

## Descriptions of Two New Pricklebacks (Perciformes: Stichaeidae) from Japan

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**Abstract** Two new Japanese stichaeid fishes, *Zoarchias hosoyai* and *Z. macrocephalus*, are described on the basis of 5 specimens [65–90 mm in total length (TL)] from Hakui, Ishikawa (coast of Japan Sea), and 37 specimens (69–123 mm TL) from Ago Bay, Shima, Mie (Pacific coast), respectively. *Zoarchias hosoyai* is similar to *Z. neglectus* in the position of the anal fin spine relative to dorsal fin rays and U-shaped dark markings with darker margins on the soft-rayed portion of the dorsal fin, but the former differs from the latter in having a low dermal ridge on top of the snout, 10 pectoral fin rays, 102–103 total vertebrae, and a pale, central spot on each dark blotch along the lateral midline. *Zoarchias macrocephalus* bears a close resemblance to the sympatric congener, *Z. glaber* in its general body appearance and meristic counts. However, the former differs from the latter in having a completely scaled tail, longer head (13.9–18.1% TL), larger infraorbital width (2.2–4.0% TL), and trapezoidal dark markings on the soft-rayed portion of the dorsal fin.

**Key word:** Stichaeidae, *Zoarchias hosoyai*, *Zoarchias macrocephalus*, New species, Japan.

The western North Pacific stichaeid genus *Zoarchias* Jordan and Snyder, 1902, is characterized by having confluent vertical fins without any notches between them, a pointed caudal fin tip, no pelvic fins, more than 70 dorsal fin rays, and no dermal flap on the head. In the genus, six valid species are known from northeastern China, Korea, and Japan: *Zoarchias glaber* Tanaka, 1908b, from the Pacific coast of central and western Honshu, Japan; *Zoarchias major* Tomiyama, 1972, from western Honshu, Shikoku, and Kyushu, Japan, and Cheju I., Korea; *Zoarchias microstomus* Kimura and Jiang, 1995, from Liaonin Province, northeastern China; *Zoarchias neglectus* Tanaka 1908a, from the Pacific coast of central Honshu, Japan; *Zoarchias uchidai* Matsubara, 1932, from southern Korea; and *Zoarchias veneficus* Jordan and Snyder, 1902, from Hokkaido and the Japan Sea coast of northern and central Honshu, Japan (Hatooka, 2002; Kimura and Sato, unpublished data; Mecklenburg and Sheiko, 2004). They inhabit rocky shores, tide pools, seagrass areas, and sargassum

mats. During revisional studies on the genus *Zoarchias*, we discovered two new species, one of which resembles *Z. neglectus*, from Ishikawa Prefecture, Japan Sea coast of central Honshu, and the other is very close to *Z. glaber*, from Mie Prefecture, Pacific coast of central Honshu, Japan. In the present account, these two new species are described as *Zoarchias hosoyai* and *Zoarchias macrocephalus*.

### Materials and Methods

Counts and measurements generally followed Hubbs and Lagler (1947). Additional measurements include pre-anus length (tip of lower jaw to the center of the anus), eye diameter (greatest fleshy diameter), and infraorbital width (lower margin of the orbit ventrally to the lower margin of the upper jaw, vertically through the center of the eye). Body depth was measured at the anus; interorbital width is the least bony width. All measurements were made with a divider to the nearest 0.1 mm. Counts of vertical fin spines and

soft rays, and vertebrae (including the urostyle), and osteological observations were made from soft X-ray photos and from cleared and stained (abbreviated as CS) specimens. Cyanine blue was used to examine scales. Total and head lengths are abbreviated as TL and HL, respectively. Sexes were determined by histological inspection of the gonads and abbreviated as F (female) and M (male). Institutional codes follow Leviton *et al.* (1985) with additional abbreviations as follows: AMBS, Aitsu Marine Biological Center, Kumamoto University, Japan; CNUC, Department of Biology, Chonbuk National University, Chonju, Korea; FRDA, National Fisheries Research and Development Agency, Korea; KA, Kanazawa Aquarium, Kanazawa, Ishikawa, Japan.

*Zoarchias hosoyai* sp. nov.

(New Japanese name: Noto kazunagi)

(Figs. 1A–C, 2A)

**Holotype.** NSMT-P 72587 (F), 90 mm TL, Shimane, Haku-gun, Ishikawa Prefecture, Japan, rocky shore, 10–15 m depth, 27 May 1984, SCUBA, collected by S. Hosoya.

**Paratypes.** Four specimens, 45–89 mm TL, collected at the same locality as the holotype by S. Hosoya. FRLM 5367 (F), 89 mm TL, 19 May 1984; FRLM 5368 (juvenile, sex unknown), 5369 (M), 45–86 mm TL, 21 May 1984; FRLM 5370 (F), 65 mm TL, Aug. 1984.

**Diagnosis.** A species of *Zoarchias* as defined by Anderson (1994) and Kimura and Jiang (1995), with the following combination of characters: dorsal fin spines 21–22; total vertebrae 102–103; interorbital space narrow, 11.3–12.1 % HL; a low dermal ridge present on top of snout (Fig. 3A); anal fin origin located just below the base of last or penultimate dorsal fin spine; U-shaped dark markings on the soft-rayed portion of the dorsal fin with darker margins (Fig. 4A); a pale spot present centrally on each dark blotch along the lateral midline (Fig. 1A–C).

**Description.** Counts and measurements are shown in Table 1. Body elongated, compressed, relatively deep, and tapering posteriorly; belly

rounded. Head small without a dermal flap; tip of snout pointed; jaws equal; mouth large, upper jaw extending posteriorly far beyond posterior margin of eye; upper jaw length approximately twice distance from snout tip to center of eye; both lips developed, but upper lip not reaching to nostrils; nostrils tubular, a single pair; a low dermal ridge present on top of snout; interorbital space narrow, somewhat concave. Teeth on jaws, vomer, and palatines small, conical; anterior teeth on upper jaw arranged in three rows, those on lower jaw in two (including holotype) or three rows; lateral teeth in both jaws in a single row; tooth patch on vomer round-triangular (including holotype) or diamond-shaped with 13–19 (19 in holotype) teeth; teeth on palatines in two rows anteriorly and a single row posteriorly. Gill opening wide; gill membranes connected under throat forming a free fold; gill rakers short with pointed tips; pseudobranch developed, with six filaments; seven branchiostegal rays, Scales small, cycloid, embedded, scattered sparsely on body; head naked; naked area present midlaterally on posterior portion of tail; lateral line absent. Dorsal fin originating above pectoral fin base; spines short, strong, and pointed; spinous portion much lower than soft-rayed portion. Anal fin origin located just behind anus and below the base of last (including holotype) or penultimate dorsal fin spine; a single spine, short and strong. Membranes of dorsal and anal fins thick, both spines and soft rays entirely hidden. Caudal fin small, pointed, confluent with dorsal and anal fins, without notches between the fins. Pectoral fins small, rounded, fan-like; pelvic fins absent. Maximum recorded length 90 mm TL (holotype).

