

A newly recorded moray *Echidna rhodochilus* Bleeker, 1863 (Anguilliformes: Muraenidae) from an estuary in Northeastern Taiwan

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Abstract

A newly recorded moray, *Echidna rhodochilus* Bleeker collected from an estuary in Northeastern Taiwan is described in detailed which represents the northernmost range extension of its distribution. It can be distinguished from other three species of *Echidna* in Taiwan by the coloration pattern, the number of branchial pore (one vs. two), and the position of dorsal fin origin (posterior vs. anterior to the gill opening).

Key words: estuary, freshwater moray, ichthyology, Muraeninae, range expansion, salinity

Introduction

The family Muraenidae (moray eels) are the second most diverse family of true eels (Anguilliformes), comprising 221 valid species across 16 genera worldwide (Fricke et al., 2021). Among them, 14 genera and 79 species have been recorded in Taiwanese waters (Ho et al., 2018; Huang et al., 2019, 2020, 2021). Moray eels have adapted to a variety of habitats in tropical and subtropical waters around the world. Most morays are saltwater fish,

inhabiting rocky or sandy inshore areas; only *Gymnothorax polyuranodon* (Bleeker, 1854) is considered a freshwater moray (Tsukamoto et al., 2014). Additionally, a few species can be occasionally or predominantly encountered in brackish waters: e.g., *Echidna rhodochilus* (Bleeker, 1863), *Echidna xanthospilos* (Bleeker, 1859), *Gymnothorax tile* (Hamilton, 1822), and *Strophidon sathete* (Hamilton, 1822) (Bucol et al., 2010; Ebner et al., 2011; Mori & Toyama, 2014).

Echidna rhodochilus was described originally from Rotti Island in Indonesia (Bleeker, 1863), is abundant in tropical waters of the Western Pacific, and has been recently recorded from the Andaman Sea (Arun-Kumar et al., 2016). *Echidna rhodochilus* is commonly observed in estuaries of Indonesia (pers. obs.) and sometimes deemed a “freshwater moray” in the aquarium trade industry (Ebner et al., 2011). However, it is rarely seen in subtropical waters, with the current northernmost record being from an estuary of Iriomote Island, Japan (Hatooka, 2013). The first Taiwanese record of *E. rhodochilus* was reported by Chou et al. (2020) based on a single specimen collected in an estuary of the Zhu’an River (about 500 m upstream of the river mouth, 1.5 m in depth) in Yilan County, Northeastern Taiwan. In this study, we have provided additional details on the morphological characteristics of the specimen of Chou et al. (2020). This record represents the fourth species of the genus *Echidna* and the 80th species of the family Muraenidae around Taiwanese waters.

Material and methods

The fresh specimen was photographed, measured, fixed in 10% formalin, and gradually transferred to a 70% ethanol for permanent preservation. Morphometric measurements followed Böhlke et al. (1989) and were expressed as

percentages of total length (TL) or head length (HL). Vertebral counts followed Böhlke (1982) and were made from X-rays. Dentition was examined under a stereomicroscope, with an emphasis on missing teeth. Nomenclature of dentition and cephalic sensory pores followed Böhlke & Smith (2002) and Smith et al. (2019), respectively. The specimen was deposited in the collection of the Department of Oceanography (DOS) of National Sun Yat-sen University (NSYSU), Kaohsiung (Taiwan). The salinity of the collection site was measured at high tide and low tide during the spring tide period on 22 August 2021 (at a depth of about 1 m) by using a refractometer.

Results

Echidna rhodochilus Bleeker, 1863

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Figs. 1 – 3, Table 1

Material examined. DOS 07324, 335 mm TL, male, caught by angling at 1.5 m depth from an estuary of the Zhu’an River (24°50'23.0"N, 121°49'20.4"E), Yilan County, Northeastern Taiwan in November 2019 by M.-T. Chou.

