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Morphological Differences between *Beryx splendens* Lowe and *B. mollis* Abe (Teleostei: Beryciformes: Berycidae)*

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Abstract

Since *Beryx mollis* Abe, 1959 was described from Sagami Bay, Honshu Island, Japan, it has been regarded as a junior synonym of *B. splendens* Lowe. Comparison of specimens of *Beryx* from Japan revealed that *B. mollis* is a valid species and distinguished from *B. splendens* in having the following characters: fewer dorsal fin rays (12-13 vs. 13-15); fewer pyloric caeca (15-20 vs. 27-36); deeper body (39.0-43.2 vs. 33.9-41.0 as % of SL); larger eyes (13.8-15.9 vs. 10.6-14.1 as % of SL); and longer pelvic fins (24.1-33.2 vs. 19.8-27.8 as % of SL); oval-shaped posterior nostril (vs. slit-like); stronger ctenoid scales. Known distribution of *B. mollis* is restricted to southern Japan from Sagami Bay to the Ryukyu Islands.

Key words: Japanese alfonsins; *Beryx mollis; B. splendens;* morphological differences; valid species.

Introduction

In addition to the wide distribution of the two *Beryx* species, *B. splendens* Lowe, 1834 and *B. dacadactylus* Cuvier, 1829, a third species, *Beryx mollis* (Fig. 1), was described by Abe (1959) based on three specimens from Sagami Bay, Honshu Island, Japan. According to him, this species is characterized in having a combination of the following characters: absence of the disk underneath the free part of each scale; presence of serrations on the keel of the lower jaw; having fewer numbers of soft rays of the dorsal fin and softer flesh. However, as these characters are not clear and do not distinguish *B. mollis* from *B. splendens*, most recent authors have regarded the former species as a junior synonym of the latter (*e.g.*, Woods and Sonoda, 1973; Heemstra, 1986). Even in Japan, Shimizu (1984) and Yamakawa (1985) did not recognize the presence of the third species in this genus.

Upon careful examination of specimens of *Beryx* from Japan, it is confirmed that *B. mollis* is a valid species and easily distinguished from *B. splendens* by morphological characters as described below.

Materials and Methods

Most specimens were obtained at local fish markets or from local fishermen in Japan,

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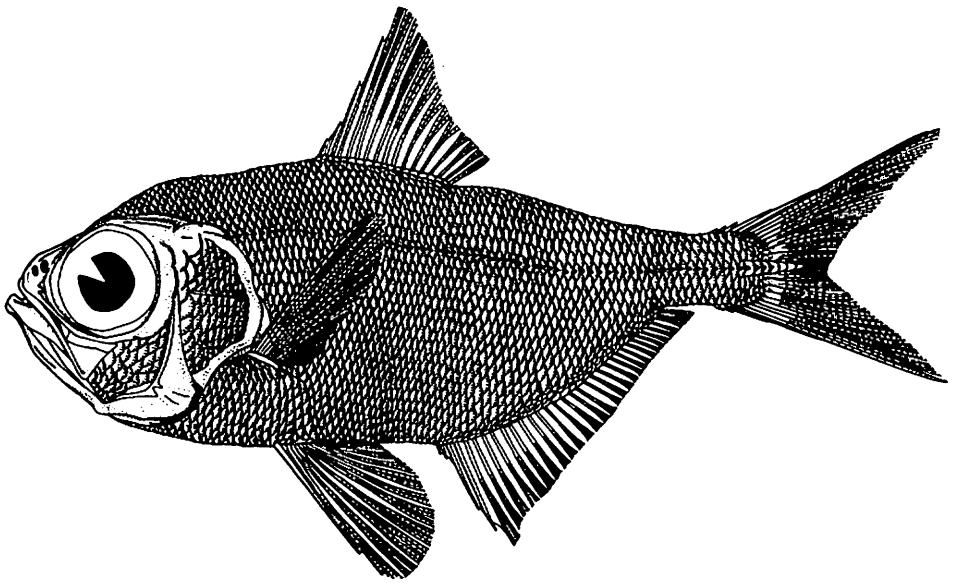

Fig.1. *Beryx mollis* Abe, URM-P 18760, 264.8 mm SL from Okinawa.

