台江國家公園七股潟湖新紀錄種：勒氏枝鰾石首魚 (Cuvier 1829)

諾哈菲斯[1]，賴建成[1]，黃光瀛[2]，陳國書[3]，陳煦森[4]，陳孟仙[1, 5, 6]

[1]國立中山大學海洋科學系；[2]台江國家公園管理處六孔管理站；[3]國家海洋研究院海洋生態及保育研究中心；[4]國立屏東科技大學水產養殖系；[5]國立中山大學海洋生態與保育研究所；[6]通訊作者 E-mail: *mhchen@mail.nsysu.edu.tw*

[摘要] 2018 年 11 月至 2022 年 12 月於台江國家公園的七股潟湖進行的魚類組成調查研究中，發現了勒氏枝鰾石首魚 (*Dendrophysa russelii*)。此魚種廣泛分布於南海熱帶海域，從東南亞延伸到海南島和中國南部。過去的研究顯示勒氏枝鰾石首魚可向北分布於中國廣東的珠江流域 (如香港，約北緯 *ca*.22º21'N)。本研究在七股潟湖內 (北緯 23º09'N)捕獲的勒氏枝鰾石首魚為台灣海域的新紀錄種，共捕獲到八尾樣本，包含一尾幼魚和七尾亞成魚，標準體長介於 57.33 到 133.22mm 之間。牠們可能是隨南海表層水來到台灣西部沿海。勒氏枝鰾石首魚可由其頰部下方具有的單一尖鬚、頸部有深棕色寬帶以及臀鰭的第二硬棘佔頭長的 38.2 至 48.1%來區分。本報告提供勒氏枝鰾石首魚詳細的測量和計數形質的數據，以及七股潟湖內及其近岸所採獲到的石首魚科魚類的清單。

關鍵字：石首魚科、南海表層水、新記錄種、魚類相

A Newly Recorded Species *Dendrophysa russelii* (Cuvier 1829) from Chiku Lagoon, Taijiang National Park, Taiwan

Norhafiz Hanafi[1], Chien-Cheng Lai[1], Kuang-Ying Huang[2], Kuo-shu Chen[3], Hsu-Sen Chen[4] and Meng-Hsien Chen[1, 5, 6]

[1]Department of Oceanography (Marine Biology group), National Sun Yat-sen University; [2]Lioukong Ranger Station, Taijiang National Park; [3]Marine Ecology and Conservation Research Center, National Academy of Marine Research; [4]Department of Aquaculture, National Pingtung University of Science and Technology; [5]Institute of Marine Ecology and Conservation, National Sun Yat-sen University; [6]Corresponding author E-mail: *mhchen@mail.nsysu.edu.tw*

ABSTRACT *Dendrophysa russelii* (Cuvier 1829), the goatee croaker, was discovered during a fish fauna survey in Chiku Lagoon, Taijiang National Park, from November, 2018, to December, 2022. The species is widespread and numerous in the South China Sea, where it is found in the tropical seas stretching from Southeast Asia to Hainan Island and southern China. Prior research revealed goatee croaker distribution in the Pearl River in Guangdong (e.g. *ca*.22º21'N, Hong Kong), China; consequently, this is a new record in Taiwan collected in Chiku Lagoon (*ca*.23º09'N). The total catch of eight samples, including one juvenile and seven in pre-adult stage, varied from 57.33 to 133.22 mm SL in standard length, indicating that they may have followed the South China Sea Current northward from the South China Sea to the Taiwan Strait. The goatee croaker could be distinguished by a single

pointed barbel on the chin, a dark brown broad band on the nape, and a long and stiff second anal spine, with a range of 38.2 to 48.1% of head length. Detailed morphometric and meristic data for this species are provided. This report also includes a list of sciaenid occurrences in Chiku Lagoon, both inshore and in the lagoon.
Keywords: sciaenidae, South China Sea Surface Current, new record, fish fauna

Introduction

Sciaenidae is a family of economically significant fishes that includes around 66 genera and 283 species found in the Indian, Pacific, and Atlantic Oceans (Fricke *et al*. 2022). The English name, Croaker, alludes to the family's distinctive vocalization, which is connected to sound production (Sasaki 1989). The dorsal fin is continuous with a deep notch between the anterior (spinous) and posterior (soft) portions; the base of the posterior portion is long, and much longer than the base of the anal fin; the swimbladder is well developed with a thick wall that is shaped like a carrot or hammer, and it has arborescent appendages. These are the traits of the Sciaenidae family (Sasaki 2001). A hydrophone was used to capture the sounds of several Taiwan sciaenid species in lagoons or large bays in order to identify the sound producer and establish its spawning places (e.g., Mok and Gilmore 1983, Lin *et al*. 2007, Mok *et al.* 2009).

Sciaenids are popular food fish that are vital to the fisheries. *Dendrophysa russelii* is a monospecies of this genus (Sasaki 2001). The goatee croaker, *D. russelii*, is a demersal marine or brackish species that lives in coastal and estuary environments with muddy bottoms and has been seen ascending tidal rivers. It is found in the Indo-West Pacific Ocean's tropical areas, from Pakistan and India to eastern Indonesia and the Philippines, and then north to northern Vietnam and southern China (Fricke *et al.* 2022).

