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Chimaera supapae (Holocephali: Chimaeriformes: Chimaeridae), a new species of chimaera from the Andaman Sea of Thailand

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Abstract. A new species of shortnose chimaera is described from a single specimen collected at 772–775 m depth in the Andaman Sea (07.54° N; 96.99° E) off Thailand. The species is distinguished from its congeners by the combination of the following characteristics: massive head with short snout; eyes relatively large, horizontally oval, eye length 32.2% head length; thin body with a relatively long trunk 40% body length (BDL), deciduous skin; uniformly dark brown; preopercular and oral lateral line canals sharing a common branch; posterior margin of pectoral fins slightly convex; long dorsal spine 27% BDL, longer than the first dorsal fin. The new species is morphologically close to *Chimaera macrospina* from Australia but differs in the length of the ventral caudal lobe, snout-vent length, and pectoral fin anterior margin length. It can be distinguished from *C. macrospina* and other *Chimaera* species based on the DNA sequence divergence of the mitochondrial ND2 gene.

Key words. Chondrichthyes, eastern Indian Ocean, SE Asia, morphology, genetics, taxonomy

INTRODUCTION

Chimaeras, ghost sharks, or ratfishes (Chondrichthyes: Holocephali: Chimaeriformes) are a small group of cartilaginous fishes that are mostly deep-sea benthic inhabitants of continental slopes and ocean ridges, usually found from depths of about 500 m and greater (Didier et al., 2012). This group comprises two mostly deep-sea families, Chimaeridae Bonaparte, 1831 and Rhinochimaeridae Garman, 1901, and a shallow-water family, Callorhinchidae Garman, 1901. Each family is characterised by a distinctive snout morphology (Didier et al., 2012). The total number of valid chimaeras species is currently 53, with the Chimaeridae comprising 42 species and the Rhinochimaeridae and Callorhinchidae with eight and three species respectively (D.A. Ebert, unpub. data).

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The family Chimaeridae is the largest family with two genera, *Chimaera* Linnaeus, 1758 and *Hydrolagus* Gill, 1862, each with 21 species (D.A. Ebert, unpub. data). These two genera are morphologically difficult to distinguish except via the fact that *Chimaera* have an anal fin separated from the ventral caudal fin by a notch, while *Hydrolagus* lacks an anal fin. However, the presence or absence of an anal fin appears to be variable in some species (Finucci et al., 2018). Since 2002, 14 new Chimaera and 10 new *Hydrolagus* species have been described (Clerkin et al., 2017; Walovich et al., 2017; Iglésias et al., 2021).

Of the 21 recognised *Chimaera* species, four have been reported in the eastern Indian Ocean (*Chimaera argiloba* Last, White & Pogonoski, 2008, *C. fulva* Didier, Last & White, 2008, *C. macrospina* Didier, Last & White, 2008, and *C. ogilbyi* Waite, 1898) and one species (*C. phantasma* Jordan & Snyder, 1900) from the western Central Pacific Ocean (Ebert, 2014; Finucci et al., 2021). Records of *Chimaera* species from the Andaman Sea off Thailand are few, with only one species, *Chimaera* aff. *macrospina*, having been recorded (Krajangdara et al., 2021).

A collaborative deep-sea survey project under the auspices of the Thailand Department of Fisheries (DoF) and the Food and Agriculture Organization (FAO) of the United Nations was conducted in the Andaman Sea off Thailand using the research vessel *Dr. Fridtjof Nansen* from October 1–15, 2018. The bottom trawl sampling was performed at various depths from 212 to 781 meters (Fig. 1). During the survey, a single specimen was collected by bottom trawl at station number 45 (07.54° N, 96.99° E) on 11 October 2018 at a depth of 772–775 m. It was one of three chimaeroid species collected during the survey and was reported as *Chimaera* aff. *macrospina* (Krajangdara et al., 2021). The other two

