

**A NEW RECORD OF THE LONG MORAY, *GYMNOTHORAX LONGINQUUS*
(ACTINOPTERYGII: ANGUILLIFORMES: MURAENIDAE), FROM SOUTHERN VIETNAM,
SUPPORTING THE UNCERTAIN RECORD IN THE GULF OF THAILAND**

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Abstract. Five specimens of *Gymnothorax longinquus* (Whitley, 1948) were collected from a fish market and a fish landing site in Tac Cau and Ha Tien, southern Vietnam. These specimens represent the first record of *G. longinquus* in Vietnam, and further support a previously uncertain record in Thailand. The specimens collected are described and illustrated. *Gymnothorax longinquus* may prefer muddy shallow water from northern Australia to the Gulf of Thailand.

Keywords: *Gymnothorax longinquus*, Muraenidae, new record, southern Vietnam, Gulf of Thailand

INTRODUCTION

Vietnam, a peripheral country of the coral triangle with diverse marine habitats along the coastline of over 3260 km, has the potential to maintain massive marine bioresources. The actual number of the muraenid species (Muraenidae), however, recorded in Vietnam and amounting to about 40 species (Nguyen and Nguyen 2006, Prokofiev 2010a, Huang et al. 2018) is much lower compared to 75 muraenid species recorded in Taiwan (Ho et al. 2018, Huang et al. 2019). The lower species number implies that the moray diversity of Vietnam may still be underestimated despite that several new muraenids and new records have been reported in the last decade (Prokofiev 2010b, Hibino et al. 2016, Huang et al. 2018, Smith et al. 2018, Prokofiev 2020). More efforts are needed in the moray taxonomic research in Vietnam.

Gymnothorax longinquus (Whitley, 1948) is a rare moray with only few specimens and reports available since its description. All known specimens were collected from the northern part of Australia except for one from a Thailand fish market with uncertain capture locality (Böhlke and McCosker 2001). The holotype was collected from Queensland, Australia (Whitley 1948). In this study, five specimens of *G. longinquus* were acquired from Kien Giang Province in southern Vietnam, located beside the Gulf of Thailand. The existence of *G. longinquus*

in southern Vietnam may further support the previous uncertain record in Thailand and the statements that *G. longinquus* is distributed through northern Australia to the Gulf of Thailand (Böhlke and McCosker 2001). The mitochondrial cytochrome oxidase subunit I (*COI*) gene of these five specimens was also sequenced to prove the identification and to provide molecular inference for future research.

MATERIAL AND METHODS

A total of five specimens of *Gymnothorax longinquus* were collected from Kien Giang Province during the fish faunal survey in September 2017. Three specimens were from a fish market in Tac Cau and two specimens were from a fish landing site in Ha Tien. A piece of muscle tissue was cut and preserved in 95% ethanol until DNA extraction. Specimens were then fixed in 10% formalin, transferred to 70% ethanol for permanent preservation deposited in the Department of Oceanography, National Sun Yat-sen University, Kaohsiung (museum number prefix: DOS). Morphometric measurements followed Böhlke et al. (1989), expressed as proportion in total length (TL) or head length (HL). Vertebral counts followed the terminology of Böhlke (1982), expressed as predorsal-preanal-total vertebrae. The dentition was determined under a stereomicroscope; the dental terminology

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followed that used in Böhlke and Randall (2000). The sex was determined by examining the gonads.

A fragment of 673 bp of *COI* gene was amplified by polymerase chain reactions (PCR) using universal primers designed by Ward et al. (2005) and DNA extracted from muscle tissue. DNA extraction and the thermal profiles of PCR followed Huang et al. (2019). *COI* sequences of two *G. longinquus* (Accession number HM376361 and FOAO2098-19) and four morphologically similar muraenid species were obtained from GenBank and BOLD online databases for the reconstruction of the phylogeny tree, including *Gymnothorax pseudothyroideus* (Bleeker, 1853) (KU942770, AMS063-06), *Gymnothorax taiwanensis* Chen, Loh et Shao, 2008 (KU893015, KU942771), *Gymnothorax tile* (Hamilton, 1822) (MF588548, MF588552), and *Strophidon dorsalis* (Seale, 1917) (HM422422, HQ564522). A maximum likelihood (ML) tree was reconstructed using MEGA version X (Kumar et al. 2018) based on the best selected GTR + I substitution model and a 1000 replicate bootstrap probability analysis (Felsenstein, 1985). *Uropterygius macrocephalus* (Bleeker, 1864) (MH400961) and *Uropterygius micropterus* (Bleeker, 1852) (MF190292) were used as outgroups. New generated *COI* sequences in this study were submitted to GenBank with accession numbers MK777090, MN399155–MN399158.