Many studies have been published to identify the sciaenid fish species from Taiwan marine waters and its adjacent waters (Shen 1984, Yu and Shen 1987, Shen 1993, Sasaki 2001, Shao and Chen 2003, Shen and Wu 2011, Shao 2012, Chen *et al*. 2019, Koeda and Ho 2019, Shao 2022), but none mention the goatee croaker. The aim of this study is to describe *Dendrophysa russelii* as a new record in Taiwanese waters, with a list of sciaenid occurrence in the inshore and lagoon waters of the Chiku area.

Moreover, the relevance of the croaker species in the Chiku Lagoon must be confirmed since they are prey and the primary targeted food of Chinese white dolphins, *Sousa chinensis*, which live largely in the Pearl River Estuary, as well as about 60 individuals in central western Taiwan (Barros *et al*. 2004, Wang *et al*. 2016). Researchers have discovered over 20 prey fish species in their stomach contents, including yellow croaker, lion-head croaker, sardines, and anchovies (Barros *et al*. 2004). It is therefore important to know that the croaker species is found in the Chiku Lagoon where it may be a food source for Chinese white dolphins.

Material and Methods

In this study, the croakers were collected by set net from Chiku lagoon, Taijiang National Park (TJNP), in southwestern Taiwan (Figure 1), and by a modified beam trawler conducted onboard Ocean Research Vessel No. 3 and New

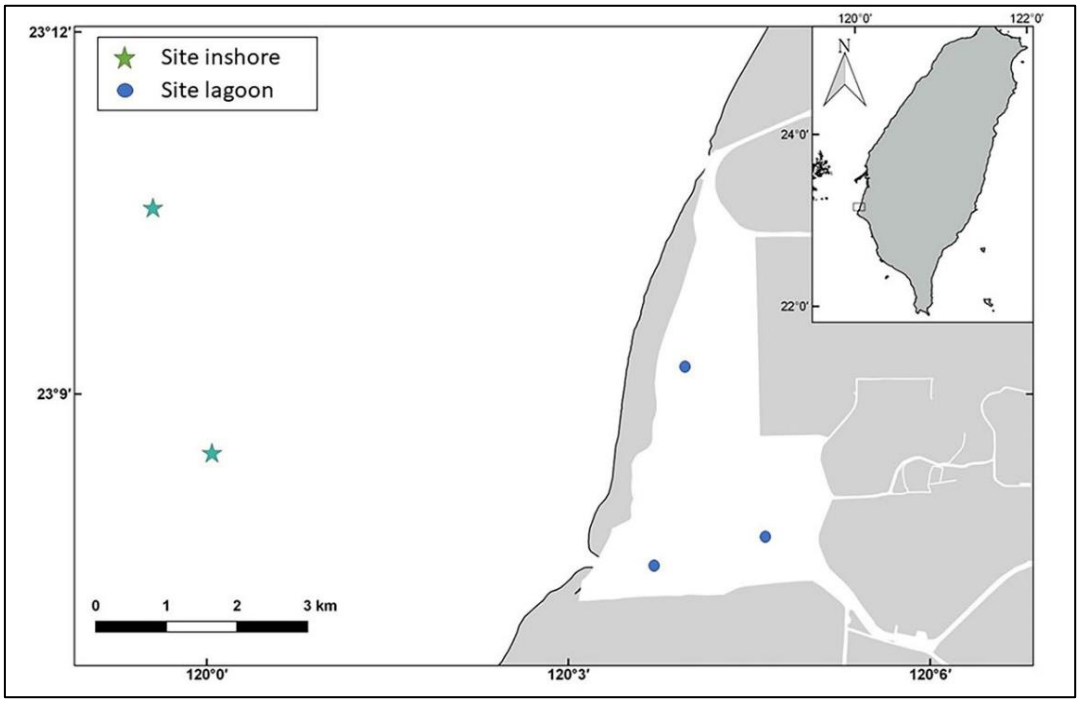

Figure 1: A map showing the sampling sites in the Chiku Lagoon and its surrounding waters

Ocean Research Vessel No. 3 in "Marine Existing Use Area 1" of TJNP, located in the coastal waters on the north side of Chiku Lagoon. The water depth is between 10 and 30 meters. The seabed here is flat, and no artificial reefs in this area so it is suitable for bottom trawling surveys by research vessels. The lagoon survey site belongs to the Taijiang National Park, which is the largest lagoon area in Taiwan. Its outside is blocked by sandbars, and limited wind means the water in the lagoon is calm, so it is suitable for fishermen to raise oysters and catch fish by set net.

All the specimens of goatee croaker are deposited in the National Museum Marine Biology and Aquarium (NMMBA), Pingtung, Taiwan (NMMBP 37188-37192). Seven meristic characters were counted employing a dissection microscope, and 19 morphometric characters were measured to the nearest mm using a fish measuring board and digital vernier following Seah *et al*. (2015) and Hanafi *et al*. (2022). Morphometric and meristic details were recorded following Hubbs and Lagler (2004) for *D. russelii*. Descriptions and identification keys have also been used to check against all species following Trewavas (1977), Sasaki (1990, 1999, 2001) and Fricke *et al*. (2022).

