



## *Scyliorhinus hachijoensis*, a new species of catshark from the Izu Islands, Japan (Carcharhiniformes: Scyliorhinidae)

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### Abstract

A new species of catshark genus *Scyliorhinus*, *S. hachijoensis* sp. nov., is described for the islands of Mikurajima, Hachijojima, and Torishima in southeastern Japan. *Scyliorhinus hachijoensis* has clasper hooks, which is a common feature in males of the most closely related species (*S. torazame*), but is distinguished by its coloration (presence of dark spots), the height of its anal fin (higher than the caudal peduncle), and the shape of pectoral and pelvic fins, and dermal denticles. Molecular data also corroborates the new species as a distinct and monophyletic taxon by nucleotide sequence analysis of three mitochondrial DNA regions.

**Key words:** *Scyliorhinus torazame*, *Scyliorhinus hachijoensis* sp. nov., Chondrichthyes, morphology

### Introduction

The catshark genus *Scyliorhinus* Blainville, 1816 consists of 16 benthic shark species with characteristic coloration such as light spots, dark spots and dark saddles, and are distributed in temperate to tropical waters around the world. These species inhabit depths ranging from the coast to the upper continental slope, and most species live at depths of less than 500 m (Springer 1979; Ebert *et al.* 2013a; Weigmann 2016; Soares & de Carvalho 2019). The main morphological characters of *Scyliorhinus* are the presence of a laterally projected flap on the upper lip margin that covers the lower labial furrow, the presence of a pelvic apron in males, and an extension of the pelvic apron that is more than half the length of the pelvic inner margin (Soares & de Carvalho 2019, 2020).

The catshark species *S. torazame* (Tanaka, 1908) and *S. tokubee* Shirai, Hagiwara & Nakaya, 1992 have been reported from Japanese coastal waters, but *S. tokubee* was considered a junior synonym of *S. torazame* by Soares & de Carvalho (2019). *Scyliorhinus torazame* is distinguished from other *Scyliorhinus* species by the presence of clasper hooks in males (Soares & de Carvalho 2019). *Scyliorhinus torazame* inhabits continental shelves (0–300 m depth), and has been found across Japan from Hokkaido to Okinawa, also occurring in South Korea, the East China Sea, and Taiwan (Nakaya 1975; Springer 1979; Compagno 1984; Shirai *et al.* 1992; Kim *et al.* 2009; Ebert *et al.* 2013a, b; Dylidin 2015; Soares & de Carvalho 2019).

Specimens that appear to be similar to *S. torazame* have been captured off the islands of Torishima and Mikurajima (Hagiwara 1993). These specimens were considered to belong to a different species because they were captured from deep water (ca. 450–500 m depth) and differed in color pattern and in the shape of their egg cases. These specimens have been kept in the Shimoda Floating Aquarium, Shizuoka, since they were first discovered. However, their precise identification has not been investigated for about three decades. Here, we assess the morphological and genetic characters of *Scyliorhinus* sp. specimens captured from the islands of Mikurajima, Hachijojima, and Torishima in 2018 and describe them as a new species of catshark, *Scyliorhinus hachijoensis*.

## Material and Methods

Morphological data on *S. hachijoensis* were obtained from fresh specimens that had been captured as bycatch in Splendid alfonso (*Beryx splendens* Lowe, 1834) longline fishery in the waters around Mikurajima Is. ( $n = 10$ ), Hachijojima Is. ( $n = 18$ ), and Torishima Is. ( $n = 3$ ) (7 males and 24 females). Specimens of *Scyliorhinus torazame* from several catch localities were also examined as comparative material ( $n = 124$ ; 57 males and 67 females, see APPENDIX. 1). The holotype and paratypes were deposited in **MSM** (Marine Science Museum, Tokai University, Shizuoka, Japan), **NSMT** (National Museum of Nature and Science, Zoology Department, Division of Fishes, Tsukuba, Ibaraki, Japan), and **SPMN** (Museum of Natural and Environmental History, Shizuoka, Japan), and comparative specimens were examined from the following collections: **ASIZ** (Academia Sinica, Biodiversity Research Museum, Taipei), **BSKU** (Kochi University, Department of Natural Science, Faculty of Science, Kochi, Japan), **FAKU** (Kyoto University, Department of Bioresource Science, Faculty of Agriculture, Kyoto, Japan), **HUMZ** (Hokkaido University, Laboratory of Marine Zoology, Faculty of Fisheries, The Hokkaido University Museum, Hakodate, Hokkaido, Japan), **KPM** (Kanagawa Prefectural Museum of Natural History, Odawara, Kanagawa, Japan), **MSM**, **NMMB** (Pisces Collection, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan), **NSMT**, **SNFR** (Seikai National Fisheries Research Institute, Nagasaki, Japan), and **SPMN**. Abbreviations were based on Fricke & Eschmeyer (2020). We collected a total of 64 external measurements for males and 62 for females based on Springer (1964) and Compagno (2001), respectively, and these are expressed as percentages of total length (%TL). The terminology used for color pattern followed Soares & de Carvalho (2019). Clasper terminology was based on Compagno (1988), Soares & de Carvalho (2019) and Soares (2020). The left clasper was used to study external anatomy and the right clasper to study internal anatomy. Counts of vertebrae were taken from radiographs obtained by using a SOFTEX M-60 (SOFTEX, Tokyo, Japan) at 25 kVp and 2.5 mA, for 3 sec. Tooth row counts and the nomenclature for dentition and dermal denticles followed Herman *et al.* (1993) and Compagno (1988). Dermal denticles were taken from the left side of the body above the pectoral fin and below the first and second dorsal fins. Photographs were taken with a Nikon D5300 digital camera and edited in the GNU Image Manipulation Program. Dermal denticles were photographed using a scanning electron microscope (JEOL. JSM-6390).

Methods for egg case measurement and terminology were based on Bustamante *et al.* (2013). Photographs were taken with a stereomicroscope (OLYMPUS SZX7) and Nikon D5300 digital camera and edited in GNU Image Manipulation Program.

The map showing the distribution of the new species was created using PanMap ver. 0.9.6 (Diepenbroek *et al.*, 2000).

We compared nucleotide sequences of *S. hachijoensis* and *S. torazame* across three mitochondrial DNA regions: the 16S rRNA gene region (16S), cytochrome c oxidase subunit I (COI), and cytochrome *b* (Cytb). Sequences from *S. canicula* (Linnaeus, 1758), *Cephaloscyllium umbratile* Jordan & Fowler, 1903, and *Poroderma pantherinum* (Müller & Henle, 1838) were used as outgroups (GenBank accession numbers: Y16067, NC 001950, KT 003686, NC 029399, and NC 043830). Muscle tissue samples were taken from 18 specimens of *S. hachijoensis* and nine specimens of *S. torazame* and preserved in 80% ethanol at  $-30^{\circ}\text{C}$ . Genomic DNA was extracted using the DNeasy Blood & Tissue Kit (QUIAGEN, Hilden, Germany). PCR primers for the 16S and Cytb gene regions were newly designed in the present study. The 16S primers were made from the complete mitochondrial genome sequences of 14 species of fishes; their GenBank accession numbers are as follows: AB032554 (*Sardinops melanostictus* (Temminck & Schlegel, 1846)), AB034825 (*Diplophos* sp.), AB282840 (*Himantolophus groenlandicus* Reinhardt, 1837), AM489717 (*Melanogrammus aeglefinus* (Linnaeus, 1758)), AP002916 (*Ateleopus japonicus* Bleeker, 1854), AP002930 (*Mugil cephalus* Linnaeus, 1758), AP002952 (*Stephanolepis cirrhifer* (Temminck & Schlegel, 1850)), AP004440 (*Dactyloptena tiltoni* Eschmeyer, 1997), AP004450 (*Petroscirtes breviceps* (Valenciennes, 1836)), AP006017 (*Amphiprion ocellaris* Cuvier, 1830), AP006238 (*Mola mola* (Linnaeus, 1758)), AP009227 (*Rudarius ercodes* Jordan & Fowler, 1902), EU082205 (*Halichoeres tenuispinis* (Günther, 1862)), and GU452728 (*Sebastes marmoratus* (Cuvier, 1829)). Cytb primers were made from the complete mitochondrial genome sequences of *S. canicula*, *C. umbratile*, and *Halaelurus buergeri* (Müller & Henle, 1838) (GenBank accession numbers Y16067, KT003686, and KU892589, respectively). The primer sequences for 16S were univ1952\_16SF (5'-TCGCCTGTTTACCAAAAACA-3') and univ2571\_16SR (5'-CTCCGGTCTGAACTCAGATC-3'), and those for Cytb were SchCytbF (5'-TTTATGGCCACAAATAYCCG-3') and SchCytbR (5'-CAGCTGATGAGAGGTATCAC-3'). For the COI region, we used the primers VF2\_t1, FishF2\_t1, FishR2\_t1, and FR1d\_t1 (Ivanova *et al.* 2007).

PCR amplification was carried out with the following 10 µL reaction mixture: 4.95 µL of distilled water, 1 µL of 10× EX buffer, 1 µL of dNTPs (2.5 mM each), 1 µL of each primer (10 µM), 0.05 µL of EX Taq polymerase (Takara Bio Inc. Shiga, Japan), and 1 µL of genomic DNA (approx. 10–50 ng). The PCR procedure was as follows: an initial denaturation step at 95 °C for 2 min, denaturation at 95 °C for 30 sec, annealing at 55 °C for 40 sec, and extension at 72 °C for 1 min (1.5 min for Cytb), followed by 30 cycles of 95 °C for 30 sec, 55 °C for 40 sec, and 72 °C for 1 min, with a final extension at 72 °C for 5 min, after which samples were maintained at 4 °C. For nucleotide sequencing, we used the BigDye Terminator ver. 3.1 Cycle Sequencing Kit (Applied Biosystems, Inc. California, USA). The reaction profile consisted of an initial denaturation step at 95 °C for 2 min, and then denaturation at 95 °C for 10 sec, annealing at 50 °C for 5 sec, and extension at 60 °C for 2.5 min, followed by 40 cycles of 95 °C for 10 sec, 50 °C for 5 sec, and 60 °C for 2.5 min, after which samples were maintained at 4 °C. The sequencing primers were univ1952\_16SF (for 16S), SchCytbF (for Cytb), and M13F (-21) (for COI; Ivanova *et al.* 2007). DNA sequences were aligned in MEGA-X ver. 10.0.5 (Kumar *et al.* 2018). Sequence divergences were calculated by using the Tamura–Nei model (Tamura & Nei 1993) with a discrete gamma distribution. Maximum likelihood phylogenetic trees were constructed in MEGA-X. The robustness of the ML tree was assessed using the bootstrap method with 1000 replicates. All sequences were deposited online (GenBank accession numbers: LC517181 to LC517261 for *S. hachijoensis* and *S. torazame*, see APPENDIX 2).

