



## *Zenarchopterus takaoensis* (Perciformes: Zenarchopteridae), a new estuary garfish from southwestern Taiwan

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### Abstract

Species of the genus *Zenarchopterus* are marine, brackish, and freshwater fishes that have modified dorsal-fin and anal-fin rays in adult males. There are 19 valid species worldwide. Three species have been recorded from Taiwan, namely *Zenarchopterus buffonis* (Valenciennes, in Cuvier & Valenciennes, 1847), *Z. dispar* (Valenciennes, in Cuvier & Valenciennes, 1847), and *Z. dunckeri* Mohr, 1926. However, Collette and Su (1986) noted one uncertain species (female, labeled “*Zenarchopterus* sp., Takao, Formosa, Hans Sauter, V–VII 1907”) in the Museum of Nature Hamburg (ZMH) from southern Taiwan. This species has only nine pectoral-fin and anal-fin rays, a longer snout, and does not agree well with any other species. In this study, *Zenarchopterus takaoensis* **sp. nov.** is described based on seven newly collected specimens from southwestern Taiwan and one (ZMH 6543, 59.4 mm SL) from southern Taiwan. This new species differs from its congeners by the following combination of characters: snout slightly longer, prominent pigmentation or dark mark on snout; nine anal-fin rays, 6<sup>th</sup> anal-fin ray not elongated or thickened in adult male; dorsal body pigmented with three longitudinal dashed lines, oval-like dashed pigmentation on dorsal lateral series scales; anterior lateral stripe on body in dashed line, ventral body with one longitudinal dashed line. In this study, specimens were examined and compared; morphological evidence revealed it is a hidden species. Taxonomic accounts, distribution, and a key to the congener species of Taiwan, along with color photographs of the new species, are provided.

**Key words:** Actinopterygii, Taxonomy, new species, cryptic species

### Introduction

The halfbeaks, or garfish, are marine, brackish, and freshwater fishes of the family Zenarchopteridae. They comprise 63 species in five genera (including *Dermogenys*, *Hemirhamphodon*, *Nomorhamphus*, *Todanichthy*, and *Zenarchopterus*) and are characterized by modified anal-fin rays of adult males for internal fertilization as viviparous. Morphological and molecular phylogenetic evidence supports that Zenarchopteridae is a monophyletic group and a sister clade to needlefishes and sauries (Lovejoy 2000; Lovejoy *et al.* 2004; Aschliman *et al.* 2005; Nelson 2016). There are 19 valid species in *Zenarchopterus*; nine species are marine, and 10 are freshwater species (Collette 2004; Fricke *et al.* 2023). The first revision of *Zenarchopterus* was conducted by Mohr (1926), followed by regional studies in Australia and New Guinea (Collette 1974, 1982). Collette and Su (1986) recorded *Zenarchopterus buffonis* (Valenciennes, in Cuvier & Valenciennes, 1847) and one uncertain species (*Zenarchopterus* sp.) from the Far East (including Taiwan). The specimen labeled “*Zenarchopterus* sp., Takao, Formosa, Hans Sauter, V–VII 1907” in ZMH (ZMH 6543, 59.1 mm SL, female) was collected from southern Taiwan and has only nine anal-fin rays and an upper jaw longer than width. It does not agree with any valid species of the genus (Collette & Su 1986).

Kao and Shao (1999) and Liao (2024) recorded *Z. dunckeri* Mohr, 1926 and *Z. dispar* (Valenciennes, in Cuvier & Valenciennes, 1847), respectively, from southwestern Taiwan. After intensive collection, seven new specimens were examined and compared; morphological evidence, consisting of the *Zenarchopterus* sp. in Collette and Su (1986), revealed it is a hidden species. Taxonomic accounts, a distribution map, a key to the species of Taiwan, and color photographs of the new species are provided.

## Materials and methods

Specimens were collected by pole and line fishing around the Taiwan coastal area between 2020 and 2023 (FIGURE 1). Photos were taken while the specimens were fresh. Voucher specimens were fixed in 10% formalin and then transferred to 70% ethanol for long-term preservation. Specimens were deposited in the Biodiversity Research Museum, Biodiversity Research Center, Academia Sinica, Taipei, Taiwan (ASIZP). Other specimens were examined at the National Museum of Marine Biology and Aquarium, Pingtung, Taiwan (NMMBP), the Museum of Nature Hamburg, Germany (ZMH), and the University Museum, the University of Tokyo, Japan (ZUMT). Vertebrae were counted using a radiograph (FIGURE 3); counts and measurements follow Nakabo (2002) and are shown in FIGURE 2.

