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Length–Weight Relationships and Condition Factor of Two Deep Water Dragonet Species from the Bay of Bengal, Bangladesh

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Abstract

The present study reports on biometric indices comprising length–weight relationships (LWRs), condition factors, and length frequency distributions of two dragonet fish species (*Callionymus profundus* and *Callionymus carebares*) from the Bay of Bengal, Bangladesh. A total of 92 specimens were collected from two fish markets (Nesarabad and Haringhata) and from a fisherman's catch who performed fishing near to the swatch of no ground in the Bay of Bengal. The value of the growth coefficient *b* of LWR ($BW = aTL^b$) was calculated as 2.4498 (male) and 2.735 (female) for *C. carebares* and 2.4098 (male) and 2.801 (female) for *C. profundus*, with a regression coefficient (r^2) above 0.95 for both species. The average calculated condition factor (K_F) were 0.383 (male) and 0.388 (female) for *C. profundus* and 0.555 (male) and 0.734 (female) for *C. carebares*. These results represent the first study of LWRs for these fish species, which may help in management and conservation of the species in the whole country, including its geographical distribution.

Keywords Biometric indices · Dragonet fishes · Condition · Bangladesh waters

Introduction

Dragonets are small, benthic fish of the diverse family Callionymidae found in the tropical and temperate waters of the western Indo-Pacific, North Atlantic and Eastern Atlantic including Mediterranean regions (Siddik and Hanif, 2020). They are mainly marine species but a few of them also inhabit in freshwater and estuarine habitats (Fricke and Golani 2013). A total of 196 species of dragonets under 20 genera has been discovered worldwide (Froese and Pauly, 2022) of which *C. carebares* is native to the Western Indian Ocean, covering the Gulf of Oman, Gulf of Aden, Persian Gulf, and south Indian coast (Gulf of Mannar) and *C. profundus* had previously been reported from the Red Sea (Gulf of Aqaba), Israel, captured at a depth of 410–480 m.

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Length–weight relationship (LWR) is a useful tool that assists to estimate approximate weight or length when solely one of these value is known and other is practically unavailable of a particular species (Chaklader et al. 2016; Hanif et al. 2018; Roshith et al. 2021; Landa and Antolínez, 2018). The parameters of LWR can describe basic biological aspects of a fish species, providing useful information for fisheries management plans and fish diversity conservation measures (Teixeira da Silva et al. 2021; Hanif et al. 2020). The condition factor is useful in determining physiological status, while the length frequency distribution is for the age, growth, and stock status of a species (Tran et al. 2021; Sutton et al. 2000; Froese and Binohlan 2000).

The Bay of Bengal, a northernmost part of the Indian Ocean harboring diversified fish species (Chaklader et al. 2018; Siddik et al. 2018) provides critically important breeding, feeding and nesting ground for migratory and native fish, shellfish and other aquatic fauna. In recent years, several species of dragonets have been recorded from the Bay of Bengal, though their richness is very low (Siddik and Hanif 2020; Habib and Islam 2020). Due to residing in deep water coupled with a low population abundance, the information of LWR for most dragonet species have yet not been investigated. Therefore, considering the demand for their baseline information to support fisheries management, the present

study estimated LWR of two dragonet species including *C. profundus* and *C. carebares* captured from the Bay of Bengal, Bangladesh.

Materials and Methods

The samples for the present study were collected occasionally between October 2020 and September 2021 from two fish markets, Nesarabad (Pirojpur district) and Haringhata (Barguna District), and from a fisherman's catch who performed fishing near the 'Swatch of No Ground' (21°39′52.5"N 89°35′11.4"E) (Fig. 1) using a gill net having a mesh size of 2 inches (50 mm). All specimens were found together with *Nemipterus japonicus*, which is a demersal species. All specimens were transported to the laboratory using an ice box for identification and subsequent data collection. Specimens were identified up to species level with the validation of scientific names in FishBase. Length observations (TL) were measured to 0.01 cm using a Vernier caliper, and body weight (BW) was measured up to 0.0001 g using a Shimadzu analytical balance (model: ATY-224). The length weight relationships ($W = aL^b$) were calculated from the log transformed equation: log (W) = log (*a*) + *b*log (TL), where W is the total weight (g), TL is the total length (cm), *a* is the intercept, and *b* is the slope. Additionally, the coefficient of determination (r^2) and 95% confidence limits of regression parameters *a* and *b* were estimated. We also calculated the length frequency distribution (%) using length data and Fulton's condition factor using the formula, $KF = (W/L3) * 100$.