### ***Scyliorhinus hachijoensis* sp. nov.**

(Table 1 and Figs. 1–9)

New English name: Cinder cloudy catshark; new Japanese name: Fukami-torazame.

*Scyliorhinus* sp.: Hagiwara, 1993: 1, 9, Tables 1–3, Fig. 3 (keeping and reproduction)

### **Holotype.**

NSMT-P135960, adult male, 370 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 200–300 m depth, 24 October 2018).

### **Paratypes.**

MSM-19-292, female, 331 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-293, female, 354 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-294, female, 326 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-295, female, 354 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-296, female, 368 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-297, female, 382 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300–400 m depth, 12 July 2018); MSM-19-298, female, 366 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 200–300 m depth, 18 August 2018); MSM-19-299, female, 350 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 200–300 m depth, 18 August 2018); MSM-19-300, female, 356 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 200–300 m depth, 18 August 2018); MSM-19-301, female, 368 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 200–300 m depth, 18 August 2018); NSMT-P 135961, female, 322 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 400–500 m depth, 12 July 2018); NSMT-P 135962, female, 348 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 500 m depth, 11 July 2018); NSMT-P 135963, male, 384 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); NSMT-P 135964, female, 364 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); NSMT-P 135965, male, 419 mm TL (off the east coast of Torishima Island, Tokyo, Japan, 600–650 m depth, 27 June 2018); NSMT-P 136476, female, 386 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300 m depth, 15 November 2018); NSMT-P 136477, female, 342 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); NSMT-P 136478, male, 346 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45542, female, 370 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300 m depth, 15 November 2018); SPMN-PI 45543, female, 364 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300 m depth, 15 November 2018); SPMN-PI 45544, female, 345 mm TL (off the east coast of Hachijojima

Island, Tokyo, Japan, 300 m depth, 15 November 2018); SPMN-PI 45545, female, 372 mm TL (off the east coast of Hachijojima Island, Tokyo, Japan, 300 m depth, 15 November 2018); SPMN-PI 45546, female, 301 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45547, female, 355 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45548, female, 305 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45549, male, 294 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45550, male, 335 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018); SPMN-PI 45551, female, 356 mm TL (off the east coast of Mikurajima Island, Tokyo, Japan, 100–200 m depth, 24 October 2018).

#### Other materials.

HUMZ113575, female, 353 mm TL (off Torishima Island, Tokyo, Japan); HUMZ113576, male, 372 mm TL (off Torishima Island, Tokyo, Japan).

#### Diagnosis.

A species of *Scyliorhinus* distinguished by its anterior nasal flaps not reaching the upper lip (vs. flaps reaching upper lip, and sometimes covering it, in *S. canicula*, *S. cervigoni*, *S. comoroensis*, *S. duhamelii*, *S. garmani* and *S. stellaris*); nasoral grooves absent and posterior nasal flaps situated posterior to excurrent apertures (vs. nasoral grooves prexents and posterior nasal flaps laterally situated in *S. canicula* and *S. duhamelii*); mouth length less than half of mouth width (vs. mouth length more than or equal half of mouth width except in *S. torazame* and *S. ugoi*); anal fin height more than caudal peduncle height (vs. less than caudal peduncle height in *S. boa*, *S. duhamelii*, *S. torazame* and *S. torrei*), and greater than or equal to half of mouth width (vs. less than half of mouth width in *S. boa*, *S. capensis*, *S. duhamelii*, *S. haeckelii*, *S. hesperius*, *S. meadi*, *S. torazame*, *S. torrei* and *S. ugoi*); saddles darker than the background color (vs. inconspicuous or absent in *S. boa*, *S. cabofriensis*, *S. cervigoni*, *S. duhamelii*, *S. garmani* and *S. torrei*, and dark lines in *S. retifer*); body grayish brown to dark brown with well-defined light spots and small dark spots (vs. spots absent in *S. retifer*, yellow to golden spots in *S. capensis*, light spots absent in *S. cervigoni*, *S. garmani*, *S. meadi* and *S. retifer*, and dark spots absent in *S. capensis*, *S. comoroensis*, *S. hesperius*, *S. meadi*, *S. torazame* and *S. torrei*); light spots spiracle-sized or larger (vs. predominantly smaller than spiracles in *S. boa*, *S. cabofriensis*, *S. canicula*, *S. duhamelii*, *S. stellaris* and *S. ugoi*); dark spots smaller than spiracles (vs. predominantly larger than spiracles in *S. cervigoni*, *S. duhamelii*, *S. garmani*, *S. haeckelii* and *S. stellaris*); number of monospondylous vertebrae 34–36 (vs. counts higher except in *S. duhamelii*, *S. torazame* and *S. torrei*); clasper with hooks (vs. absent in all other species except *S. torazame*); accessory terminal cartilage present (vs. absent in *S. cabofriensis*, *S. cervigoni*, *S. comoroensis*, *S. duhamelii*, *S. haeckelii*, *S. stellaris*, *S. torrei* and *S. ugoi*); egg case surface with irregularities (vs. smooth in all other species).

#### Description.

Morphometric measurements are given in Table 1.

Body slender and tapering to caudal fin (Fig. 1), precaudal length 77.3 %TL (72.0–76.4 %TL in palatotypes). Prepectoral length 0.4 times prepelvic length. Pectoral–pelvic space 1.5 times pelvic–anal space (1.7–2.5 times in female, 1.4–1.9 times in male). Interdorsal space 1.6 times dorsal–caudal space. Trunk shorter than tail; snout–vent length 44.1 %TL (42.0–44.6 %TL). First dorsal origin above insertion of pelvic fin, second dorsal origin forward to anal insertion. No interdorsal, postdorsal, or postanal ridges; lateral crest on caudal peduncle absent.

Head (Fig. 2) moderately broad and depressed. Head length (HL) 18.9 %TL (17.2–19.6 %TL) and 1.4 times head width. Snout short, prenasal length 2.3 %TL (2.1–2.6 %TL) and 0.6 times preoral length. Preoral length 3.8 %TL (3.2–4.4 %TL), 0.4 times mouth width and 0.9 times preorbital length. Preorbital length 4.1 %TL (4.1–5.1 %TL), 0.5 times interorbital space.

Eyes (Fig. 2A) large and slitlike, eye length 4.1 %TL (3.3–4.4 %TL), 0.2 times head length, with lower edges medial to horizontal head rim in dorsal view; subocular ridge strong. Nictitating lower eyelid of rudimentary type, with shallow subocular pocket and secondary lower eyelid free from upper eyelid. Eye length 5.3 times and interorbital distance 9.6 times spiracle length.

Spiracles (Fig. 2A) close behind but clearly separated from eyes, positioned dorsolaterally on head and somewhat lower than level of eye notch.

**TABLE 1.** Morphometric and meristic data for *Scyliorhinus hachijoensis* (n = 31) and *S. torazame* (n = 124). SD, Standard deviation; n, number of examined specimens. Total length (TL) is reported in mm, other measurements are shown as percentages of TL. The number of specimens for spiral valves is 18 in each species, and for vertebral counts is 11 *S. hachijoensis* and 23 *S. torazame*. †this study, ††Soares & de Carvalho (2019).

Measurements	<i>Scyliorhinus hachijoensis</i>				<i>Scyliorhinus torazame</i>			
	Holotype	Paratypes			Range†	Mean†	SD†	Range††
		Range	Mean	SD				
Total length (TL)	370	294–419	353	27	87–465	357	94	95.8–778.0
Precaudal length	77.3	72.0–76.4	74.8	1.0	66.7–79.4	73.8	2.5	68.2–78.2
Prenasal length	2.3	2.1–2.6	2.4	0.2	1.8–3.8	2.4	0.3	1.6–4.1
Preoral length	3.8	3.2–4.4	4.0	0.3	3.2–5.6	4.0	0.4	3.4–5.9
Preorbital length	4.1	4.1–5.1	4.6	0.2	3.2–5.8	4.4	0.5	5.3–7.8
Prespiracular length	8.8	7.9–9.6	8.7	0.4	7.3–10.7	8.5	0.6	8.4–12.4
Prebranchial length	14.1	12.5–15.3	13.7	0.7	11.9–17.2	13.5	0.9	12.7–17.7
Head length (HL)	18.9	17.2–19.6	18.4	0.6	15.9–21.8	18.1	0.9	17.1–22.4
Prepectoral length	16.5	14.4–17.6	15.9	0.7	13.8–19.5	15.7	0.9	15.5–20.5
Prepelvic length	38.4	37.7–40.1	39.2	0.7	35.0–43.6	39.1	1.7	36.2–45.3
Snout-vent length	44.1	42.0–44.6	43.4	0.7	36.9–46.6	43.1	1.9	40.4–50.1
Preanal length	60.3	55.1–59.2	57.5	0.9	52.7–62.5	59.0	1.9	–
Pre-first dorsal length	48.9	46.8–50.3	48.1	1.0	43.4–53.2	48.7	1.9	43.0–51.9
Pre-second dorsal length	65.7	62.6–65.8	64.3	1.0	57.5–68.9	65.0	2.1	–
Interdorsal distance	9.7	8.1–11.3	9.3	0.8	7.1–11.8	9.3	0.9	7.5–12.3
Dorsal-caudal distance	6.2	3.3–6.1	4.9	0.7	0.8–6.5	3.4	1.5	1.1–5.9
Pectoral-pelvic distance	16.6	14.9–19.8	17.0	0.9	9.3–21.9	16.6	2.1	11.7–20.2
Pelvic anal distance	11.0	6.9–11.8	8.4	1.0	7.1–14.2	9.8	1.2	5.9–14.5
Anal caudal distance	7.0	5.6–8.1	6.9	0.6	4.3–9.6	7.2	1.0	5.2–9.7
Interorbital distance	7.5	5.6–8.0	7.4	0.5	6.0–8.6	7.3	0.5	5.7–9.2
Internarial distance	2.2	1.5–2.2	1.9	0.2	1.3–3.2	1.9	0.3	4.8–8.5
Mouth width	8.6	8.0–9.4	8.6	0.4	6.7–9.4	8.3	0.5	7.5–10.6
Mouth length	2.9	2.5–4.4	3.0	0.4	2.3–4.7	3.0	0.3	4.2–6.9
Lower labial furrow length	1.0	0.9–1.5	1.2	0.2	0.4–1.4	0.8	0.2	1.3–2.7
Eye length	4.1	3.3–4.4	3.8	0.3	3.0–6.3	3.9	0.4	2.9–7.5
Spiracle length	0.8	0.5–0.9	0.6	0.1	0.3–1.0	0.7	0.1	0.6–2.1
Eye-spiracle length	0.7	0.4–0.7	0.6	0.1	0.2–0.9	0.4	0.1	0.8–3.4
First gill slit height	2.2	1.5–2.3	2.0	0.2	0.8–2.7	1.7	0.3	1.6–3.3
Fifth gill slit height	1.4	0.7–1.6	1.1	0.2	0.4–1.3	0.8	0.2	0.7–1.7
Head width	13.2	11.5–13.3	12.5	0.4	10.9–14.3	12.7	0.7	10.6–14.8
Pectoral base	7.0	6.1–8.0	6.9	0.5	6.2–8.8	7.2	0.5	5.5–8.8