*Color of fresh specimens.* Based on the holotype (female) and two paratypes [FRLM 5367 (female) and 5368 (juvenile)] photographed by S. Hosoya: females reddish (including holotype), juvenile brownish in ground color; highly complicated dark, reticulated markings on body; square, dark markings with a central pale spot along the lateral midline; lower half of head paler; belly whitish without markings. A black spot on anteriormost dorsal fin; U-shaped red (fe-

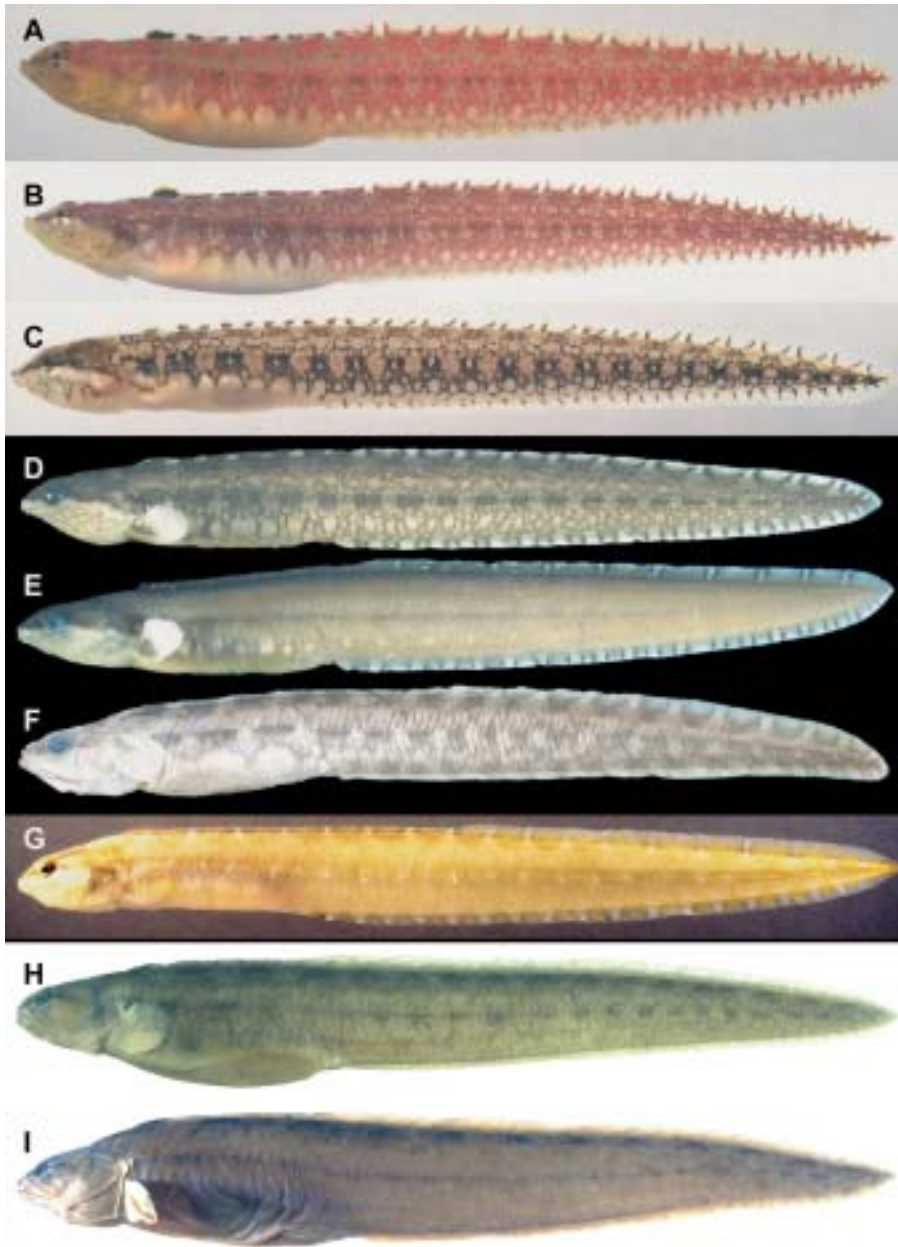


Fig. 1. Photographs of A: *Zoarchias hosoyai* sp. nov., holotype, NSMT-P 72587, female, 90 mm TL, Shika-machi, Hakui-gun, Ishikawa, Japan (photographed by S. Hosoya); B: *Z. hosoyai* sp. nov., paratype, FRLM 5367, female, 89 mm TL, Shika-machi, Hakui-gun, Ishikawa, Japan (photographed by S. Hosoya); C: *Z. hosoyai* sp. nov., paratype, FRLM 5368, juvenile, sex unknown, 45 mm TL, Shika-machi, Hakui-gun, Ishikawa, Japan (photographed by S. Hosoya); D: *Z. neglectus*, YCM-P 14215-1, 61 mm TL, Hayama, Kanagawa, Japan (preserved specimen); E: *Z. neglectus*, YCM-P 14232-3, 73 mm TL, Hayama, Kanagawa, Japan (preserved specimen); F: *Z. major*, holotype, AMBS unnumbered, 104 mm TL, Amakusa, Kumamoto, Japan (preserved specimen); G: *Z. major*, FRLM 5372, 86 mm TL, Matsuyama, Ehime, Japan (photographed by S. Hosoya); H: *Z. microstomus*, holotype, NSMT-P 45961, 100 mm TL, Dalian, Liaonin, China (preserved specimen); I: *Z. uchidai*, FRLM 13775, 97 mm TL, Phonsan-myon, Chollabuku-do, Korea (preserved specimen).

Table 1. Counts and measurements of *Zoarchias hosoyai* sp. nov., *Z. neglectus*, and *Z. major*.

