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A new species of the genus *Dysommina* (Teleostei: Anguilliformes: Synaphobranchidae: Ilyophinae) from the Western Pacific

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Abstract

Dysommina orientalis, a new species of Ilyophine eel from off Taiwan and Japan is described and illustrated. The species had long been recognized as *Dysommina rugosa* in the western Pacific and is distinguished from *D. rugosa* by a lower number of predorsal vertebrae, a higher number of total vertebrae, shorter head length, smaller eye size, reduced vomerine dentition, and an increased number of both mandibular and maxillary teeth, as well as significant differences in DNA sequence in COI and 16S.

Key words: Pisces, Teleostei, taxonomy, *Dysommina orientalis* **sp. nov.**, distribution

Introduction

The genus *Dysommina* and its type species, *D. rugosa*, was described by Ginsburg (1951) based on a single specimen taken off Cumberland Island, Georgia. Since the original description, *D. rugosa* has been reported to be widely distributed in the western North Atlantic from off the Carolinas to the Caribbean Sea by Robins and Robins (1989). The species is also known from off Surinam (Uyeno & Sasaki 1983), off southern Brazil (Haimovici *et al*. 1994), off Angola (Tweddle & Anderson 2008), in the Mozambique Channel (Karrer 1983), Taiwan (Chen & Mok 2001), Japan (Hatooka 1997), Vailulu'u Seamount (Staudigel *et al*. 2006) and Hawaii (Robins & Robins 1976). Recent collection of genetic samples from specimens taken off the east coast of the United States and from specimens collected off Taiwan enabled DNA barcoding which revealed significant differences in both COI and 16S sequences. Close examination of specimens from these two areas revealed subtle, but significant morphological differences enabling the description of the Taiwan and Japan specimens as a new species.

Materials and methods

General methods for morphometric and meristic data for this study are given in Böhlke (1989). Measurements were made with a 450 mm ruler to the nearest 1 mm and a digital caliper to the nearest 0.1 mm, measurements under 10 mm which were taken with an ocular micrometer. All measurements are given as a proportion of the total length (TL) except for subunits of the head which are presented as proportions of the head length (HL). Vertebral and fin ray counts were taken from radiographs. Total vertebral counts are of all elements including the hypural plate. Preanal and predorsal vertebral counts were taken using the definitions of Böhlke (1982). The number of dorsal rays anterior to the anal origin are counted back to vertical through the first anal ray base. Cyanine blue was used for staining cephalic sensory pores (Saruwatari *et al.*, 1997). Meristic and morphometric data for the type series of *Dysommina orientalis* are presented with the values of the holotype first and values of the paratypes given in brackets.

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Extractions of genomic DNA were conducted on an Auto-Genprep 965 (2011 AutoGen, Inc.), using standard phenol manufacturer protocols. Genomic DNA was eluted in 100 µl of AutoGen R9 re-suspension buffer. The DNA barcode 5' region of the COI mtDNA locus was amplified in 10 µl reactions using the FISHCOILBC (5' TCAACYAATCAYAAAGATATYGGCAC) and FISHCOIHBC (5' ACTTCYGGGTGRCCRAARAATCA) primers and protocol in Table 2 of Weigt *et al*. (2012) and a 600 base-pair segment of 16S was amplified using the primers 16Sar (5' CGCCTGTTTATCAAAAACAT) and 16Sbr (5' CCGGTCTGAACTCAGATCACGT) of Palumbi *et al*. (1991) and the same protocol as COI except for a 54°C annealing temperature. Cycle-sequence reactions were performed in both directions, using the PCR primers and BigDye Terminator v3.1 Cycle Sequencing Kit's in 0.25 x 10 µl reactions run on an ABI3730 Sequencer (2011 Life Technologies). Raw trace files were edited in Geneious 9.1.5 (Biomatters Ltd 2005–2016), complementary strands were aligned, edited, and inspected for translation. Consensus sequences were generated and deposited in GenBank under the accession numbers KY990002-KY990007 (COI) and KY990008-KY990013 (16S). Maximum-likelihood (ML) analyses were performed using RAxML (v8.2.9, Stamatakis, 2014) with the rapid bootstrap inferences (1000 replicates) and subsequent thorough ML search, with COI and 16S treated as separate partitions.