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**TABLE 1.** (Continued)

Measurements	<i>Scyliorhinus hachijoensis</i>				<i>Scyliorhinus torazame</i>			
	Holotype	Paratypes			Range <sup>†</sup>	Mean <sup>†</sup>	SD <sup>†</sup>	Range <sup>††</sup>
		Range	Mean	SD				
Pectoral anterior margin	16.5	14.0–17.1	15.6	0.7	10.6–16.2	13.2	1.1	11.7–17.0
Pectoral posterior margin	10.9	9.1–11.5	10.3	0.5	5.6–11.0	8.7	1.0	5.8–10.1
Pectoral inner margin	5.1	4.2–6.0	5.0	0.5	3.4–6.4	4.8	0.6	4.7–7.8
Pelvic length	19.1	11.2–20.8	13.3	2.9	9.3–22.5	14.8	3.8	10.4–22.0
Pelvic base	11.1	9.3–10.7	10.0	0.4	7.4–13.5	10.1	1.0	6.9–13.7
Pelvic anterior margin	9.7	8.2–10.7	9.0	0.5	5.1–9.6	7.5	0.9	6.3–10.7
Pelvic inner margin	8.6	1.5–11.1	3.3	2.9	0.9–11.2	4.9	3.3	2.1–12.2
Clasper inner length	14.1	6.8–17.2	13.8	4.1	3.6–17.3	12.2	4.7	3.6–17.1
Clasper outer length	9.0	1.4–12.3	8.8	4.4	0.4–12.1	7.5	4.1	1.5–13.2
Anal length	10.7	10.1–12.9	11.3	0.6	9.1–11.8	10.3	0.6	–
Anal base	8.1	7.9–11.0	9.1	0.6	6.8–9.7	8.0	0.5	4.1–11.1
Anal anterior margin	8.0	7.5–9.3	8.7	0.4	6.1–9.3	7.6	0.6	7.1–11.5
Anal posterior margin	5.3	4.9–6.9	5.8	0.5	2.3–5.8	4.5	0.6	3.6–5.7
Anal inner margin	2.4	1.7–2.6	2.2	0.2	0.9–3.0	2.3	0.3	1.9–5.1
Anal height	4.3	4.0–5.3	4.7	0.3	2.3–4.1	3.2	0.4	3.1–7.7
First dorsal length	10.6	9.5–11.5	10.4	0.5	8.0–11.8	10.0	0.6	–
First dorsal base	7.3	6.4–8.0	7.2	0.4	6.0–9.7	7.3	0.6	6.9–10.8
First dorsal anterior margin	10.9	10.0–12.6	11.0	0.6	8.0–11.3	9.5	0.6	8.6–12.6
First dorsal posterior margin	5.9	5.3–6.6	6.1	0.3	3.3–6.6	5.1	0.7	–
First dorsal inner margin	2.5	1.9–3.0	2.2	0.3	1.6–3.2	2.3	0.3	1.7–3.8
First dorsal height	6.4	6.0–7.2	6.8	0.3	3.6–6.7	5.4	0.6	4.8–7.8
Second dorsal length	8.4	7.5–9.0	8.4	0.4	6.6–9.6	8.0	0.5	–
Second dorsal base	5.8	5.1–6.5	5.9	0.4	4.6–7.3	5.5	0.5	5.2–7.9
Second dorsal anterior margin	7.6	6.9–8.5	7.8	0.4	5.1–7.9	6.6	0.5	6.1–9.4
Second dorsal posterior margin	4.5	3.7–4.6	4.1	0.3	2.0–4.6	3.5	0.5	–
Second dorsal inner margin	2.3	2.0–2.7	2.3	0.2	1.3–3.0	2.4	0.3	1.6–3.1
Second dorsal height	4.2	3.6–4.6	4.1	0.3	2.1–4.2	3.3	0.4	2.8–5.0
Dorsal caudal margin	22.5	23.3–26.9	24.9	0.8	21.4–33.0	26.1	2.3	21.8–31.8
Preventral caudal margin	10.8	10.4–13.2	11.5	0.7	8.9–17.5	11.3	1.1	8.8–17.7
Terminal caudal margin	6.4	4.8–6.8	5.9	0.5	3.1–7.0	5.3	0.7	3.3–6.3
Subterminal caudal margin	3.8	3.7–5.6	4.3	0.4	2.7–6.1	4.0	0.5	2.8–6.8
Caudal peduncle height	3.0	2.4–3.4	3.0	0.2	2.5–4.4	3.2	0.3	3.1–4.8
Caudal peduncle width	2.3	1.8–2.7	2.2	0.2	1.7–3.6	2.7	0.3	2.2–3.9

.....Continued on the next page

**TABLE 1.** (Continued)

Measurements	<i>Scyliorhinus hachijoensis</i>				<i>Scyliorhinus torazame</i>			
	Holotype	Paratypes			Range <sup>†</sup>	Mean <sup>†</sup>	SD <sup>†</sup>	Range <sup>††</sup>
		Range	Mean	SD				
Meristics								
Upper tooth rows	39	36–49	–	–	34–57	–	–	50–76
Lower tooth rows	36	32–43	–	–	34–52	–	–	45–81
Spiral valves	8	7–8	–	–	6–7	–	–	6–7
Monospondylous vertebrae	34	34–36	–	–	34–37	–	–	32–37
Precaudal vertebrae	77	71–78	–	–	66–77	–	–	–
Total vertebrae	112	109–115	–	–	102–112	–	–	105–126

First and second gill openings about equal in height, with last three tapering down to fifth (Fig. 2A, B). First gill opening height 1.6 times that of fifth. All gill openings slightly concave and not elevated on dorsolateral surface of head. Gill filaments not visible externally.

Nostrils (Fig. 2C) with broad incurrent apertures, without nasoral grooves or nasal barbels and with small and oval excurrent apertures. Anterior nasal flaps large, triangular, and covering posterior nasal flap and excurrent aperture, extending just anterior to mouth, close to but not touching upper lip. Mesonarial ridge distinct but not exceeding posterior border of anterior nasal flap. Posterior nasal flaps small and rectangular, situated on posterior border of excurrent aperture. Internarial distance 0.3 times interorbital distance.

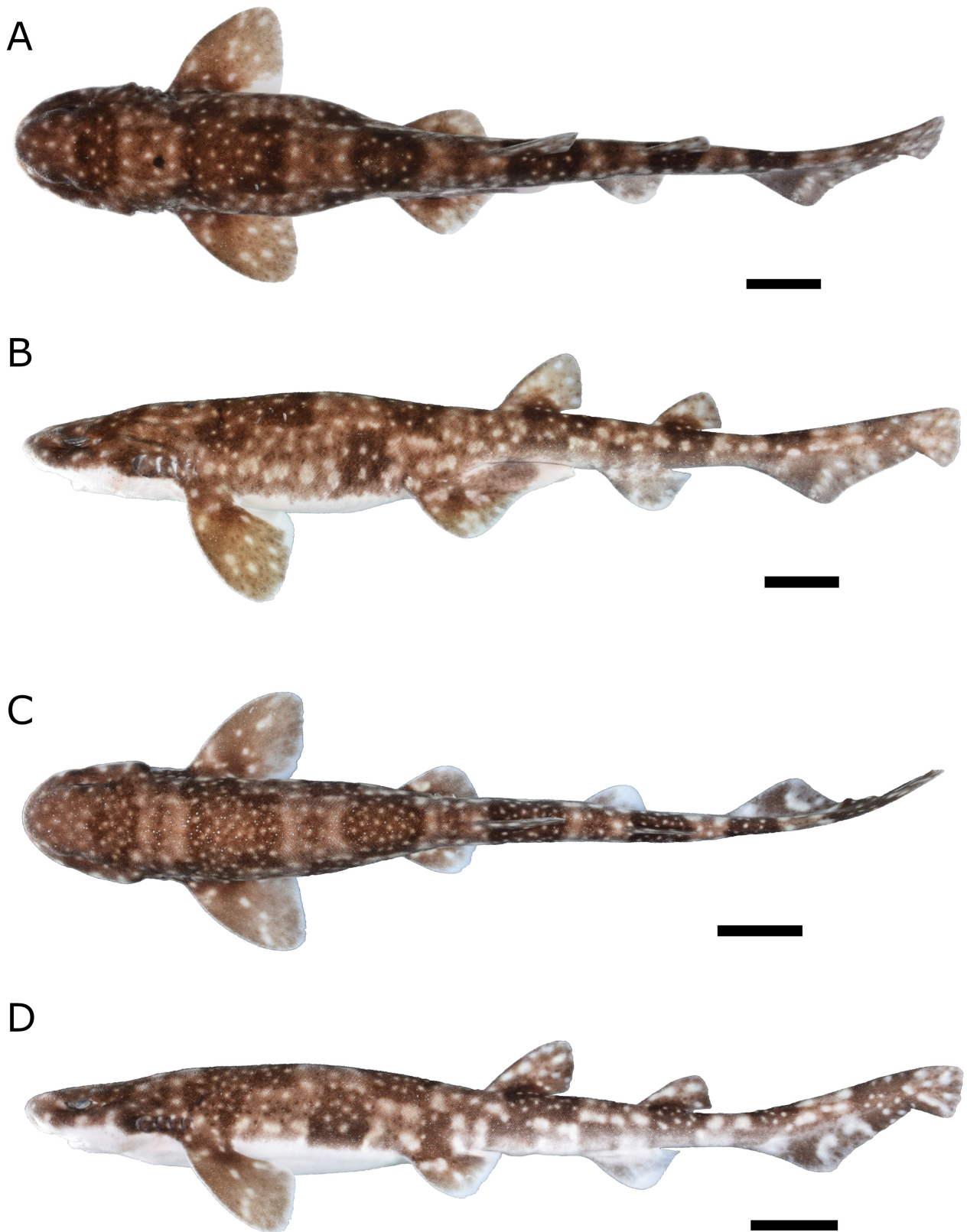
Mouth (Fig. 2A, C) arched, moderately wide, and short. Mouth length 2.9 %TL (2.5–4.4 %TL), 0.3 times mouth width and 0.2 times head length; mouth width 0.7 times head width. Upper labial furrows absent. Lower labial furrows short and narrow, length 0.1 times mouth width.