Material examined. *Gymnothorax longinquus*: DOS 05881, $n = 3$, 554–610 mm TL, Tac Cau, Kien Giang Province, Vietnam; 09°52'21.3"N, 105°07'38.0"E, 18 September 2017; Coll. W.-C. Huang. DOS 06038, $n = 2$, 627–702 mm TL; Ha Tien, Kien Giang Province, Vietnam; 10°22'43.2"N, 104°29'06.6"E, 23 September 2017; Coll. W.-C. Huang.

RESULTS

Brief description of specimens in this study. Body moderately stout, tail tapering (Fig. 1), depth at gill opening 13.7–17.9 and at anus 17.6–22.1 in TL (Table 1). Anus slightly posterior to mid-body, preanal length 1.9–2.0 in TL. Dorsal fin moderately high, origin anterior to gill opening, predorsal length 1.3–1.5 in HL. Anal fin low, originating immediately behind anus. Gill opening slightly below midline of body. Head moderately elongated, 7.5–7.8 in TL. Eyes slightly closer to corner of mouth rather than tip of snout, diameter 10.9–13.8 in HL. Snout short and stout, 5.9–6.6 in HL. Jaws subequal, 2.3–2.5 in HL, lower jaw slightly longer in our specimens, teeth not visible when mouth closed. Anterior nostril at snout tip, tubular, shorter than eye radius; posterior nostril as pore with raised rim, above and posterior to anterior margin of eye.

Head pores typical, 3 supraorbital pores; 4 infraorbital pores; 6 mandibular pores; 1–4 branchial pores 1 (1), 2 (8), 4 (1) (counts on both sides of body, two counts for each specimen) above and before gill opening. Predorsal vertebrae 5 (4)–6 (1), preanal vertebrae 58 (3), 59 (1), 62 (1), total vertebrae 128 (1), 129 (1), 130 (1), 131 (1), 134 (1).

Dentition (Fig. 2): teeth smooth, strong, and slightly retrorse. All teeth uniserial in our specimens. Intermaxillary

teeth plate with 5–7 large teeth each side peripherally 5 (2), 6 (7), 7 (1) (counts on both sides of upper jaw) and 1–3 [1 (1), 2 (1), 3 (3)] slender teeth medially. Maxillary teeth 11 (1), 12 (1), 13 (3), 14 (2), 15 (2), 16 (1) (counts on both sides of upper jaw), larger at the most anterior side and gradually smaller posteriorly. Vomerine teeth 2 (1), 3 (1), 7 (1), 9 (1), 12 (1), small and stout. Dentary teeth 18 (2), 19 (2), 20 (2), 22 (4) (counts on both sides of lower jaw), first 4 large and long, remaining teeth obviously smaller, with same size posteriorly.

Color of fresh specimens (Fig. 1): whole body uniformly dark brown with irregularly scattered pale blotches. Pale blotches light gray to cream, depending on specimens. Fin margin darker, especially at posterior part of tail. Head pores with fine dark rims. Inner mouth same color with body. Gular folds slightly darker. Corner of mouth and gill opening not dark (although not significant in the figure). Iris of eye yellowish.

Phylogenetic analysis. The topology of ML tree revealed that all sequences generated in this study clustered with two *Gymnothorax longinquus* sequences from Cape York (HM376361) and Channel Island (FOAO2098-19) in northern Australia, confirming the morphological identification of the Vietnamese specimens (Fig. 3). All species are monophyletic with the smallest inter-species genetic distance 19.3% between *G. longinquus* and *G. tile*. *Gymnothorax longinquus* is a sister group of *G. tile*, *G. pseudothyroideus*, and *S. dorsalis*.