The type specimens are deposited at the Biodiversity Research Center, Academia Sinica (ASIZP), National Museum of Marine Biology & Aquarium, Pingtung, Taiwan (NMMB-P), the National Museum of Natural History, Washington, DC, USA (USNM) and the Osaka Museum of Natural History, Osaka, Japan (OMNH). Comparative material of *Dysommina rugosa* is from the National Museum of Natural History (USNM) and The Center for Marine Science, University of North Carolina Wilmington which will eventually be deposited at the North Carolina Museum of Natural Sciences (NCSM).

***Dysommina orientalis* Tighe, Ho & Hatooka, sp. nov.**

English name: Oriental arrowtooth eel; Japanese name: Suruga-anago
Figs. 1, 2, 3A; Table 1

Dysommina rugosa (not of Ginsburg): Hatooka, 1997:8; Chen & Mok, 2001:79; Shao *et al*., 2008:238; Ho *et al*., 2015:100.

Holotype: NMMB-P11131, 413 mm TL, collected from Dong-gang fishing port, Pingtung, Taiwan, collected by H.-C. Ho, 13 Sep. 2010.

Paratypes (n = 6): USNM 441667 (1, 316 mm TL; formerly NMMB-P14012), Dong-gang fishing port, Pingtung, Taiwan, 20 Oct. 2011; NMMB-P3847 (1, 290 mm TL; formerly THUP 4077). Dong-gang fishing port, Pingtung, Taiwan, 21 Mar. 1979; NMMB-P8361 (1, 258 mm TL), Dong-gang fishing port, Pingtung, Taiwan, 16 Mar. 2005; USNM 441750 (1, 325 mm TL; formerly NSYSU 3028), Dong-gang fishing port, Pingtung, Taiwan, Jan. 1996; ASIZP 57954 (1, 238 mm TL), Dong-sha Island, South China Sea, 17 Aug. 1991; OMNH-P10000 (1, 625 mm TL), Suruga Bay, Shizuoka Prefecture, Japan, 34°54'N, 138°30.5'E, 300–400 m depth, 17 Dec. 1996.

Diagnosis. A species of the genus *Dysommina* with the following combination of characters: predorsal vertebrae 11–12, total vertebrae 137–141, eye diameter less than 10% head length, vomerine dentition reduced to 3 large compound teeth set in papillose pads with a fourth small tooth more posteriorly, maxillary and mandibular teeth numerous but small.

Description. Body moderately elongate, slightly compressed in head and trunk. Pectoral fin present; dorsal-fin origin over tip of pectoral fin; anal fin origin more than 1 head length behind tip of pectoral fin. Snout projects slightly beyond tip of lower jaw. Body light greyish-brown dorsally, paler ventrally; dorsal and anal fins with light margins; posterior one third of anal-fin base and posterior one-seventh of anal fin dark.

Morphometric data of the holotype (in mm): total length 413; predorsal length 65.4; preanal length 119; tail length 294; head length 51.2; body depth at gill opening 19.6; body depth at anus 24.6; eye diameter 4.1; interorbital width 8.0; snout length 13.3; upper jaw length 24.4; lower jaw length 23.5; pectoral fin length 10.5.

Proportions as percentage of total length: predorsal length 15.8 (14.0–16.2 in paratypes); preanal length 30.0 (27.0–29.8); tail length 70.0 (70.2–73.0); head length 12.8 (12.6–15.0); body depth at gill opening 5.6 (4.9–5.3); body depth at anus 5.8 (3.7–5.9). Proportions as percentage of head length: eye diameter 8.5 (7.6–9.8); interorbital width 16.0 (17.1–19.5); snout length 25.1 (23.2–27.8); upper jaw length 48.1 (43.9–48.0); lower jaw length 44.3 (39.0–43.4). Meristic data for the holotype (paratypes in parentheses): total vertebrae 139 (137–141); predorsal vertebrae 11 (11–12); preanal vertebrae 30 (26–32); dorsal rays 310 (304–321); anal rays 295 (260–289); anal origin at dorsal ray 50 (51–60).