Tooth counts 39/36 (36–49/32–43 in paratypes); teeth morphologically similar in both jaws. Monognathic heterodonty gradual and well developed; anterolateral teeth abruptly larger than symphyisial ones and smaller distally; posterior teeth with smaller principal cusps than anterolateral teeth (Fig. 3). Sexual heterodonty weak. Symphyisial teeth with principal cusp and one weak cusplet on each side. Anterolateral teeth with more developed principal cusp than symphyisial teeth and two to four cusplets; most outside cusplets small and undeveloped when with three or four cusplets. Posterior teeth have two or three cusplets and tilted to the outside; principal cusp weakly developed.

Pectoral fins (Figs. 1, 4A, B) large and rounded-triangular, not falcate, with broadly convex anterior margins and almost straight posterior and inner margins. Pectoral fin inner corner obtuse angle (96° in holotype, 90°–102° in paratypes). Pectoral origin under third gill opening, with base length 0.8 times mouth width. Pectoral anterior margin 2.4 times base length and 1.5 times posterior margin.

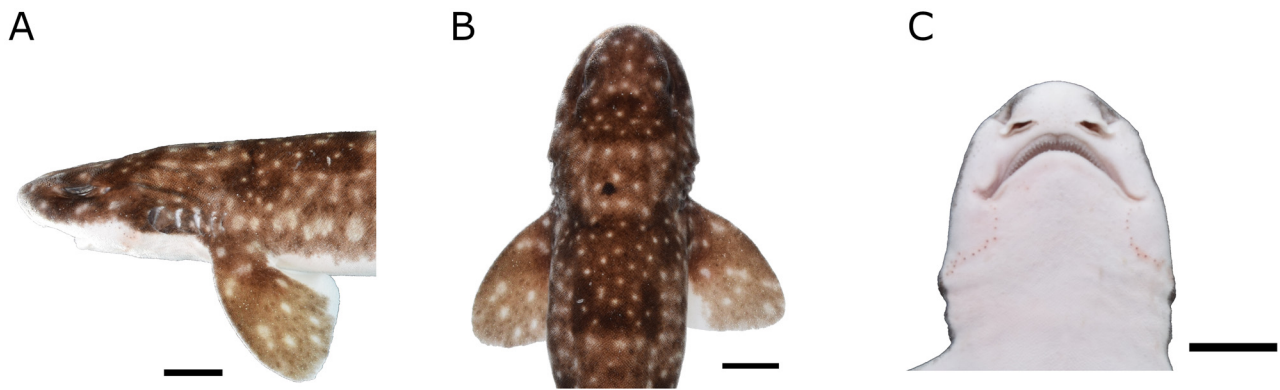
Pelvic fins (Figs. 1, 4A, B) broadly triangular, with rounded outer corner. Pelvic anterior margin 0.9 times base length. In males, pelvic inner margins fused together forming a pelvic apron, elongated posteriorly and covering claspers. In females, the pelvic fin apex located obviously posterior to middle of fin, and angle of pelvic fin inner corner 63°–75° in paratypes.

Claspers (Fig. 5A) moderately long and cylindrical, extending beyond free rear tips of pelvic fins in adult specimens. Clasper inner length 14.1 %TL (14.1–17.2 %TL in mature males of paratypes), 1.4 times (1.4–1.8 times in mature males of paratypes) pelvic anterior margin and 1.6 times (1.4–1.7 times) clasper outer length. Most of clasper surface (except part of medial surface of clasper shaft and part of exorhipidion, rhipidion, and terminal dermal cover) covered by dermal denticles with anteriorly directed crowns. Clasper hooks present, forming row from behind apophyle to posterior tip of exorhipidion, running along medial border of exorhipidion (Fig. 5A, B). Rhipidion well developed, partly covered medially by prominent exorhipidion and anteriorly by cover rhipidion. Rhipidion insertion point located in anterior portion of dorsal terminal 2 cartilage and extending to end of glans. Cover rhipidion expanded medially, reaching exorhipidion with nearly straight border at the shaft and meandering border at glans. Both cover rhipidion and exorhipidion cover clasper groove. Envelope, pseudopera, and pseudosiphon absent. Terminal dermal cover smooth, and contacting exorhipidion and rhipidion.

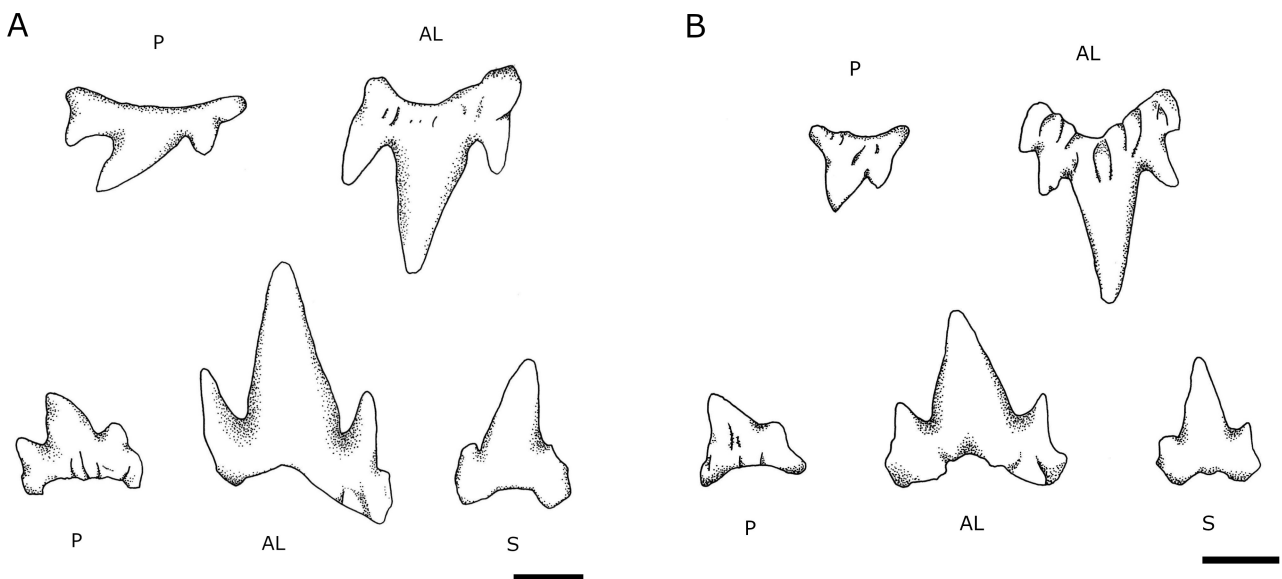


**FIG. 1.** *Scyliorhinus hachijoensis*, external morphology. (A, B) NSMT-P 135960, male, 370 mm TL (off the east coast of Hachijojima Island). (C, D) NSMT-P 135961, female, 322 mm TL (off the east coast of Hachijojima Island). Panels show (A, C) dorsal and (B, D) lateral views of the specimens. Scale bar = 30 mm.





**FIG. 2.** Close-ups of the head of *Scyliorhinus hachijoensis*, NSMT-P 135960, male, 370 mm TL (off the east coast of Hachijojima Island). Panels show (A) lateral, (B) dorsal, and (C) ventral views. Scale bar = 20 mm.



**FIG. 3.** Teeth of *Scyliorhinus hachijoensis*, labial view. (A) NSMT-P 135960, male, 370 mm TL (off the east coast of Torishima Island). (B) NSMT-P 135962, female, 348 mm TL (off the east coast of Hachijojima Island). AL, anterolateral tooth; P, posterior tooth; S, symphyseal. Scale bar = 0.5 mm.

Clasper skeleton relatively simple (Fig. 5C). Ventral and dorsal terminal cartilage forms spoon-shaped structure; dorsal terminal begins anteriorly but ends together with ventral cartilage. Accessory terminal cartilage quadrangle situated posteriorly and inside ventral marginal cartilage. Dorsal terminal 2 cartilage beginning posteriorly and ventrally to dorsal marginal cartilage, elongated and rod-like, laterally positioned on dorsal terminal cartilage and extending throughout its length. Ventral terminal 2 cartilage elongated and oval, laterally and posteriorly positioned on ventral terminal cartilage and extending to half its length.

First dorsal fin (Fig. 1) sub-rectangular and triangular, not falcate, with nearly straight anterior margin, round apex, and angular free rear tip. First dorsal base 0.8 times the interdorsal space. First dorsal anterior margin length 1.5 times its base, and first dorsal height 0.9 times its base.

Second dorsal fin (Fig. 1) triangular, not falcate and smaller than first dorsal fin, with nearly straight anterior margin, straight posterior margin, rounded apex, and sharper free rear tip than first dorsal fin. Second dorsal fin base 1.4 times its height and 0.9 times dorsal–caudal distance. Second dorsal anterior margin 1.3 times its base. Second dorsal fin base 0.8 times first dorsal fin base, second dorsal fin height 0.6 times first dorsal fin height.

Anal fin (Fig. 1) triangular, slightly high, apically narrow, and not falcate. Anal fin anterior margin nearly straight, apex rounded, free rear tip acutely pointed, and posterior margin straight. Anal fin base 0.8 times interdorsal space and 1.3 times dorsal–caudal distance. Anal fin anterior margin 1.5 times its posterior margin and 1.0 times its base. Anal fin height 0.5 times its base and 1.4 times caudal peduncle height. Anal fin larger than second dorsal fin, base 1.4 times second dorsal fin base, and anal fin height 1.0 times second dorsal fin height.

Caudal fin (Fig. 1) narrow-lobed and asymmetrical, with developed terminal lobe. All caudal fin margins nearly straight, all tips rounded. Dorsal caudal margin without lateral undulations and crest of denticles. Dorsal caudal margin 0.3 times precaudal length and 2.1 times preventral caudal margin. Subterminal margin 0.6 times terminal margin.

Total vertebral counts 112 (109–115 in paratypes), monospondylous vertebral counts 34 (34–36), and precaudal vertebral counts 77 (71–78).