Description of DOS 07324. Proportions (% of TL): tail length 51.3, trunk length 39.1, HL 9.6, predorsal length 12.5, depth at gill opening 4.4, depth at anus 4.4. Proportions (% of HL): length of upper jaw 34.1, length of lower jaw 33.7, interorbital width 13.5, snout length 16.2,

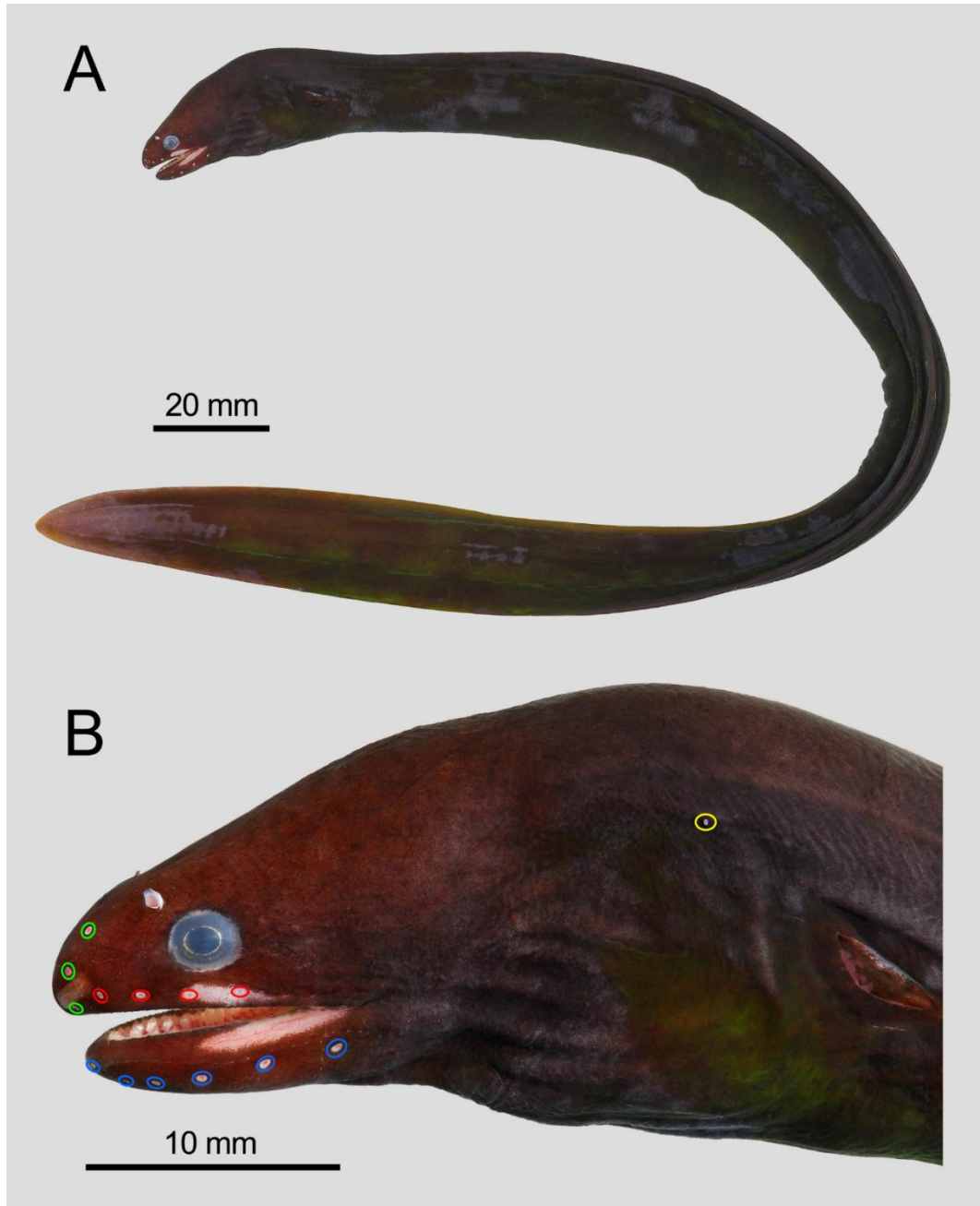


Fig. 1. Fresh coloration of DOS 07324. (A) lateral view; (B) lateral view of head marks with cephalic sensory pores: green for supraorbital pores; red for infraorbital pores; blue for preoperculo-mandibular pores; yellow for branchial pore.



