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Redescription of *Lophiodes lugubris* (Alcock, 1894), with the largest record of *Lophiodes triradiatus* (Lloyd, 1909) from the South China Sea (Lophiiformes: Lophiidae)

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Abstract

A rare lophiid anglerfish species, *Lophiodes lugubris*, is redescribed on the basis of two syntypes and non-types. It is unique in having only 4 dorsal-fin spines, among the congeners. Examination of specimens reveals this species is widespread in the Indian Ocean and a specimen newly collected from off Dongsha Island represents the first record of the South China Sea, as well as the Pacific Ocean. A largest record specimen of *Lophiodes triradiatus* known to date is also documented. Comments on the morphology of sagittal otoliths taken from Taiwanese lophiids are provided.

Key words: Ichthyology, taxonomy, biodiversity, biogeography, otolith

Introduction

The anglerfish species *Lophius lugubris* (Fig. 1A) was described by Alcock (1894a) based on three specimens collected from off Colombo, Sri Lanka. Although subsequent authors recognized it as valid, Caruso (1981) placed it in the synonymy of *Lophiodes mutilus* (Alcock, 1894b). The first author (HCH) examined two syntypes and additional specimens collected from India, together with a specimen newly collected from off Indonesia, and recognized it as a valid species (Ho *et al.*, 2016). When collecting the otoliths of fishes collected from around Dongsha Island (Pratas Island), a specimen of *Lophiodes* with four dorsal-fin spines was found (Figs. 1B, C). Its morphology agrees with that of *Lophiodes lugubris* from the Indian Ocean, except that most spines on the head are relatively blunt. Here we redescribe the species based on all known specimens.

In addition, a large female of *Lophiodes triradiatus* (Lloyd, 1907) is also collected together with the specimen of *L. lugubris*. This specimen is by far the largest individual (404 mm SL) among the specimens examined (Ho *et al*., 2009, 2014). We document this specimen in order to provide a better understanding of this species.

Fish otoliths (sagittae) are valuable tools for assisting taxonomic identification (Nolf, 2013). Lin & Chang (2012) documented otoliths of several Lophiidae species from Taiwan. Here, we present images of otoliths of all Taiwanese lophiids to highlight their inter-and intra-specific diversity.

Methods and materials

Method for taking proportional measurements, abbreviations of proportional measurements, and terminology followed Caruso (1981). Specimens examined were deposited at Pisces collection of National Museum of Marine Biology & Aquarium, Taiwan (NMMB-P) and Zoological Survey of India (ZSI). Data used for comparison were adopted from Ho *et al.* (2011).

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Results

Family Lophiidae

Lophiodes lugubris (Alcock 1894)

Figs. 1–2; Table 1

Lophius lugubris Alcock, 1894a (Type locality: 13.5 miles north 64° west of Columbo Light House, Sri Lanka, Investigator station 151, 142–400 fathoms [260–731 m]; syntypes: ZSI F13467, 670/1, 671/1). Alcock, 1895: pl. 14, fig. 1 (drawing). Alcock, 1899:55 (based on type series). Lloyd, 1907: 5 (listed, 3 specimens). Weber, 1913:557 (mentioned).
Chirolophius lugubris (Alcock): Regan, 1903:281 (review). Le Danois, 1975:88 (review).
Lophiodes lugubris (Alcock): Ho *et al*., 2016:83 (record of Indonesia).

Specimens examined. Syntypes. ZSI F670/1 (92.2 mm SL), ZSI F671/1 (94.3), west of Columbo Light House, Sri Lanka, Investigator station 151, 260–731 m. **Non-types. India**: ZSI F6846/1 (115), Investigator station 391, 9°14'10"N, 75°45'E, southwestern Indian, 237 fms [433 m], 27 Apr. 1911. **Gulf of Aden**: ZSI F1281/1 (86.8, 1 of 3 in Lloyd 1907), Investigator station 360, 13°36'N, 47°32'E, 130 fms [238 m], 1897–1898; plus 18 uncatalogued specimens (78.8–198), collected from off southern Indian coast, precise locality not recorded. **Dongsha Island**: NMMB-P36203 (214), South China Sea, bottom trawl, ca. 500 m, Mar. 2022. **Indonesia**: HUMZ 190869 (41.6), 3°24.19'S, 100°21.06'E–3°23.44'S, 100°19.56'E, off Sumatra, Eastern Indian Ocean, 396–453 m, 28 September 2004.