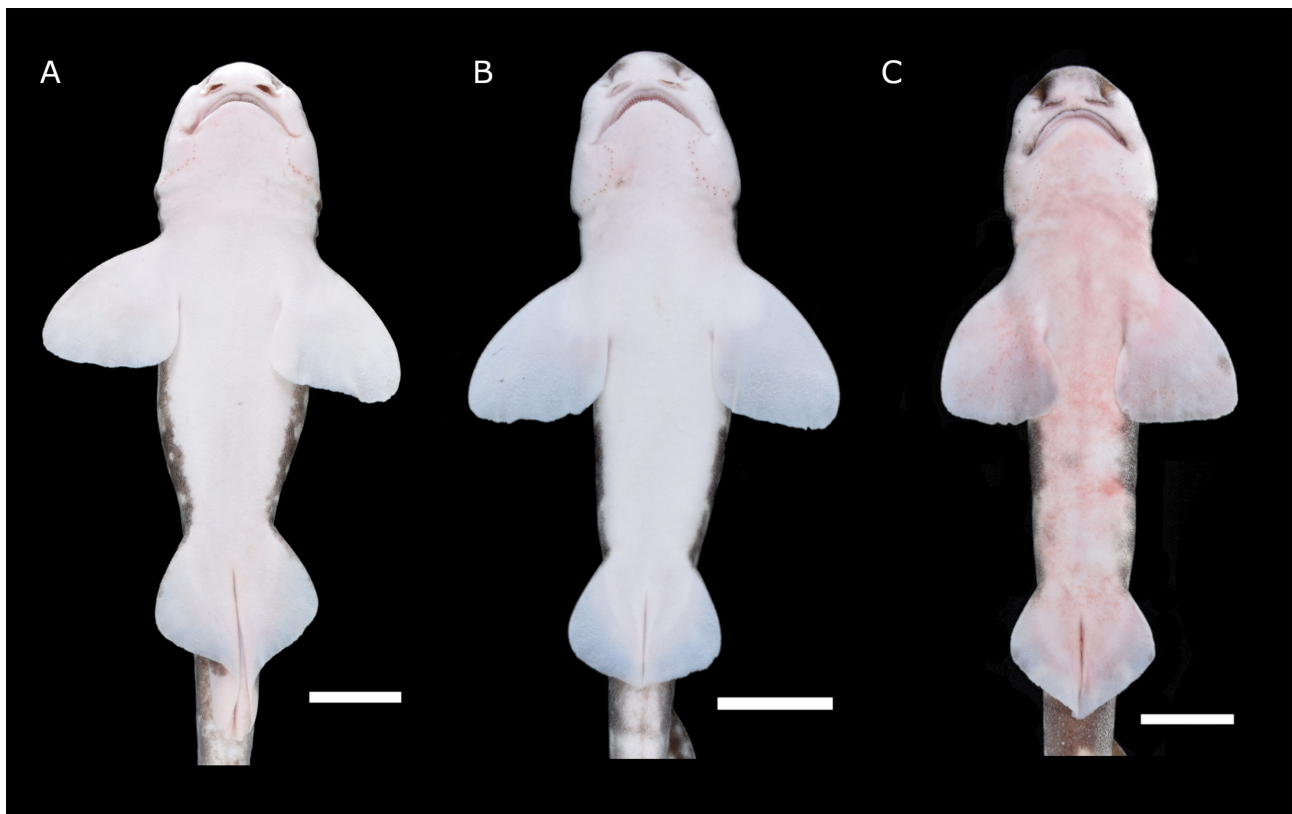
Intestinal valve type conicospiral, with 8 turns (7–8 turns in paratypes).

Dermal denticles (Fig. 6) with flat, elongated, teardrop-shaped crowns. Crown with a strong medial ridge extending its entire length onto a long principal cusp. Dermal denticles above pectoral fin present three ridges, with medial ridge less prominent than in denticles of other regions. Denticles below dorsal fins are longer and present a prominent medial ridge, extending to distal tip of cusplet. In all regions, lateral ridges do not extend beyond intersection between principal cusp and cusplets, and are less prominent. Lateral cusps of denticles well developed above pectoral fin, but not well developed below dorsal fins.

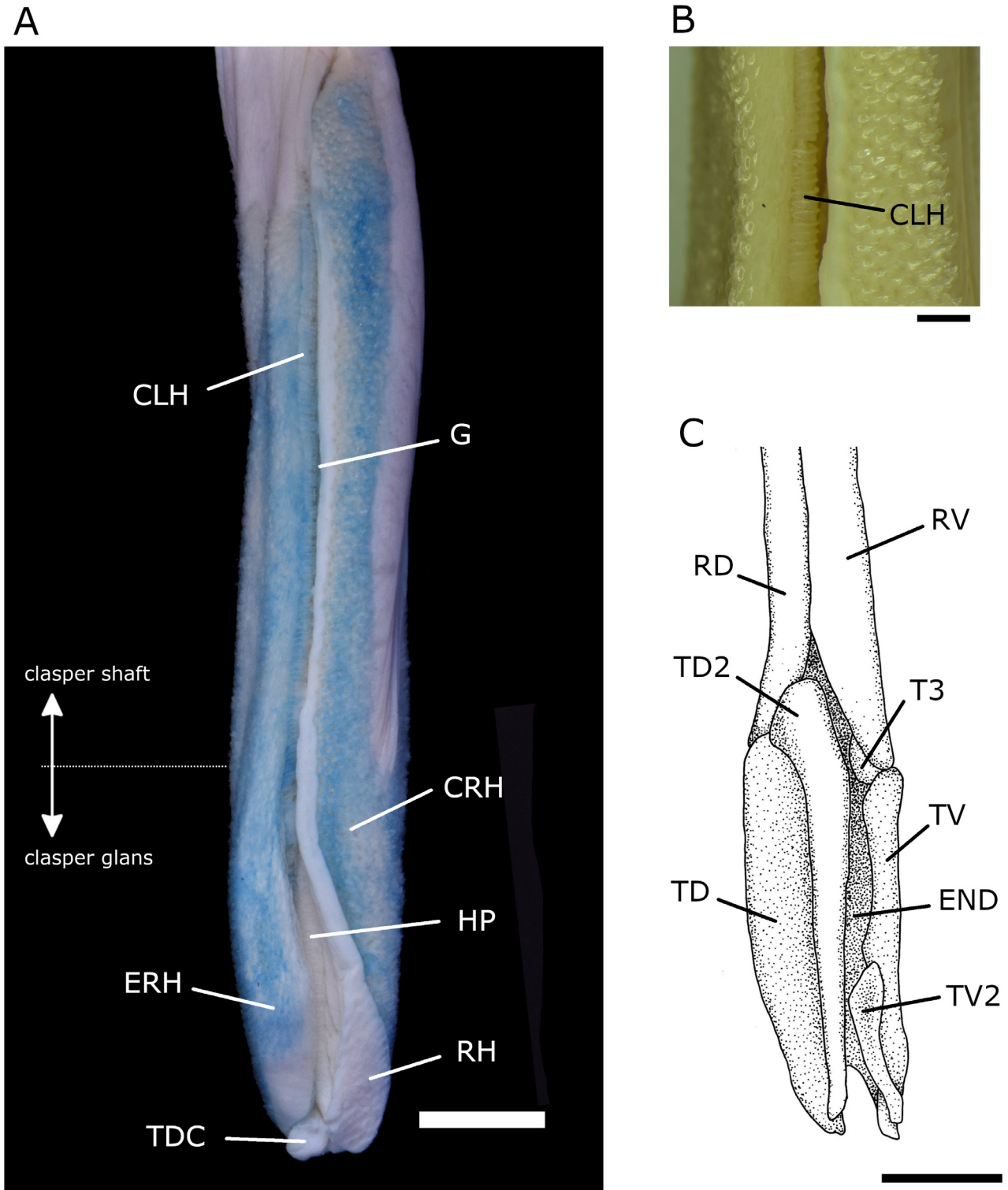
Color pattern (Figs. 1, 4A, B) with dark brown saddles on a brown background. Light spots present on dorsolateral surfaces and fins, spiracle-sized or larger. Dark spots present on lateral body and fins, smaller than spiracles and light spots. Outlines of dark spots not distinct. Light spots on saddles slightly smaller than on body, with spots largest on fins and smallest on saddles. Saddles darker than background, with pectoral saddles extending diagonally forward. Ventral region white to cream, turning dark anterior of the nostrils.

#### Distribution.

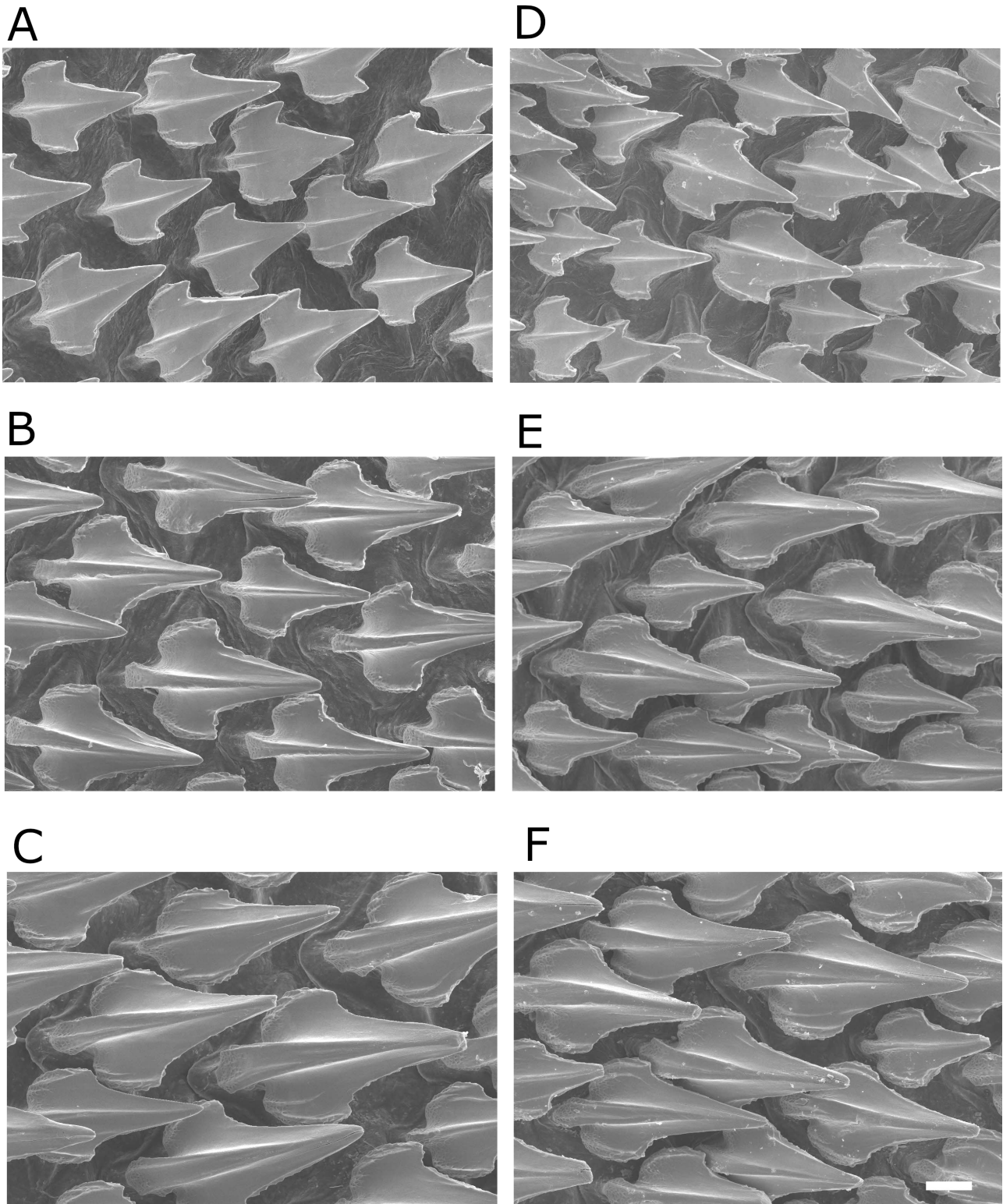
This species was recorded from the waters around the Izu Islands, Japan (Fig. 7). All specimens were captured by longline fishing for Splendid alfonsino, at depths of ca. 100–200 m around Mikurajima Island, ca. 200–400 m around Hachijojima Island, and ca. 500–600 m around Torishima Island.