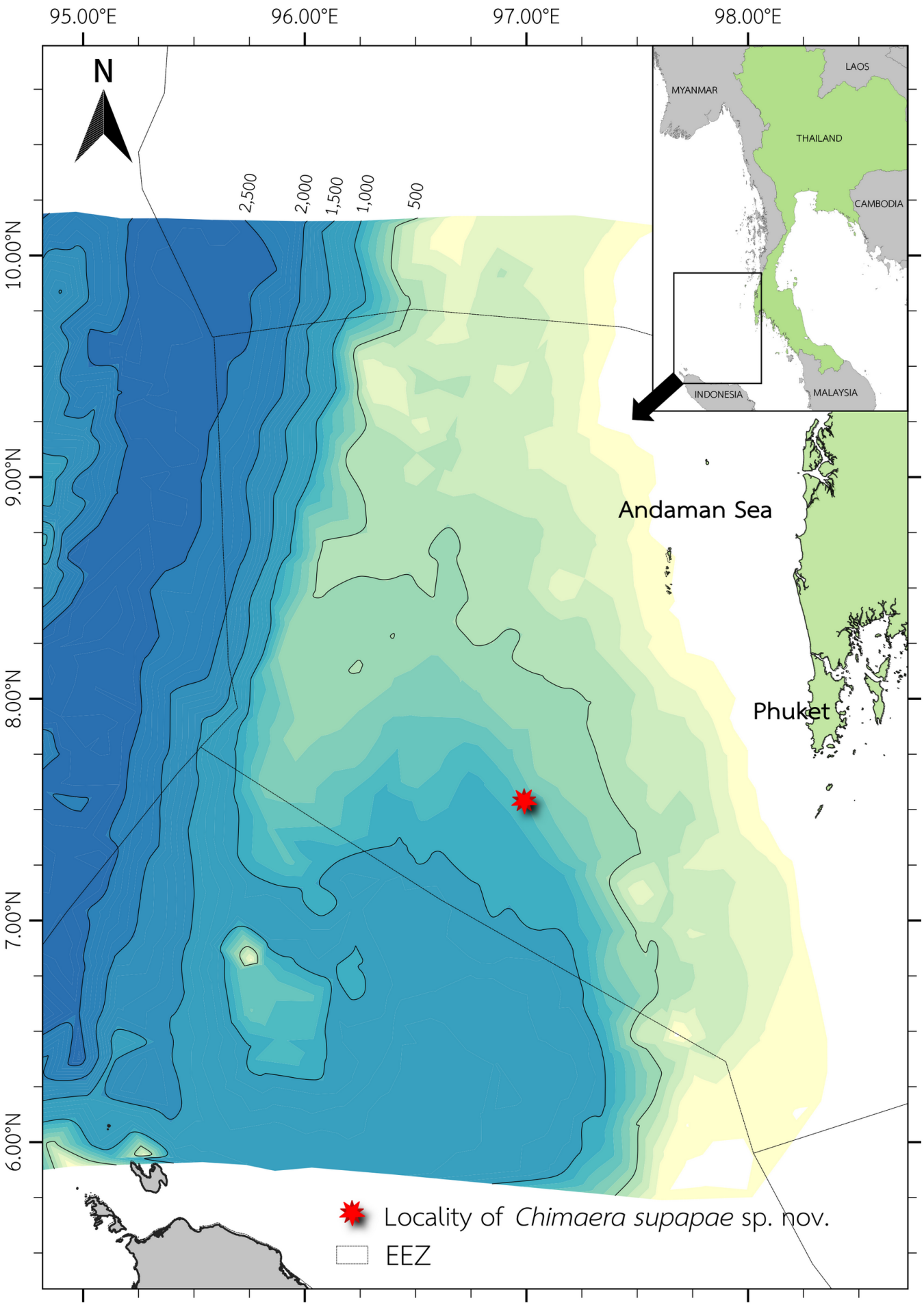

Fig. 1. Map of type locality of *Chimaera supapae*, new species, in the Andaman Sea of Thailand.

species collected were *Hydrolagus* cf. *deani* (Chimaeridae) and *Neoharriotta pinnata* (Krajangdara et al., 2021).

Upon further morphological analysis and the acquiring of additional genetic data, we conclude that the specimen previously identified as *Chimaera* aff. *macrospina* is in fact an undescribed species. Here we describe this new species as *Chimaera supapae*, new species, a new chimaeroid from the Andaman Sea off Thailand.

MATERIAL AND METHODS

Morphometric measurements were taken using measuring tape and digital Vernier callipers to the nearest millimetre (mm), with terminology generally following Clerkin et al. (2017), Walovich et al. (2017), and Iglésias et al. (2021). The holotype is deposited in the fish reference collection of the Phuket Marine Biological Center (PMBC), Thailand with the accession number PMBC 30399.