Table 1. Frequency distributions of counts in two species of *Beryx*

		Dorsal fin soft rays					Pectoral fin rays				
	n	12	13	14	15		16	17	18	19	20
B. splendens	24	—	3	18	3		—	1	10	11	2
B. mollis	21	3	18*	—	—		5	13*	3	—	—

		Anal fin soft rays								Pelvic fin soft rays			
	n	25	26	27	28	29	30	31	32	9	10	11	12
B. splendens	24	2	4	4	10	3	1	—	—	—	8	15	1
B. mollis	21	—	—	2	4*	7	5	2	1	3	18*	—	—

		Pored scales in lateral line											
	n	59	60	61	62	63	64	65	66	67	68	69	70
B. splendens	23	1	—	2	2	2	2	5	3	3	2	—	1
B. mollis	21	—	2	—	3	5	3	2	4	—	1*	1	—

		Gill rakers on lower limb					
	n	14	15	16	17	18	19
B. splendens	22	—	—	—	5	14	3
B. mollis	21	3*	—	14	4	—	—

		Pyloric caeca																
	n	15	16	17	18	19	20	···	27	28	29	30	31	32	33	34	35	36
B. splendens	14	—	—	—	—	—	—		1	3	2	—	—	3	2	2	—	1
B. mollis	14	1	3	5	3	2	—		—	—	—	—	—	—	—	—	—	—

* Including holotype

Table 2. Variation in Proportional measurements of two species of *Beryx*, expressed as percentages of the standard length

Characters	*B. splendens* range	*n*	mean	SD	*B. mollis* range	*n*	mean	SD
Standard length(mm)	117.4—372.2	25	288.6	59.9	114.3—308.9	21	189.3	74.6
Body depth	33.9—41.0	25	36.6	1.62	39.0—43.2	21	41.5	1.12
Head length	33.0—39.7	24	35.6	1.45	31.8—39.3	21	34.0	2.11
Snout length	7.5—10.1	24	8.7	0.50	6.5—9.5	21	8.2	0.60
Eye diameter	10.6—14.1	24	13.4	0.73	13.8—15.9	20	15.1	0.63
Interorbital width	3.2—7.1	23	6.5	0.30	6.8—8.4	20	7.4	0.44
Maxillary length	16.8—19.7	24	18.8	0.72	17.1—19.5	21	18.5	0.98
Suborbital width	1.1—2.2	24	1.7	0.27	1.0—2.1	21	1.6	0.29
Caudal peduncle depth	9.7—11.0	24	10.3	0.40	6.7—10.4	21	9.6	0.84
Caudal peduncle length	12.1—14.9	24	13.9	0.71	11.1—14.3	21	12.6	0.92
Pectoral fin length	26.5—30.4	24	28.2	1.17	25.1—31.8	21	29.7	1.36
Pelvic fin spine length	11.9—20.4	24	13.8	1.54	14.3—24.4	21	19.5	2.62
Pelvic fin length	19.8—27.8	25	22.7	1.94	24.1—33.2	21	27.8	2.72
Longest dorsal spine	12.4—19.9	24	15.5	1.66	14.4—21.6	21	17.9	2.50
Shortest dorsal spine	0.9—2.5	20	1.5	0.44	1.5—4.6	21	3.2	0.84
Longest dorsal ray	18.3—25.8	23	20.3	1.66	18.7—24.9	21	22.3	1.77
Longest anal spine	10.3—17.5	20	12.5	1.35	10.4—17.2	21	15.0	2.02
Longest anal ray	12.5—17.5	24	14.8	0.89	10.5—18.2	21	15.8	1.92

and are deposited at the following institutions or museum: BSKU, Department of Biology, Faculty of Science, Kochi University; FUMT, Department of Fisheries, University Museum, University of Tokyo; URM, Department of Marine Sciences, University of the Ryukyus; ZUMT, Zoological Department, University Museum, University of Tokyo. Examined specimens, preserved in 10 % formalin or 70 % alcohol, are as follows.