Diagnosis. A species of *Lophiodes* that can be separated from congeners in having only four dorsal-fin spine (fourth and sixth spines absent) and combination of following characters: esca a tiny bulb; third dorsal-fin spine thin and long, 42.1–73.5% SL (mean 56.4% SL), extending to origin to middle of soft dorsal-fin base; 15–16 pectoral-fin rays.

Description. Morphometric data are provided in Table 1. Dorsal-fin spines 4, 3 cephalic and 1 post-cephalic (fourth and sixth spines absent); dorsal-fin rays 8; anal-fin rays 6; pectoral-fin rays 15–16. Head relatively short (HL 34.6–38.5% SL) and narrow (head width 52.9–61.1% HL); interorbital space flat; eyes large and rounded, directed dorsolaterally.

Anterior half of premaxilla with two irregular rows of enlarged teeth, loosely arranged, those on the innermost row largest, followed by a single row of small teeth on posterior half; lower jaw with three rows of teeth anteriorly, those on the innermost row largest, gradually becoming 2 rows of smaller teeth; vomer with 1–3 fang teeth on each end, the outer teeth largest; palatine with a single row of few fang teeth; fifth ceratobranchial with two rows of small teeth, forming a V-shaped patch; those on second and third pharyngobranchials forming small and rounded patches. No gill rakers. Pseudobranch present.

Illicium relatively short to moderately long, 19.2–31.6% SL, slightly extending beyond posteriormost frontal spine to slightly beyond epiotic spine (when retracted); esca a small simple bulb, without cirri at tip; second dorsal-fin spine short to moderately long 18.2–34.4% SL, generally longer than illicium, extending to the base of third-dorsal fin spine to postemporal spine; third dorsal-fin spine moderately long, 34.6–73.5% SL, rather thin, bearing many tendrils along the entire length, extending to origin (larger specimens) to middle (smaller specimens) of soft dorsal-fin base; fourth dorsal-fin spine absent; fifth dorsal-fin spine short to moderately long (11.8–24.6% SL), extending to origin of soft dorsal fin.

All spines associated with skull short, sharp (smaller specimens), blunt or weakly developed (larger specimens), mostly beneath skin but feeble though skin. Palatine spines pointed but short; frontal ridge elevated posteriorly, serrated with 3 spines, the last spine largest, or a smooth ridge without spines in 214 mm specimen; inner frontal spine absent; inner sphenotic spines pointed and short or reduced with a feeble knob; outer sphenotic spines blunt, broad and compressed; epiotic spines blunt, beneath skin completely; quadrate and anterior articular spines blunt to strongly reduced, both knob-like; hyomandibular bears two low and blunt spines; opercular spines blunt, forming small knobs; subopercular and interopercular spines sharp or reduced and knob-like; cleithral spines strong and blunt; humeral spines slightly developed, simple with a small spine or knob on its base.