Comparative material was examined from the American Museum of Natural History (AMNH), California Academy of Sciences (CAS), Commonwealth Scientific & Industrial Research Organization, Division of Marine & Atmospheric Research (CSIRO), Florida Museum Natural History (FMNH), Hokkaido University Museum, Fisheries Science Center, Hakodate, Hokkaido (HUMZ), Museum of Comparative Zoology (MCZ) at Harvard University, Muséum National d'Histoire Naturelle of Paris (MNHN-IC), Natural History Museum New Zealand (NMNZ), South African Institute for Aquatic Biodiversity (SAIAB), Iziko South African Museum (iSAM), and National Museum of Natural History, Smithsonian (USNM). Institutional abbreviations follow Sabaj (2020). Details on the comparative material for 11 *Chimaera* species including types from the Indian Ocean and southwestern Pacific can be found in Didier, 2002; Didier et al., 2008; Last et al., 2008; Kemper et al., 2010, 2015, and Clerkin et al., 2017.

Genetic analysis. The selection of genetic markers for analyses were based on reference sequences available in GenBank and the Barcode of Life Data System (BOLD) databases. The mitochondrial COI marker was used in a previous study for this specimen and indicated a unique species (Krajangdara et al., 2021). Here, we add an additional analysis using the mitochondrial ND2 marker to support the previous finding. Eight *Chimaera* species were used in the analysis as comparative material including the five species that are closest geographically (*C. argiloba*, *C. fulva*, *C. macrospina*, *C. ogilbyi*, and *C. phantasma*), two species that were also included in the previous COI analysis (*C. opalescens* and *C. lignaria*), and *C. notafricana.*

The genetic material of the specimen was taken from the pelvic fin. Initial amplification of the mitochondrial ND2 sequence was conducted using specific primers (Naylor et al., 2012) but failed to produce clear sequence information, possibly due to tissue degradation. Due to DNA templates being degraded into short fragments, specific primers were designed for PCR amplification. For amplification of the ND2 region, the whole mitochondrial DNA sequence of *C. fulva* (GenBank accession No. HM147138.1) was used to design 4 pairs of primers (Appendix 3). Short regions of this gene were then specified, and primers were designed to cover these fragments using Primer3 (ver. 0.4.0) (Koressaar & Remm, 2007; Untergasser et al., 2012).

The ND2 region was amplified following standard PCR protocol. Successfully amplified products were visualised, purified, and sequenced. The ND2 sequence was edited and aligned to the reference sequences of the comparative *Chimaera* species using MEGA7 (Tamura et al., 2004; Kumar et al., 2016). The final alignment was 1,046 base pairs (bp). The ND2 sequence of *C. supapae*, new species, was deposited in the NCBI database (GenBank accession No. OQ885041). A phylogenetic tree was constructed from the aligned ND2 sequences using maximum likelihood (ML) estimation in MEGA7. The selected model for ML was HKY+G (bootstrap support values = 1,000 iterations). Calculation of genetic pair wise distance based on Kimura 2-parameter (K2P) using bootstrap support values of 1,000 iterations was performed in MEGAX. *Harriotta raleighana* was used as an outgroup to root the tree.

TAXONOMY

Family Chimaeridae Bonaparte, 1831

Genus *Chimaera* Linnaeus, 1758

Chimaera supapae, new species

Andaman shortnose chimaera
(Figs. 1–3; Table 1)

Chimaera aff. *macrospina*: Krajangdara et al. 2021: 219, fig. 4.

Holotype. PMBC 30399, 508 mm TL, 276 mm BDL, immature male, Andaman Sea of Thailand, 07.54° N, 96.99° E, bottom trawl between 772 m–775 m, collected by I. Jithlang, 11 October 2018.

Diagnosis. *Chimaera supapae* can be distinguished from all other chimaeroids by the following combination of characters: massive head with a short snout; eyes relatively large, horizontally oval, eye length 32.2% head length; thin and relatively long trunk 40% BDL, deciduous skin; uniformly dark brown, without any spots or stripes; preopercular and oral lateral line canals sharing a common branch; posterior margin of pectoral fins slightly convex; long dorsal spine 27 % BDL, longer than first dorsal fin.