## Key to species of the genus *Zenarchopterus* from Taiwan

- 1A. Snout length slightly longer than width, with only 9 anal-fin rays . . . . . *Zenarchopterus takaoensis* sp. nov.
- 1B. Snout wider than length, with 10–12 anal-fin rays. . . . . 2
- 2A. Prominent dark stripe on middle snout and extending posteriorly to interorbital; 4–5<sup>th</sup> dorsal-fin rays without elongated flap on tip and 6<sup>th</sup> anal-fin ray not elongated in adult male . . . . . *Z. buffonis*
- 2B. Prominent dark stripe on snout absent; 4–5<sup>th</sup> dorsal-fin rays with elongated flap on tip and 6<sup>th</sup> anal-fin ray elongated and expended in adult male. . . . . 3
- 3A. Only the 6<sup>th</sup> anal-fin ray elongated in adult male, the length extending to caudal-fin base . . . . . *Z. dunckeri*
- 3B. Both 6<sup>th</sup> and 7<sup>th</sup> anal-fin rays elongated in adult male, the length extending over caudal-fin base . . . . . *Z. dispar*

## Taxonomy

### Genus *Zenarchopterus* Gill, 1863

*Zenarchopterus* Gill, 1863: 273. (Type species *Hemiramphus dispar* Valenciennes, in Cuvier & Valenciennes, 1847)

### *Zenarchopterus takaoensis* sp. nov.

(FIGURES 1–3, 4A–B, 5–6A–B; Tables 1–2)

[New English name: Takao's garfish]

[Chinese name: 打狗異鰭鱗]

*Zenarchopterus* sp. Collette & Su, 1986: 291. ZMH 6543, female (59.1 mm SL), Takao (Kaohsiung City), Formosa (Taiwan), Hans Sauter, V–VII 1907, date uncertain.

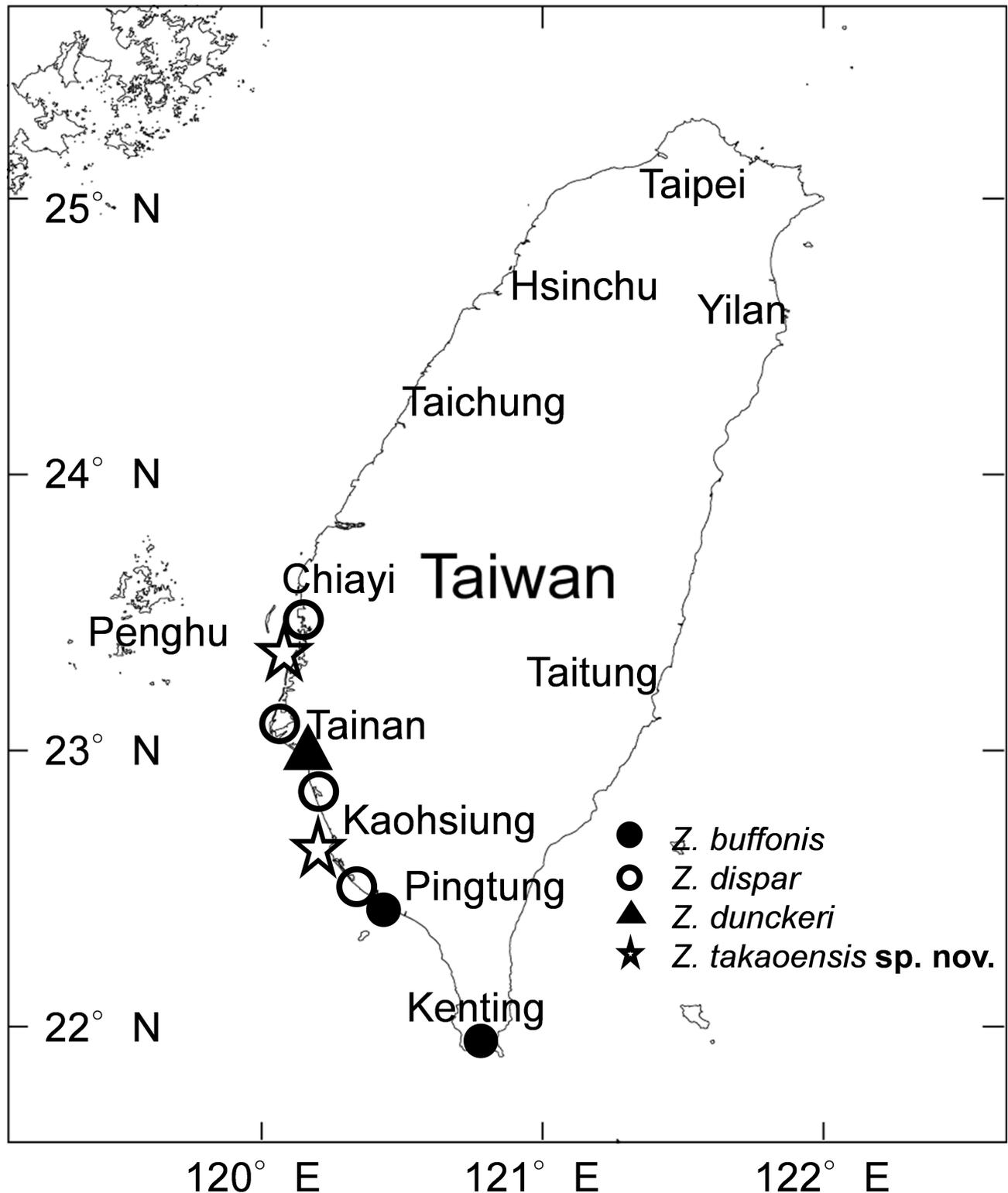
**Holotype.** ASIZP0081779, 76.6 mm SL, male; 9 Apr. 2023, Dongshi, Chiayi County, southwest Taiwan, 23°27'01.5"N 120°08'27.2"E, pole and line fishing, YC Liao coll.