Cephalic lateralis pores (Fig. 2A): supraorbital 3 (3); adnasal 1 (1); infraorbital 4 (4); preoperculomandibular 6 (6). Lateral line pores absent.

TABLE 1. Morphometric and meristic data of *Dysommina rugosa* and *Dysommina orientalis*.

	D. rugosa		*D. orientalis* sp. nov.	
	Holotype	non-types	Holotype	Paratypes
Total length (mm)	194	96–318 (n=17)	413	238–625 (n=5)
% TL		Mean (range)	?	Mean (range)
Predorsal length	21.1	18.1 (16.1–21.1)	15.8	15.0 (14.0–16.2)
Preanal length	29.9	29.0 (26.3–31.0)	30.0	28.7 (27.0–29.8)
Tail Length	70.1	70.9 (69.0–73.7)	70.0	71.3 (70.2–73.0)
Head length	14.7	14.7 (13.0–15.5)	12.8	13.2 (12.6–15.0)
Depth at gill opening	6.2	5.5 (4.3–6.6)	5.5	5.2 (4.9–5.3)
Depth at anus	6.2	6.1 (3.9–6.7)	5.8	4.7 (3.7–5.9)
% HL				
Eye Diameter	12.3	12.3 (9.8–14.3)	8.5	8.7 (7.6–9.8)
Interorbital width	19.6	16.6 (14.7–20.4)	16	18.5 (17.1–19.5)
Snout length	26.3	28.2 (24.6–33.0)	25.1	25.3 (23.2–27.8)
Upper jaw length	41.7	42.6 (39.2–47.1)	48.1	45.9 (43.9–48.0)
Lower jaw length	41.4	40.4 (33.3–44.1)	44.3	41.3 (39.0–43.4)
Vertebrae				
Predorsal	14	14–15	11	11–12
Preanal	28	28–31	30	26–32
Total	127	126–132	139	137–141
Lateral Line	Absent	Absent	Absent	Absent
Head pores				
Supraorbital	3	3	3	3
Infraorbital	5	5	5	5
Adnasal	1	1	1	1
Preoperculomandibular	6	6	6	6
Fin rays				
Dorsal-fin rays	313	286–333	310	304–321
Anal-fin rays	287	257–289	295	260–289
Anal origin at DR	47	38–48	50	51–60
Dentition				
Mandibular tooth rows	3–4	3–5	6–7	5–7
Mandibular teeth (inner row)	ca. 30	20–30	ca. 45	44–50
Maxillary tooth rows	4–5	4–5	7–8	6–8
Maxillary teeth (inner row)	ca. 42	24–40	ca. 55	50–60
Intermaxillary teeth	0	0	0	0
Vomerine teeth	4	4–5	3 large + 1 small	3–4 large + 0–1 small

FIGURE 1. Holotype of *Dysommina orientalis*, NMMB-P11131, 417 mm TL; Dong-gang fishing port, Pingtung, Taiwan.

Dentition (Fig. 2B): Intermaxillary teeth absent. Three relatively large, compound vomerine teeth set in papillose pads; usually a much smaller compound tooth posteriorly on the palate. Mandibular teeth set in a band composed of 5–7 irregular rows increasing in size gradually from outer to inner with approximately 44–50 teeth in the inner row; maxillary teeth similar, but set in a band composed of 6–8 irregular rows increasing in size gradually from outer to inner with approximately 50–60 teeth in the inner row. Bands of both mandibular and maxillary teeth extend well back along the jaws.

Distribution. Known from the type specimens collected from the South China Sea off Taiwan and Dongsha Islands, and from Suruga Bay, Japan. This species is probably more widespread in the western Pacific. The bathymetric range is estimated to be 200–400 m based on the collection data of one paratype and other fishes collected together.

Etymology. The name is derived from the Latin orientalis, "of the east" and refers to the type locality in the Far East off Taiwan and Japan.

Comparison. Morphometric and meristic data for the holotype and study material of *Dysommina rugosa* and the type series of *Dysommina orientalis* are given in Table 1. One paratype, ASIZP 57954, is excluded from this comparison because it has a regenerated tail which biases all of the morphometric and meristic data.