DISCUSSION

Gymnothorax longinquus is a poorly known moray with only eight specimens recorded in previous studies since its description. Before the presently reported study, seven out of eight specimens were from the northern areas of Australia. The only record out of Australian water was reported by Böhlke and McCosker (2001) from a fish market in Thailand with an emphasis on uncertain capture location. Imamura (2013) has already recorded a 540 mm *G. longinquus* specimen (Museum ID: KAUM-I. 33142) off Chanthaburi in Thailand but it was misidentified as *G. pseudothyroideus*. *Gymnothorax longinquus* was also reported as *Gymnothorax* sp. by Hibino (2017) from Panay Island in the Philippines based on a 770.5 mm specimen (KAUM-I. 91755). Our morphological and molecular analyses show the five specimens from Vietnam are *G. longinquus*. Based on our results and previous records (Böhlke and McCosker 2001, Imamura 2013, Hibino 2017), the distribution range of *G. longinquus* is further extended to the Gulf of Thailand. The gulf is rich with sediments and the water depth is relatively shallow (58 m on average and 85 m in maximum) (Khongchai et al. 2003). Therefore, *G. longinquus* may prefer to inhabit muddy shallow water.

The majority of morphometric measurements and meristic counts conform to those in Böhlke and McCosker (2001) and Böhlke and Smith (2002), except for smaller eye diameter (10.9–13.8 vs. 9.4–11 in references) and the anus slightly posterior to mid-body (vs. anus at mid-body). The differences may attribute to individual

variations among geographic regions or differences in measurers. No mature specimens have been identified in either previous or this study (Böhlke and McCosker 2001). Böhlke and McCosker (2001) indicated that the muscles of all preserved specimens they examined were unevenly contracted, giving a curious “lumpy” surface to the body. However, all our preserved specimens have soft and smooth surfaces.

Four morphologically similar species, *G. pseudothyroideus*, *G. taiwanensis*, *G. tile*, and *S. dorsalis* characterized by gray to dark brown body with pale blotches or obscure reticular pattern, short anterior nostril, and blunt snout, may be confused with *G. longinquus*. *Gymnothorax pseudothyroideus* is most similar to *G. longinquus*, with overlapping of most morphometrics and meristics. However, *G. longinquus*



Fig. 1. Fresh specimens of *Gymnothorax longinquus* from southern Vietnam; lateral view (A), DOS 06038-1 (627 mm); lateral view of head (B), DOS 06038-2 (702 mm)

Table 1
Morphometric measurements and meristic counts of *Gymnothorax longinquus*

Character	This study (n = 5)				Böhlke and Smith 2002 (Holotype AMS IA.6953)				Böhlke and McCosker 2001 (n = 8 ^b)					
	Absolute value [mm]	Percentage TL	Proportion TL	Percentage HL	Proportion TL	Proportion HL	Absolute value [mm]	Count	Proportion TL	Proportion HL	Absolute value [mm]	Proportion TL	Proportion HL	Count
Total length	554–702						736				258–736			
Tail length		48.0–49.6	2.0–2.1											
Trunk length		37.3–38.4	2.6–2.7											
Body depth at gill opening		5.6–7.3	13.7–17.9					24			15–24			
Body depth at anus		4.5–5.7	17.6–22.1					22			18–27			
Predorsal length		8.5–10.2	9.8–11.8	65.2–76.0	1.3–1.5									
Preanal length		50.5–51.9	1.9–2.0					2.0			2.0			
Head length		12.8–13.4	7.5–7.8					8.7			7.2–8.7			
Upper jaw length				39.7–43.2 ^a	2.3–2.5 ^a				2.7				2.4–2.9	
Lower jaw length				40.1–44.1 ^a	2.3–2.5 ^a									
Snout length				15.2–16.8 ^a	5.9–6.6 ^a				6.9				2.5–6.9	
Interorbital width				11.9–14.6 ^a	6.8–8.4 ^a									
Eye diameter				7.3–9.2	10.9–13.8				11				9.4–10	
Peripheral intermaxillary T														5–5
Median intermaxillary T														3
Maxillary T														10–12
Vomerine T														1
Dentary T														15–18
Predorsal vertebrae														5–6 (5)
Preanal vertebrae														58–62 (59)
Total vertebrae														128–134 (130)

TL = total length, HL = head length; T = teeth; ^a measurements from 4 specimens, not including holotype; ^b measurements including holotype; ^c data from 6 specimens; the means of vertebral number are given in parentheses.