**Paratypes.** 7 specimens: ZMH 6543, female, 60.4 mm SL; date uncertain, 1907, Takao (Kaohsiung City), Formosa (Taiwan), Hans Sauter, V–VII 1907. ASIZP0081778, 2 males (69.9–76.0 mm SL), 4 females (72.5–80.0 mm SL); the same as in Holotype.

**Diagnosis.** A species of genus *Zenarchopterus*, snout length slightly longer than width, prominent stripe on middle snout absent, prominent pigmentation or dark mark on snout. Anal-fin with 9 rays that is distinct from other congener species. Sixth anal-fin not elongated or thickened in adult males; dorsal body pigmented with three

longitudinal dashed lines, with oval-like dashed pigmentation on dorsal lateral series scales; anterior lateral stripe on body in dashed line, ventral body with one longitudinal dashed line (FIGURES 4–5). No sexual dimorphism except anal papilla in adult (FIGURE 6).

**Description.** Proportional measurements and counts are presented in TABLE 1. Data of the holotype are presented first, and followed by those of the paratypes in parentheses, if different.

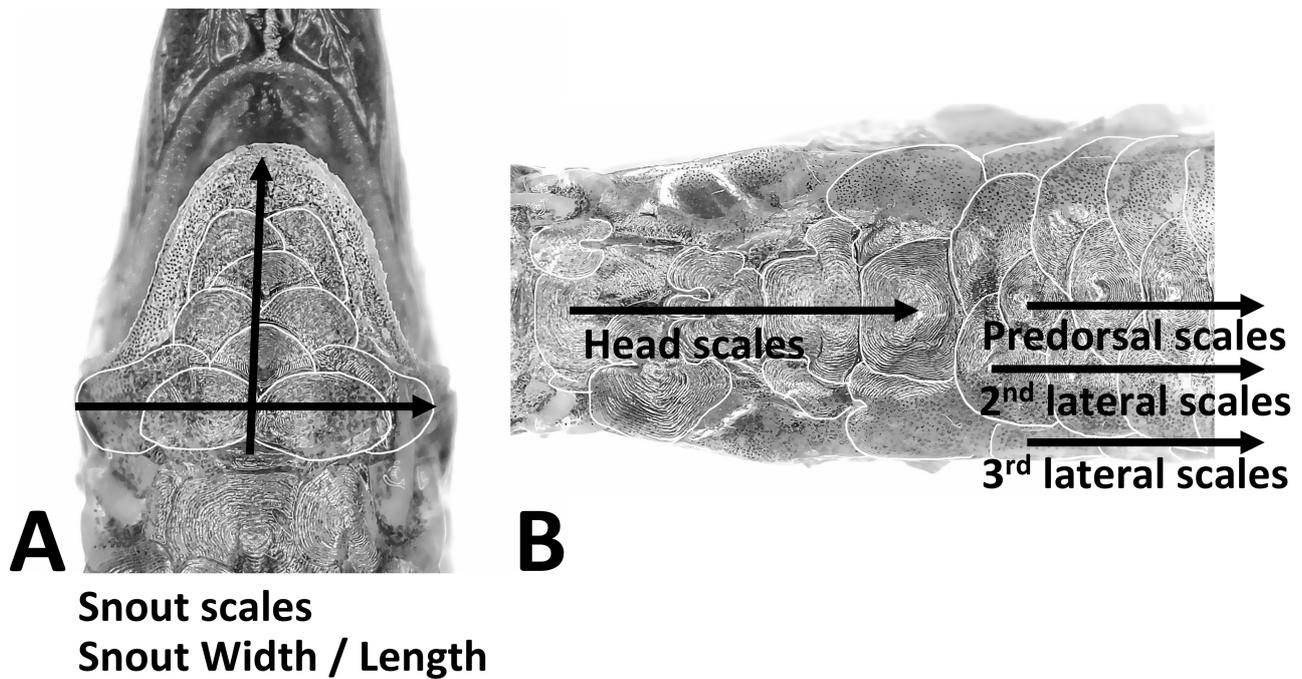


**FIGURE 1.** Distribution of *Zenarchopterus* species from Taiwan. Symbols represent different species as follows: solid circle, *Z. buffonis*; open circle, *Z. dispar*; solid triangle, *Z. dunckeri*; star, *Z. takaoensis* sp. nov.

