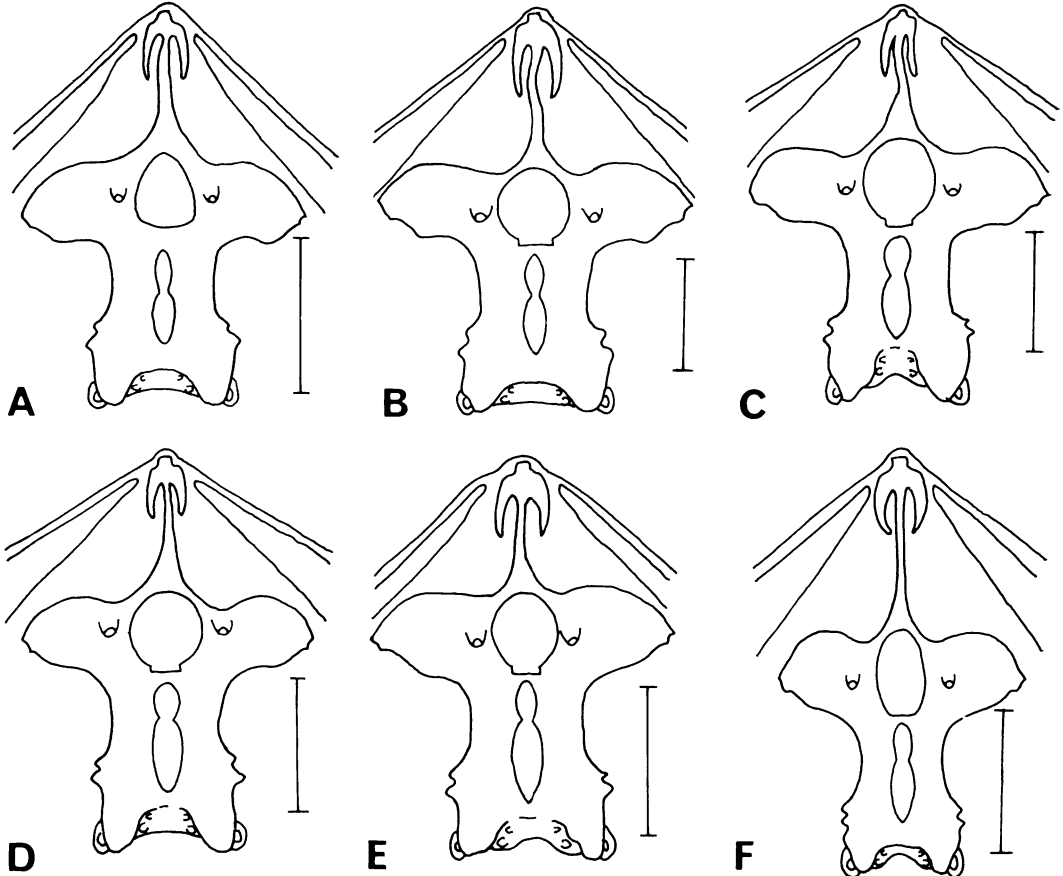


Fig. 7. Dorsal view of cranium. A, *Bathyraja matsubarai*; B, *B. caeluronigricans*; C, *B. notoroensis*; D, *B. maculata*; E, *B. lindbergi*; F, *B. minispinosa*. Scales indicate 50 mm.