Description. The holotype, 276 mm BDL, is an immature male (Fig. 2). Morphometric proportions of the holotype are provided in Table 1. Body elongated, tapering to a caudal fin with a filamentous tail. Head moderate sized, length 30.4% BDL, 0.2 times precaudal length, height relatively tall 24.3% BDL, postorbital head compressed. Snout short, bluntly pointed; preorbital snout 0.1 times body length,

Fig. 2. Lateral view of *Chimaera supapae*, new species, holotype (PMBC 30399), immature male, 508 mm TL, 276 mm BDL (Before preservation).

preoral length 2.7 times in head length. Trunk slightly compressed, tapering slightly to pectoral fin origins before tapering somewhat rapidly to tail, and continuing into caudal filament. Tail moderately long making up 54.0% precaudal length, short trunk, 40.2% precaudal length. Eyes large, length 9.8% BDL making up about one-third (32.2%) head length, height 0.6 times its length, and horizontally oval, located in posterior half of head, preorbital length 33.2% head length.

Lateral lines on head open, preopercular and oral lateral line canals share a common branch connecting to the infraorbital canal on both sides of the head. Mouth narrow and short, upper labial folds and furrows prominent, upper and lower furrows deep. Body slightly compressed, lateral line canal originating at the level of upper eye, forming a notch anteriorly below the dorsal spine origin; lateral line on trunk relatively straight, not undulating and running along to caudal filament. Skin smooth without denticles, strongly deciduous.

Pectoral fins are relatively broad and long, semi-falcate, with slightly convex on both anterior and posterior margins; its anterior length is 36.2% of body length and reaches slightly posterior to the origin of pelvic fin. Pelvic fins are moderately broad and large, paddle-shape with angular apex; its maximum length is about 2.1 times in pectoral maximum length. First dorsal fin is relatively long with a narrow base; its base 15.6% body length, and its height 4.6 times in body length. Dorsal spine is straight and long, taller than the soft first dorsal fin; its length more than 1.3 times first dorsal fin height and 1.1 times in head length. The origin of the dorsal spine is just over the pectoral fin origin; anterior margin of spine forms a narrow keel, not serrated; posterior distal margin of the spine is finely serrated. First dorsal is short-based and longer than preorbital length, posterior margin of fin slightly concave. Second dorsal fin is moderately low and prolonged, the upper margin relatively straight with similar height; its height 3.5 times in first dorsal fin height; its base 79.7% body length, and 5.1 times the first dorsal fin base. First dorsal and second dorsal fins are well separated, connected with a low membrane; the interdorsal space 5.8% body length. Anal fin present, the position of anal fin insertion is slightly behind the second dorsal fin insertion. Anal fin is separated from the lower caudal fin