Beryx splendens (25 specimens): URM-P 18758—18759, 19540, 19542—19553, 20 specimens including 5 uncataloged specimens, 241.2—372.2 mm standard length (SL), off Iheya Island, Okinawa; URM-P 37892 and 37896, 2 specimens, 270.8 and 304.7 mm SL, off Iheya Island, Okinawa; FUMT-P 1390, 179.2 mm SL, Misaki, Kanagawa; FUMT-P 3981, 160.0 mm SL, Owase, Mie; ZUMT 58-31, 117.4 mm SL, Odawara, Kanagawa.

Beryx mollis (21 specimens): ZUMT 49687 and 59-2, holotype and a paratype, 250.0 and 251.9 mm SL, off Sagami Bay, Kanagawa; URM-P 18760 and 19541, 2 specimens, 264.8 and 237.1 mm SL, off Iheya Island, Okinawa; URM-P 34829—34831, 3 specimens, 260.3—288.3 mm SL, off Iheya Island, Okinawa; URM-P 37893—37895, 3 specimens, 239.1—308.9 mm SL, off Iheya Island, Okinawa; ZUMT 25352, 118.1 mm SL, Shima, Mie; FUMT-P 787, 892, 1237, 2836 and 21067, 8 specimens, 114.3—132.0 mm SL, Owase, Mie; BSKU 29817 and 34092, 2 specimens, 132.2 and 121.4 mm SL, Okinawa Trough (30° 28.8' N, 127° 50.5' E).

In the present study, counting and measuring methods mainly followed Hubbs and Lagler (1947) except for body depth (measured from dorsal origin to vertically downward)

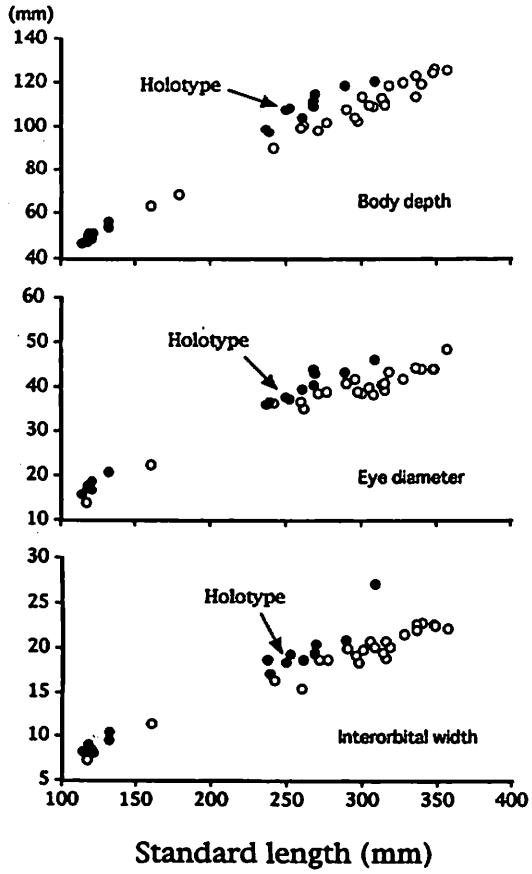

Fig.2. Comparison of body depth, eye diameter and interorbital width for two species of *Beryx*. ●—*B. mollis*; ○—*B. splendens*.