Fig. 2. Photograph of DOS 07324, taken when the specimen was alive.

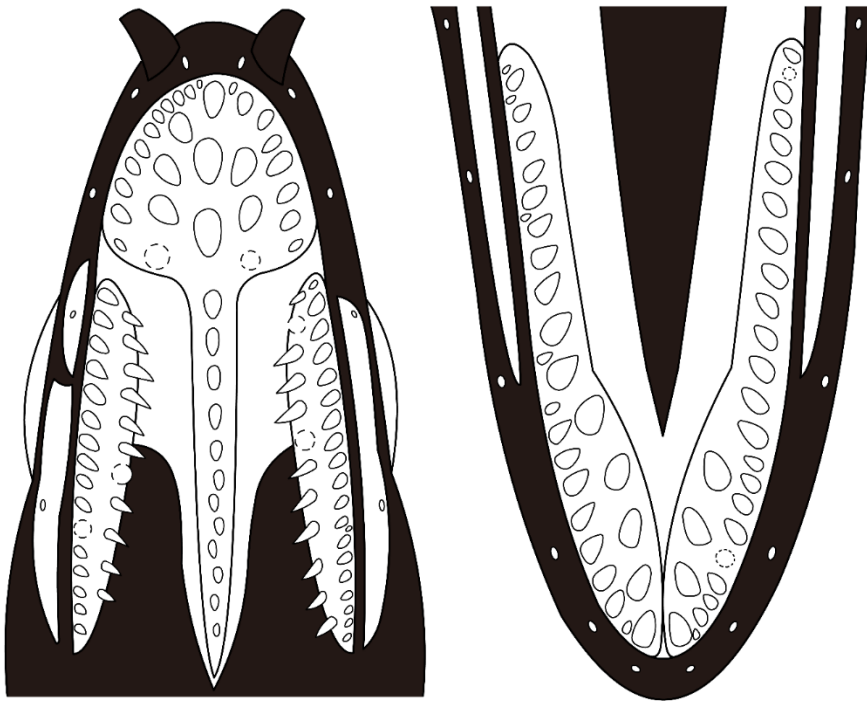


Fig. 3. Dentition of DOS 07324. Dotted-line circles represent the locations of the missing teeth. Left: upper jaw, right: lower jaw.

Table 1. Comparison of morphometric measurements and meristic counts of *Echidna rhodochilus*. TL=total length; HL=head length.

Source	This study	Böhlke & Smith (2002) holotype	Arun-Kumar et al. (2016) n = 2
Catalog number	DOS 07324	BMNH 1867.11.28.277	-
TL (mm)	335	318	324-326
As % of TL			
Tail length	51.3	50.0	47.8-48.1
Preanal length	48.7	50.0	51.9-52.2
Trunk length	39.1	39.0	40.5-40.8
Head length	9.6	11.0	11.1-11.7
Predorsal length	12.5	-	17.3-17.8
Body depth at gill opening	4.4	5.0	5.5-5.6
Body depth at anus	4.4	5.6	5.6-6.1
As % of HL			
Length of upper jaw	34.1	27.0	29.0-30.6
Length of lower jaw	33.7	-	29.0-30.6
Snout length	16.2	13.7	13.2-13.9
Interorbital width	13.5	-	
Eye diameter	9.1	9.1	7.9-8.3
Vertebrae			
Predorsal	14	12	-
Preanal	54	53	-
Total	121	119	-