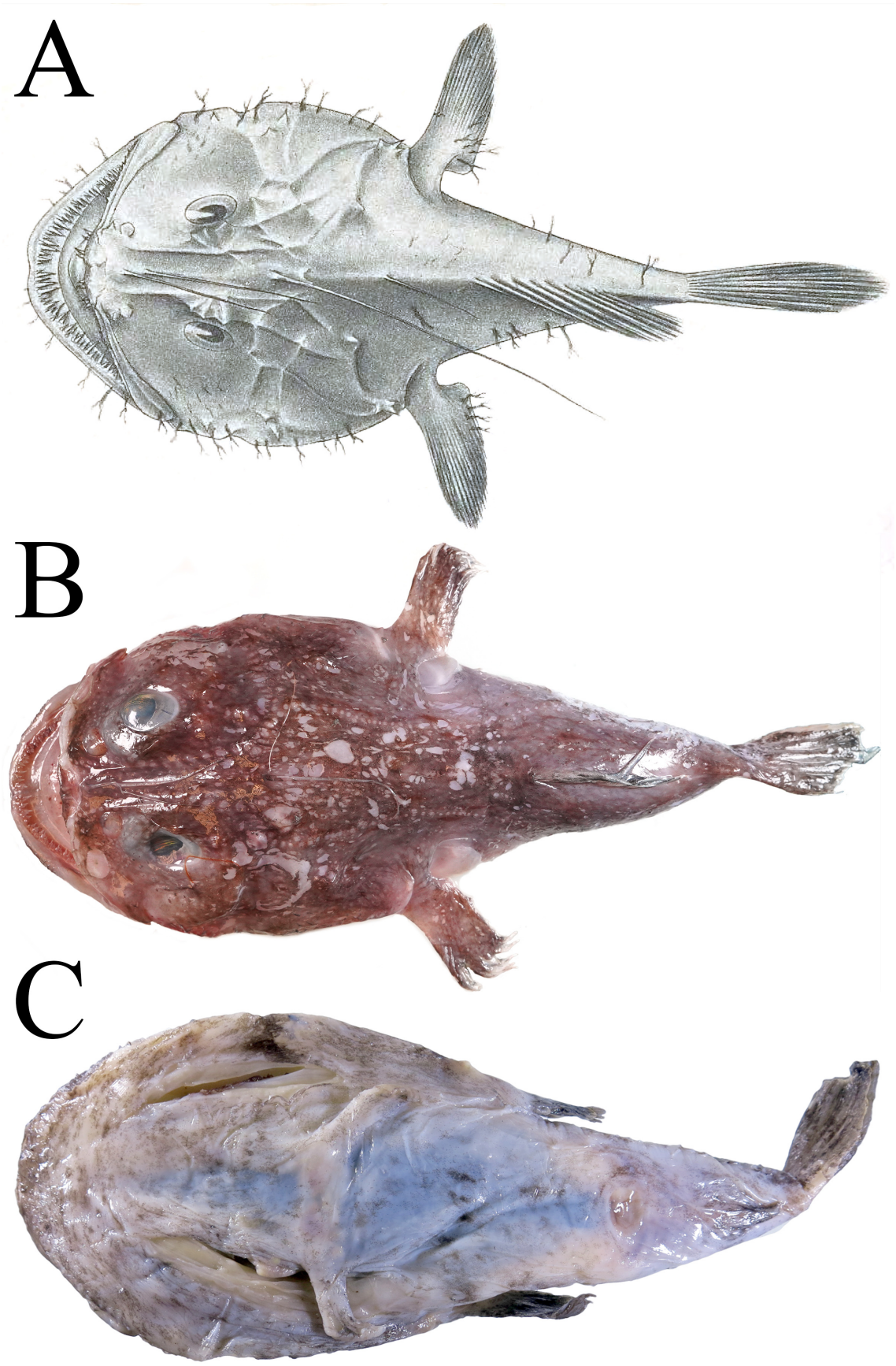

FIGURE 1. *Lophiodes lugubris* (Alcock, 1894). A. Original drawing, reproduced from Alcock (1895). B–C. NMMB-P36203, 214 mm SL, fresh caught specimen, from off Dongsha Island. B. After frozen, dorsal view. C. After preservation, ventral view.