	<i>Zoarchias hosoyai</i> sp. nov.			<i>Zoarchias neglectus</i>			<i>Zoarchias major</i>		
	Holotype	Paratypes	Paratypes	Paratypes	Non-type specimens	Holotype	Paratype	Non-type specimens	
Total length (mm)	90	45–89 (71.3, 4)	47–66 (56.6, 12)	47–66 (56.6, 12)	55–84 (66.8, 37)	104	85	43–108 (79.4, 48)	
Counts									
Dorsal fin spines	21	21–22 (21.3, 4)	23–25 (24, 14)	23–25 (24, 14)	22–25 (23.3, 37)	29		26–36 (31.3, 47)	
Dorsal fin soft rays	79	77–79 (78, 4)			77–82 (79.8, 37)			72–85 (77.8, 39)	
Anal fin soft rays	77	78–79 (78.5, 4)			79–84 (81.9, 37)			82–91 (87.2, 40)	
Pectoral fin rays	10	10–10 (10, 4)			9–10 (9.0, 35)	9		8–10 (9.0, 48)	
Abdominal vertebrae	19	19–20 (19.5, 4)	20–21 (20.3, 14)	20–21 (20.3, 14)	19–21 (20.3, 36)	20	21	19–22 (20.9, 46)	
Caudal vertebrae	83	82–84 (82.8, 4)	85–87 (86.4, 12)	85–87 (86.4, 12)	84–88 (86.3, 36)	92		86–97 (91.4, 46)	
Total vertebrae	102	102–103 (102.3, 4)	105–108 (106.8, 12)	105–108 (106.8, 12)	104–108 (106.6, 36)	112		108–118 (112.3, 46)	
Measurements									
As % of total length									
Head length	16.1	15.2–16.9 (16, 4)	15.5–18.2 (16.4, 12)	15.5–18.2 (16.4, 12)	14.6–16.7 (15.6, 36)	16.2	16.4	12.5–16.8 (14.1, 46)	
Predorsal length	14.4	13.9–15.2 (14.4, 4)	14.5–16.1 (15, 12)	14.5–16.1 (15, 12)	13.4–14.9 (14.1, 36)	13.2	14.9	11.6–15.3 (13.2, 46)	
Prenasal length	36.0	33.8–35.8 (34.4, 4)	31.1–36.3 (33.7, 12)	31.1–36.3 (33.7, 12)	30.9–35.9 (33.6, 36)	32.8	34.2	30.5–35.1 (32.4, 46)	
Body depth	11.1	9.4–10.6 (10.3, 4)	10.1–12.5 (11.1, 12)	10.1–12.5 (11.1, 12)	9.8–11.6 (10.7, 36)			7.5–10.1 (8.8, 46)	
As % of head length									
Eye diameter	15.4	16.4–22.1 (18.5, 4)	17.0–23.5 (20.1, 12)	17.0–23.5 (20.1, 12)	16.2–20.8 (18.7, 36)	9.8	10.1	13.5–23.7 (18.7, 46)	
Snout length	20.0	17.6–19.4 (18.8, 4)	14.1–19.8 (17.4, 12)	14.1–19.8 (17.4, 12)	15.6–21.1 (18, 36)	8.3	9.4	15.6–23.1 (18.7, 46)	
Infraorbital width	17.2	13.2–17.3 (15.8, 4)	9.4–13.3 (11.5, 12)	9.4–13.3 (11.5, 12)	11.4–17.5 (13.6, 36)	11.9	10.1	9.2–18.4 (15.2, 46)	
Interorbital width	11.3	11.8–12.1 (11.9, 4)	11.8–17.0 (14.1, 12)	11.8–17.0 (14.1, 12)	14.4–20.0 (17.5, 36)			12.0–21.0 (16.4, 45)	
Length of upper jaw	62.1	44.1–60.9 (54.8, 4)	37.6–51.5 (47.1, 12)	37.6–51.5 (47.1, 12)	47.1–60.0 (52.8, 36)	9.5		34.4–65.2 (51.6, 46)	

Figures in parentheses indicate mean values and sample size

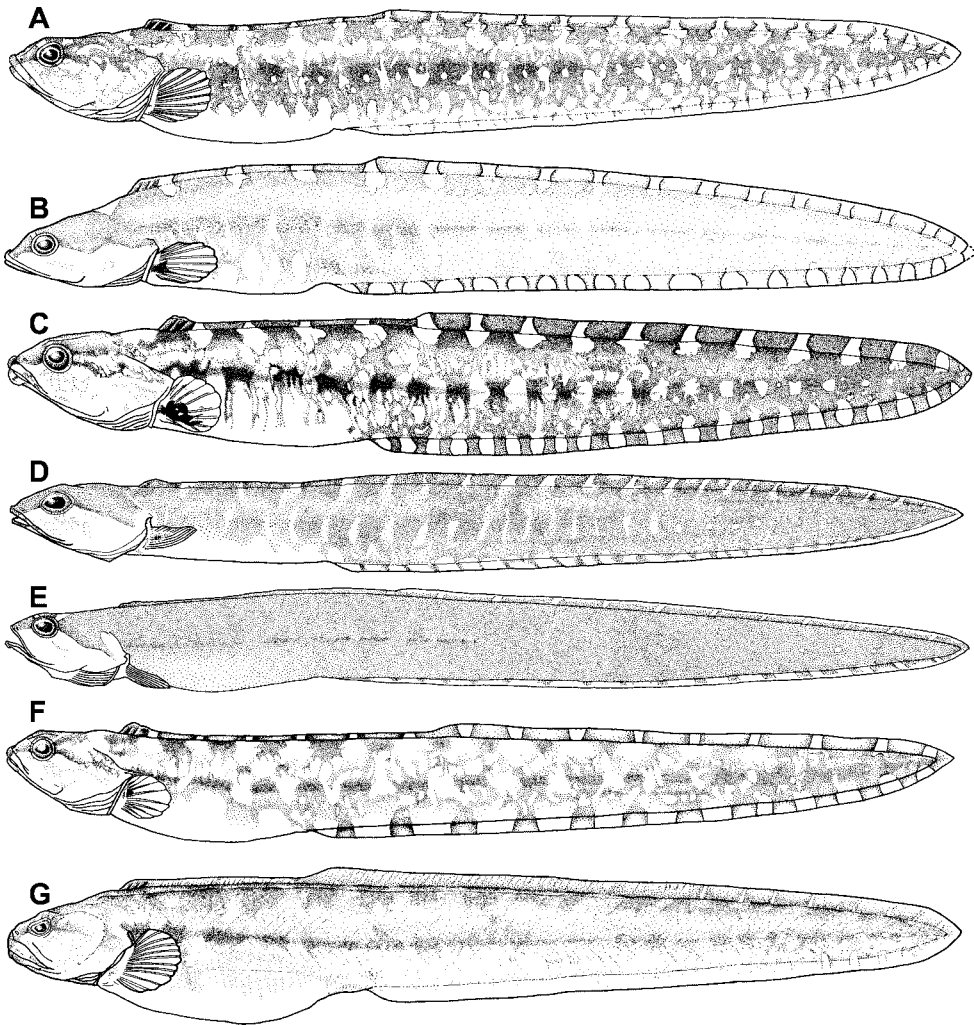


Fig. 2. Line drawings of A: *Zoarchias hosoyai* sp. nov., holotype, NSMT-P 72587, 90 mm TL, Shika-machi, Hakui-gun, Ishikawa, Japan; B: *Z. neglectus*, paratype, ZUMT 57527, 61 mm TL, Miura, Kanagawa, Japan; C: *Z. neglectus*, YCM-P 14232-1, 84 mm TL, Hayama, Kanagawa, Japan; D: *Z. major*, FAKU 56443, 64 mm TL, Maizuru Bay, Kyoto, Japan; E: *Z. major*, MTUF 26130, 91 mm TL, Shijiki Bay, Nagasaki, Japan; F: *Z. major*, FRLM 5023, 77 mm TL, Kamiura, Oita, Japan; G: *Z. microstomus*, holotype, NSMT-P 45961, 100 mm TL, Dalian, Liaonin, China.

males, including holotype) or brown (juvenile) markings with darker margins on dorsal fin (Fig. 4A); dark reddish (females, including holotype) or black (juvenile) slender triangles on anal fin.