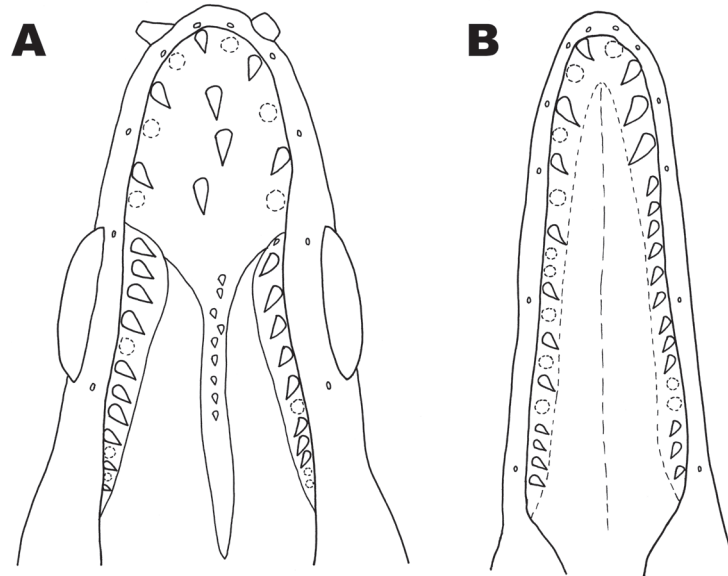


Fig. 2. The dentition of *Gymnothorax longinquus*, DOS 06038-1, 627 mm; upper jaw (A), lower jaw (B); dotted-line circles represent the missing teeth

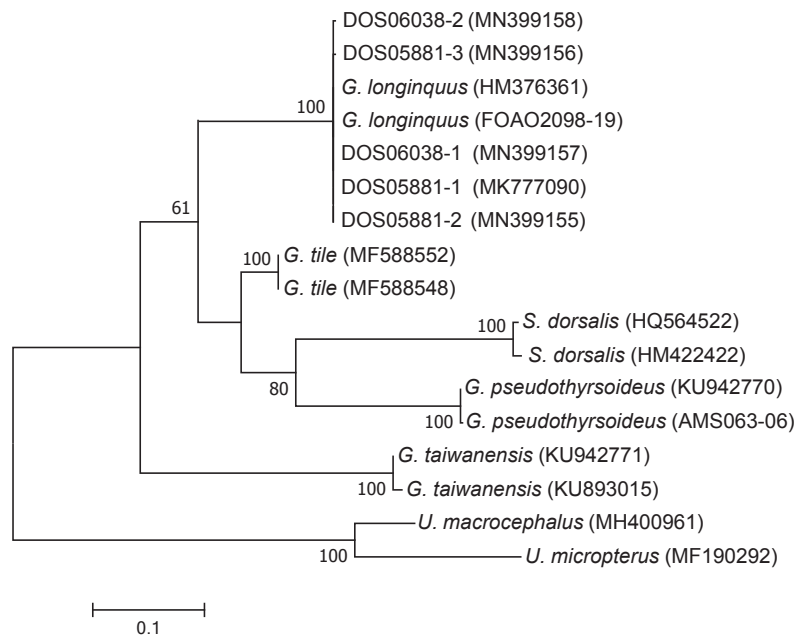


Fig. 3. The maximum likelihood tree based on GTR + I model of the partial *COI* gene sequences with *Uropterygius macrocephalus* and *U. micropterus* as outgroups; numbers beside the internal branches are bootstrap values; bootstrap values below 50 are not shown

can be distinguished from *G. pseudothyrsoides* by having shorter teeth (vs. slender and pointed) and dark fin margin (vs. white fin margin at posterior tail) (Chen et al. 1994). *Gymnothorax longinquus* differs from *G. taiwanensis* in dentition (uniserial vs. biserial in dentary and vomerine teeth) and vertebral formula (preanal and total vertebrae 58–62 and 128–137, respectively, vs. 55–56 and 117–121) (Böhlke and McCosker 2001, Chen et al. 2008). *Gymnothorax tile* is characterized by 7–12 predorsal

vertebrae and two rows of peripheral intermaxillary teeth (Mohapatra et al. 2017). The most distinguishable characters between *G. longinquus* and *S. dorsalis* are the position of eyes (at mid-jaw vs. closer to the tip of snout), dentition (dentary teeth biserial in *S. dorsalis*), preanal length (50.5%–51.9% vs. 41.0%–44.3% of TL), and vertebral formula (predorsal, preanal, and total vertebrae 8–9, 66–69, 164–167, respectively, in *S. dorsalis*) (Loh et al. 2015).

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