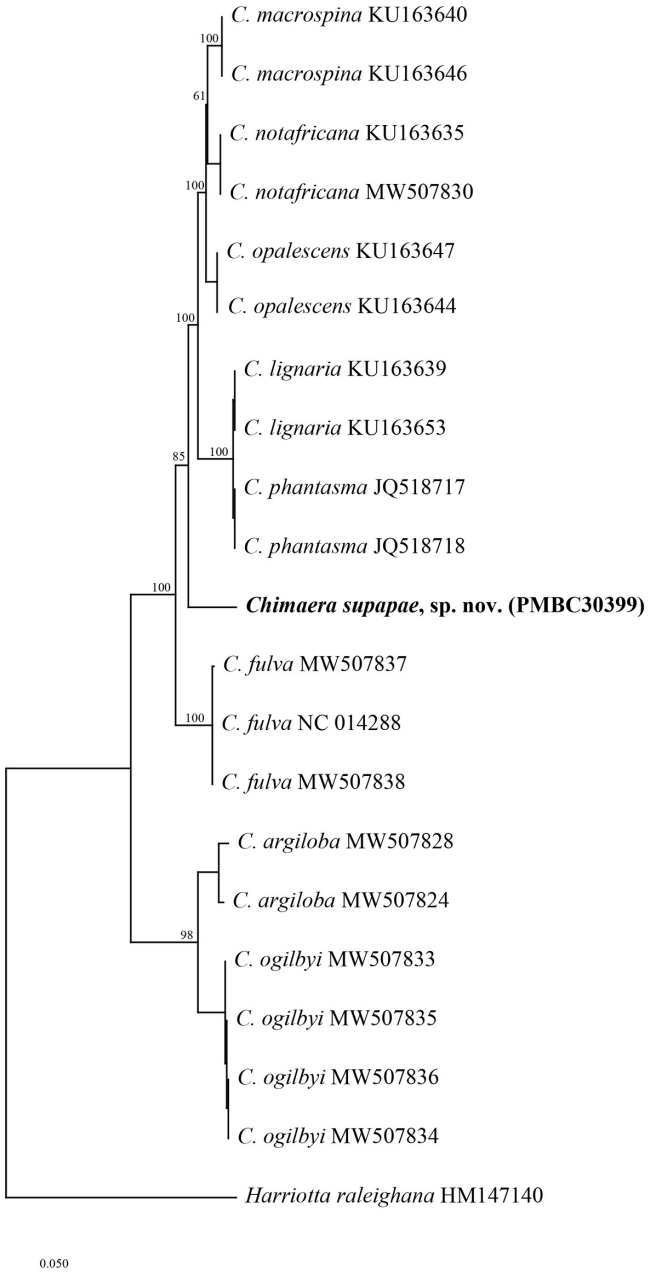

Fig. 3. Maximum likelihood tree based on mitochondrial ND2 sequences representing the relationship of the *Chimaera supapae*, new species (PMBC 30399). Numbers at nodes indicate posterior probability.

Table 1. Body length proportions (% BDL) of *Chimaera supapae*, new species, holotype (PMBC 30399), immature male 508 mm TL, 276 mm BDL.

Measurements	Holotype
Total length (TL)	508 mm
Precaudal length (PCL)	360 mm
Body length (BDL)	276 mm
Preorbital length (POB)	10.1
Prenarial length (PRN)	13.0
Preoral length (POR)	11.2
Snout-vent length (SVL)	71.4
Pre-first dorsal (PD1)	29.7
Pre-second dorsal (PD2)	48.2
Pre-pectoral (PP1)	33.0
Pre-pelvic (PP2)	65.9
Snout width (SWF)	8.0
Snout width at base (SWB)	9.1
Snout height at base (SHB)	9.4
Head length (HDL)	30.4
Head height (HDH)	24.3
Head width (HDW)	12.0
Eye length (EYL)	9.8
Eye height (EYH)	6.2
Interorbital space (INO)	6.9
Mouth length (MOL)	4.4
Mouth width (MOW)	8.0
Trunk width (TRW)	15.9
Trunk length (TRL)	40.2
Pectoral-pelvic space (PPS)	26.1
Dorsal-caudal space (DCS)	1.8
Anal-caudal space (ACS)	1.5
Interdorsal space (IDS)	5.8
Pelvic-caudal space (PCA)	62.3
Pectoral fin max. length (P1L)	36.2
Pectoral fin anterior margin (P1A)	35.1
Pectoral fin base (P1B)	8.7
Pelvic fin max. length (P2L)	17.0
Pelvic fin anterior margin (P2A)	15.9
Pelvic fin base (P2B)	5.8
First dorsal fin anterior margin (D1A)	23.9
First dorsal fin base (D1B)	15.6
First dorsal fin height (D1H)	21.7
Dorsal spine height (DSA)	27.2
Second dorsal fin base (D2B)	79.7
Maximum height of anterior of second dorsal fin (D2AH)	6.2
Maximum height of posterior of second dorsal fin (D2PH)	6.2
Second dorsal fin length (D2L)	81.2
Second dorsal fin inner margin (D2I)	2.9
Anal fin length (ANL)	6.5
Anal fin base (ANB)	3.3
Anal fin height (ANH)	4.7
Dorsal caudal margin length (CDM)	19.9
Ventral caudal margin length (CVM)	22.8
Caudal filament length (CFI)	34.1
Total caudal length (CTL)	54.0
Maximum height of upper lobe of caudal fin (CDH)	2.9
Maximum height of lower lobe of caudal fin (CVH)	2.9
Origin of D1 to origin of P1 (D1P1)	17.0
Origin of D1 to origin of P2 (D1P2)	39.5
Origin of D2 to origin of P1 (D2P1)	23.2
Origin of D2 to origin of P2 (D2P2)	22.5

lobe by a deep notch; its base 14.5% lower caudal fin lobe. The lower caudal fin is slightly longer than the upper lobe, its length about 1.1 times but the height is similar to the upper lobe, origin slightly posterior to the upper caudal fin origin. Tail filament longer than caudal fin lobes, 1.7 times the length of upper caudal lobe, and 34.1% body length. The immature male specimen has a pair of undeveloped and short claspers, equipped with poorly developed pre-pelvic tenaculae. Denticles on the medial edge are not prominent and a frontal tenaculum is not fully developed.

Colouration. Prior to preservation body and head uniformly dark brown (whitish where skin deciduous), without any noticeable spots, stripes, or longitudinal striation along tail. Head darker brown on cheek area between lower posterior of eyes and pectoral fin origin, and extending ventrally across mouth. All fins are a slightly darker brown than body trunk. Eye an iridescent green. After preservation deciduous skin, body, and tail filament a uniform pale brown, head has somewhat darker colour than body trunk, and all fins uniformly dark brown.