*Color of preserved specimens.* Ground color yellowish brown, paler in females (including holotype); marking on body and fins brownish; a black spot on anteriormost dorsal fin.

**Distribution.** *Zoarchias hosoyai* is known

only from Hakui, Ishikawa Prefecture, Japan (Japan Sea coast of central Honshu I.).

**Etymology.** The specific name “hosoyai” is named in honor of Mr. Seiichi Hosoya, Director of Okinawa Branch, IDEA Consultants Inc., who collected the holotype and paratypes, and donated them to the first author.

**Comparison.** *Zoarchias hosoyai* is most similar to *Z. neglectus* (Figs. 1D, E, 2B, C) in the

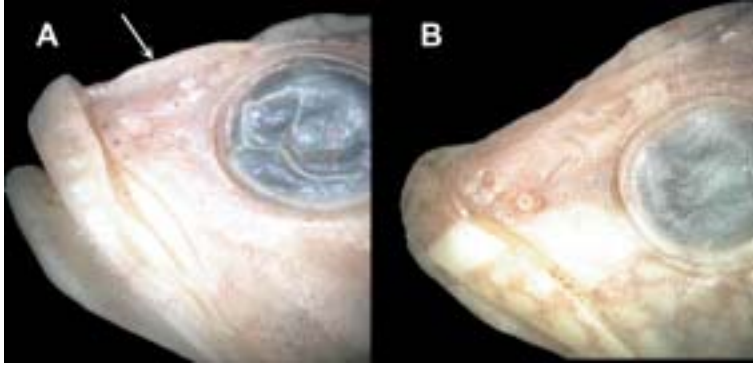


Fig. 3. Comparison of contour of snout between *Zoarchias hosoyai* sp. nov. (A) and *Z. neglectus* (B). A: Holotype, NSMT-P 72587, 90 mm SL; B: YCM-P 14232-1, 84 mm TL. Arrow shows dermal ridge on snout.

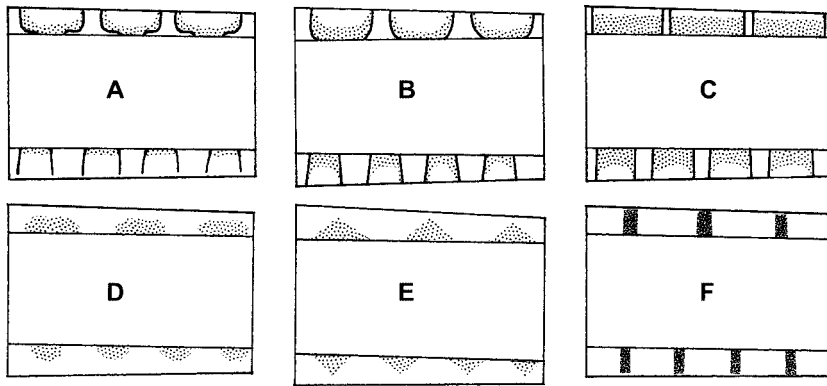


Fig. 4. Patterns of dorsal and anal fin markings in Japanese *Zoarchias* species. A: *Z. hosoyai* sp. nov.; B, C: both *Z. neglectus* and *Z. major*; D: *Z. macrocephalus* sp. nov.; E: *Z. glaber*; F: *Z. veneficus*.

position of the anal fin spine relative to the dorsal fin rays and the U-shaped dark markings on the soft-rayed portion of the dorsal fin with darker margins (Fig. 4A–C). However, the former differs from the latter in having a low dermal ridge on top of the snout (vs. dermal ridge absent in the latter; Fig. 3B), pectoral fin rays 10 (vs. usually 9); total vertebrae 102–103 (vs. 104–108), and a pale, central spot present on each dark blotch along the lateral midline (vs. pale spot absent on each dark blotch along the lateral midline; Fig. 1D). *Zoarchias neglectus* is hitherto known from the Pacific coasts of Chiba and Kanagawa Prefectures, Japan, not from Japan Sea coasts. *Zoarchias major* (Figs. 1F, G, 2D) is widely distributed in western Japan [Kumamoto (type locality), Nagasaki, Hyogo, Kyoto, Ohita, Ehime,

Okayama, Osaka, Mie, and Aichi Prefectures], and Cheju I., Korea [present study, Kim and Kang, 1991 (as *Z. glaber*), and Kim *et al.*, 2005: 393 (as *Z. glaber*)]. *Zoarchias major* shares the U-shaped dark markings on the soft-rayed portion of the dorsal fin with *Z. hosoyai* and *Z. neglectus* (Fig. 4A–C), but the former is distinguishable from the latter two species in having more numerous dorsal fin spines (26–36 vs. 21–22 in *Z. hosoyai*, 22–25 in *Z. neglectus*) and total vertebrae (108–118 vs. 102–103 in *Z. hosoyai*, 104–108 in *Z. neglectus*). *Zoarchias microstomus* (endemic to northeastern China; Figs. 1H, 2E) and *Z. uchidai* (endemic to Korea; Fig. 1I; Kim *et al.*, 2005: 394) also have the U-shaped dark markings on the soft-rayed portion of the dorsal fin, but these two species have fewer dor-

sal fin spines (15–18) and the anal fin origin is located below the soft-rayed portion of the dorsal fin (vs. below the spinous portion of the dorsal fin in *Z. hosoyai*).

**Comments on identification of *Zoarchias neglectus*.** *Zoarchias neglectus* was originally described by Tanaka (1908a) from 18 specimens collected from the southern tip of Miura Peninsula, Kanagawa Prefecture, Pacific coast of central Honshu I., Japan. The holotype was originally designated as ZUMT 1969, but it is considered to have been lost during World War II (the late Y. Tominaga and M. Aizawa, personal communication). Subsequently Tomiyama (1956a) re-described in detail and figured *Z. neglectus* based on the specimen (ZUMT 48582) that he collected near the type locality, and stated that 14 paratypes and other non-type specimens obtained by S. Tanaka were available for his redescription. Afterwards, these 14 paratypes were registered as ZUMT 57527–57540. Therefore, the present identification of *Z. neglectus* was made on the basis of these 14 paratypes and Tomiyama's (1956a) redescription.

*Zoarchias macrocephalus* sp. nov.

(New Japanese name: Shinju kazunagi)

(Figs. 5A–D, 6A, B)

*Zoarchias veneficus* (not of Jordan and Snyder): Kimura and Suzuki, 1980: 36, fig. 19 (Hamajima, Ago Bay, Shima, Mie Prefecture, Japan).

**Holotype.** NSMT-P 72588 (M), 123 mm TL, Zaga I., Ago Bay, Shima, Mie Prefecture, Japan, empty shells of the cultured pearl oyster, *Pinctada martensii*, in the pearl farm, 5–15 m depth, 2 May 1983, collected by S. Kimura.