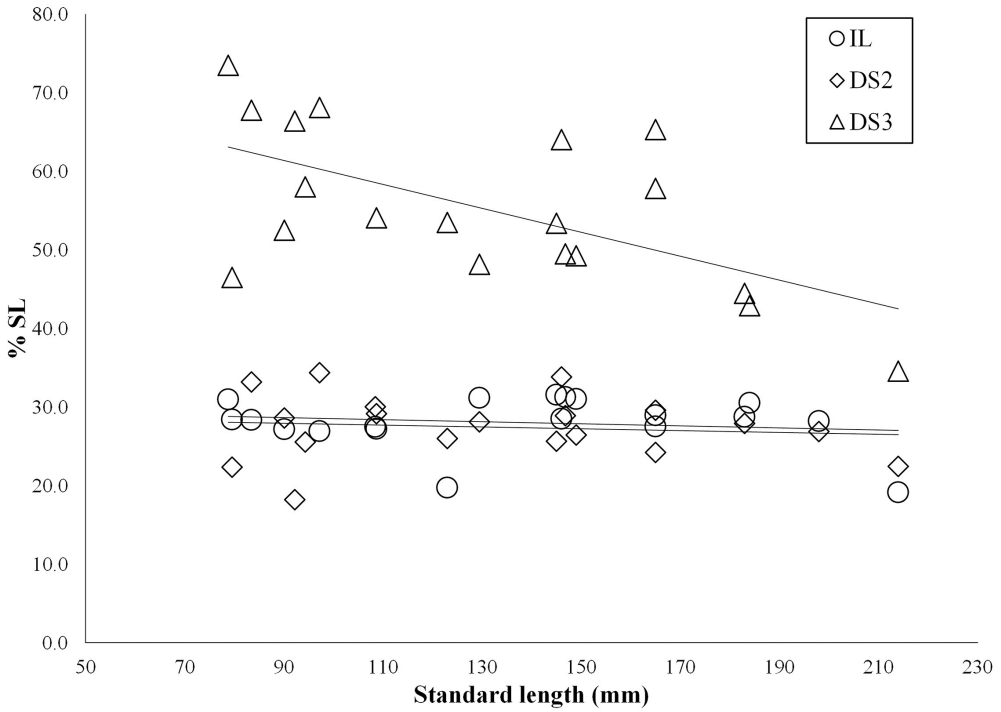

FIGURE 2. Proportions of lengths of illicium (IL), second dorsal-fin spine (DS2), and third dorsal-fin spine (DS3), versus SL, in *Lophiodes lugubris*, showing the growth changes.

Coloration. When fresh, dorsal surface of body pinkish gray to brown; ventral surface pale with irregular light gray marbles and patches; pectoral fin with white margin. When preserved, dorsal surface grey to brown with many large light brown patches on dorsal surface, pale to light grey on ventral surface; color of illicium and esca as on dorsal surface; all fins pale distally. Peritoneum black.

Distribution. Specimens examined were collected from off India, Sri Lanka (holotype) and eastern Indian Ocean side off Indonesia (Ho *et al*., 2016) and now off Dong-sha Island (South China Sea). Bathymetric range 238–731 m based on the Indian Ocean records.

Size. Adults attain at least 214 mm.

Otolith. The otolith (CHLOL 15743) described here is collected from NMMB-P36203 (Fig. 4-6a, b). The inner face of the otolith is nearly flat, and the outer face is concave with its posterior part thicker than the anterior one. The otolith is characterized by two horn-shaped protrusions on the dorsal rim with a deeply incised notch in the middle of the otolith. The ventral rim is straight. The sulcus is only observable in the crista inferior, where it swells and becomes crest-like in the middle of the otolith. A dorsal depression occupies most of the dorsal area.

Comparison. *Lophiodes lugubris* is closely similar to *L. mutilus*, *L. iwamotoi* Ho, Séret & Shao, 2011 and *L. maculatus* Ho, Séret & Shao, 2011. Except for the only four dorsal-fin spine (vs. five dorsal-fin spines), it can be separated from *L. mutilus* by having relatively broad head deep (66.2–71.4% HL, vs. 61.1–68.6% HL), relatively broad distance between inner sphenotic spines (43.0–50.7% HL, vs. 38.8–45.1% HL), relatively long snout length (56.9–63.2% HL, vs. 51.5–59.1% HL), relatively broad distance between pterotic and sphenotic spines (19.3–23.7% HL, vs. 16.9–20.1% HL); from *L. iwamotoi* by having relatively long snout length (56.9–63.2% HL, vs. 55.4–57.5%) and relatively broad distance between inner sphenotic spines (43.0–50.7% HL, vs. 40.4–42.5% HL); and from *L. maculatus* in having relatively short third dorsal-fin spine (34.6–73.5% SL, vs. 71.9–87.6% SL), relatively narrow head width (52.9–61.1% HL, vs. 61.6–67.5% HL) and head depth (66.2–71.4% HL, vs. 73.3–78.9% HL), relatively short snout length (56.9–63.2% HL, vs. 63.2–68.5% HL), relatively narrow snout width (17.3–22.9% HL, 21.7–28.6% HL), distance between posterior frontal spines (38.0–45.6% HL, vs. 47.4–56.0% HL), and distance between opercular and subopercular spines (42.7–47.0% HL, vs. 50.0–60.3% HL).