**TABLE 1.** Counts and proportional measurements of characters in *Zenarchopterus takaoensis* sp. nov.

	<b>Holotype</b>	<b>Paratypes</b>						<b>Paratype</b>
Catalog number	ASIZP0081779	ASIZP0081778 (n=6)						ZMH6543
Sex	Male	Male	Male	Female	Female	Female	Female	Female
Standard Length (mm)	76.6	69.9	76.0	80.0	76.1	76.6	72.5	60.4
Total Length (mm)	115.2	107.1	115.2	123.0	116.4	119	113.2	74.2
Head Length	17.6	15.8	17.3	18.5	17.2	18	16.1	14.9
<b>Counts</b>								
Gill rakers on first arch	2 + 9	2 + 11	2 + 9	2 + 9	2 + 8	2 + 8	2 + 9	2 + 6
Pectoral-fin rays	9	9	9	9	9	9	9	9
Pelvic-fin rays	6	6	6	6	6	6	6	6
Dorsal-fin rays	11	12	12	12	12	12	12	11
Anal-fin rays	9	9	9	9	9	9	9	9
Caudal-fin rays ( <i>ub+b+ub</i> )	2 + 13 + 2	2 + 13 + 2	2 + 13 + 2	2+13+2	2 + 13 + 2	2+13+2	2 + 13 + 2	2 + 15 + 1
Vertebrae	30 + 11	30 + 11	30 + 11	30 + 11	30 + 11	30 + 11	30 + 11	30 + 11
Snout scales	7	8	8	8	8	8	7	N/A
Predorsal scales	13 + 21	13 + 20	13 + 21	13 + 21	13 + 20	13 + 20	13 + 21	17+
2nd lateral scales	10/43	10/42	10/45	10/43	10/44	10/44	10/43	N/A
3rd lateral scales	8/44	7/42	9/45	9/45	7/43	8/44	9/44	N/A
4th lateral scales	38	39	40	40	40	39	39	N/A
Lateral line scales	4 + 5 + 41	3 + 3 + 39	4 + 5 + 42	4 + 5 + 41	3 + 5 + 40	3 + 5 + 40	3 + 4 + 41	N/A
<b>Proportions as % of SL</b>								
Head length	23.0	22.6	22.8	23.1	22.6	23.5	22.2	24.7
Orbital diameter	5.5	6.0	5.9	5.6	5.7	5.6	5.7	5.6
Interorbital width	6.5	6.9	6.7	6.5	6.3	7.2	6.8	6.1
Snout length	6.5	6.9	6.6	6.8	6.2	6.8	7.0	6.3
Lower jaw length	41.8	46.8	41.8	43.1	48.0	44.5	N/A	N/A
Pectoral-fin length	12.9	14.2	12.8	13.4	13.4	13.1	13.2	13.9
Pelvic-fin length	6.9	6.9	6.6	7.0	7.1	6.4	7.2	N/A
Body depth	12.5	13.0	12.5	12.8	13.1	13.4	13.1	8.9
Caudal-fin length	16.7	18.9	17.1	17.0	17.6	16.6	17.5	13.1
Caudal-peduncle depth	5.7	6.3	5.8	6.4	6.6	6.7	6.5	6.1
Dorsal-fin base length	16.3	21.7	17.5	17.8	16.3	18.1	18.3	18.5
Anal-fin base length	5.4	5.2	6.2	5.4	6.3	5.1	5.4	5.5
<b>Proportions as % of HL</b>								
Orbital diameter	23.9	26.6	26.0	24.3	25.0	23.9	25.5	22.8
Interorbital width	28.4	30.4	29.5	28.1	27.9	30.6	30.4	24.8
Snout length	28.4	30.4	28.9	29.2	27.3	28.9	31.7	25.5

*ub* and *b* of caudal-fin rays in parentheses indicate "unbranched" and "branched", respectively.



**FIGURE 2.** Schematic diagrams of snout scales, head scales, predorsal scales, and lateral series scales in species of *Zenarchopterus*.