**Paratypes.** 36 specimens, 69–123 mm TL, the same locality as the holotype collected by S. Kimura and A. Sato. CAS 223497 (M), 89 mm TL, 18 June 1984; CAS 223498 (F), 100 mm TL, 24 June 1984; CAS 223499 (M), 106 mm TL, 25 June 1984; FAKU 91742 (F), 94 mm TL, 13 July 1983; FAKU 91743 (F), 99 mm TL, 18 July 1983; FAKU 91744 (M), 89 mm TL, 21 June 1984; FRLM 2616 (F), 108 mm TL, 24 July 1980; FRLM 3932 (F), 3933 (F), 3935 (M), 119–123 mm TL, 2 May 1983; FRLM 4125 (F), 4132 (M), 103–106 mm TL, 11 July 1983; FRLM

4133 (F), 105 mm TL, 27 June 1983; FRLM 4137 (M), 4138 (F), 4140 (M), 102–110 mm TL, 17 July 1983; FRLM 4413 (M, CS), 75 mm TL, 31 May 1984; FRLM 4415 (M), 4416 (M, CS), 70–81 mm TL, 5 June 1984; FRLM 4417 (M, CS), 75 mm TL, 6 June 1984; FRLM 4422 (M), 79 mm TL, 21 June 1984; FRLM 4425 (M), 4426 (F, CS), 76–78 mm TL, 27 June 1984; FRLM 4427 (M), 4428 (F), 4429 (F, CS), 4430 (F), 69–72 mm TL, 15 July 1984; HUMZ 195731 (M), 100 mm TL, 21 July 1983; HUMZ 195732 (F), 101 mm TL, 8 Aug. 1983; HUMZ 195733 (F), 94 mm TL, 25 July 1983; NSMT-P 72589 (M), 72590 (F), 72591 (F), 82–100 mm TL, 16 July 1981; YCM-P 42625 (F), 83 mm TL, 29 May 1984; YCM-P 42626 (F), 90 mm TL, 30 May 1984; YCM-P 42627 (M), 78 mm TL, 31 May 1984.

**Diagnosis.** A species of *Zoarchias* as defined by Anderson (1994) and Kimura and Jiang (1995) with the following combination of characters: dorsal fin spines 28–33; total vertebrae 116–122; head large, 13.9–18.1 % TL (Fig. 6); infraorbital width broad, 2.2–4.0 % TL (Fig. 6); interorbital space wide, 13.8–21.7 % HL; posterior part of tail completely scaled (Fig. 8A); dark markings on soft portion of dorsal fin trapezoidal without darker margins (Fig. 4D), or indistinct.

**Description.** Counts and measurements are shown in Table 2. Body elongated, deep, laterally compressed, and tapering posteriorly. Head large, adult males (>ca. 100 mm TL) having significantly larger head than females [mean HL being 17.5 % TL and 15.4 % TL in males and females, respectively (>100 mm TL;  $F=40.9$ ,  $d.f.=1, 12$ ,  $P<0.001$ )]; no dermal flap on head; tip of snout rounded; jaws equal; mouth large, upper jaw extending posteriorly far beyond posterior margin of eye; upper jaw length approximately twice distance from snout tip to center of eye; both lips developed, but upper lip not reaching to nostrils; nostrils tubular, a single pair; no dermal ridge on top of snout; interorbital space wide and flat. Teeth on jaws, vomer, and palatines small, conical; anterior teeth in upper jaw arranged in three rows, those on lower jaw in two or three (including holotype) rows; lateral teeth on both jaws in a single row; tooth patch on vomer triangular (including holotype) or circular with 7–9 (9 in holotype) teeth; teeth on palatines in two rows anteriorly.

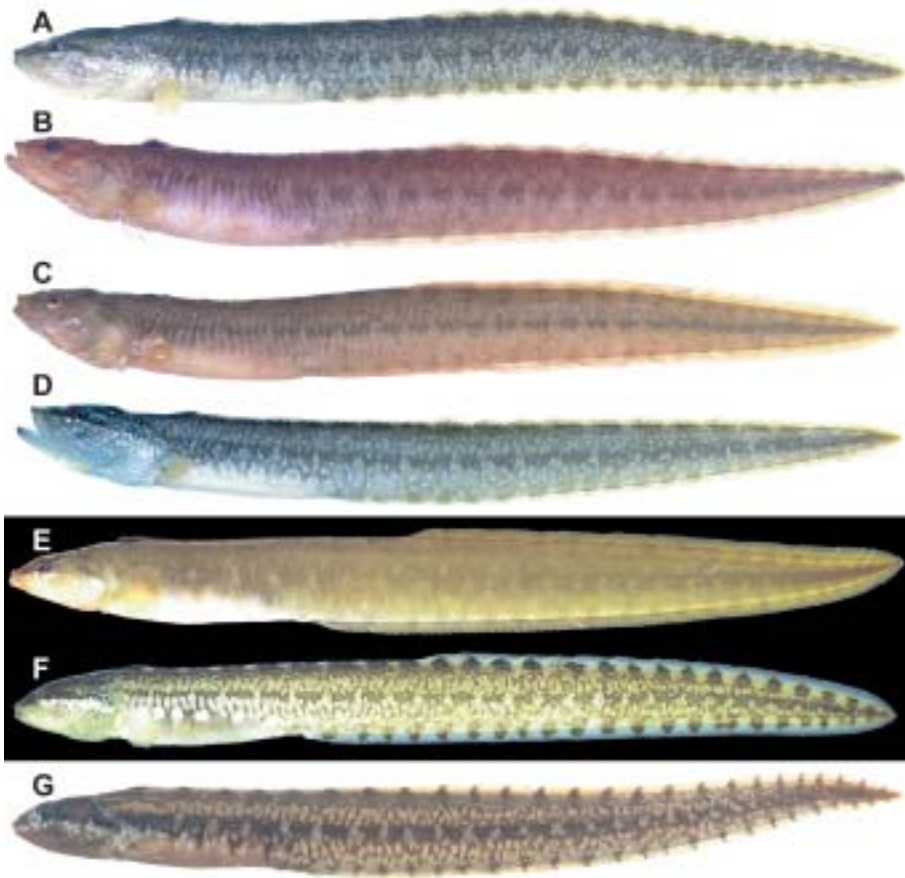


Fig. 5. Photographs of A: *Zoarchias macrocephalus* sp. nov., holotype, NSMT-P 72588, male, 123 mm TL, Shima, Mie, Japan; B: *Z. macrocephalus* sp. nov., paratype, FRLM 3932, female, 122 mm TL, Shima, Mie, Japan; C: *Z. macrocephalus* sp. nov., paratype, FRLM 3933, female, 119 mm TL, Shima, Mie, Japan; D: *Z. macrocephalus* sp. nov., paratype, FRLM 3935, male, 123 mm TL, Shima, Mie, Japan; E: *Z. glaber*, MTUF 22534, 117 mm TL, Kamogawa, Chiba, Japan; (photographed by S. Hosoya); F: *Z. glaber*, MTUF 23189, 105 mm TL, Kamogawa, Chiba, Japan; G: *Z. veneficus*, FRLM 11752, 78 mm TL, Hakui, Ishikawa, Japan (photographed by S. Hosoya).

only and a single row posteriorly. Gill opening wide; gill membranes connected under throat forming a free fold; gill rakers relatively long, slender, with pointed tip; pseudobranch developed with six filaments; seven branchiostegal rays. Scales small, cycloid, embedded, scattered sparsely on body; head naked; posterior portion of tail completely scaled (Fig. 8A); lateral line absent. Dorsal fin originating above pectoral fin base; spines short, strong, and pointed; spinous portion much lower than soft-rayed portion. Anal fin origin located just behind anus and below the

base of 21st to 24th (23rd in holotype) dorsal fin spine; a single spine, short and strong. Membranes of dorsal and anal fins thick, both spines and soft rays entirely hidden. Caudal fin small, pointed, confluent with dorsal and anal fins, without notches between the fins. Pectoral fins small, rounded, fan-like; pelvic fins absent. Maximum recorded length 123 mm TL (holotype and a paratype, FRLM 3935).