**FIG. 4.** Ventral view of (A, B) *Scyliorhinus hachijoensis* and (C) *S. torazame* specimens. (A) NSMT-P 135960, male, 370 mm TL (off the east coast of Hachijojima Island). (B) NSMT-P 135961, female, 322 mm TL (off the east coast of Hachijojima Island). (C) NSMT-P 136479, female, 407 mm TL (35°10.04'N 139°30.08'E, Misaki, Miura, Kanagawa, Japan). Scale bar = 30 mm.



**FIG. 5.** Clasper of *Scyliorhinus hachijoensis*. All panels show dorsal views of specimen NSMT-P 135965, 419 mm TL (off the east coast of Torishima Island). (A) External morphology, scale bar = 5 mm. (B) Close-up of clasper hooks, scale bar = 1 mm. (C) Skeleton, scale bar = 5 mm. AP, apopyle; CLH, clasper hooks; CRH, cover rhipidion; END, endstyle; ERH, exorhipidion; G, clasper groove; HP, hypopyle; RD, dorsal marginal cartilage; RH, rhipidion; RV, ventral marginal cartilage; T3, accessory terminal cartilage; TD, dorsal terminal cartilage; TD2, dorsal terminal 2 cartilage; TDC, terminal dermal cover; TV, ventral terminal cartilage; TV2, ventral terminal 2 cartilage.



**FIG. 6.** Dermal denticles of *Scyliorhinus hachijoensis*. (A–C) NSMT-P 135965, male, 419 mm TL (off the east coast of Torishima Island). (D–E) NSMT-P 135962, female, 348 mm TL (off the east coast of Hachijojima Island). Panels show denticles located (A, D) above the pectoral fin base, (B, E) below the first dorsal fin base, and (C, F) below the second dorsal fin base. Scale bar = 200  $\mu$ m.

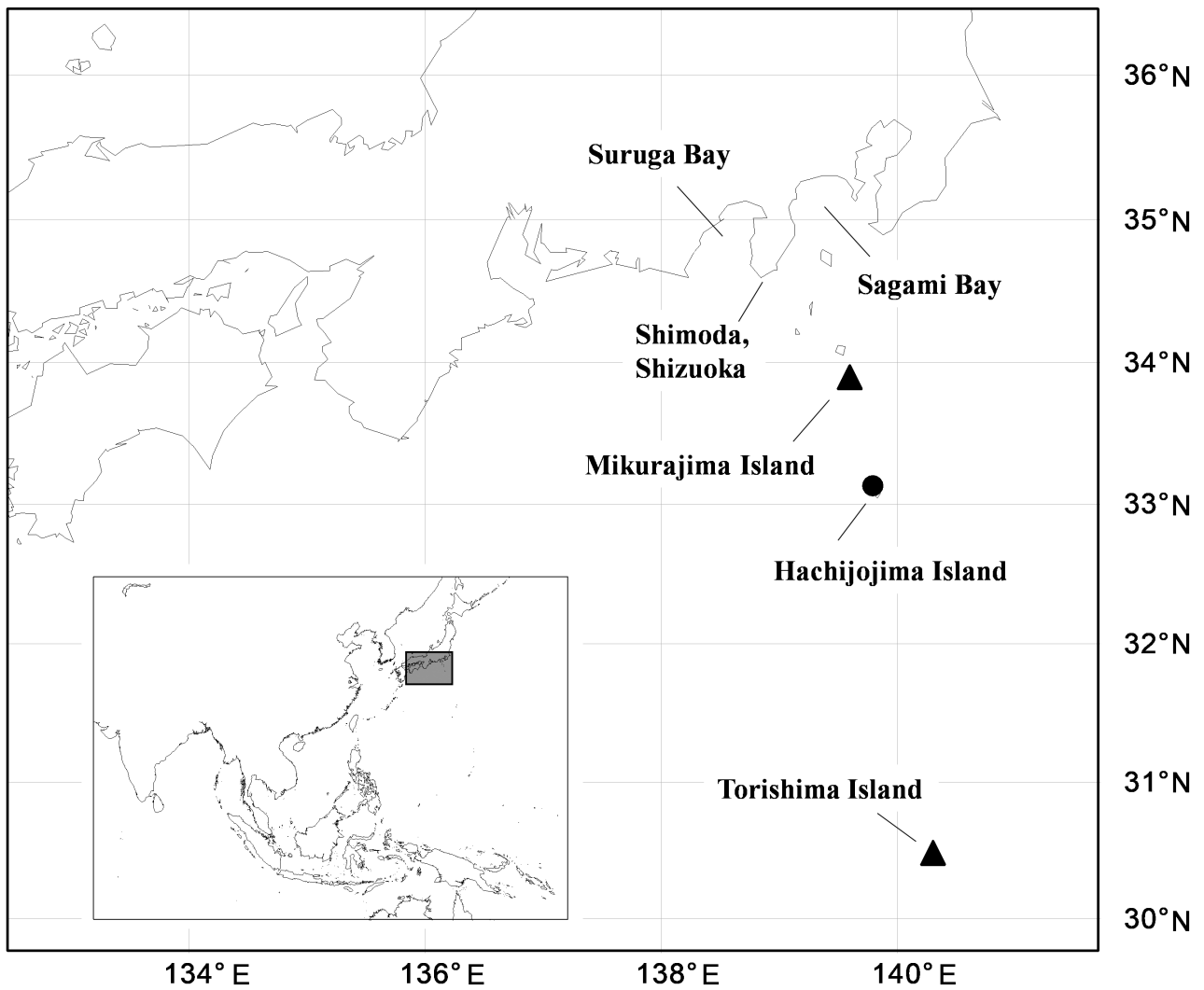


FIG. 7. Distribution of *Scyliorhinus hachijoensis*. Circle and triangles show catch locations of holotype and paratypes, respectively.