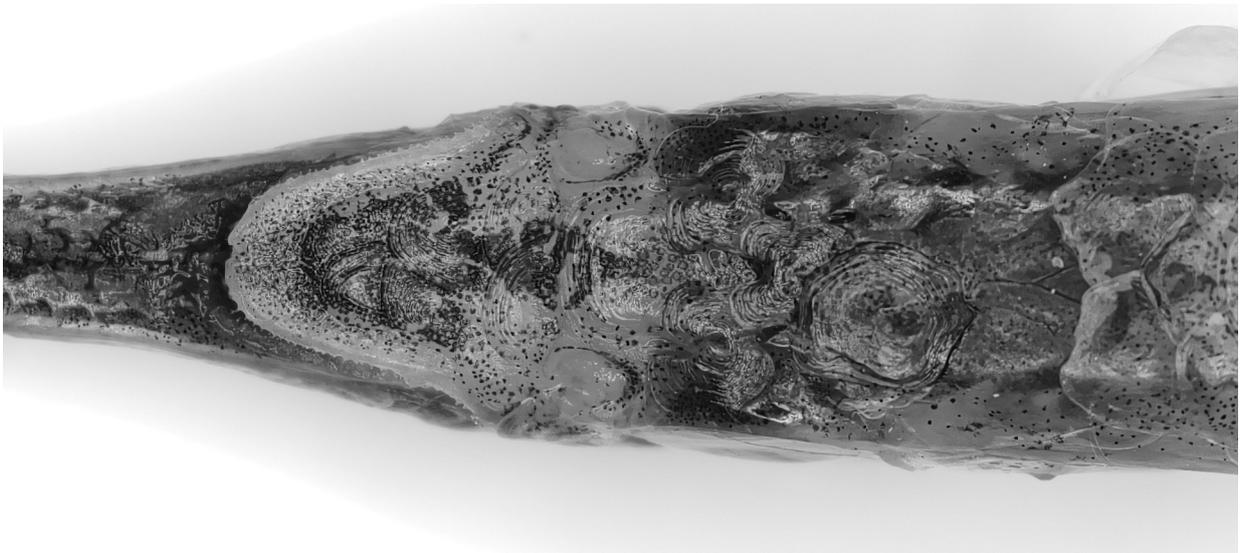
**FIGURE 3.** Radiograph of *Zenarchopterus takaoensis* **sp. nov.** from Taiwan. ZMH 6543, Paratype, male, 70.7 mm SL, Kaohsiung City (Takao, Formosa, Hans Sauter, V–VII 1907).

Single dorsal-fin, dorsal-fin short, dorsal-fin base length 6.1 (4.6–6.1) in SL; its origin behind vertical line at middle between pelvic-fin and anal-fin, dorsal-fin spine absent, with 11 (11–12) soft rays, anterior and posterior rays slightly shorter than others. Anal-fin base 18.7 (15.9–19.6) in SL; its origin behind vertical line of 5<sup>th</sup> dorsal-fin ray base, anal-fin spine absent, with one unbranched and 8 branched soft rays, 1<sup>st</sup> ray shortest, 5–7<sup>th</sup> rays longer than others, 6<sup>th</sup> ray not thickened and elongated. Caudal-fin slightly rounded or truncated, lower lob slightly acute, caudal-fin length 6.0 (5.3–6.0) in SL, caudal-peduncle depth 2.9 (2.1–3.0) in caudal-fin length, caudal-fin with 17 (17–18) soft rays. Pectoral-fin short, pectoral-fin length 7.7 (7.1–7.7) in SL, with 9 branched soft rays. Pelvic-fin short, pelvic-fin length 14.5 (13.9–15.6) in SL, with one unbranched and 8 branched soft rays; its origin before dorsal-fin. Gill rakers on 1st arch with 2 upper and 9 (6–11) lower slender fences. Vertebrae: with 30 abdominal vertebrae + 11 caudal vertebrae, total 41; with 5 anal-fin pterygiophores anterior to 1<sup>st</sup> haemal spine.

Head length 4.4 (4.1–4.4) in SL. Eye moderate, orbital diameter 4.2 (3.8–4.4) in HL, interorbital width 3.5 (3.3–4.0) in HL. Upper jaw triangular, Snout slightly longer than width, snout width 1.1 (1.0–1.1) in snout length; lower jaw length 2.4 (2.1–2.3) in SL. Teeth on jaws small, dense. Nasal papilla short and elongate, its length about 1/2 orbital diameter. Body slender and elongated; body depth 8.0 (7.4–8.0) in SL.



**FIGURE 4.** Photographs of *Zenarchopterus takaoensis* sp. nov. A: lateral; B: anterior dorsal. ASIZP0081778, Paratype, female, 76.1 mm SL, Dongshi, Chiayi County.



**FIGURE 5.** Snout and head scales of *Zenarchopterus takaoensis* sp. nov., Dorsal view: ASIZP0081778, Paratype, female, 76.1 mm SL, Dongshi, Chiayi County.