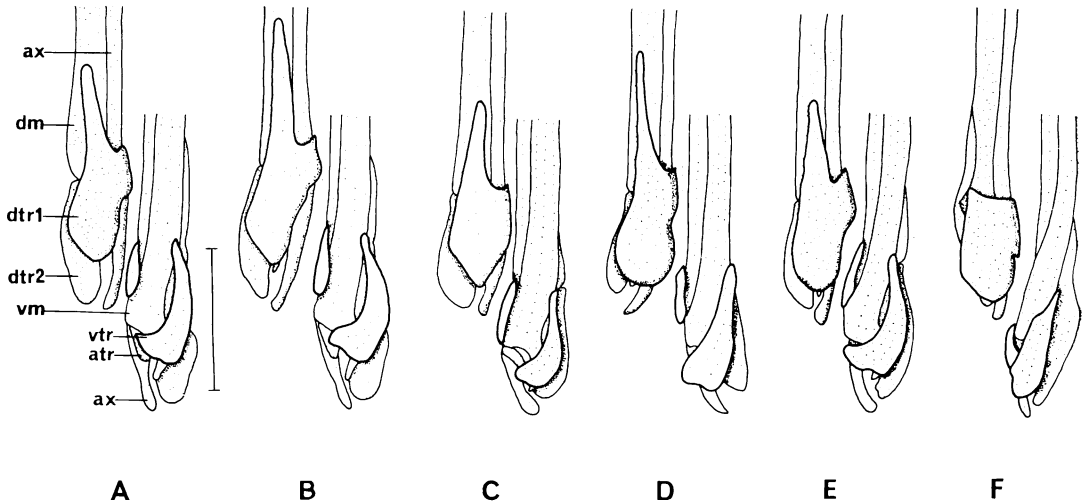


Fig. 8. Dorsal and ventral views of clasper cartilages. A, *Bathyraja matsubarai*; B, *B. caeluronigricans*; C, *B. notoroensis*; D, *B. maculata*; E, *B. lindbergi*; F, *B. minispinosa*. For each species, dorsal view is shown on top left, and ventral view on bottom right. atr, accessory terminal; ax, axial cartilage; dm, dorsal marginal; dtr 1, dorsal terminal 1; dtr 2, dorsal terminal 2; vm, ventral marginal; vtr, ventral terminal. Scale indicates 50 mm.

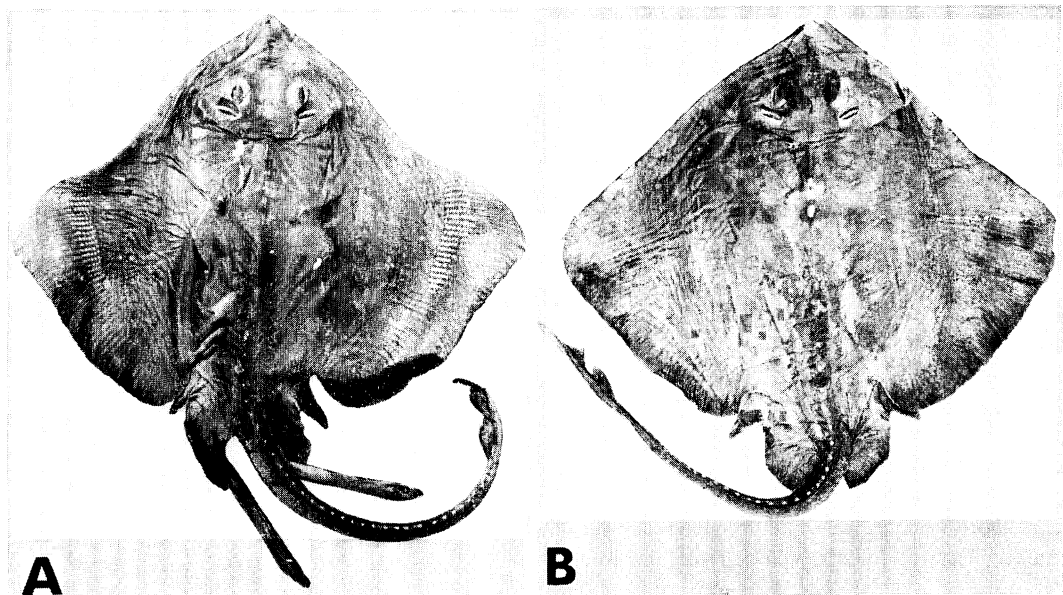


Fig. 9. *Bathyraja caeluronigricans* sp. nov. A, holotype, MTUF 21803, male, 744 mm in disk width; B, paratype, MTUF 21807, female, 700 mm in disk width.