Remarks. Le Danois (1975) reviewed the family Lophiidae and recognized *Chirolophius lugubris* as valid. She also put two junior synonyms, *Lophiodes papillosus* Weber, 1913 and *Chirolophius japonicus* Kamohara, 1938, under this name. These three names were further included in the synonymy of *Lophiodes mutilus* (Alcock) by

Caruso (1981). However, the original descriptions of *C. papillosus* and *C. japonicus* showed both have five dorsal-fin spines, thus we retained in the junior synonyms of *L. mutilus*, as suggested by Caruso (1981).

TABLE 1. Morphometrics data of *Lophiodes lugubris* and *L. triradiatus* examined in present study.

	Lophiodes lugubris		*Lophiodes triradiatus*
SL (mm)	78.8–214 (n=21)		404 (n=1)
	Mean (Range)	SD	
% SL			
HL	36.4 (34.6–38.5)	1.2	33.4
HW	20.7 (19.2–23.5)	1.4	18.1
HD	25.4 (23.9–27.3)	1.2	24.8
IL	28.1 (19.2–31.6)	3.4	-
DS2	27.4 (18.2–34.4)	4.1	18.6
DS3	55.3 (34.6–73.5)	10.2	16.6
DS5	16.4 (11.8–24.6)	3.3	N/A
IF	15.4 (13.8–17.6)	1.3	9.7
ISP	16.9 (15.2–19.3)	1.5	14.1
SNL	21.7 (19.7–23.8)	1.4	18.6
SNW1	7.3 (6.1–8.1)	0.6	8.7
PTSP	7.9 (6.8–9.1)	0.7	4.7
QPAL	25.4 (22.9–29.1)	2.2	22.8
OPSOP	16.5 (15.0–18.3)	1.1	18.6
TL	26.8 (23.5–31.2)	2.6	34.7
%HL			
HW	56.3 (52.9–61.1)	2.5	54.1
HD	69.3 (66.2–71.4)	1.6	74.1
IF	42.1 (38.0–45.6)	2.5	28.9
ISP	46.3 (43.0–50.7)	3.0	42.2
SNL	59.3 (56.9–63.2)	2.1	55.6
SNW	20.1 (17.3–22.9)	1.9	25.9
PTSP	21.5 (19.3–23.7)	1.5	14.1
QPAL	69.6 (62.2–77.6)	5.2	68.1
OPSOP	44.7 (42.7–47.0)	1.4	55.6

Ho *et al*. (2016) examined two syntypes and many additional individuals of *L. lugubris* collected from off India and concluded that *L. lugubris* is a valid species, with comments on the type series. In the large among specimens collected from the Indo-west Pacific Ocean examined by the first author, we found that only *L. mutilus* present in the western Pacific Ocean and none of them can be referred to *L. lugubris*, except for the 214 mm specimen reported herein.

The 214 mm specimen is by far the largest individual of *L. lugubris*. It has a pair of moderately developed gonads with sex cannot be determinate. It is presumed that this species is matured at slightly larger than this size.

The 214 mm specimen has first threes spines relatively short. An analysis on the proportions of these three spines versus SL shows that the lengths of illicium and second dorsal-fin spine have very minor negative trend, whereas that of third dorsal-fin spine has a strong negative trend (Fig. 2). The relatively short third dorsal-fin spine is attributed to the growth change, whereas the lengths of illicium and second dorsal-fin do not change significantly. In addition, we also found that all head spines associated with skeleton are either strongly reduced, knob-like or blunt. Judging from the relatively large size, these reduced spines may also attribute to the growth change, which is common in congeners (Ho, pers. obse.).