Results

Thirty-seven specimens of croaker fish (twenty-three sciaenid samples in the inshore waters, and fourteen sciaenid samples in the lagoon) were caught during sampling in and off the Chiku area from 2010 to 2022.

Morphometric and meristic details were recorded for *Dendrophysa russelii*; the data are presented in Table 1. The specimens of sciaenid collected in the lagoon were deposited in the fish collection of the National Museum Marine Biology and Aquarium (NMMBA), Pingtung, Taiwan; catalogue numbers NMMB-P37188-37192; NMMB-P (2) for *D. russelii*, NMMB-

Table 1. Morphometric and meristic characteristics of *Dendrophysa russelii* in the Chiku Lagoon. HL, head length; SL, standard length; ED, eye diameter.

	Voucher specimen (5 individuals)					
	NMMBP 37188	NMMBP 37189	NMMBP 37190	NMMBP 37191	NMMBP 37192	Min-Max (Ave.±SD)
Total length (mm)	116.17	75.47	135.48	133.5	165.2	75.5-165.2(120.4±0)
Standard Length (mm)	94.89	57.53	110.76	107.57	133.79	57.5-133.8(100.9±0)
Head Length (mm)	28.03	17.86	34.85	33.51	41.72	17.9-41.7(31.2±0)
Eye Diameter (mm)	7.12	4.52	7.93	7.73	9.15	4.5-9.2(7.3±0)
Meristic count						
1st dorsal-fin spine	X	X	X	X	X	-
2nd dorsal-fin spine	I	I	I	I	I	-
2nd dorsal-fin soft rays	25	24	26	23	26	23-26 (24)
Anal-fin spine	II	II	II	II	II	-
Anal-fin soft rays	7	7	7	7	7	-
Pectoral-fin rays	14	14	16	15	17	14-17 (15)
Outer gill rakers of 1st arch	13	12	13	14	13	12-14 (13)
upper limb	4	4	4	4	4	4
lower limb	9	8	9	10	9	8-10 (9)
Inner gill rakers of 1st arch	10	10	10	11	11	10-11 (10)
upper limb	3	3	3	3	3	3
lower limb	7	7	7	8	8	7-8 (7)
Pored lateral line scales	47	44	50	47	51	44-51 (47)
Scales above lateral line	6	5	5	5	6	5-6 (5)
Scales below lateral line	10	9	11	11	10	9-11 (10)
Measurements as %HL						
Snout length	26.94	26.99	28.84	27.75	26.27	26.3-28.8(27.4±1.0)
Maxillary length	46.59	44.06	44.85	44.05	43.96	44.0-46.6(44.7±1.1)
Eye diameter	25.4	25.31	22.75	23.07	21.93	21.9-25.4(23.7±1.6)
Interorbital width	22.94	22.68	22.15	21.28	21.52	21.3-22.9(22.1±0.7)
2nd spine length	48.06	46.53	38.25	38.7	39.57	38.2-48.1(42.2±4.7)
1st ray length	52.76	48.77	46.31	42.58	43.91	42.6-52.8(46.9±4.1)
Measurements as %SL						
Snout to anal-fin origin	63.8	64.18	66.48	67.71	70.64	63.8-70.6(66.6±2.8)
Snout to 1st dorsal-fin origin	36.4	36.05	36.85	35.19	35.79	35.2-36.9(36.1±0.6)
Snout to 2nd dorsal-fin origin	55.95	56.79	58.71	54.57	57.67	54.6-58.7(56.7±1.6)
Snout to pectoral-fin insertion	31.42	30.82	30.86	30.58	30.30	30.3-31.4(30.8±0.4)
Snout to pelvic-fin insertion	34.46	34.00	34.91	35.79	35.00	34.0-35.8(34.8±0.7)
Head length	29.54	31.04	31.46	31.15	31.18	29.5-31.5(30.9±0.8)
Pectoral-fin length	20.24	20.25	22.74	19.37	23.38	19.4-23.4(21.2±1.8)
Pelvic-fin length	19.93	18.62	17.56	18.09	19.19	17.6-19.9(18.7±0.9)
Body depth (D1-P2)	28.71	28.47	30.77	30.28	32.27	28.5-32.3(30.1±1.6)
Body width (P1-P1)	16.24	11.65	16.03	15.31	15.7	11.6-16.2(15.0±1.9)
1st dorsal-fin base length	23.67	24.13	25.44	23.03	24.34	23.0-25.4(24.1±0.9)
longest spine length	14.65	13.98	14.37	14.42	14.47	14.0-14.6(14.4±0.2)
2nd dorsal-fin base length	36.42	39.98	39.89	39.90	38.14	36.4-40.0(38.9±1.6)
longest ray length	10.28	11.54	9.25	8.75	8.98	8.7-11.5(9.8±1.2)
Anal-fin base length	12.02	12.85	11.07	10.80	10.53	10.5-12.8(11.5±1.0)
2nd spine length	14.2	14.44	12.04	12.06	12.34	12.0-14.4(13.0±1.2)
1st ray length	15.59	15.14	14.57	13.27	13.69	13.3-15.6(14.5±1.0)
Caudal-peduncle depth	10.24	9.06	10.55	10.09	10.06	9.1-10.5(10.0±0.6)
Measurements as %ED						
Longest gill raker on 1st arch	13.48	17.26	14.75	15.14	13.88	13.4-17.2(14.9±1.5)
Longest gill filament on 1st arch	39.33	38.72	39.09	39.84	50.60	38.7-50.6(41.5±5.1)

P37193-37194 for *Johnius belangerii* (Cuvier 1830), NMMB-P37195 for *J. borneensis* and NMMB-P (1) for *Otolithes ruber*.