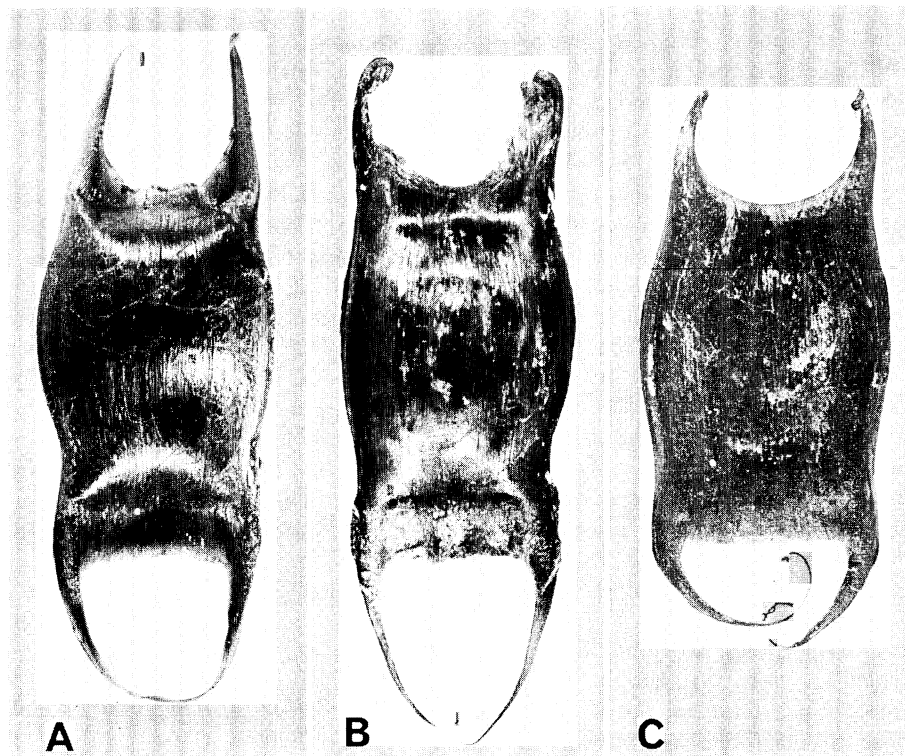


Fig. 10. Egg capsules. A, *Bathyraja caeluronigricans*; B, *B. maculata*; C, *B. minispinosa*. See Table 4 for the size of the capsules.

paratypes were captured with the holotype. The collecting locality is shown in Fig. 1.

Diagnosis. *Bathyraja caeluronigricans* differs from other species of the genus *Bathyraja* in the combination of dark purplish brown both sides of body, spiracle longer than eyeball and with deep concavity at their anterior part, deep cleft of clasper, and egg capsule densely covered with silky fibres.

Description. Meristic counts and morphometric measurements of the holotype and 13 paratypes are shown in Table 1.

External features: Snout short, soft and broad; eyeball less than spiracle; interorbital space flat and wide; spiracle large, deeply concave anteriorly. Two dorsals large, rather thick, equal in size, separated from each other by a short interspace. Tail longer than pre-caudal. Lateral folds developed on posterior half of tail. Dorsal side of disk rough with both large spines and minute prickles; scapular and interdorsal spines absent. A row of mid-dorsal spines running from before scapular arch to first dorsal; the row interrupted at middle of trunk. Lumbar spines, when present, followed by tail spines. Prickles developed on dorsal surface of disk, posterior pelvic lobes, and two dorsals and caudal, and absent in central part of pectorals, on tip of snout and anterior pelvic lobes. Ventral side of body smooth. Skin covering eyes without prickles.

Coloration: Ground color of dorsal side dark purplish brown, ventral side lighter. Areas in front of mouth, immediately before gill slits and around cloaca, distal portion of anterior pelvic lobes, and sensory pores whitish.

Internal features: Cranium wide; rostral cartilage short, soft, poorly calcified, slightly undulated; rostral appendix elongate, extending to middle of rostral cartilage. Anterior fontanelle spade-shaped, posterior margin flat, anterior margin extending to the line connecting front edge of nasal capsules; posterior fontanelle long, with a constriction in the middle (Fig. 7, B).