It is also notable that the 214 mm specimen has its ventral surface pale with irregular gray marbles or patches (Fig. 1C). Because all other specimens examined are either small individuals or had been preserved for a long time, the coloration of ventral surface is rather pale or faded. When more specimens are available, it may be proved that the coloration on ventral surface is a diagnostic character since most members we examined have a uniformly gray to brown ventral surface.

Although Fricke *et al*. (2018) recorded *Lophiodes lugubris* from Madagascar, most of specimens they listed were identified as *Lophiodes mutilus* by the first author. Fricke *et al*. (2018) probably wrongly inferred "*Chirolophius* (*Lophiodes*) *lugubris* var. *madagascariensis*" described by Le Danois (1975) to *L. lugubris*. Because this variation was described after 1960 and thus not available according to Article 15.2 of the International Code of Zoological Nomenclature (ICZN, 1999). Moreover, the original drawing of "var. *madagascariensis*" has six dorsal-fin spines and is clearly different from the definition of *L. lugubris*. Base on the original drawing and description, "var. *madagascariensis*" is likely misidentification of *Lophiodes insidiator* (Ragan, 1921).

Largest record of *Lophiodes triradiatus* (Lloyd 1909)

Ho *et al*. (2009, 2014) examined a number of specimens and synonymized two junior synonyms with *L. triradiatus*. The largest specimen examined by them was 337 mm SL (ZSI 878/1). The specimen reported herein (NMMB-P36204; Fig. 3) was also collected from near Dongsha Island (Pratas Island), South China Sea. It is measured 404 mm SL and is a mature female with large ovaries containing numerous small immature eggs. As a result, this specimen represents the largest known individual of *L. triradiatus* to date.

The measurements and proportions are showed in Table 1. The morphology of present specimen agrees with previous description (Ho *et al.*, 2009, 2014), except for most spines on head are relatively blunt or reduced. The esca is damaged and the leaf-like structure is not detectable. These blunt or reduced spines on head may be attributed to the large body size, which is likely an old individual.

FIGURE 3. *Lophiodes triradiatus* (Lloyd, 1909), NMMB-P36204, 404 mm SL, from South China Sea.

Otoliths of Taiwanese lophiids

The otoliths of Lophiidae (Fig. 4) are characterized by a large dorsal area and a much smaller, flatter ventral area, irregularly lobed dorsal rim, less clearly delimited sulcus that may present small ostial and caudal depressions,

swelling and elevated crista inferior, and large and deep dorsal depression. The combination of these features readily separates lophiid otoliths from these of other lophiiform families. However, lophiid otoliths exhibit considerable intra-specific variations associated with growth.

Our otoliths of lophiids from Taiwan demonstrate such typical ontogenetic variation: otoliths of young lophiids are generally more rounded, their dorsal margin is usually ornamented with rounded lobes, and their ostium and cauda are marked by small, oval depressions (Lin & Chang, 2012); whereas otoliths of larger individuals have a more specialized dorsal rim and less delimited sulcus that is often only visible as a depression with crest-like crista inferior. The thick otoliths from the largest *L. triradiatus*, with two large horn-shaped angles on the dorsal rim and a very rudimentary sulcus, are of particular interest documenting a peculiar shape that has never been known to date (Fig. 4-14a, b). Although more otoliths from different body sizes are needed to understand the variation of each lophiid species, we note that further sampling would potentially decipher its phylogenetic implications through the analysis of otolith morphology.