Dendrophysa russelii, *J. belangerii*, *J. borneensis* and *O. ruber* specimens (Figure 2) were captured from several series survey (October to March, 2018-2022) in the Chiku lagoon during collection (see Table 2). A set net was set up in the Chiku lagoon which caught 14 specimens (8 of *D. russelii*, 4 of *J. belangerii*, 1 of *J. borneensis*, and 1 of *O. ruber*), and 23 specimens (1 of *J. amblycephalus*, 10 of *J.*

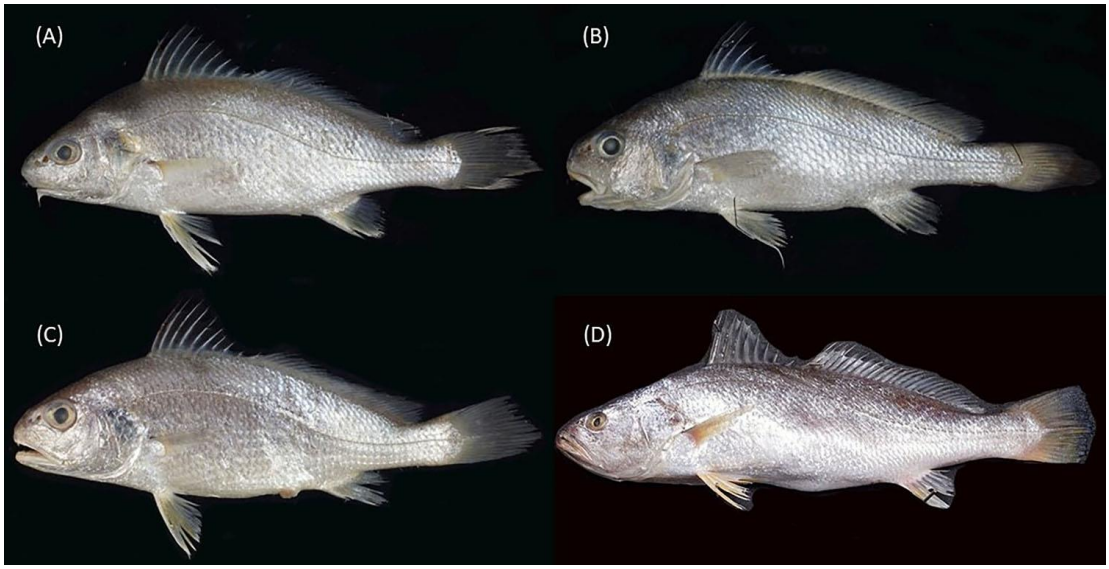

Figure 2. Photographs of the sciaenid samples collected using set nets in the Chiku Lagoon. (A) *Dendrophysa russelii*, NMMBA-P37192, 133.79 mm SL; (B) *Johnius belangerii*, NMMBA-P37194, 90.65 mm SL; (C) *Johnius borneensis*, NMMBA-P37195, 146.6 mm SL; (D) *Otolithes ruber*, NMMBA-P37700, 248 mm SL

Table 2. Morphometric information of *Dendrophysa russelii* and other sciaenids in the Chiku Lagoon (TL, total length; SL, standard length; BW, body weight). Please refer to sciaenid morphology, presented in Figure 2 (Lagoon) and Figure 3 (Inshore).

Species name	Chinese name	n	Site area	Date Collection	TL (mm) Range (Mean±SD)	SL (mm) Range (Mean±SD)	BW (g) Range (Mean±SD)
D. russelii	勒氏枝鰾石首魚	1	Lagoon	2018 Nov. 10	119.08	97.79	20.2
D. russelii	勒氏枝鰾石首魚	2	Lagoon	2021 Dec. 2	76.88-137.89	57.33-109.91	3.6-34.5
D. russelii	勒氏枝鰾石首魚	1	Lagoon	2022 Mar. 8	135.08	108.93	28.71
D. russelii	勒氏枝鰾石首魚	1	Lagoon	2022 Mar.19	164.15	133.22	59.2
D. russelii	勒氏枝鰾石首魚	3	Lagoon	2022 Oct. 11	96.4-121.79 (111.6±13.4)	75.67-96.21 (88±10.9)	11.3-22.1 (17.8±5.7)
J. belangerii	皮氏叫姑魚	1	Lagoon	2021 Sep.10	108.29	87.63	13.8
J. belangerii	皮氏叫姑魚	1	Lagoon	2022 Feb. 1	156.98	127.83	44.3
J. belangerii	皮氏叫姑魚	1	Lagoon	2022 Mar. 8	112.58	90.65	13.7
J. belangerii	皮氏叫姑魚	1	Lagoon	2022 Aug. 14	106.44	86	13.1
J. borneensis	婆羅州叫姑魚	1	Lagoon	2022 Jun. 9	177.94	146.6	73.7
J. amblycephalus	鈍頭叫姑魚	1	Inshore	2017 Dec. 9	125.21	97.92	23.81
J. distinctus	鱗鰭叫姑魚	10	Inshore	2017 Dec. 9	46.15-135.1 (106.38±28.6)	33.23-99.26 (78.25±21.8)	0.74-23.25 (14.27±7.95)
O. ruber	紅牙鮸	1	Lagoon	2022 Oct. 27	286	248	277.5
P. pawak	斑鰭白姑魚	1	Inshore	2010 Apr.30	131.43	-	29.77
P. pawak	斑鰭白姑魚	3	Inshore	2017 Dec.9	63.02-64.91 (63.73±1.03)	44.02-44.79 (44.57±0.48)	2.05-2.27 (2.22±0.15)
P. macrocephalus	大頭白姑魚	8	Inshore	2017 Dec.9	72.25-116.8 (103.13±16.2)	50.22-86.08 (74.99±12.64)	3.44-18.63 (13.17±5.62)