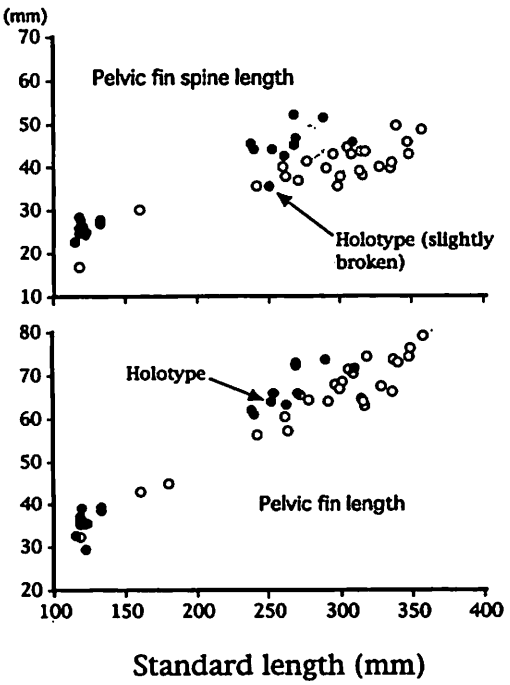

Fig.3. Comparison of pelvic fin spine length and pelvic length for two species of *Beryx*. ●—*B. mollis*; ○—*B. splendens*.

and interorbital width (between outer front tips of two ridges on frontal). Proportional measurements are presented as percentages of standard length (SL).

Scales were removed from the following three parts vertically below the dorsal fin base on the right side of the body: below lateral line (A), above lateral line (B) and in lateral line (C). These scales were immersed in sodium hydroxide to clean, and dyed with Alizarin-Red, and observed under a profile projector.

Results

Counting characters.— Comparison between the two species is shown in Table 1.

For fin-ray counts, the number of dorsal fin rays was 13—15 (mean 14.0, mode 14) for *B. splendens* and 12—13 (mean 12.9, mode 13) for *B. mollis*. There was no specimen with dorsal fin rays exceeding 13 for *B. mollis*. Frequency distributions of the number of pored lateral line scales were widely dispersed in two species, and largely overlapped with each other.

The number of gill-rakers on the lower limb was 17—19 (mean 17.9) for *B. splendens*,

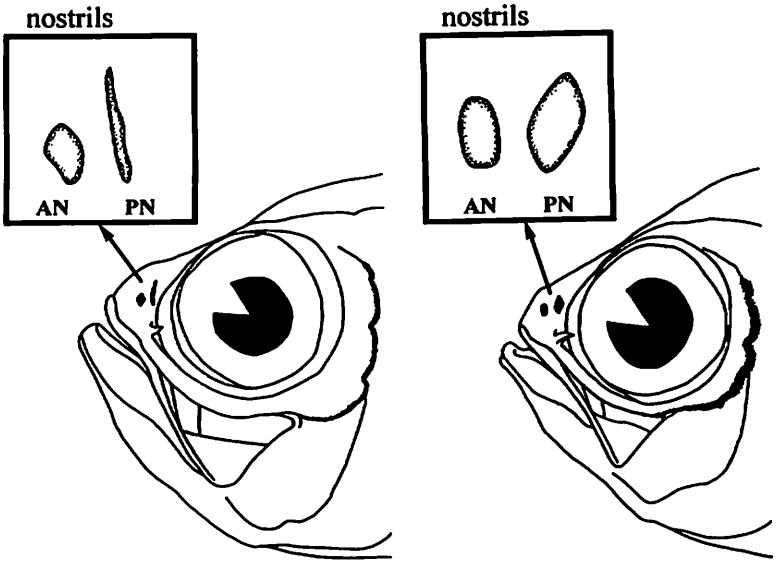

Fig.4. Comparison between *Beryx splendens* (left) and *B. mollis* (light). Lateral view of heads and magnified view of nostrils (AN, anterior nostril; PN, posterior nostril).

14—17 (mean 15.9) for *B. mollis*; the mode also differed, 18 vs. 16, for *B. splendens* and *B. mollis*, respectively.

The number of pyloric caeca was 27—36 (mean 31.1) for *B. splendens* and 15—19 (mean 17.3) for *B. mollis*.