eye diameter 9.1. Body slender, head short, anus slightly anterior to mid-point of body. Fins moderately high and concealed by thick skin. Dorsal fin origin posterior to gill opening and anal fin origin immediately behind anus. Gill opening elliptical, below lateral midline, larger than eye in diameter. Eyes above mid-jaw and moderate in size. Snout blunt. Jaws subequal, upper jaw slightly longer; teeth not visible when mouth closed. Anterior nostril at tip of snout, about eye radius in length. Posterior nostril above and slightly anterior to anterior margin of eye; as a round hole with slightly raised rim. Three supraorbital pores, all along front margin of snout. Four infraorbital pores along upper jaw (third & fourth pores inside of white blotch). Six preoperculo-mandibular pores along lower jaw (anterior to corner of mouth). One branchial pore above and anterior to gill opening. Predorsal vertebrae 14, preanal vertebrae 54, total vertebrae 121.

Dentition. Teeth stout, bluntly conical, with smooth edges. Intermaxillary teeth in five rows: two rows of 8 (left side) and 11 (right side) small, peripheral intermaxillary teeth; two rows of 3 and 4 intermediate intermaxillary teeth; and one row of three large, median intermaxillary teeth. Maxillary teeth biserial, 19 and 16 smaller teeth on outer row decreasing in size posteriorly; 12 and 11 teeth on inner row, longer and pointier than outer teeth. Vomerine teeth uniserial, with 12 teeth

decreasing in size posteriorly. Dentary teeth biserial anteriorly, uniserial posteriorly, with 4 and 5 larger and spaced teeth on inner row flanked by 23 and 18 smaller outer teeth. Some small teeth in space between larger teeth on outer maxillary and outer dentary.

Coloration. Uniformly dark brown, with conspicuous white blotches around corner of mouth. Head pores with white rims. Inner skin of posterior nostril, gill opening, and oral cavity whitish. Preserved color not significantly different to when fresh. Body covered with fluorescent-green mucus when alive.

Distribution. This species has been found in the Indo-West Pacific, from the Andaman and Nicobar Islands to Fiji, north to Iriomote Island (Hatooka et al., 1992; Hatooka, 2013; Arun-Kumar et al., 2016), and now extending northward to Yilan in Northeastern Taiwan.

Remarks. Including the present study, four species of the genus *Echidna* have been recorded in Taiwan: viz. *Echidna nebulosa* (Ahl, 1789), *Echidna polyzona* (Richardson, 1845), *E. rhodochilus*, and *E. xanthospilos*. All species possess short, blunt teeth arranged in multiple series; this is the diagnostic feature of the genus, and such teeth are optimal for masticating shells (Mehta, 2009). The four species of *Echidna* in Taiwan can be distinguished from each other solely by coloration patterns and are rarely confused. Aside from coloration, *E. rhodochilus* is

remarkably different from the remainder by having only a single branchial pore (vs. two in the other three); the origin of its dorsal fin is posterior to the gill opening (vs. anterior to the gill opening in the other three; Chen & Böhlke, 1996; Smith et al., 2019).

In comparison to *E. rhodochilus* specimens described in prior publications (Table 1), the Taiwanese specimen has a relatively longer tail, shorter head, shorter predorsal length, smaller body depth, longer jaws, and longer snout (Böhlke & Smith, 2002; Arun-Kumar et al., 2016). These differences are well within the scope of the variation observed within other muraenids.

The salinity measured at the collection site of *E. rhodochilus* during spring tide fluctuated between 3.5 (low tide) and 7 (high tide) and is therefore considered brackish (2.6-23.9; Monkes, 2006). According to Ebner et al. (2011), large individuals of *G. polyuranodon* prefer to stay at, or upstream of, the upper tidal influence, while small ones can be sporadically found in estuarine environments. Although *E. rhodochilus* is commonly referred to as a “freshwater moray,” few articles actually support its ability to withstand long-term freshwater immersion; our observation of its residing in a salinity of 3.5 might represent the lower limit of its halo-tolerance. Clearly, there is much to be learned about the

environmental physiology of *E. rhodochilus*. As a closing remark, our specimen’s size (335 mm TL) approached that of the largest ever recorded (338 mm TL) by Kottelat et al. (1993). Our collection site might represent the “terminal habitat” of the adult phase.

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