Dysomma orientalis is very similar in overall appearance to *D. rugosa*, but differs in several key characters. The first character is the shorter predorsal length in *D. orientalis* (14.0–16.2 % TL versus 16.1–21.1 in *D. rugosa*). Related to the shorter predorsal length is a lower number of predorsal vertebrae (11–12 versus 14–15) and a higher number of dorsal rays anterior to the anal origin (50–60 versus 38–48).

The second character distinguishing *D. orientalis* from *D. rugosa* is the dentition. The number of large, compound teeth set in pads of papillose tissue is less in *D. orientalis* (3 versus 4). The position of the teeth along the vomer is also different. Figure 3 shows x-rays of the skulls of the holotype of *D. orientalis* and one of the comparative specimens of *D. rugosa*. In *D. orientalis*, the first tooth is set slightly back from the tip of the ethmo-vomer, the second is approximately halfway between the tip of the ethmo-vomer and the posterior margin of the orbit, and the third is set near the posterior third of the orbit. In *D. rugosa*, the first tooth is set near the tip of the ethmo-vomer, the second is approximately halfway between the tip of the ethmo-vomer and the anterior margin of the orbit, the third is set near the anterior margin of the orbit, and the fourth is set under the center of the orbit. In addition to the differences in the large vomerine teeth, most of our *D. orientalis* has a fourth small vomerine tooth set well back on the palate behind the orbit. *D. rugosa* does not have a corresponding tooth. There are 2 specimens, one of each species, that have an extra vomerine tooth. However, in both of these specimens, there are 2 close-set teeth that are in the same pad of papillose tissue. These pairs of teeth probably represent an original tooth that was injured and a subsequent replacement tooth. The original tooth was not injured enough to break off, resulting in both the original tooth and the replacement tooth together in a single pad.