Consequently, at least six counting characters (numbers of dorsal fin rays, pectoral fin rays, soft anal fin rays, soft pelvic fin rays, lower gill-rakers and pyloric caeca) were significantly different between *B. mollis* and *B. splendens* (Mann-Whitney *U*-test, $p<0.01$). Although the distributions of the former five counts slightly overlapped, the number of pyloric caeca was the most distinct character elucidating a difference between the two species.

Morphometric characters.— Proportional measurements of 46 specimens from 114.3 mm to 372.2 mm SL are shown in Table 2. Although statistically not confirmed, because of the different size ranges of specimens examined for each species, the following five characters indicated differences between the two species (Figs. 2 and 3): Body depth was greater in *B. mollis* than *B. splendens* (39.0—43.2 % vs. 33.9—41.0 % of SL); eye diameter was larger for *B. mollis* than *B. splendens* (13.8—15.9 % vs. 10.6—14.1 % of SL); interorbital width was wider for *B. mollis* than *B. splendens* (6.8—8.4 % vs. 3.2—7.0 % of SL); pelvic fin spine length and pelvic fin length were longer for *B. mollis* than *B. splendens* (14.3—24.4 % and 24.1—33.2 % vs. 11.9—20.4 % and 19.8—27.8 % of SL, respectively).