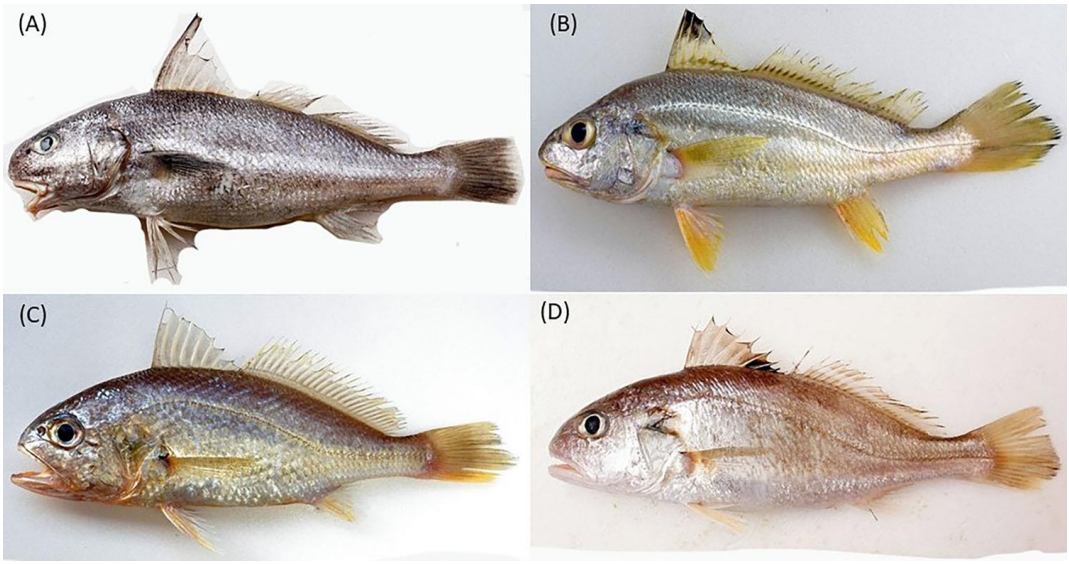

Figure 3. Photographs of the sciaenid samples collected by beam trawling in inshore sites off the Chiku Lagoon. (A) *Johnius amblycephalus*, 97.92 mm SL, (B) *J. distinctus*, 99.26 mm SL, (C) *Pennahia pawak*, 44.02 mm SL, (D) *Pennahia macrocephalus*, 86.08 mm SL

distinctus, 8 of *Pennahia macrocephalus*, and 4 of *P. pawak*) (Figure 3) were caught in the Chiku inshore area using a modified shrimp trawling net onboard OR3 research vessels.

Diagnosis genera of *Dendrophysa*. The genus *Dendrophysa* (Cuvier, 1830) is a small to medium-sized group widely distributed to the Indo-West Pacific region with monospecies in this genus (Fricke et al. 2020). The genus *Dendrophysa*, type species, *Umbrina russelii* Cuvier, 1830, designated by Cuvier (1830), has been widely applied. The genus *Dendrophysa* can be distinguished from other genera of Sciaenidae by the following character states: (i) swimbladder carrot-shaped, first bladder appendage transitional entering head, fan like; (ii) teeth of lower jaw uniform, small; (iii) sagitta, with a tadpole shaped impression, the tail bent at a sharp angle and terminally cutting into the ventral edge; and (iv) a long median single mental barbels on chin, no specialized scales (Trewavas, 1977, Sasaki, 2001).