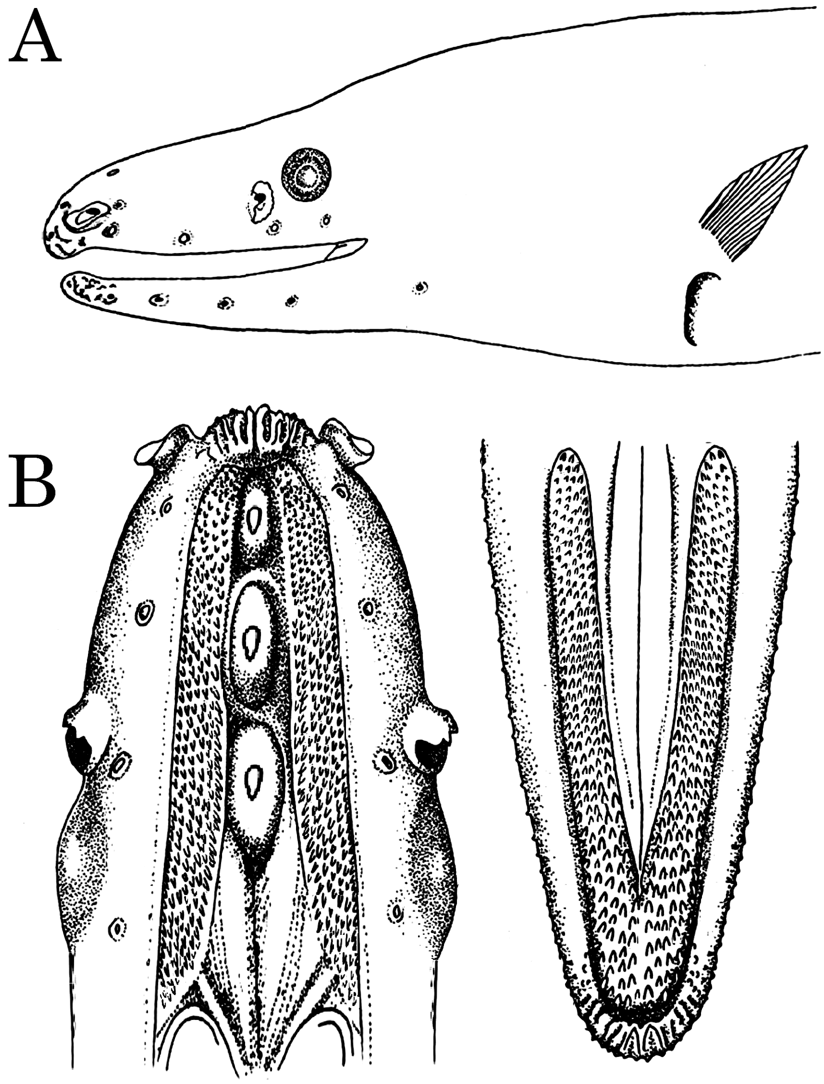

FIGURE 2. Holotype of *Dysommina orientalis*, NMMB-P11131. A. Head pores. B. Upper and lower jaws.

In addition to the differences in the vomerine dentition, there are significant differences in the mandibular and maxillary dentition. The number of tooth rows in the bands of teeth on both the mandible and the maxilla are more abundant in *D. orientalis* than in *D. rugosa*. There are 5–7 tooth rows across the mandibular tooth band in *D. orientalis* and 3–5 in *D. rugosa*. Moreover, there are 44–50 teeth in the inner mandibular row in *D. orientalis* and only 20–30 in *D. rugosa*. In the maxillary tooth bands, there are 6–8 tooth rows in *D. orientalis* and 4–5 in *D. rugosa*, and there are 50–60 teeth in the inner maxillary row versus 24–42 in in *D. rugosa*. In *D. orientalis*, both the mandibular and maxillary tooth bands extend further posteriorly than in *D. rugosa*.