Clasper: Clasper long, extending to middle of tail, cylindrical, with a round tip, pseudo-siphon large, located far from tip of clasper. Inner surface of dorsal lobe with a deep cleft and a pseudorhipidion. Posterior portion of inner surface of ventral lobe with a large pro-

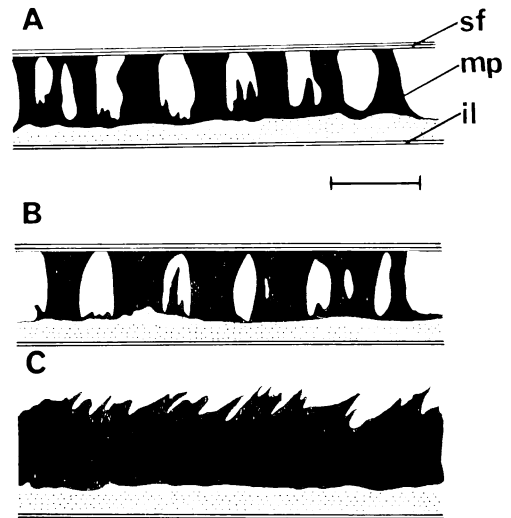


Fig. 11. Cross section (longitudinal) of the egg capsule. A, *Bathyraja caeluronigricans*; B, *B. maculata*; C, *B. minispinosa*. Outer surface up. il, inner layer; mp, minute prickles; sf, silky fibre. Scale indicates 2 mm.

jection and a small spur. Axial cartilage spatulated distally. Three dorsal terminals (1~3) more or less well developed. Dorsal terminal 1 elongate, pointed at anterior and posterior ends, middle portion swollen. Ventral terminal narrow anteriorly, gradually broadened toward posterior end, assuming the shape of the leaf of ginkgo. Accessory terminal small, firmly connected to posterior portion of ventral marginal (Fig. 8, B).

Egg capsule: Measurements are shown in Table 4. Egg capsule large; each horn with a filamentous tip; long respiratory fissure present near middle of outer surface of each horn; posterior apron wider than anterior one; keel on lateral side quite narrow; bands of silky fibres covering main portion of capsule (Fig. 10, A). Surface rough with minute prickles in numerous longitudinal rows (Fig. 11, A). Coloration in fresh brilliant yellow-brown.

Etymology. The Latin adjective *caeluronigricans*, meaning purplish black, refers to the color of the dorsal side of the disk.

Bathyraja notoroensis sp. nov.

(New Japanese name: Notoro-kasube)