*Color of fresh specimens.* Ground color and distinctiveness of markings on body and vertical fins highly variable, but ventrolateral surface of



Table 2. Counts and measurements of *Zoarchias macrocephalus* sp. nov., *Z. glaber*, and *Z. veneficus*.

	<i>Zoarchias macrocephalus</i> sp. nov.			<i>Zoarchias glaber</i>			<i>Zoarchias veneficus</i>		
	Holotype	Paratypes	Non-type specimens	Holotype	Paratype	Non-type specimens	Holotype	Paratype	Non-type specimens
Total length (mm)	123	69–123 (92.4, 36)	62–117 (87.8, 94)	65	48–66 (56.7, 25)	49–90 (67.1, 113)			
Counts									
Dorsal fin spines	31	28–33 (30.4, 36)	28–37 (31.8, 94)	27	26–30 (28, 25)	22–33 (28.6, 110)			
Dorsal fin soft rays	84	80–87 (84.7, 35)	78–89 (84.5, 90)	78	76–85 (79.6, 20)	71–87 (76.6, 55)			
Anal fin soft rays	93	91–95 (92.8, 35)	89–98 (93.5, 89)	88	84–88 (85.8, 21)	80–91 (84.8, 56)			
Pectoral fin rays	9	8–9 (8.9, 34)	9–10 (9.1, 90)		8–9 (8.8, 25)	8–9 (8.6, 113)			
Abdominal vertebrae	22	20–22 (21.2, 36)	20–23 (22.1, 93)	19	18–20 (19.7, 25)	18–21 (19.6, 110)			
Caudal vertebrae	96	95–100 (97.5, 36)	93–101 (97.5, 94)	88	88–92 (89.8, 25)	85–94 (88.8, 111)			
Total vertebrae	118	116–122 (118.6, 36)	115–123 (119.6, 93)	107	107–112 (109.5, 25)	104–114 (108.4, 110)			
Measurements									
As % of total length									
Head length	18.1	13.9–17.8 (15.8, 36)	12.2–15.2 (13.4, 94)	14.3	13.8–15.8 (14.7, 25)	12.7–19.2 (15.2, 113)			
Predorsal length	16.4	13.2–16.5 (14.7, 36)	11.1–14.5 (12.9, 94)	12.0	13.0–15.2 (14.0, 25)	12.5–17.7 (14.0, 113)			
Preal length	35.0	29.9–35.5 (32.8, 36)	29.2–34.7 (31.8, 94)	33.1	29.4–33.5 (31.6, 25)	29.5–35.7 (33.0, 113)			
Body depth	9.0	8.3–10.2 (9.3, 36)	5.8–9.5 (8.2, 94)	9.4	6.8–10.2 (8.7, 25)	6.5–11.1 (8.8, 113)			
As % of head length									
Eye diameter	12.2	12.5–19.1 (15.7, 36)	15.1–20.8 (18.1, 92)	25.8	18.0–22.9 (20.9, 25)	15–21.9 (18.5, 113)			
Snout length	22.3	19.1–25 (21.9, 36)	16.0–22.3 (19.1, 92)	16.1	15.9–22.1 (18.8, 25)	14.1–22.5 (18.9, 113)			
Infraorbital width	19.7	15–23.8 (19.6, 36)	12.2–20.3 (15.0, 89)		11.1–18.1 (14.2, 25)	11.4–23.2 (15.8, 113)			
Interorbital width	13.9	13.8–21.7 (17.6, 36)	11.9–22.2 (18.3, 89)	9.7	12.0–18.2 (15.5, 25)	10.8–23.2 (16.6, 113)			
Length of upper jaw	71.2	56.2–72.5 (64.3, 36)	48.9–62.5 (55.2, 90)	50.5	43.1–54.3 (47.8, 25)	41.3–70.4 (53.5, 113)			

Figures in parentheses indicate mean values and sample size

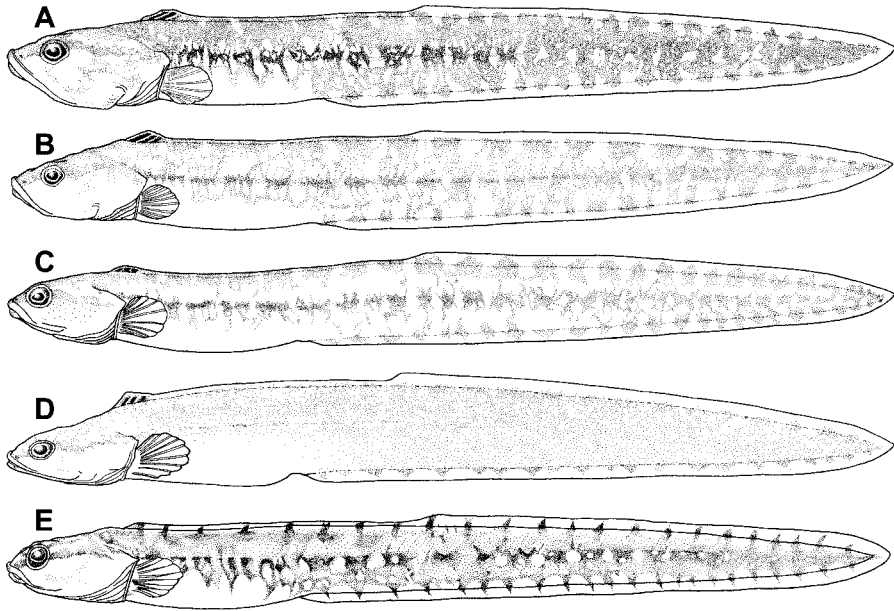


Fig. 6. Line drawings of A: *Zoarchias macrocephalus* sp. nov., holotype, NSMT-P 72588, 123 mm TL, Shima, Mie, Japan; B: *Z. macrocephalus* sp. nov., paratype, FRLM 4125, 106 mm TL, Shima, Mie, Japan; C: *Z. glaber*, MTUF 26095, 108 mm TL, Kamogawa, Chiba, Japan; D: *Z. glaber*, YCM-P 6781, 111 mm TL, Yokosuka, Kanagawa, Japan; E: *Z. veneficus*, MTUF 26124, 75 mm TL, Kamiiso, Hokkaido, Japan.