Diagnostic character of *D. russelii.* A fairly small species with an oblong body. Snout steeply rounded, projecting slightly in front of the upper jaw; mouth inferior, upper jaw extending backward below the posterior half of the eye; a single, pointed barbel on the chin; upper rostral pores 3, marginal rostral pores 5; mental pores in 3 pairs, the first close together, opening in a common pit at the base of the barbel; teeth weakly differentiated into large and small in the upper jaw, large ones not widely spaced, forming an outer series; lower jaw teeth uniformly small. Gill rakers stiff, less than 1/2 length of gill filaments at angle of arch, 8 to 10 on lower limb of first gill arch. Dorsal fin with X spines, followed by a notch, second part of fin with I spine and 23 to 26 soft rays; anal fin with II spines and 7 soft rays, second spine long, stiff, its length 38.2 to 48.1% of head length; caudal fin rhomboidal. Scales cycloid (smoot on snout and below eye, elsewhere ctenoid (rough to touch); lateral-line scales reaching to the tip of the caudal fin. Swimbladder carrot-shaped, with about 14 to 17 pairs of fan-like appendages along its sides, the first pair entering the head beyond the

transverse septum. Sagitta with tadpole-shaped impressions, the tail of which is bent at a sharp angle and terminally cuts into the ventral edge. Color: back grey, shading to white on belly; a dark brown broad band on the nape; opercula with a deep blue blotch; upper edge of spiny part of dorsal fin dark.

According to Shao (2022), from the Fish Database of Taiwan has been mention *Dendrophysa russelii* was synonym and frequently misapplied name as *Johnius amblycephalus* in Taiwanese waters. *Dendrophysa russelii* can be resembled from similar species, *J. amblycephalus* by both species were presence a single pointed barbel on the chin which both easily can be differ by a long barbel in *D. russelii* versus a stiff short, blunt in *J. amblycephalus*. In addition, *D. russelii* can be further dissimilar with *J. amblycephalus* with long second anal spine length (38-47% vs moderate short, 24-40% of HL); scales larges, 5-6 above lateral lines (vs scales small, 7-12 above lateral lines); scales on body ctenoid (vs cycloid); caudal fin rhomboidal (vs truncate); and swimbladder carrot-shaped (vs hammer-shaped).

Discussion

1. Chiku lagoon as new dispersal ground for *Dendrophysa russelii*

Dendrophysa russelii is found from Pakistan to the Bay of Bengal (India) to southern China, the Philippines, Malaysia, and Indonesia (Mansor *et al*. 1998, Sasaki 2001, Psomadakis *et al*. 2015). Thus, the new extension of the distributional range extends to the southwest of Taiwan coastal waters. The depth range for this species is 15–40 m (Manilo and Bogorodsky 2003). This shows that this species is heavily dependent on and dominates the rivers and areas near the estuarine inlet or river mouth where nutrients are found in abundance (Lin *et al*. 2007). According to Jayasankar (1994), the length at the first maturity stage for *D. russelii* is 144 mm SL, which made all our specimens in this study under the length of the maturity stage (largest 133.22 mm SL), when they move to the low salinity habitats for feeding and to shelter from predators (Flannery et al. 2002). Meanwhile, Li *et al.* (2000) caught *D. russelii* samples at the Pearl River in Guangdong, China, mostly in the maturing stage (Male: n=106: stage III; Female: n=95: stage IV), suggesting that the goatee croaker population in Chiku lagoon may have dispersed from the early-maturing stage in southern China due to northbound warm water currents, that is, the South China Sea Current.

2. Biology and habitat of goatee croaker and sciaenid in Chiku lagoon

This benthic species lives in estuaries and coastal waters over muddy bottoms and seagrass beds. In the mangrove estuary, this species eats pelagic shrimp (Lee *et al*. 2005) and other invertebrates (Premcharoen 2014). The maximum length is 250 mm standard length and it is common to 150 mm (Sasaki 2001). Jayasankar (1994) suggested that the species may have numerous spawning events during a protracted breeding season, with a length at maturity of 144 mm SL.

Goatee croaker is a common species in the South China Sea, and it can be found in warm waters ranging from Southeast Asia to Hainan Island and southern China (Sasaki 2001). This species has also been found in the Pearl River in Guangdong (*ca*.22º21’N, Hong Kong) (Li *et al.* 2000), their most northern expansion

distribution in the Pacific Ocean. However, the recent record of this study of the goatee croaker made it a new occurrence and the most northward range extension to the southwestern part of Taiwan at *ca*.23º09'N (Chiku Lagoon). As our new occurrence finding indicates, *D. russelii* were only found in Chiku Lagoon, and nowhere else, even in inshore or other areas in Taiwan coastal waters, highlighting the importance of tropical lagoons to sciaenid fish. This could be due to the South China Sea warm current circulation, which confines tropical coastal water in southwestern Taiwan, allowing several semi-adult dispersals to the Chiku Lagoon, which is a suitable habitat with shallow and calm waves.

Chiku Lagoon is a semi-enclosed, sandy-barrier tropical lagoon in southwestern Taiwan. The ichthyofauna of Chiku Lagoon has similar components in common with other tropical lagoon systems studied in the subtropical and tropical regions (Kuo *et al*. 2001, Bruno *et al.* 2013, Yahya *et al.* 2016, Sheikh Abdul Kadir *et al.* 2019, Hussin *et al.* 2020, Ismail *et al*. 2020). The site of the discovery of goatee croakers was located inside Chiku Lagoon, and they were only distributed in the tropical lagoon in Taiwan with shallow water depth, broad salinity, and warm temperatures, which might account for the lagoon's function as a feeding and shelter ground.