Figs. 12, A and B

Breviraja matsubarai Ishiyama, 1952: 10 (in

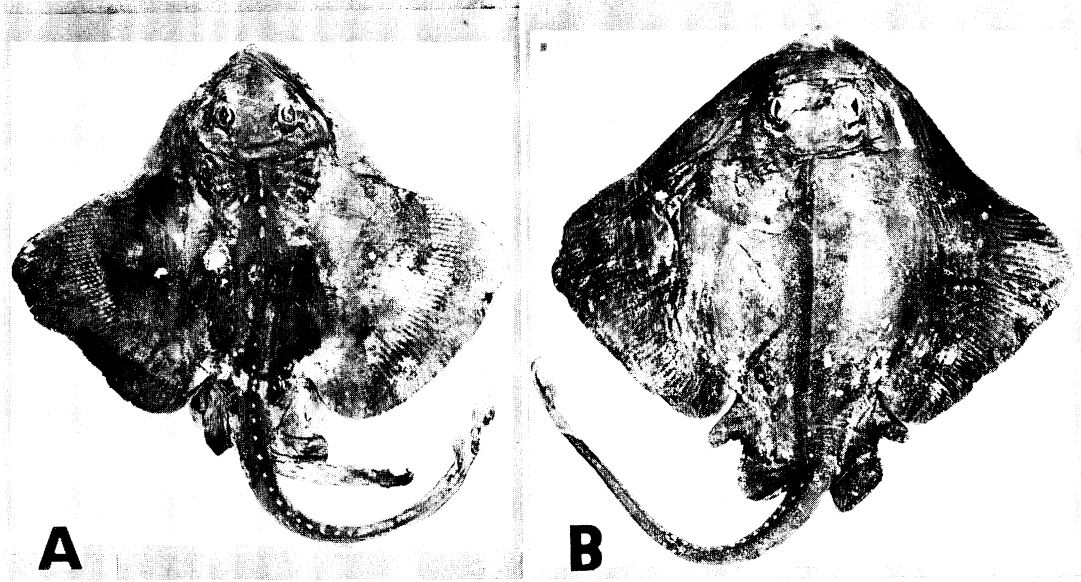


Fig. 12. *Bathyraja notoroensis* sp. nov. A, holotype, MTUF 21817, male, 582 mm in disk width; B, paratype, MTUF 21818, female, 590 mm in disk width.

part).

Holotype: MTUF 21817, adult male, 582 mm in disk width, collected off the Notoro Peninsula ($44^{\circ}00'N$, $144^{\circ}30'E$), at a depth of about 600 m, on Oct. 2~3, 1971.

Paratypes: 4 adult males, MTUF 21819, 623 mm, captured with the holotype. HUMZ (Laboratory of Marine Zoology, Faculty of Fisheries, Hokkaido University) 34830, 546 mm, HUMZ 34833, 570 mm, HUMZ 34870, 585 mm, all from the type locality, on Aug. 2, 1971; 1 adult female, MTUF 21818, 590 mm, captured with the holotype; 1 young male, FAKU 49459, 545 mm, Akkeshi Fish Market ($43^{\circ}00'N$, $144^{\circ}50'E$), in 1938, designated as paratype of *B. matsubarai* by Ishiyama (1952) with Dr. Matsubara's Catalogue No. 5765. The collecting localities are given in Fig. 1.

Diagnosis. *Bathyraja notoroensis* differs from other species of the genus *Bathyraja* in the combination of dark greyish brown both sides of body, rather short clasper with a shallow cleft, and wide distance between extremity of pseudosiphon and tip of clasper.

Description. Meristic counts and morphometric measurements of the holotype and six paratypes are shown in Table 2.

External features: Snout short, soft and

broad; interorbital space flat and wide. Two dorsals large, equal in size, separated from each other by a short interspace. Tail longer than precaudal. Lateral folds developed on posterior half of tail. Dorsal side of disk rough with both large spines and minute prickles; scapular and interdorsal spines absent. A row of mid-dorsal spines running from before scapular arch to first dorsal; the row interrupted at middle of trunk. Lumbar spines, when present, followed by tail spines. Prickles developed on whole dorsal surface of disk, and absent in central part of pectorals, on tip of snout and anterior pelvic lobes. Ventral side of body smooth. Skin covering eyes without prickles.

Coloration: Ground color of dorsal side dark greyish brown, ventral side lighter. Areas in front of mouth, immediately before gill slits, around cloaca, distal portion of anterior pelvic lobes, and sensory pores whitish.

Internal features: Cranium wide; rostral cartilage short, soft, poorly calcified, slightly undulated. Anterior fontanelle spade-shaped, anterior margin extending to the line connecting front edge of nasal capsules. Posterior fontanelle long with a constriction in the middle (Fig. 7, C).