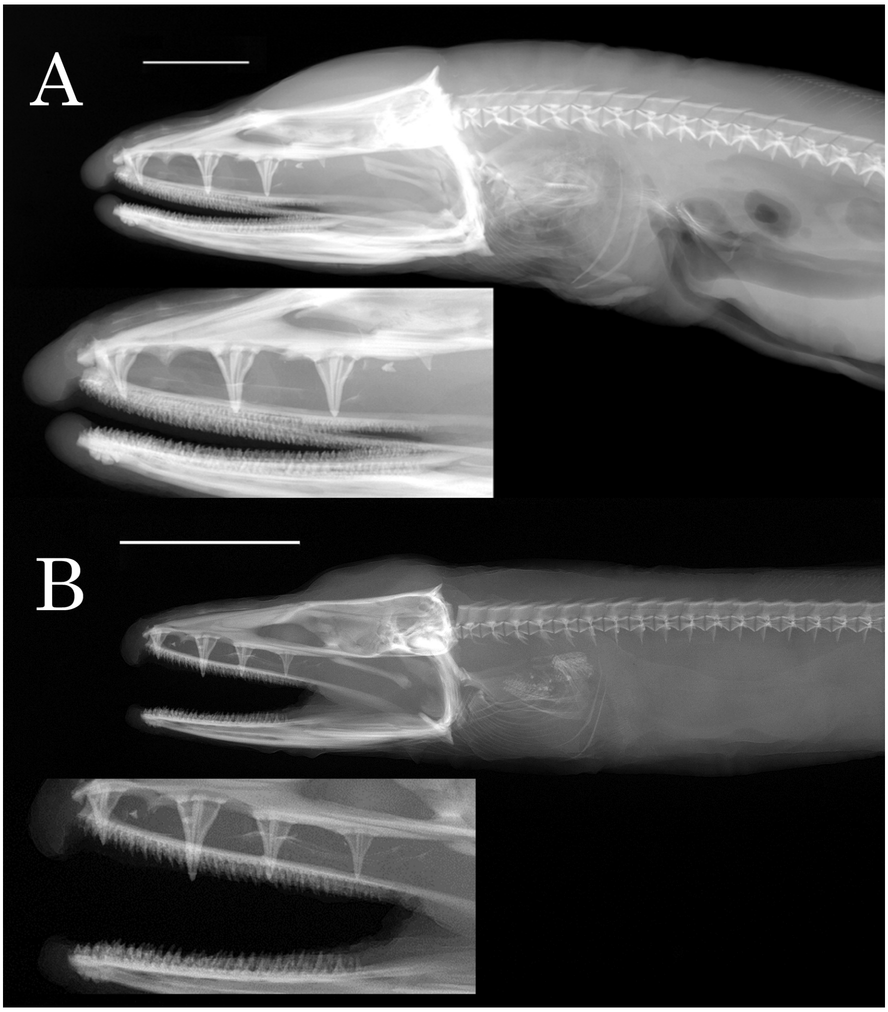

FIGURE 3. X-rays of skull and anterior body of *Dysommina* with inserts showing vomerine dentition (scale bar = 1 cm): A. Holotype of *Dysommina orientalis*, NMMB-P11131. B. *Dysommina rugosa*, USNM 441962.

The final and conclusive character that distinguishes *D. orientalis* and *D. rugosa* is the DNA sequences. Table 2 shows the distance matrices for COI, 16S and Combined. As can be seen in the table, the COI sequences for the four samples of *D. rugosa* were identical, and 7.2–7.3 % different from the two samples of *D. orientalis*. The 16S sequences for the four samples of *D. rugosa* were also identical and differed 0.8–1.0 % from the two samples of *D. orientalis*. The differences between the two species for the combined COI and 16S sequences ranged from 4.1 to 4.5 %, clearly indicating that they are two distinct species. Figure 4 is a maximum likelihood tree of combined COI and 16S sequences showing the difference between the 2 species compared to the two outgroups, *Dysomma anguillare* and *Protanguilla palau*. The high bootstrap value for the node linking *D. orientalis* and *D. rugosa* indicates the close relationship between the two species showing that they belong together in the genus *Dysommina*.

Remarks. The present species has long been recognized as *Dysommina rugosa*, a species originally described from the western Atlantic Ocean. Specimens collected from Taiwan and Japan are now described as *D. orientalis*. The records from Hawaii (Robins & Robins 1976) and specimens collected from the Solomon Islands, Philippines, Madagascar and New Caledonia (listed in Ho *et al.* 2015) as well as the specimens reported from Vailulu'u Seamount (Staudigel *et al*. 2006) are presently under study by the senior author and apparently represent several cryptic species in the genus *Dysommina*. A redescription of *D. rugosa* sensu stricto is being prepared by the senior author and will discuss the variation of this species as well as its geographic and bathymetric distribution.

TABLE 2. Uncorrected pairwise distances between *Dysommina rugosa*, *Dysommina orientalis* **sp. nov.**, *Dysomma anguillare* and *Protanguilla palau*.

	CO1		1	2	3	4	5	6	7	8
1	*Protanguilla palau*	SMLS09001	–							
2	*Dysomma anguillare*	WJC545	0.17162	–						
3	*Dysommina orientalis*	NMMB-P11131	0.1771	0.13266	–					
4	*D. orientalis*	USNM 441667	0.17789	0.13342	0.00492	–				
5	*D. rugosa*	USNM 441963	0.18168	0.1374	0.07328	0.07183	–			
6	*D. rugosa*	USNM 441964	0.18168	0.1374	0.07328	0.07183	0	–		
7	*D. rugosa*	USNM 441960	0.18168	0.1374	0.07328	0.07183	0		–	
8	*D. rugosa*	USNM 441961	0.18168	0.1374	0.07328	0.07183	0	0	0	–
	16S		1	2	3	4	5	6	7	8
1	*Protanguilla palau*	SMLS09001	–							
2	*Dysomma anguillare*	WJC545	0.11286	–						
3	*Dysommina orientalis*	NMMB-P11131	0.09522	0.06098	–					
4	*D. orientalis*	USNM 441667	0.09684	0.06364	0.00163					
5	*D. rugosa*	USNM 441963	0.09217	0.05327	0.00832	0.00997	–			
6	*D. rugosa*	USNM 441964	0.09217	0.05327	0.00832	0.00997	0	–		
7	*D. rugosa*	USNM 441960	0.0924	0.05312	0.00796	0.00996	0	0	–	
8	*D. rugosa*	USNM 441961	0.0913	0.05324	0.00826	0.00991	0	0	0	–
	CO1 + 16S Combined		1	2	3	4	5	6	7	8
1	*Protanguilla palau*	SMLS09001	–							
2	*Dysomma anguillare*	WJC545	0.14929	–						
3	*Dysommina orientalis*	NMMB-P11131	0.13781	0.10474	–					
4	*D. orientalis*	USNM 441667	0.13779	0.10502	0.00326	–				
5	*D. rugosa*	USNM 441963	0.13933	0.10458	0.04121	0.0422	–			
6	*D. rugosa*	USNM 441964	0.13933	0.10458	0.04121	0.0422	0	–		
7	*D. rugosa*	USNM 441960	0.1429	0.10464	0.04363	0.04461	0	0	–	
8	*D. rugosa*	USNM 441961	0.1387	0.10453	0.04105	0.04204	0	0	0	–