3. Oceanic currents dispersal due to the South China Sea warm currents.

Eight specimens of *D. russelii*, with a range of 57.33 - 133.22 mm SL, were all premature; it is considered that they use the Lagoon as a feeding site. It is possible that this species will establish a sustainable population at its new locality. To ascertain this, additional research is required to determine the frequency of occurrence and to examine the biological traits of this species.

The distributional range of the goatee-croaker appears to follow the warm water of the South China Current (Li *et al*. 2000), whereas another current appears to be restricted to the cold waters of the China Coastal Current, which flows southward (with the northeastern monsoon) during the winter (Lim *et al*. 2021; Shen *et al*. 2011). The presence of *D. russelii* in Chiku Lagoon on southern Taiwan's coast suggests that these places are crucial for coastal fishing. Further study is clearly needed to identify the links between the water column and benthic productivity, as well as fish abundance and production. The majority of the marine fish in Chiku Lagoon are recruited from the sea outside the lagoon; oceanographic conditions must take recruitment trends into account.

The collection of specimens during this investigation might indicate the existence of a preliminary self-sustaining population of this species in Taiwanese waters, particularly in Chiku lagoon. Hence, suitable protection and management in Taijiang National Park should be provided. This species is among the new dispersion coastal fishes from the South China Sea and should be monitored from time to time for its frequency of occurrence in this lagoon.

References

Barros NB, Jefferson TA, and Parsons ECM. 2004. Feeding habits of Indo-Pacific humpback dolphins (*Sousa chinensis*) stranded in Hong Kong. *Aquatic Mammals* 30(1), 179-188.

Bruno DO, Barbini SA, Díaz de Astarloa JM, and Martos P. 2013. Fish abundance and distribution patterns related to environmental factors in a choked temperate coastal lagoon (Argentina). *Brazilian Journal of Oceanography* 61, 43-53.

Chen KS, Chen HS, Chen CY, Su YL, Meng PJ, and Chen MH. 2022. Multivariate analysis of the spatial species diversity of demersal fish assemblages in relation to habitat characteristics in a subtropical national park, Taiwan. *Marine Biodiversity* 52(1), 4.

Chen MH, Chen KS, Chen HS, and Chen CY. 2019. *The marine fishes of Taijiang National Park.* Taijiang National Park, Tainan. (in Chinese).

Flannery MS, Peebles EB, and Montgomery RT. 2002. A percent-of-flow approach for managing reductions of freshwater inflows from unimpounded rivers to southwest Florida estuaries. *Estuaries* 25(6), 1318–1332.

Fricke R, Eschmeyer WN. and Van der Laan R. 2021. Catalog of fishes: genera, species, references. Electronically accessible: an online version 8 June 2021. California Academy of Sciences, San Francisco, CA, USA. Available from: http://research. calacademy.org/ichthyology/catalog/fishcatmain.asp (accessed 10 July 2021)

Hanafi N, Chen MH, Seah YG, Chang CW, Liu SYV, and Chao NL. 2022. *Johnius sasakii*, a new species of croaker (Perciformes: Sciaenidae) with a key to *Johnius* from East Malaysia, Borneo. *Zootaxa* 5116(3), 393-409.

Hubbs CL, and Lagler KF. 2004. *Fishes of the Great Lakes region. Rev. Edition by G.R. Smith*. University of Michigan Press, Ann Arbor, Michigan, 332 pp.

Hussin WMRW, and Ab Lah R. 2020. Community structure and taxonomic diversity of macrobenthic communities in Merchang Lagoon, Malaysia. *Aquaculture, Aquarium, Conservation & Legislation* 13(6), 3593-3604.

Ismail SS, Ramli NH, Semawi NM, Kadir MAA, and Ali AN. 2020, May. Variations in physico-chemical parameters and Chl-a concentration in Setiu Wetlands lagoon during the northeast and inter-monsoon seasons 2018. In *IOP Conference Series: Earth and Environmental Science* (Vol. 494, No. 1, p. 012014). IOP Publishing.

Jayasankar P. 1994. Observations on the biology of some sciaenid fishes from Mandapam region. *Indian Journal of Fisheries* 41(2): 80-86.

Koeda K, and Ho H.C. 2020. Fishes of Southern Taiwan II. National Museum of Marine Biology and Aquarium.650pp.

Kuo SR, Lin HJ, and Shao KT. 2001. Seasonal changes in abundance and composition of the fish assemblage in Chiku Lagoon, southwestern Taiwan. *Bulletin of Marine Science* 68(1), 85-99.

Lee L, Cing CV, and Hanamura CY. 2005. Sustainable production systems of aquatic animal in brackish mangrove areas. In: *JIRCAS working report* (ed.).

Li YZ, Chen GH and Sun DR. 2000. Analysis of the composition of fishes in the Pearl River estuarine waters. *Journal of Fisheries of China* 24(4).

Lim HC, Habib A, and Chen WJ. 2021. Comparative Phylogeography and Phylogeny of Pennah Croakers (Teleostei: Sciaenidae) in Southeast Asian Waters. *Genes* 12(12), 1926.