Scales cycloid, snout scales 7 (7–8) in 3 rows; predorsal scales 33 (33–34), arranged in two series: anterior series including 4 head scales and 9 scales directed posteriorly to middle of body, posterior series including 21

(20–21) scales directed posteriorly until dorsal-fin base; first scale covering two scale series. Second lateral scale 43 (42–45), 10<sup>th</sup> scale covering two series. Third lateral scales starting above opercle, with 44 (40–45) scales, 8<sup>th</sup> (7–9<sup>th</sup>) scale covering two series. Fourth lateral scales running after pectoral-fin base, with 38 (39–40) scales. Lateral line scales trifurcated and located on lower body, 4 (3–4) scales direct upward to pectoral-fin base, 5 (3–5) scales direct anteriorly to thorax, with 41 (39–42) scales running posteriorly to caudal-fin base with additional small scales on caudal-fin membrane, 30<sup>th</sup> (29–31<sup>th</sup>) lateral scale located on vertical line of anal-fin start. Membrane scale on dorsal-fin, anal-fin absent. Anal papilla sexually dimorphic, anal papilla teardrop-shaped and expanded with elongated and slender projection in male, genital opening pointed at tip; anal papilla ellipse with prominent slender projection in female, genital opening at base of projection with two small flaps on two sides.

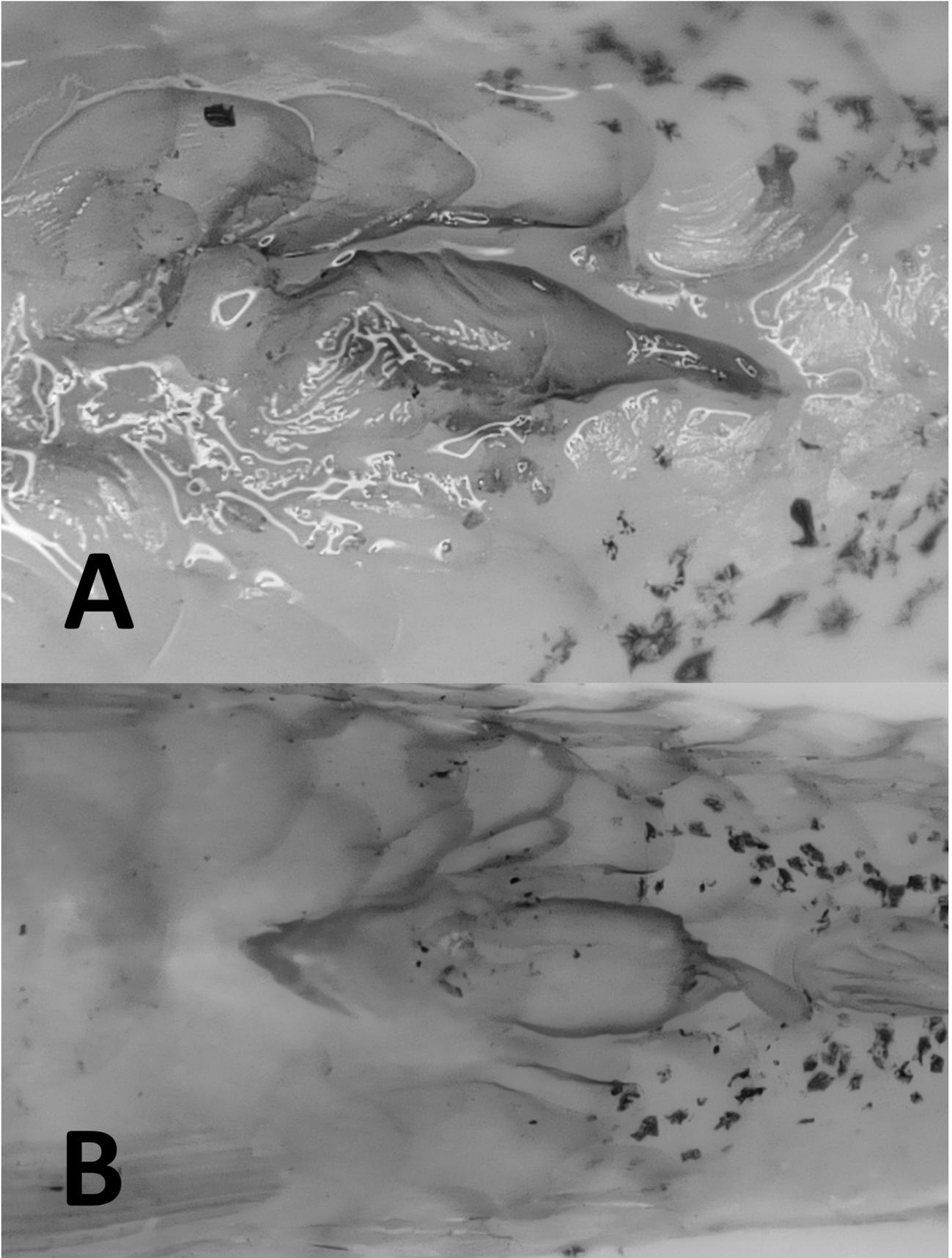
Color when fresh: Head lateral side upper half dark brown and lower part silver, lower jaw dark green and pigmented with yellow anterior end, proximal of lower jaw pigmented, maxillary pigmented, ventral lower jaw with longitudinal pigmented flap and stripe, thorax with longitudinal line and peripheral pigmentation; lower half orbital socket with dashed line, dorsal surface of orbital pigmented not extending posteriorly to vertical line of posterior eye; upper half of opercle pigmented; snout with prominent pigmentation or dark mark, extended posteriorly to middle interorbital, nasal papilla white without pigmentation, nasal socket pigmented. Body sides silver with prominent longitudinal gray stripe under dorsal-fin, starting from vertical line of first dorsal-fin ray running posteriorly to caudal-fin base, with pigmentation extending to base of caudal-fin rays; one dashed line running along lower margin of 3<sup>rd</sup> lateral scale row, starting above pectoral-fin, running posteriorly and connecting to longitudinal stripe; belly white, area between lateral stripe and belly not pigmented. Dorsal body with three longitudinal dashed lines running posteriorly to anterior dorsal-fin, oval-like dash-like pigmentation on margin of 2<sup>nd</sup> and on upper half of 3<sup>rd</sup> lateral scales scattered posteriorly to dorsal-fin base until caudal-fin base; area above anal-fin base pigmented on two sides and running posteriorly to caudal-fin base; ventral body with longitudinal dash-like pigmentation between middle body to pelvic-fin. Color in preserved specimens: in ZMH 6543, body uniformly pale, lower jaw, maxillary, upper half opercle, dorsal surface of orbital, and area after interorbital prominently pigmented. Body sides with unclear longitudinal white stripe with dash-like pigmentation running posteriorly from upper pectoral-fin to caudal-fin base; dorsal body with three dashed lines running posteriorly under dorsal-fin base and to caudal-fin base; area above anal-fin base pigmented on two sides and running posteriorly to caudal-fin base; ventral body with longitudinal dash-like pigmentation between middle body and pelvic-fin. However, snout with prominent pigmentation or dark mark in all type specimens except ZMH 6543 because of absence of snout scale (TABLE 1).