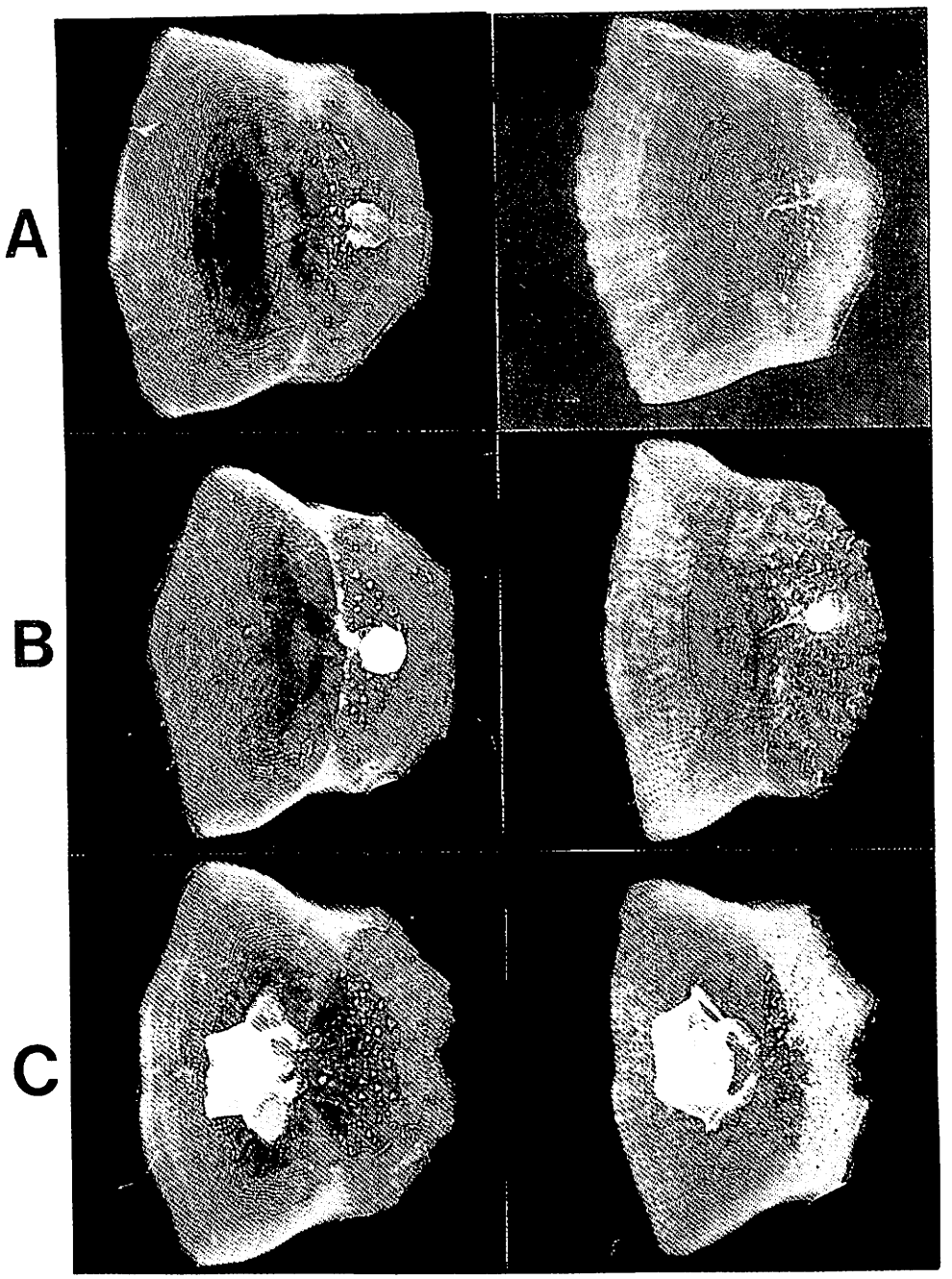

Fig.5. Comparison of scales of *Beryx splendens* (left) and *B. mollis* (right). A) from ventral side of body; B) from dorsal side of body; C) in lateral line.

Head morphology. —Some differences were found in morphological characters of the head. (1) The shape of the posterior nostril is different between *B. splendens* and *B. mollis*. The former has a slit-like posterior nostril as compared with the latter having a wide, oval nostril (Fig. 4). (2) *B. mollis* has serrated keels on the ventral side of the lower

jaw, although the keels in *B. splendens* are weak or almost not serrated. (3) In the posterior membrane bone (infraorbital) of the eye, *B. mollis* has a stronger serration on the edge that is weak for *B. splendens*. (4) The flesh on the infraorbital between the eye and cheek is thin for *B. mollis* but thick for *B. splendens*. (5) A single spine on the lacrymal of *B. mollis* is larger than that of *B. splendens* (Fig. 4).

Scales. —Scales of both species are shown in Fig. 5. Notable differences between *B. splendens* and *B. mollis* are evident in forms of the scale spinules, especially in part B. There is a difference between the two species in the series of spinules continued to the posterior edge. For *B. splendens*, spinules are not acute and do not extentd to the edge. Accordingly, the outline of the edge in *B. splendens* is smooth, whereas the outline in *B. mollis* is serrated. The scales of part A do not have many spinules in both species, but in *B. mollis*, some spinules extend to the edge and make the outline of the edge rough. The shape of the roof on the pore of the lateral line scales, in part C, also varies between the two species. It is longer in *B. splendens*, and wider in *B. mollis*.

Discussion

The specimens of *Beryx mollis* examined in this study agree well with the holotype, especially in the following characters: number of soft rays of dorsal fin (12 vs. 12—13); number of soft rays of anal fin (16 vs. 16—18); number of gill-rakers on lower limb (14 vs. 14—18); body depth; eye diameter; interorbital width; pelvic fin length (see Figs. 3 and 4 for morphometric characters). Although we did not dissect the types, Abe (1959) reported the number of pyloric caeca to be ca. 20 in a paratype specimen. The count closely fits with the range (15—19) in our examined specimens and differs considerably from the range (27—36) for *B. splendens* (Table 1). Suyehiro (1942) also described *B. splendens* with 31 pyloric caeca in his monograph on the digestive systems of fishes found in Japanese waters.

B. mollis is a valid and morphologically differerent species from *B. splendens*. The distinguishing characters used by Abe (1959), except for number of dorsal fin rays, do not differentiate *B. splendens* and *B. mollis*. Serrations on head bones were described as unique characters to *B. mollis*, in Abe's original description, however, such serrations also exist in *B. splendens*, even if those in *B. mollis* are more developed. Likewise, "windows", the openings at the proximal parts of the dorsal and anal fins, are not a valid character for differentiation. Moreover, the smaller the size of the specimen, the harder it is to distinguish the two species by these characters.