Clasper: Clasper rather short, extending to

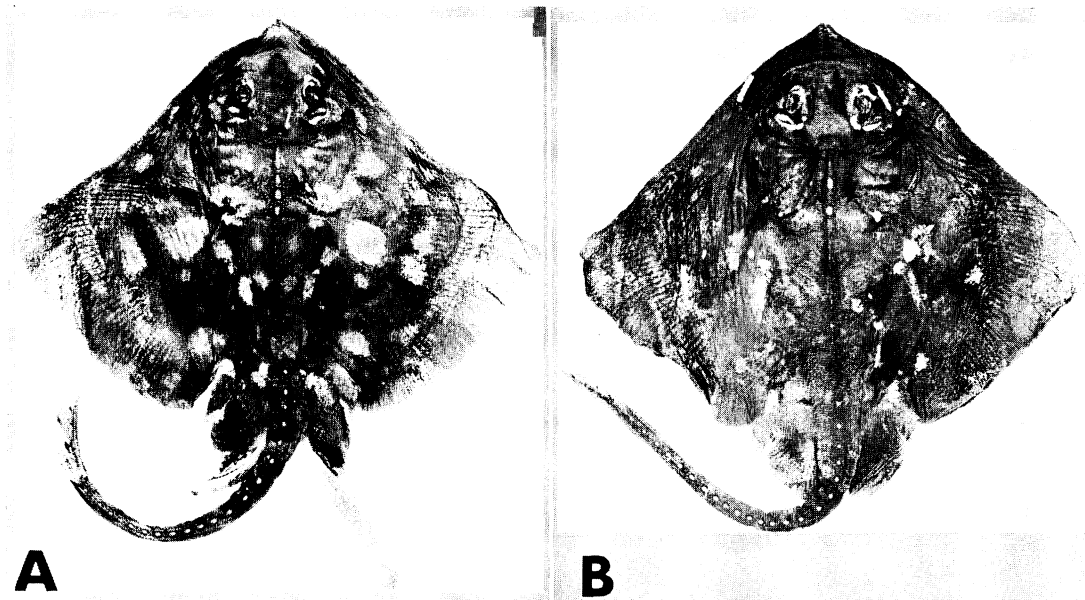


Fig. 13. *Bathyraja maculata* sp. nov. A, holotype, MTUF 21870, male, 644 mm in disk width; B, paratype, MTUF 21871, female, 700 mm in disk width.

middle of tail, with a round tip; pseudosiphon well developed, located far from tip of clasper. Inner surface of dorsal lobe with a shallow cleft and a pseudorhipidion. Posterior portion of inner surface of ventral lobe with a large projection and a small spur. Axial cartilage spatulated distally. Three dorsal terminals (1~3) more or less well developed. Dorsal terminal 1 elongate, pointed at anterior and posterior ends, middle portion swollen. Ventral terminal small, narrow anteriorly, broad posteriorly, assuming the shape of the leaf of ginkgo. Accessory terminal small, firmly connected to posterior edge of ventral marginal (Fig. 8. C).

Etymology. This species is named after the Notoro Peninsula, Hokkaido, where the holotype was collected.

Bathyraja maculata sp. nov.

(New Japanese name: Montsuki-kasube)

Figs. 13, A and B

Holotype: MTUF 21870, adult male, 644 mm in disk width, collected from the Bering Sea (59°10'N, 166°19'E), at a depth of about 450 m, on May 22, 1963.

Paratypes: 1 adult male, MTUF 21879, 617 mm, Bering Sea (61°07'N, 179°10'W), at

a depth of about 245 m, on July 2~3, 1963; 3 adult females, MTUF 21871, 700 mm, MTUF 21880, 610 mm, MTUF 21881, 598 mm, Bering Sea (57°47'N~61°07'N, 174°33'E~173°47'W), at depths of about 245~570 m, from May 30 to July 2, 1963; 9 young males, MTUF 21883, 423 mm, MTUF 21884, 539 mm, MTUF 21885, 517 mm, MTUF 21886, 643 mm, MTUF 21887, 513 mm, MTUF 21888, 444 mm, MTUF 21889, 518 mm, MTUF 21890, 484 mm, MTUF 21891, 582 mm, Bering Sea (52°52'N~60°59'N, 160°06'E~179°00'W) at depths of about 190~450 m, from May 22 to July 12, 1963; 7 young females, MTUF 21892, 533 mm, MTUF 21893, 480 mm, MTUF 21894, 623 mm, MTUF 21895, 561 mm, MTUF 21896, 529 mm, MTUF 21897, 580 mm, MTUF 21898, 595 mm, Bering Sea (52°52'N~61°11'N, 160°06'E~173°47'W) at depths of about 190~570 m, from May 22 to July 12, 1963. The collecting localities are shown in Fig. 1.

Diagnosis. *Bathyraja maculata* differs from other species of the genus *Bathyraja* in the combination of white blotches of various sizes on dorsal side of disk, broad lateral folds of tail, clasper with a large pseudosiphon, and egg capsule densely covered with silky fibres.

Description. Meristic counts and morpho-