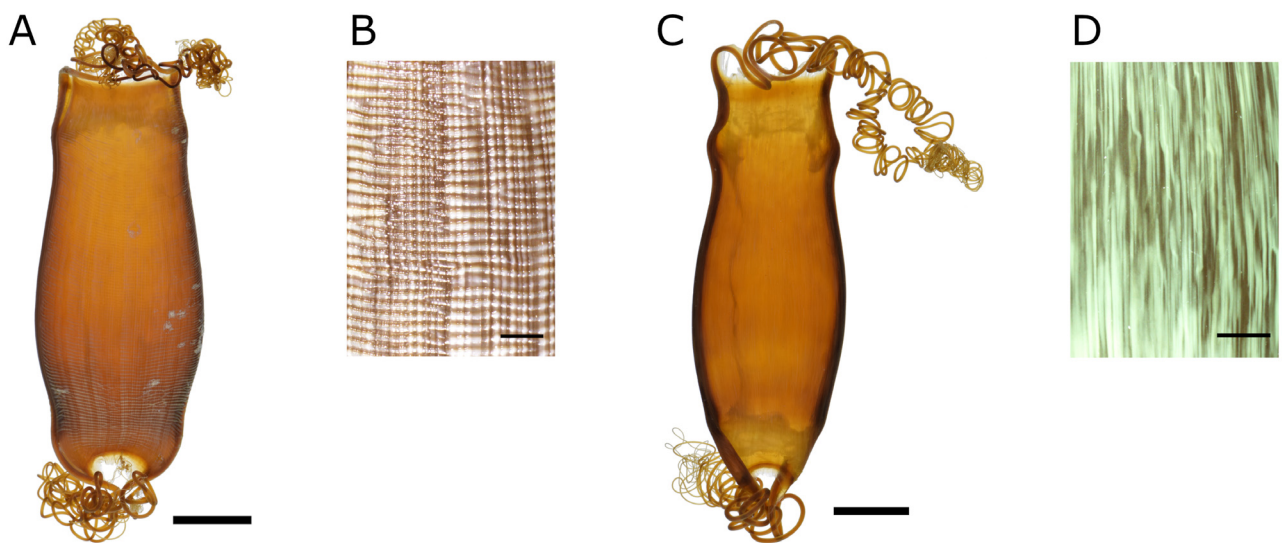


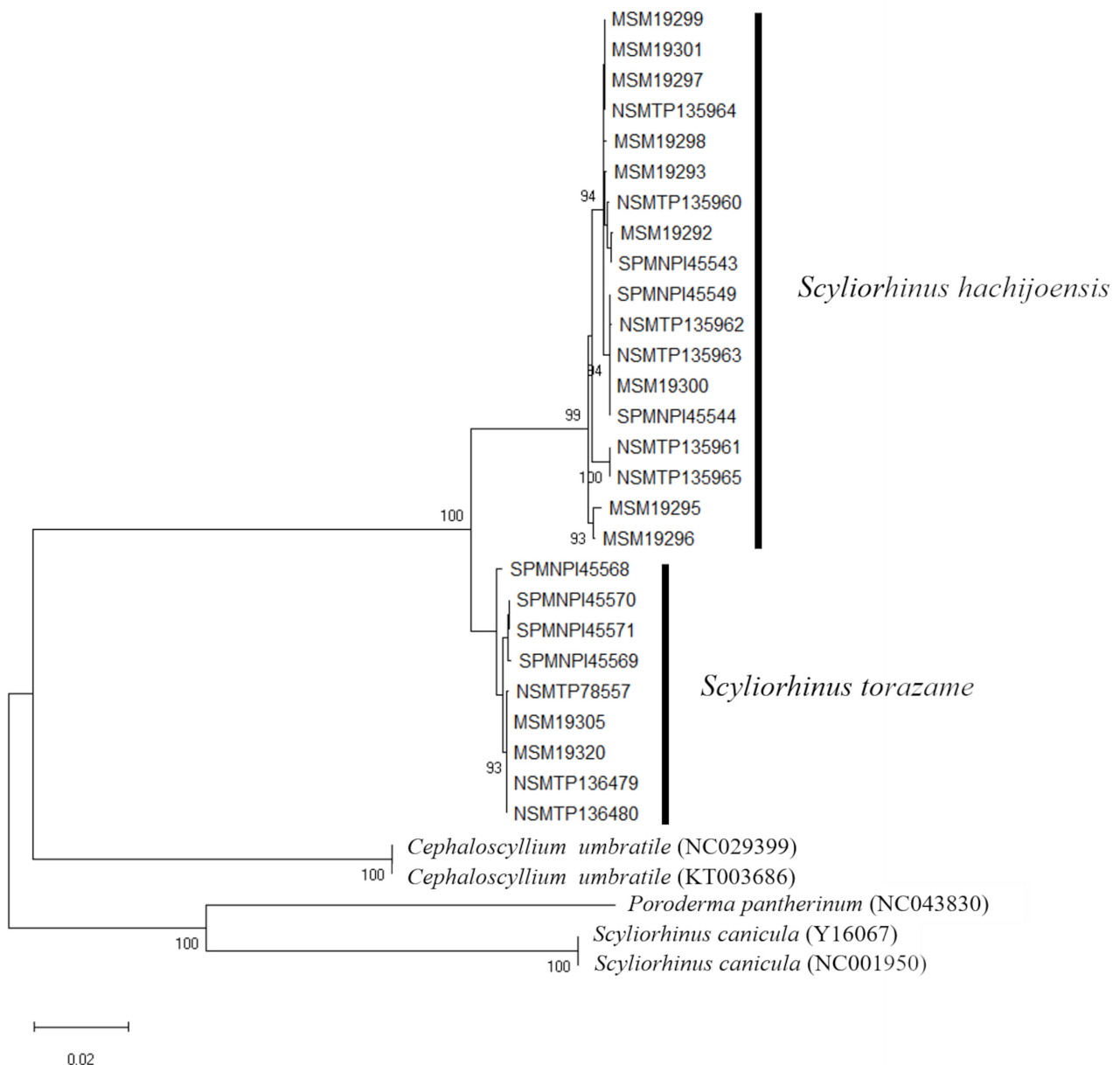
FIG. 8. Egg cases of (A, B) *Scyliorhinus hachijoensis* and (C, D) *S. torazame*. (A, C) Dorsal view, scale bar = 10 mm. (B, D) Close-up of surface. Scale bar = 2 mm.

**Biological data.**

Males ranged in size from 294 to 416 mm TL ( $n = 6$ ) and females from 301 to 386 mm TL ( $n = 22$ ). Size at first maturity is not precisely defined, but males had well-developed claspers at 346 mm TL and females had egg cases at 342 mm. Reproduction is by single oviparity, one egg case for each oviduct. Egg cases are amber in color, with tendrils and surface irregularities that resemble wrinkles (Fig. 8). Maximum case length without tendrils (ML) was 44.6–56.25 mm, and maximum case width was 19.45–22.5 mm (33.4–42.1 %ML) ( $n = 7$ ). Stomachs were found to contain small crustaceans, small bony fishes, and polychaets.

**Genetic data.**

A total of 2164 base pairs (bp) from three mitochondrial DNA regions were examined: 487 bp for the 16S region, 664 bp for COI, and 1013 bp for Cytb. The monophyly of *S. hachijoensis* was strongly supported by molecular phylogenetic analysis (Fig. 9). The genetic distances between *S. hachijoensis* and *S. torazame* were 0.3702 (16S), 0.0295 (COI) and 0.0403 (Cytb), respectively.



**FIG. 9.** Maximum likelihood tree of 16S rRNA, cytochrome c oxidase subunit I, and cytochrome *b* sequences from specimens of *Scyliorhinus hachijoensis* and *S. torazame* from Japan. Numbers at the nodes are bootstrap values (only values >90 are shown). Sample names of *Scyliorhinus hachijoensis* and *S. torazame* correspond to museum-deposited numbers (see APPENDIX 1).

## Etymology.

The species name “*hachijoensis*” refers to the species’ main collection area, Hachijojima Island. The English name is derived from “Cinderella”, because the dark spots on the body surface are similar to black ashes “cinder”. The Japanese name “Fukami” means “deep sea”.

## Remarks.

Clasper hooks are a unique character observed in *S. torazame* (Soares & de Carvalho 2019, 2020), and the same character was also observed in *S. hachijoensis*.

Both male and female *S. hachijoensis* can be easily distinguished from eleven other *Scyliorhinus* species by color pattern: *S. cervigoni* Maurin & Bonnet, 1970, *S. garmani* (Fowler, 1934), *S. meadi* Springer, 1966 and *S. retifer* (Garman, 1881) have no light spots, *S. capensis* (Müller & Henle, 1838) has light yellow to golden spots, and *S. torrei* Howell-Rivero, 1936 has beige to cream spots. *Scyliorhinus canicula*, *S. cabofriensis* Soares, Gomes & de Carvalho, 2016, *S. cervigoni*, *S. garmani*, *S. haeckelii* (Miranda Ribeiro, 1907) and *S. stellaris* (Linnaeus, 1758) have conspicuous dark spots, and *S. boa* (Goobe & Bean, 1896) has various dark spots (Springer 1979; Ebert *et al.* 2013a; Soares & de Carvalho 2019). *Scyliorhinus comoroensis* Compagno, 1988 and *S. duhamelii* (Garman, 1913) (as well as *S. canicula*, *S. cervigoni*, *S. garmani* and *S. stellaris*, which are also listed above) can be distinguished from *S. hachijoensis* because the nasal flaps reach or cover the upper lip (Springer 1979; Ebert *et al.* 2013a; Soares & de Carvalho 2019). *Scyliorhinus hesperius* Springer, 1966 and *S. ugoi* Soares, Gomes & Gadig, 2015 are very similar to *S. hachijoensis* in color pattern, but differ in the number of monospondylous vertebrae and size of maturity. The number of monospondylous vertebrae is 39–42 in *S. hesperius* and 38–39 in *S. ugoi*. Adult males mature at least 420 mm TL in *S. hesperius*, and by at least 450 mm TL and 470 mm TL in male and female specimens of *S. ugoi*, respectively. By contrast, the number of monospondylous vertebrae in *S. hachijoensis* is 34–36 and the size at maturity is less than 350 mm TL. In addition, *S. ugoi* has saddles with antero- and posteromedial projections (Springer 1979; Ebert *et al.* 2013a; Soares *et al.* 2015; Soares & de Carvalho 2019).

*Scyliorhinus torazame* is similar in external characters to *S. hachijoensis*, but differs in fin height and fin angle. In *S. torazame*, anal fin height is less than 4 %TL and approximately equal to caudal peduncle height (as compared to more than 4 %TL and higher than the caudal peduncle in *S. hachijoensis*) (Table 1), the pectoral fin angle in adults is 70°–96° and the pelvic fin angle in adult females is 40°–65° (as compared to a pectoral fin angle of 90°–102° and pelvic fin angle of 63°–75° in *S. hachijoensis*), the pelvic fin apex is located in the middle of the fin (vs. apex obviously behind the middle of the fin in *S. hachijoensis*) (Figs. 1, 4), and the dermal denticles present five ridges (vs. three ridges in *S. hachijoensis*). Also, *S. torazame* has no dark spots. Finally, whereas the egg case surface is irregularities that resemble wrinkles in *S. hachijoensis*, the egg case is smooth in *S. torazame* (Fig. 8).

Previously, *S. torazame* had not been reported from any waters farther south than Taiwan. Also, reports of this species from Okinawa have been rare (Springer 1979; Carpenter 1998; Ebert *et al.* 2013a; Soares & de Carvalho 2019). In this study, we identified numerous specimens from the Ryukyu Islands (specifically, the islands of Okinawa and Haterumajima) and Taiwan, including the first confirmed specimen from the South China Sea, thus expanding the known distribution of *S. torazame* (see APPENDIX 1).

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the *Zoeimaru*, No. 3 *Idoinkyomaru*, *Koeimaru*, *Eishinmaru*, *Chokomaru*, No. 88 *Takamaru*, No. 10 *Hukuichimaru* and *Asashiomaru*.

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## APPENDIX 1. Comparative materials.