Ho *et al*. (2015) also pointed out that some members of the genus *Dysomma* have multiple rows of teeth on both jaws and lacking intermaxillary teeth which may suggest they are congeners of *Dysommina* rather than *Dysomma*. The osteology and relationships of members of the subfamily Ilyophinae are under study by the senior author and will probably result in several changes in the generic taxonomy of these eels.

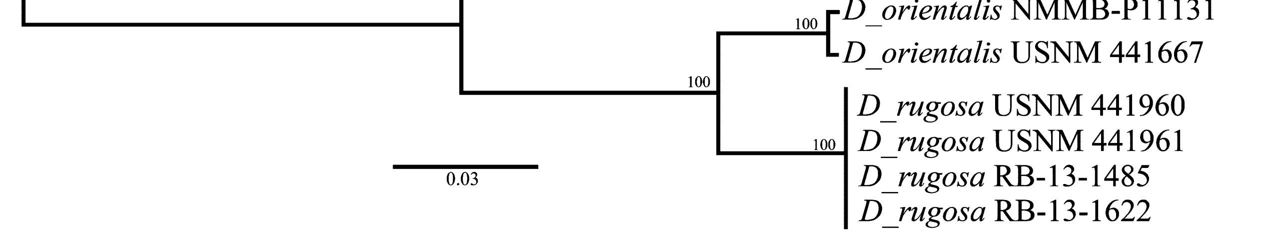

FIGURE 4. Maximum likelihood tree of *Dysommina orientalis* and *Dysommina rugosa* based on combined COI and 16S sequences.

Comparative materials. *Dysommina rugosa*: USNM 131594 (holotype, 196 mm TL), off Cumberland Island, Georgia, United States, Atlantic Ocean, 30°53'00"N, 79°42'30"W, 499 m, 5 May 1886. USNM 44324 (1, 283 mm TL), off Savannah, Georgia, United States, Atlantic Ocean, 31°09'00"N, 79°33'30"W, 644 m, 5 May 1886. USNM 179213 (1, 194 mm TL), off Florida, Gulf of Mexico, 28°16'N, 85°50'W, 439 m, 3 Dec 1962. USNM 190541 (1, 265 mm TL), Southwest of Dry Tortugas, Florida Keys, Gulf of Mexico, 24°28'N, 83°24'W, 329 m, 7 Jun 1959. USNM 200776 (1, 248 mm TL), East coast of Florida, 29°59'N, 80°09'W, 347 m, 21 Nov. 1965. Atlantic Ocean, 404.2 m, 6 Aug. 2009. USNM 441960 (1, 226 mm TL), USNM 441961 (1, 224 mm TL), off Maryland, Baltimore Canyon seep, Atlantic Ocean, 38°02'53"N, 73°49'19"W, 398 m, 16 May 2013. USNM 441962 (1), off Maryland, Baltimore Canyon seep, 414 m, 7 Sep. 2012. To be deposited at North Carolina Museum of Natural Sciences: CH-06-018 (1, 174 mm TL); JSL-05-4894 (1, 128 mm TL); JSL-4362 (1, 184 mm TL); JSL-4364 (1, 176 mm TL); JSL-4366 (3, 145-217 mm TL); JSL-4894 (2, 128-157 mm TL); ROV-2012-NF-14 (1, 193 mm TL); ROV-2013-RB-689 (2, 220-225 mm TL); SJ-02-036 (1, 210 mm TL); SJ-2004-025 (1, 96 mm TL).

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