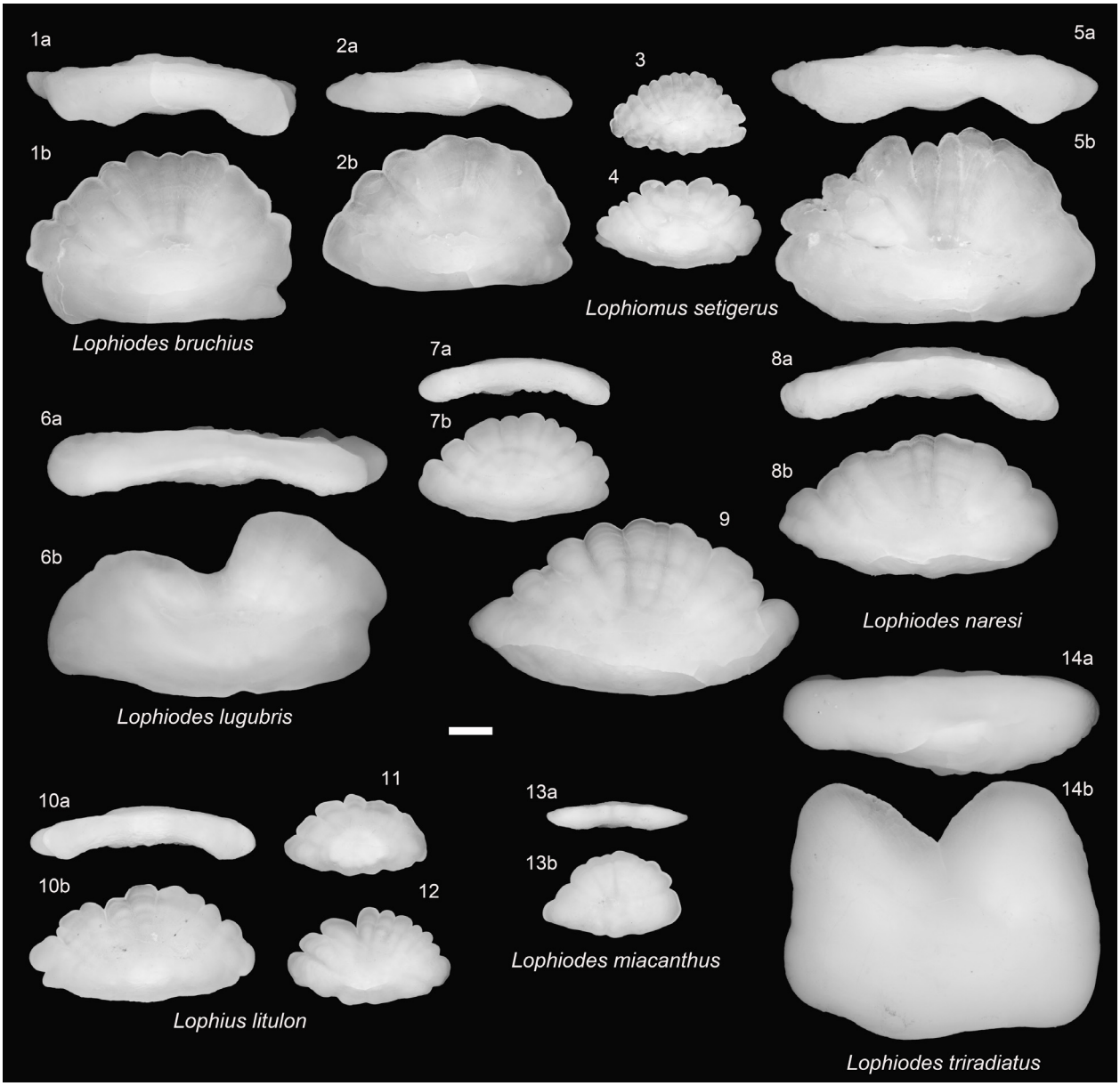

FIGURE 4. Otoliths of species of Lophiidae from Taiwan. Images are view of left otoliths unless otherwise indicated. a, ventral views; b, inner views; scale bar = 1 mm. 1. *Lophiodes bruchius*, 279 mm SL, northern Taiwan. 2–5. *Lophiomus setigerus*: 2, 187 mm SL, northern Taiwan; 3, 70.6 mm SL, Daxi; 4, 89.6 mm SL, Dong-gang; 5, 272 mm SL, northern Taiwan. 6. *Lophiodes lugubris*, 214 mm SL, Dongsha Island. 7–9. *Lophiodes naresi*: 7, 96.0 mm SL, Dong-gang; 8, 157 mm SL, Dongsha Island; 9, 214 mm SL, Dongsha Island. 10–12. *Lophius litulon*: 10, no data; 11, 66.2 mm TL, Dong-gang; 12, 94.6 mm TL, Dong-gang. 13. *Lophiodes miacanthus*, 90.0 mm SL, Daxi. 14. *Lophiodes triradiatus*, 404 mm SL, Dongsha Island.

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