**Distribution.** Currently known only from the estuary from southwestern Taiwan. However, after an intensive collection around Taiwan, it was not seen at Kaohsiung City and Kaohsiung Harbor. The original habitats might had been destroyed and lost during the harbor construction in 1970s.

**Etymology.** The new species is named after the type locality “Takao”, based on the type specimen in the ZMH labeled “*Zenarchopterus* sp., Takao, Formosa, Hans Sauter, V–VII 1907”. “Takao” was the old name of Kaohsiung City, and “Formosa” was the old name of Taiwan during that time.

**Remarks.** The prominent differences between the new species and the other three congeners in this region are as follows: snout slightly longer than width, rather than wider than length as in *Z. buffonis*, *Z. dispar*, *Z. dunckeri*; only 9 anal-fin rays rather than 12 in *Z. buffonis*, and 11–13 in others; prominent pigmentation or dark marks on snout, rather than dark stripe on middle snout in *Z. buffonis*, and without prominent pigmentation nor dark stripe on snout in others; dorsal body pigmented with three longitudinal dashed lines, rather than slender or bold longitudinal lines as in others; anterior longitudinal lateral stripe on body with dashed line, rather than prominent slender stripe; ventral body with one longitudinal dashed line, rather than absent in others. For more comparisons between these congeners, see TABLE 2.

*Zenarchopterus takaoensis* sp. nov. is similar to *Z. buffonis* in that 6<sup>th</sup> anal-fin ray and 4–5<sup>th</sup> dorsal-fin rays are not elongated in the adult male. However, the former differs from *Z. buffonis* in the following ways: with prominent pigmentation or dark mark on snout, rather than prominent dark stripe on middle snout; anterior nasal papilla not pigmented, rather than pigmented in latter; anterior dorsal body with three longitudinal dashed lines running posteriorly to anterior dorsal-fin, oval-like dash-like pigmentation on margin of 2<sup>nd</sup> and on upper half of 3<sup>rd</sup> lateral series scales scattered posteriorly to dorsal-fin base until caudal-fin base, rather than dorsal longitudinal line slender on two sides and one bold line in middle, 2<sup>nd</sup> and 3<sup>rd</sup> lateral series scales pigmented entirely; dorsal-fin and anal-fin membrane not pigmented in adult, rather than pigmented in adult; 6<sup>th</sup> anal-fin ray not thickened in adult male, rather than thickened in latter.



**FIGURE 6.** The anal papilla of *Zenarchopterus takaoensis* **sp. nov.** Ventral view: A: ASIZP0081779, Holotype, 76.6 mm SL, male; B: ASIZP0081778, Paratype, 76.1 mm SL, female.