### *Scyliorhinus torazame*

HUMZ 107358, male, 410 mm TL (Shimoda, Shizuoka, Japan—holotype of *S. tokubee*); HUMZ 113574, female, 391 mm TL (Shimoda, Shizuoka, Japan—paratype of *S. tokubee*); HUMZ 113578, female, 378 mm TL (Shimoda, Shizuoka, Japan—paratype of *S. tokubee*); HUMZ 117472, female, 378 mm TL (Shimoda, Shizuoka, Japan—paratype of *S. tokubee*); HUMZ 117496, male, 384 mm TL (Shimoda, Shizuoka, Japan—paratype of *S. tokubee*); NSMT-P 34976, female, 381 mm TL (Shirahama, Shizuoka, Japan, 100 m depth—paratype of *S. tokubee*); ASIZP 57958, male, 194 mm TL, male, 166 mm TL (24°34.91'N 121°52.01'E, Nanfangao, Yilan, Taiwan); BSKU 115160, male, 240 mm TL (Hachinohe, Aomori, Japan); BSKU 115161, male, 155 mm TL (Hachinohe, Aomori, Japan); FAKU no number, male, 435 mm TL (Haterumajima Island, Japan); FAKU 5727, female, 403 mm TL (Haterumajima Island, Japan); FAKU 7569, female, 382 mm TL (Haterumajima Island, Japan); FAKU 13723, male, 404 mm TL (Haterumajima Island, Japan); FAKU 13914, female, 405 mm TL (Haterumajima Island, Japan); FAKU 31905, female, 372 mm TL (Haterumajima Island, Japan); FAKU 75430, male, 423 mm TL (Tachibana Bay, Nagasaki, Japan); FAKU 75431, male, 413 mm TL (Tachibana Bay, Nagasaki, Japan); FAKU 131312, male, 438 mm TL (Maizuru, Kyoto, Japan); FAKU 131729, male, 442 mm TL (Ine, Kyoto, Japan); FAKU 131730, female, 437 mm TL (Ine, Kyoto, Japan); FAKU 135531, female, 424 mm TL (35°49.92'N 135°25.57'E, Kyoto, Japan, 155 m depth); FAKU 135817, female, 450 mm TL (Miyazu, Kyoto, Japan); FAKU 137000, female, 428 mm TL (western Wakasa Bay, Kyoto, Japan); KPM-NI 40163, male, 462 mm TL (Moroiso, Misaki, Kanagawa, Japan); KPM-NI 40164, female, 465 mm TL (Moroiso, Misaki, Kanagawa, Japan); KPM-NI 40165, female, 389 mm TL (Moroiso, Misaki, Kanagawa, Japan); KPM-NI 23080, female, 429 mm TL (Nagai, Yokosuka, Kanagawa, Japan); KPM-NI 47684, female, 385 mm TL (Numazu, Shizuoka, Japan); HUMZ 39414, female, 344 mm TL (30°36'N 130°03'E, Yakushima Island, Japan); HUMZ 49642, male, 171 mm TL (Mitani fish market, Aichi, Japan); HUMZ 49643, male, 143 mm TL (Mitani fish market, Aichi, Japan); HUMZ 49644, sex unknow, 130 mm TL (Mitani fish market, Aichi, Japan); HUMZ 111033, male, 341 mm TL (Shimoda, Shizuoka, Japan); HUMZ 111034, male, 367 mm TL (Shimoda, Shizuoka, Japan); HUMZ 189927, female, 392 mm TL (Hakodate Bay, Hokkaido, Japan); HUMZ 189934, female, 463 mm TL (Hakodate Bay, Hokkaido, Japan); HUMZ 197854, female, 384 mm TL (Wakimoto fishing port, Shiriuchi, Hokkaido, Japan, 200 m depth); HUMZ 202569, male, 456 mm TL (41°05.20'N 140°43.80'E, Mutsu Bay, Kaizaki, Aomori, Japan, 62 m depth); HUMZ 202570, male, 445 mm TL (41°05.20'N 140°43.80'E, Mutsu Bay, Kaizaki, Aomori, Japan, 62 m depth); HUMZ 210796, female, 408 mm TL (Nanaehama, Hokkaido, Japan); HUMZ 230732, male, 388 mm TL (hakodate port, Nanaehama, Hokkaido, Japan); MSM-19-302, female,

417 mm TL (Ose, Ibaraki, Japan); MSM-19-303, female, 419 mm TL (Ose, Ibaraki, Japan); MSM-19-304, male, 455 mm TL (Ose, Ibaraki, Japan); MSM-19-305, male, 456 mm TL (Ose, Ibaraki, Japan); MSM-19-306, female, 368 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-307, female, 390 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-308, female, 412 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-309, male, 255 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-310, female, 233 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-311, female, 207 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-312, female, 163 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-313, male, 138 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-314, female, 129 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-315, male, 95 mm TL (36°30.32'N 140°57.36'E, Mito, Ibaraki, Japan, 150 m depth); MSM-19-316, male, 301 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-317, female, 240 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-318, female, 213 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-319, female, 184 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-320, male, 256 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); MSM-19-321, female, 290 mm TL (36°59.93'N 141°17.56'E, Hitachi, Ibaraki, Japan, 150 m depth); NMMB-P 033383, male, 341 mm TL (24°21.60'N 122°24.00'E, Yilan, Taiwan, 460 m depth); NSMT-P 5952, male, 87 mm TL (Mamezu, Tsushima, Nagasaki, Japan, 100 m depth); NSMT-P 50323, female, 341 mm TL (southeast off Tsushima, Nagasaki, Japan); NSMT-P 50333, male, 368 mm TL (off the southeast coast of Tsushima, Nagasaki, Japan); NSMT-P 50625, male, 395 mm TL (off the southeast coast of Tsushima, Nagasaki, Japan); NSMT-P 50626, female, 280 mm TL (off the southeast coast of Tsushima, Nagasaki, Japan); NSMT-P 52632, male, 416 mm TL (Kanaya, Chiba, Japan); NSMT-P 61264, female, 384 mm TL (36°29.10'N 140°58.40'E, Ibaraki, Japan); NSMT-P 63286, male, 416 mm TL (31°27.10'N 127°53.90'E, East China Sea); NSMT-P 65831, female, 404 mm TL (Kamaya, Hamasaka, Hyogo, Japan); NSMT-P 65836, female, 209 mm TL (Kamaya, Hamasaka, Hyogo, Japan, 250–270 m depth); NSMT-P 66232, male, 238 mm TL (Tateyama, Chiba, Japan, 200–300 m depth); NSMT-P 69076, male, 221 mm TL (31°21.31'N 128°19.12'E, East China Sea, 260 m depth); NSMT-P 74816, male, 400 mm TL (Hiragata, Hukushima, Japan); NSMT-P 74879, female, 426 mm TL, female, 440 mm TL (Ippongi, Aomori, Japan); NSMT-P 78557, male, 440 mm TL (36°31.30'N 140°58.20'E, Ibaraki, Japan); NSMT-P 79500, female, 385 mm TL (36°59.60'N 141°17.40'E, Ibaraki, Japan); NSMT-P 96552, male, 348 mm TL (off the southeast coast of Tsushima, Nagasaki, Japan); NSMT-P 105485, female, 358 mm TL (33°30.10'N 128°20.40'E, Goto, Nagasaki, Japan); NSMT-P 105871, female, 462 mm TL (Misaki, Kanagawa, Japan); NSMT-P 136479, male, 424 mm TL (35°10.04'N 139°30.08'E, Misaki, Miura, Kanagawa, Japan, 200 m depth); NSMT-P 136480, female, 407 mm TL (35°10.04'N 139°30.08'E, Misaki, Miura, Kanagawa, Japan, 200 m depth); NSMT-P 136481, female, 320 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); NSMT-P 136482, female, 327 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); NSMT-P 136483, female, 385 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); OCF-P 2620, male, 442 mm TL (Okinawa, Japan); OCF-P 3848, male, 400 mm TL (Onna, Okinawa, Japan, 500 m depth); SNFR 11621, female, 408 mm TL (South China Sea); SNFR 13396, male, 385 mm TL (East China Sea); SNFR 14485, female, 374 mm TL (East China Sea); SNFR 14588, male, 380 mm TL (East China Sea); SNFR 14916, female, 408 mm TL (East China Sea); SNFR 18693, female, 393 mm TL (Niigata, Japan); SNFR 18694, female, 313 mm TL (Niigata, Japan); SNFR 19129, male, 337 mm TL (East China Sea); SPMN-PI 45552, male, 465 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45553, male, 450 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45554, male, 462 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45555, female, 413 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45556, female, 419 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45557, female, 456 mm TL (Kakutahama, Niigata, Japan, 120 m depth); SPMN-PI 45558, male, 375 mm TL (34°40.0'N 130°20.0'E, Japan Sea, Shimonoseki, Yamaguchi, Japan, 126 m depth); SPMN-PI 45559, female, 365 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); SPMN-PI 45560, female, 325 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); SPMN-PI 45561, female, 368 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); SPMN-PI 45562, male, 375 mm TL (31°39.063'N 129°53.401'E, Kushikino, Kagoshima, Japan, 325 m depth); SPMN-PI 45563, female, 437 mm TL (32°46.80'N 129°0.60'E, Narujima Island, Nagasaki, Japan, 92 m depth); SPMN-PI 45564, female, 410 mm TL (32°46.80'N 129°0.60'E, Narujima Island, Nagasaki, Japan, 92 m depth); SPMN-PI 45565, male, 362 mm TL (32°46.80'N 129°0.60'E,

Narujima Island, Nagasaki, Japan, 92 m depth); SPMN-PI 45566, female, 413 mm TL (32°46.80'N 129°0.60'E, Narujima Island, Nagasaki, Japan, 92 m depth); SPMN-PI 45567, female, 382 mm TL (Oshima Island, Tokyo, Japan); SPMN-PI 45568, female, 370 mm TL (Oshima Island, Tokyo, Japan); SPMN-PI 45569, female, 332 mm TL (Oshima Island, Tokyo, Japan); SPMN-PI 45570, male, 225 mm TL (Oshima Island, Tokyo, Japan); SPMN-PI 45571, male, 203 mm TL (Oshima Island, Tokyo, Japan); URM-P 39137, male, 423 mm TL (Okinawa, Japan); URM-P 39138, male, 444 mm TL (Okinawa, Japan); URM-P 39139, male, 393 mm TL (Okinawa, Japan); URM-P 39140, male, 437 mm TL (Okinawa, Japan); URM-P 39141, male, 405 mm TL (Okinawa, Japan); URM-P 39142, male, 415 mm TL (Okinawa, Japan).

## APPENDIX 2. GenBank accession numbers.

deposit number	GenBank accession number		
	16S	COI	Cytb
MSM-19-292	LC517195	LC517222	LC517249
MSM-19-293	LC517196	LC517223	LC517250
MSM-19-295	LC517197	LC517224	LC517251
MSM-19-296	LC517198	LC517225	LC517252
MSM-19-297	LC517199	LC517226	LC517253
MSM-19-298	LC517200	LC517227	LC517254
MSM-19-299	LC517201	LC517228	LC517255
MSM-19-300	LC517202	LC517229	LC517256
MSM-19-301	LC517203	LC517230	LC517257
MSM-19-305	LC517181	LC517208	LC517235
MSM-19-320	LC517182	LC517209	LC517236
NSMT-P 78557	LC517183	LC517210	LC517237
NSMT-P 135960	LC517206	LC517233	LC517260
NSMT-P 135961	LC517193	LC517220	LC517247
NSMT-P 135962	LC517194	LC517221	LC517248
NSMT-P 135963	LC517192	LC517219	LC517246
NSMT-P 135964	LC517190	LC517217	LC517244
NSMT-P 135965	LC517207	LC517234	LC517261
NSMT-P 136479	LC517184	LC517211	LC517238
NSMT-P 136480	LC517185	LC517212	LC517239
SPMN-PI 45543	LC517204	LC517231	LC517258
SPMN-PI 45544	LC517205	LC517232	LC517259
SPMN-PI 45549	LC517191	LC517218	LC517245
SPMN-PI 45568	LC517186	LC517213	LC517240
SPMN-PI 45569	LC517187	LC517214	LC517241
SPMN-PI 45570	LC517188	LC517215	LC517242
SPMN-PI 45571	LC517189	LC517216	LC517243