head and belly pale yellowish brown in almost all specimens (including holotype). In specimens with obvious body marking (including holotype; Fig. 5A, D), ground color pale greenish brown with dark brownish, complicated reticulations and trapezoidal markings on soft-rayed portions of dorsal and anal fins; dark brownish horizontal band extending from tip of snout, through center of eye, to posterior margin of preopercle. In specimens with faint body markings, body almost uniformly brown or greenish brown. Juveniles (less than ca. 80 mm TL) with a silvery, white oblique band from posteroventral margin of eye to posterior margin of opercle, several white circles on trunk and anterior portion of tail, and a black spot on anteriormost portion of dorsal fin. White band on head and white circles on body obscure, a blue black spot on anteriormost portion of dorsal fin with a red margin in adults. Pearl white spots scattered on head and body in some adult males (including holotype; Fig. 5A, D). In adult females, body color gradually changing to vivid red in the natural habitat and reticu-

lations on body becoming obscure.

*Color of preserved specimens.* In specimens with obvious body markings (including holotype), ground color yellowish-brown with dark brownish markings on body and vertical fins. In specimens with faint body markings, body almost uniformly pale brown.

**Distribution and ecological notes.** *Zoarchias macrocephalus* is known only from Ago Bay, Shima, Mie Prefecture, Pacific coast of central Honshu I., Japan. It inhabits crevices of rocks, seaweed (*Sargassum*) areas, or empty shells of large bivalves in the infralittoral zone. The authors often collected the specimens from empty shells of the pearl oyster at pearl farms in Ago Bay, just front of FRLM. Spawning takes place in winter, and either both parents or the female parent guard their egg mass. The egg mass is oval or pear-shaped, ca. 30 mm in major axis and ca. 15 mm in minor axis, including ca. 120 eggs; eggs are spherical in shape, 3.2–3.6 mm in diameter with numerous red oil globules (0.8–0.9 mm in diameter).

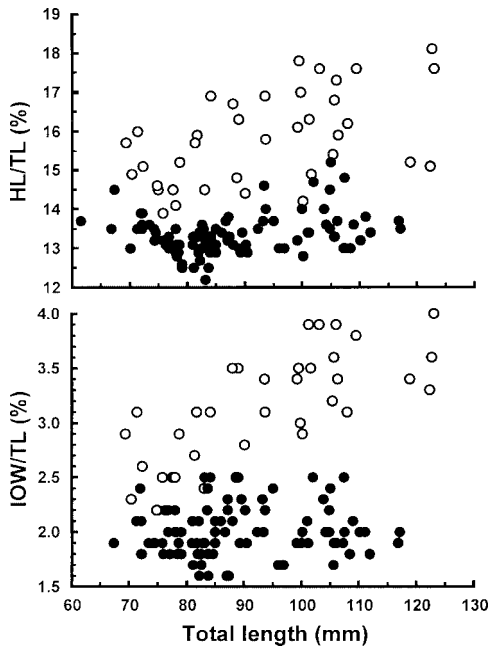


Fig. 7. Proportional differences between *Zoarchias macrocephalus* sp. nov. (open symbols) and *Z. glaber* (solid symbols). HL: Head length; IOW: infraorbital width; TL: Total length.

**Etymology.** The specific name “*macrocephalus*” is derived from the Greek meaning “long head,” in reference to the relatively big head.

**Comparison.** *Zoarchias macrocephalus* bears a close resemblance in general body appearance and meristic counts to *Z. glaber* (Figs. 5E, F, 6C, D), occurring along the Pacific coast of central Japan [Mie, Aichi, Shizuoka (type locality), Kanagawa, and Chiba Prefectures]. However, the former differs from the latter in having a completely scaled tail (vs. naked area generally present on posterior part of tail in the latter, Fig. 8B), longer head [13.9–18.1 (mean 15.8) % TL vs. 12.2–15.2 (mean 13.3) % TL; Fig. 7], greater infraorbital width [2.2–4.0 (mean 3.1) % TL vs. 1.5–2.5 (mean 2.0) % TL; Fig. 7], and trapezoidal dark markings on the soft-rayed portion of the dorsal fin (vs. triangular dark markings on the soft-rayed portion of the dorsal fin; Fig. 4D, E). Larger specimens of *Z. glaber* (>90 mm TL)

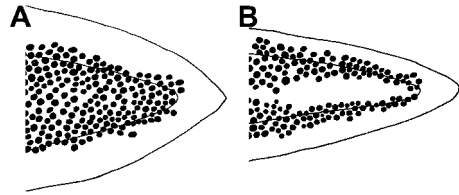


Fig. 8. Squamation on posterior tail in *Zoarchias macrocephalus* sp. nov., paratype, FRLM 4415, 70 mm TL (A) and *Z. glaber*, FRLM 4716, 84 mm TL (B).

rarely have a completely scaled tail, but their infraorbital width is clearly narrower than *Z. macrocephalus* (1.7–2.5 % TL vs. 2.8–4.0 % TL; Fig. 7). *Zoarchias macrocephalus* is rarely collected in seagrass (*Zostera*) beds where *Z. glaber* is often found in the spring. Although *Z. veneficus*, distributed throughout the northern Japan Sea coasts of Ishikawa, Niigata, Akita, and Aomori Prefectures, and Hokkaido, has similar dark markings on the dorsal and anal fins as in *Z. macrocephalus* and *Z. glaber* (Fig. 4D–F), the former is clearly distinguished from the latter two species in having lower vertebral counts (104–114 vs. 116–122 in *Z. macrocephalus* or 115–123 in *Z. glaber*). *Zoarchias major* also has higher meristic counts (dorsal fin XXVI–XXXVI, 72–85; anal fin I, 82–91; total vertebrae 108–118), but it differs from *Z. macrocephalus* and *Z. glaber* in having U-shaped dark markings (Fig. 4B, C) on the soft-rayed portion of the dorsal fin [vs. trapezoidal (Fig. 4D) or triangular (Fig. 4E) dark marking in the latter two species].

**Comments on identification of *Zoarchias glaber*.** *Zoarchias glaber* was described by Tanaka (1908b) based on a single specimen collected from Sagami Bay, Kanagawa Prefecture, Pacific coast of central Honshu I, Japan (ZUMT 2011). The type was lost during World War II (late Y. Tominaga and M. Aizawa, personal communication). Subsequently, a detailed redescription was made by Tomiyama (1956b) and a good line drawing was also provided by him based on a specimen collected by S. Tanaka from Miura Peninsula, Kanagawa Prefecture, Japan (ZUMT 38973). Therefore, our identification of *Z. glaber*

was made on the basis of Tomiyama's (1956b) redescription.