**TABLE 2.** Comparison of selected characters for *Zenarchopterus takaoensis* sp. nov. and three congeners.

Counts and Color/ Species	<i>Z. takaoensis</i>	<i>Z. buffonis</i>	<i>Z. dispar</i>	<i>Z. dunckeri</i>
Snout length/width	1.0–1.1	0.7–0.9	0.7–0.9	0.6–1.0
Snout scales	7–8 in 3 rows	8–9 in 3–4 rows	9–11 in 4–5 rows	7–9 in 3–4 rows
Predorsal scales	33–34	32–35	31–37	31–34
Anal-fin rays	9	12	11–13	11–13
Pectoral-fin rays	9	8–9	9–10	10
Gill raker on first arch	2 + (6–11) = 8–13	(3–5) + (12–15) = 16–18	(3–5) + (12–15) = 16–18	(3–6) + (11–13) = 15–18
Vertebrae	30 + 11 = 41	(27–28) + (12–13) = 40–42	(26–30) + (13–15) = 40–43	(24–30) + (12–14) = 37–42
6 <sup>th</sup> anal-fin elongated in adult male	absent	absent	present	present
4–5 <sup>th</sup> dorsal-fin ray with flap in adult male	absent	absent	present	present
Prominent stripe on middle snout	absent	present	absent	absent
Longitude lines on anterior dorsal body	3 dashed lines	3 lines, middle bold	3 slender lines	3 slender lines
Anterior lateral stripe	dash-like	slender stripe	slender stripe	slender stripe
Ventral body line	dashed line	absent	absent	absent
Dorsal-fin membrane pigmented	absent	present	present	present
Anal-fin membrane pigmented	absent	present	present	present

All the specimens of *Zenarchopterus takaoensis* sp. nov. were collected by pole and line fishing and were smaller than other congeners in Taiwan. The species might be difficult to collect by traditional trawling or net fishing because of its small size and lower economic value. However, it has often been overlooked or confused with other species, making it a cryptic species in Taiwan.

## Comparative materials

### *Zenarchopterus buffonis* (Valenciennes, in Cuvier & Valenciennes, 1847)

**Material examined:** 36 specimens, ASIZP0081764, 4 (85–99 mm SL), ASIZP0081765, 8 (61–74 mm SL), ASIZP0081766, 5 (74–78 mm SL), ASIZP0081767, 6 (73–95 mm SL), Nov. 26, 2022. ASZIP0081768, 9 (73–95 mm SL), ASIZP0081769, 5 (84–98 mm SL), Apr. 9, 2023. Dapengwan mangrove, Pingtung; NMMB–P0022746, 94 mm SL, Apr. 9, 2011, Danang, Vietnam, collected by HC Ho.

### *Zenarchopterus dispar* (Valenciennes, in Cuvier & Valenciennes, 1847)

**Material examined:** 51 specimens, ASIZP0081775, 10 (75–117 mm SL), Aug. 1, 2022. Shihtsao mangrove, Tainan County; ASIZP0081773, 8 (97–102 mm SL), ASIZP0081776, 6 (92–112 mm SL), ASIZP0081777, 5 (93–112 mm SL), Aug. 1, 2022. Kaohsiung Harbour, Kaohsiung City; NMMB–P009032, 94 mm SL, female, Oct. 18, 2005. NMMB–P007325, 52 mm SL, juv., Jul. 30, 1999; ASIZP0081769, 5 (84–98 mm SL), Apr. 9, 2023. ASIZP0081774, 6 (70–92 mm SL), ASIZP0081772, 5 (77–96 mm SL), Nov. 26, 2022. Dapengwan mangrove,

Pingtung; ASIZP0081770, 6 (88–99 mm SL), ASIZP0081771, 4 (80–98 mm SL), Apr. 9, 2023. Fangliao mangrove, Pingtung County.

### *Zenarchopterus dunckeri* Mohr, 1926

**Material examined:** 6 specimens, ZUMT 52415–52418, 4 (53.0–58.7 mm SL), Oct. 9, 1968. Miyara Riv., Ishigaki-I., Yaeyama Is., Ryukyu Arch.; ASIZP0081780, 2 (85–86 mm SL), Jun. 13, 2023. Nakama Riv., Iriomote-I., Yaeyama Is., Ryukyu Arch.

### Acknowledgements

The authors thank Dr. H. M. Chen and Mr. J. F. Huang for radiographs from the National Taiwan Ocean University, and Dr. H. Wada and Dr. R. Ueshima (The University Museum, The University of Tokyo, ZUMT), Dr. I. Eidus (Zoologisches Museum, Hamburg, ZMH), Dr. S. P. Huang (ASIZ), and Mr. P. N. Lee (NMMB) for curatorial assistance. Research was supported by the University of Taipei, the National Academy of Marine Research, and the National Science and Technology Council (MOST 111-2621-M-845-001-).

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