Lin YC, Mok HK, and Huang BQ. 2007. Sound characteristics of big-snout croaker, *Johnius macrorhynus* (Sciaenidae). *The Journal of the Acoustical Society of America* 121(1), 586-593.

Manilo LG and Bogorodsky SV. 2003. Taxonomic composition, diversity and distribution of coastal fishes of the Arabian Sea. *Journal of Ichthyology* 43: S75-S149.

Mansor MI, Kohno H, Ida H, Nakamura HT, Aznan Z, and Abdullah S. 1998. *Field guide to important commercial marine fishes of the South China Sea*, SEAFDEC.

Mok HK, and Gilmore RG. 1983. Analysis of sound production in estuarine aggregations of *Pogonias cromis, Bairdiella chrysoura*, and *Cynoscion nebulosus* (Sciaenidae). *Bulletin of the Institute of Zoology, Academia Sinica.*

Mok HK, Yu HY, Ueng JP, and Wei RC. 2009. Characterization of sounds of the blackspotted croaker *Protonibea diacanthus* (Sciaenidae) and localization of its spawning sites in estuarine coastal waters of Taiwan. *Zoological Studies* 48(3), 325-333.

Premcharoen S. 2014. Feeding patterns of resident fishes in Thai mangrove estuary: Implications for conservation and sustainable use of coastal resources. *European Journal of Sustainable Development* 3(3): 201-210.

Psomadakis PN, Osmany HB and Moazzam M. 2015. *Field identification guide to the living marine resources of Pakistan*. Food and Agriculture Organization of the United Nations, Marine Fisheries Department, Ministry of Ports & Shipping, Government of Pakistan, Rome, Italy.

Sasaki K. 1989. *Phylogeny of the family Sciaenidae, with notes on its zoogeography (Teleostei, Perciformes).* Doctor's degree in Fisheries Science at Hokkaido University. 137.

Sasaki K. 1990. *Johnius grypotus* (Richardson, 1846), resurrection of a Chinese sciaenid species. *Japanese Journal of Ichthyology* 37 (3), 224–229.

Sasaki K. 1999. *Johnius (Johnieops) philippinus* a new sciaenid from the Philippines, with a synopsis of species included in the subgenus Johnieops. *Ichthyological Research* 46 (3), 271–279. https://doi.org/10.1007/BF02678513

Sasaki K. 2001. Sciaenidae. *In*: Carpenter KE and Niem VH. *FAO Species Identification Guide for Fishery Purposes.* The Living Marine Resources of the Western Central Pacific. Volume 5: Bony Fishes Part 3 (Menidae to Pomacentridae). Rome, FAO, pp. 3117–3174.

Seah YG, Hanafi N, Mazlan AG and Chao NL. 2015. A new species of *Larimichthys* from

Terengganu, east coast of Peninsular Malaysia (Perciformes: Sciaenidae). *Zootaxa* 3956 (2), 271–280.
Shao KT. 2012. The Fishes of Matsu. Lienchiang County Government. 240pp
Shao KT. 2022. The Fish Database of Taiwan. WWW Web electronic publication. http://fishdb.sinica.edu.tw, (2022-5-25).
Shao KT, and Chen JY. 2003. The fish illustrations - Taiwan more than seven hundred kinds of common fish illustrations. Yuan-Liou Publishing Company.1-431pp.
Sheikh Abdul Kadir ST, Mohamad-Norizam M, Baharim NB, Arai T, Motomura H, Husain ML, Mazlan MA and Ambak MA. 2019. Diversity and Abundance Fish Assemblages in the Setiu Wetlands, Terengganu, Malaysia. In *Greater Kenyir Landscapes* (pp. 219-241). Springer, Cham.
Shen KN, Jamandre BW, Hsu CC, Tzeng WN and Durand JD. 2011. Plio-Pleistocene sea level and temperature fluctuations in the northwestern Pacific promoted speciation in the globally-distributed flathead mullet *Mugil cephalus. BMC evolutionary biology* 11(1), 1-17.
Shen SC and Wu RK. 2011. *Fishes of Taiwan.* National Museum of Marine Biology & Aquarium.896pp.
Shen SC. 1984. Coastal Fishes of Taiwan. National Taiwan University.190pp
Shen SC. 1993. Fishes of Taiwan. Published by National Taiwan University.960pp.
Trewavas E. 1977. The sciaenid fishes (croakers or drums) of the Indo-West-Pacific. *Transactions of the Zoological Society of London* 33, 253–541.
Wang JY, Riehl KN, Klein MN, Javdan S, Hoffman JM, Dungan SZ, Dares ZE and Araújo-Wang C. 2016. Biology and conservation of the Taiwanese humpback dolphin, *Sousa chinensis taiwanensis*. In *Advances in marine biology* (Vol. 73, pp. 91-117). Academic Press.
Yahya N, Zakaria NZ, Taufeq ZM, Rosli NS, and Bachok Z. 2016. Ecology of bivalves in the lagoon area of Setiu Wetlands, Terengganu, Malaysia. *Middle East Journal of Scientific Research* 24(6), 2145-2151.
Yu LC and Shen SC. 1987. Study on sciaenoid fishes from the adjacent waters around Taiwan. *Ann. Taiwan. Mus* 30:665-133. (In Chinese with English abstract).