**Comparative materials.** *Zoarchias glaber*, 95 specimens, 58–117 mm TL, all from Japan: FRLM 4682, 4683, 4685, 4688–4697, 4699, 4700, 4703–4709, 4711–4723, 4725, 4726, 4729–4730, 41 specimens, 67–95 mm TL, Hamajima, Ago Bay, Shima, Mie Prefecture; FRLM 15984, 58 mm TL, Yamami, Minamichita, Aichi Prefecture; MTUF 22534, 23189, 26072–26081, 26084, 26085, 26095, 26099, 16 specimens, 90–117 mm TL, Kominato, Kamogawa, Chiba Prefecture; MTUF 26086–26089, 26091, 5 specimens, 68–83 mm TL, Tenjin-jima I., Yokosuka, Kanagawa Prefecture; MTUF 26096, 26097, 84–85 mm TL, Ubara, Katsuura, Chiba Prefecture; MTUF 26100–26107, 26109, 9 specimens, 67–97 mm TL, Shimoda, Shizuoka Prefecture; YCM-P 2374, 2380 (2 specimens), 2386 (2), 3360, 5309, 6781, 8 specimens, Tenjin-jima I., Yokosuka, Kanagawa Prefecture; YCM-P 11972, 18834, 100–101 mm TL, Shimoda, Shizuoka Prefecture; YCM-P 14228 (2), 72–78 mm SL, Hayama, Kanagawa Prefecture; YCM-P 14598, 79 mm TL, Akiya, Yokosuka, Kanagawa Prefecture; ZUMT 38973, 38976, 48583, 54744-03, 54773, 54777, 54778, 54802, 8 specimens, 62–107 mm TL, Misaki, Kanagawa Prefecture. *Zoarchias major*, 53 specimens, 43–108 mm TL: AMBS unnumbered, holotype, 104 mm TL, Amakusa, Kumamoto Prefecture, Japan; AMBS unnumbered, paratype, 85 mm TL, the same locality as the holotype; CNUC 16122, 16125, 43–53, Cheju I., Korea; FAKU 54926, 55325, 77–80 mm TL, Shijiki Bay, Hirado I., Nagasaki Prefecture, Japan; FAKU 56443, 64 mm TL, Maizuru Bay, Kyoto Prefecture, Japan; FRLM 5019–5023, 5025, 5026, 5028, 5032, 9 specimens, 63–86 mm TL, Kamiura, Oita Prefecture, Japan; FRLM 5371, 5372, 77–86 mm TL, Matsuyama, Ehime Prefecture, Japan; FRLM 5391, 5392, 85–108 mm TL, Kusudomarimen, Kozasa, Nagasaki Prefecture, Japan; FRLM 6793, 88 mm TL, Osaka Bay, Japan; FRLM 10208–10209, 85–90 mm TL, Uramura, Toba, Mie Prefecture, Japan; FRLM 13089–13096, 8 specimens, 67–74 mm TL, Kasumi, Hyogo Prefecture, Japan; FRLM 15983, 83 mm TL, Yamami, Minamichita, Aichi, Japan; FRLM 32472, 32473, 84–90 mm TL, Okayama Prefecture, Japan; MTUF 26126–26132, 7 specimens, 73–91 mm TL, Shijiki Bay, Hirado I., Nagasaki Prefecture, Japan; MTUF 26134, 85 mm TL, Ikata, Ehime Prefecture, Japan; MTUF 26142, 26148–26153, 26157, 8 specimens, 81–96 mm TL, Matsuyama, Ehime Prefecture, Japan; MTUF 26143, 50 mm TL, Iki I., Nagasaki Prefecture, Japan; OMNH 2010, 85 mm TL, Kasumi, Hyogo Prefecture, Japan; ZMUT 33579, 86 mm TL, Yoi I., Matsuyama, Ehime Prefecture, Japan. *Zoarchias microstomus*, 7 specimens, 80–103 mm TL, all from Dalian, Liaoning, China: FRLM 7635, 7636, 13267, 13268, 4 paratypes, 80–103 mm TL; NSMT-P 45961, holotype, 100 mm TL; NSMT-P

45962, paratype, 84 mm TL; USNM 331200, 93 mm TL. *Zoarchias neglectus*, 51 specimens, 47–84 mm TL, all from Japan: FRLM 5373, 55 mm SL, Chikura, Chiba Prefecture; YCM-P 14215 (2), 14232 (3), 5 specimens, 73–84 mm TL, Hayama, Kanagawa Prefecture; ZUMT 23638 (13), 48582, 54743 (3), 54744-01–54744-04 (4), 54744-06–54744-09 (4), 54744-11–54744-14 (4), 54774, 54775, 57527–57540 (14 paratypes), 45 specimens, 47–68 mm TL, Miura, Kanagawa Prefecture. *Zoarchias uchidai*, 11 specimens, 68–97 mm TL, all from Korea: CNUC 15637, 15639, 68–79 mm TL, Sonyu I., Chollabuk-do; CNUC 19799–19803, 5 specimens, 73–83 mm TL, Kumo I., Chollanam-do; FRDA 2179 (2), 85–96 mm TL, Pyonsanmyon, Chollabuk-do; FRLM 13775, 97 mm TL, Pyonsanmyon, Chollabuk-do; NSMT-P 46417, 92 mm TL, Pyonsanmyon, Chollabuk-do. *Zoarchias veneficus*, 139 specimens, 48–90 mm TL, all from Japan: ACAP 3985, 3987, 4073, 4547, 4 specimens, 59–76 mm TL, Ajigasawa, Aomori Prefecture; ACAP 4885, 4887, 4889, 5051, 5055, 5142, 5284, 5287, 5288, 9 specimens, 59–90 mm TL, Mimmaya-Kamiutetsu, Sotogahama, Aomori Prefecture; ACAP 4975, 64 mm TL, Mimmaya-Narukami, Sotogahama, Aomori Prefecture; CAS-SU 7076, holotype, 65 mm TL, Hakodate, Hokkaido; CAS-SU 4104, 25 of 166 paratypes, 48–66 mm TL, Hakodate, Hokkaido; FRLM 4651, 4660–4671, 13 specimens, 50–74 mm TL, Usujiri, Hakodate, Hokkaido; FRLM 4672, 4733–4736, 5 specimens, 59–754 mm TL Wakkanai, Hokkaido; FRLM, 5317–5322, 5324–5332, 5334–5353, 11751–11755, 40 specimens, 49–90 mm TL, Hakui, Ishikawa Prefecture; FRLM 6792, 11704–11706, 4 specimens, 64–78 mm TL, Noto-Jima I., Ishikawa Prefecture; FRLM 13255, 77 mm TL, Murakami, Niigata; HUMZ 44717, 100950, 60–73 mm TL, Moheji, Kamiiso, Hokkaido; HUMZ 80877, 91879, 74–86 mm TL, Usujiri, Hakodate, Hokkaido; HUMZ 96719, 65 mm TL, Oshoro, Otaru, Hokkaido; KA 91–291 (5), 68–77 mm TL, Hakui, Ishikawa; MTUF 26110–26124, 55–75 mm TL, Moheji, Kamiiso, Hokkaido.

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