Busakhin (1982) reported that cartilaginous growth was absent in *B. mollis*, without examining any specimens, that was one of the distinctive characters used by Abe "absence of the disk underneath the free part of each scale". However, the cartilaginous growth (= "the disk" in Abe's description) is usually found in both *B. mollis* and *B. splendens*

(see Fig. 5), although it comes off easily.

The specimen (170.0 mm SL) reported as *B. mollis* by Zama and Yasuda (1979) should be considered as *B. splendens*, judging by the numbers of dorsal and pectoral fin rays (D. IV, 14; P. 19), gill-rakers (6+19) and the length of pelvic fin (24.1% of SL). Yamakawa (1985) described a deep-bodied *Beryx* as *B. splendens* from the Okinawa Trough. Re-examination of these specimens (BSKU 29817 and 34092) confirmed that they were not *B. splendens* but *B. mollis*. Hayashi (1993) briefly described Japanese members of the genus by referring the abstract of our study presented at the 1st Sino-Japanese colloquium on systematic fishes in 1989. Okiyama (1988) illustrated a juvenile specimen (10.0 mm SL) identified as *B. splendens* with 12 dorsal fin rays (counted from his figure). As the dorsal fin elements are completely formed at sizes greater than 5.9 mm SL (Mundy, 1990), Okiyama's specimen seems to be *B. mollis*. Mundy (1990) described larval and juvenile stages of two *Beryx* species (*B. splendens* and *B. decadactylus*), rejecting the validity of *B. mollis*. Careful examination is needed for comparisons of larval and juvenile stages between *B. splendens* and *B. mollis*.

B. splendens is widely distributed in the world's oceans. It is difficult to determine if *B. mollis* is combined in the previous descriptions of *B. splendens*. In reports from the Atlantic Ocean, there were two specimens with 23 pyloric caeca (Krefft, 1961, 1976). It is necessary to investigate whether the specimens include *B. mollis* or not. At least, one of them, reported by Krefft (1961), seems to be *B. splendens* judging by the description of number of dorsal and pectoral fin rays (D. IV, 14; P. 18), gill-rakers (7 + 1 + 18) and pelvic fin length (21.7 % of SL). The description of *B. splendens* from the western North Atlantic, by Woods and Sonoda (1973), also includes a specimen with 13 dorsal fin rays. Evidence from the present study suggests that the specimen is not *B. mollis* but *B. splendens*, because it has more pelvic fin rays (I, 11 or 12) and gill-rakers (6 or 7 + 1 + 18—20). The descriptions of *B. splendens* from southwest Atlantic (Krefft, 1976) and South Africa (Heemstra, 1986) include specimens with fewer dorsal fin rays (IV, 13). Re-examination of those specimens is needed, because their descriptions are too brief to be certain of their identify.

Judging from previous reports, there is no verified record of *B. mollis* except for southern Japan. Another species, *B. decadactylus*, is easily distinguished from *B. splendens* in having more dorsal soft rays (16—20), more pyloric caeca (74—100), and deeper body (44—50 % of SL) (Shimizu, 1983; Maul, 1986). These characters are also useful to distinguish it from *B. mollis* (vs. 12—13, 15—20, 39—43 % of SL, respectively).

Key to species of the genus *Beryx* based on the Japanese specimens

1a. Dorsal fin III—IV, 16—20; pyloric caeca more than 70 ..... *B. decadactylus*
1b. Dorsal fin III—IV, 12—15; pyloric caeca less than 40 2
2a. Dorsal fin III—IV, 13—15; pyloric caeca more than 27; posterior nostril slit-shaped

..... *B. splendens*

2b. Dorsal fin IV, 12—13; pyloric caeca 15—20; posterior nostril oval-shaped ··· *B. mollis*

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