Distribution. Known only from the type location at 07.54° N, 96.99° E in the Andaman Sea off Thailand, eastern Indian Ocean at 772–775 m depth (Fig. 1).

Etymology. The epithet *supapae* is named to honor the late Professor Supap Monkolprasit (1934–2013), for her extensive work on the cartilaginous fishes of Thailand. She was the Dean of Faculty of Fisheries, Kasetsart University, Thailand during the years 1991–1995, but devoted her entire life to the study of cartilaginous fishes in Thailand.

DISCUSSION

Chimaera supapae is compared to 11 *Chimaera* species from the Indian and southwestern Pacific Oceans. It differs from *C. argiloba* and *C. fulva* from Australian waters based on the colouration of fresh specimens by having a dark brown colour relative to the silvery colour in both *C. argiloba* and *C. fulva*, and a total length less than 200% BDL, shorter snout (vs moderate 15–17% BDL), and a short tail (54% vs 70–80% BDL) (Last et al., 2008; Didier et al., 2008). It also differs from the southern Indian Ocean *C. compacta* which has distinct yellow blotches on its body (Iglésias et al., 2021). *Chimaera supapae* has a long dorsal spine (27% BDL), exceeding the height of the first dorsal fin, differentiating it from *C. didierae* and *C. buccanigella* from the southwestern Indian Ocean (23% BDL) (Clerkin et al., 2017). It differs from *C. lignaria* of the southwestern Pacific Ocean by having a longer tail (54% vs 30% BDL) (Didier, 2002). It differs from *C. carophila* from New Zealand waters in the height of the first dorsal fin (22% vs 13% BDL) but having shorter ventral caudal margin (23% vs 41% BDL) (Kemper et al., 2015). The new species differs from *C. obscura* from Australian waters in the tail length (54% vs 64% BDL) and has a shorter interdorsal space (6% vs 12% BDL) (Didier et al., 2008). The new species differs from *C. willwatchi* from the southwestern Indian Ocean (Clerkin et al., 2017) by having shorter dorsal and ventral caudal lobes (20% vs 27% BDL and 23% vs 36% BDL, respectively). It differs from *C. notafricana* from southern Africa (Kemper et al., 2010) with a longer head length (30% vs 22% BDL) and higher dorsal fins.

Morphological characteristics of the new species revealed many similarities to *Chimaera macrospina* from Australian waters, the eastern Indian Ocean, and the southwestern Pacific Ocean (Didier et al., 2008; Last & Stevens, 2009; Ebert, 2014; Kemper et al., 2015; Weigmann, 2016; Krajangdara et al., 2021). Moreover, *C. supapae* was compared with the holotype, paratypes, and immature male specimens of *C. macrospina*. We found that the new species differs from *C. macrospina* by having a shorter ventral caudal lobe (23% vs 28–38% BDL); slightly higher snout-vent length (71% vs 55–70% BDL); shorter anterior margin of the pectoral fin (35% vs >38% BDL), and the distance between dorsal and pectoral fins is shorter. When compared with the minimum measurements of the paratypes and immature males of *C. macrospina*, the new species has a longer first dorsal fin spine (27% vs 21–25% BDL), head length (30% vs 24–26% BDL), and interdorsal space (6% vs 2–4% BDL). Moreover, the proportions of head length/dorsal spine length, distance from posterior base of pectoral fin to anterior base of pelvic fin/head length, eye height/eye length, and dorsal spine length /max height of first dorsal fin, are different between the two species.

Genetic results. The result of genetic analysis using the ND2 marker supports the previous analysis using COI (Krajangdara et al., 2021). The maximum likelihood tree topology indicates that *Chimaera supapae* is a unique lineage which formed its own clade and does not cluster with Australian *C. macrospina* or other closely related *Chimaera* species (Fig. 3). The resulting ND2 analysis was similar to that of the COI analysis in that the new species formed its own terminal clade and showed substantial sequence divergence from other *Chimaera* species. The pairwise distance value between the new species and the reference *C. macrospina* was 7.9%, while comparing to other *Chimaera* species ranged from 7.9% to 16.4%. Overall, based on the genetic results of both the ND2 marker and the COI marker from the previous study, there is strong support for *C. supapae*, new species, from the Andaman Sea of Thailand to be a new species.

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