Results

The investigated species were *C. profundus* and *C. carebares*, according to their morphometric traits. Overall, 50 specimens of *C. profundus* (33 male and 17 female) and 42 specimens of *C. carebares* (27 male and 15 female) were examined for LWR, condition factor, and length frequency distribution. In case of *C. carebares*, the percentage of small and large individuals were very low and specimen in length

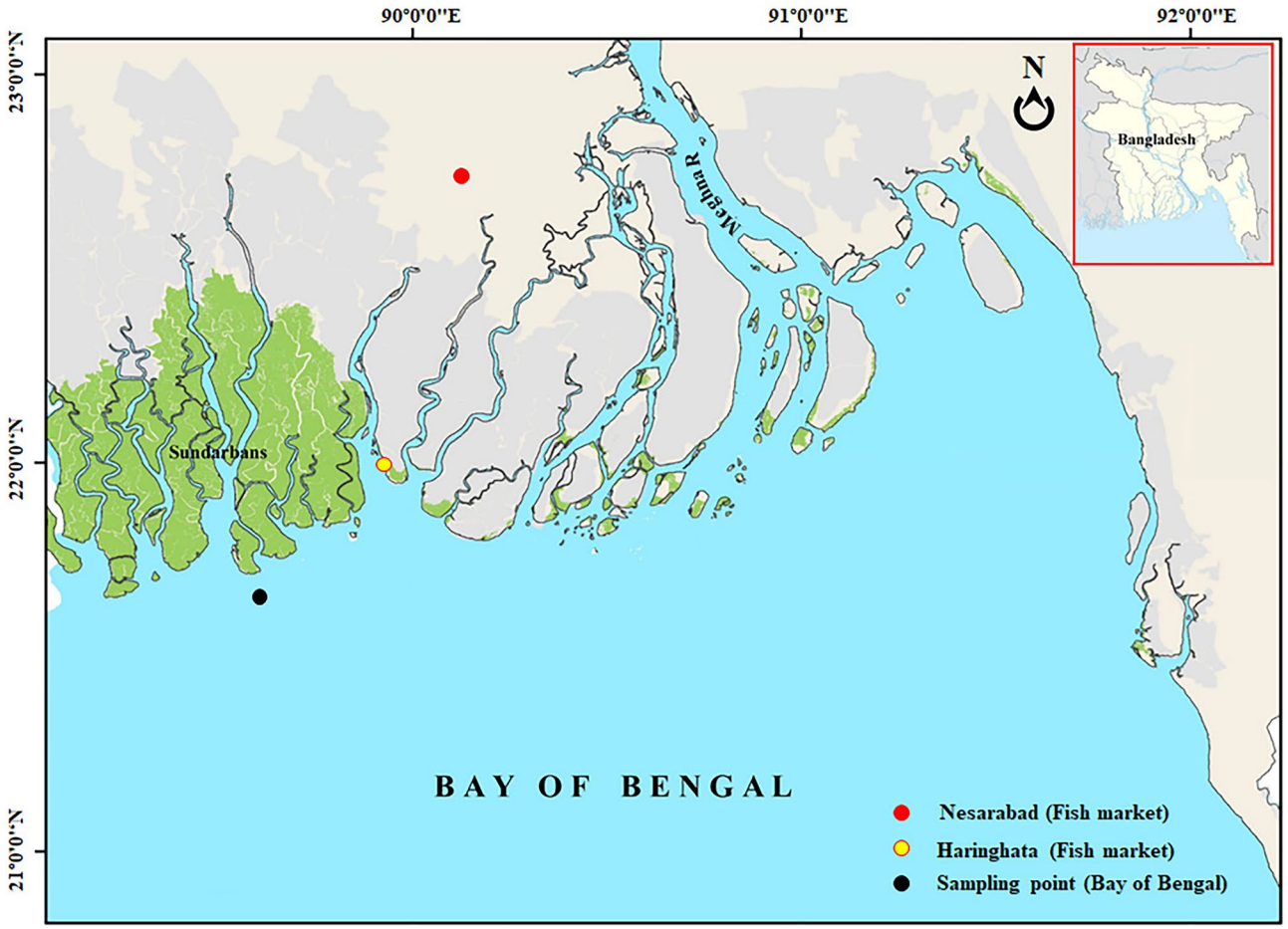

Fig. 1 Sampling points of two dragonet species, captured from the Bay of Bengal, Bangladesh between October 2020 and September 2021

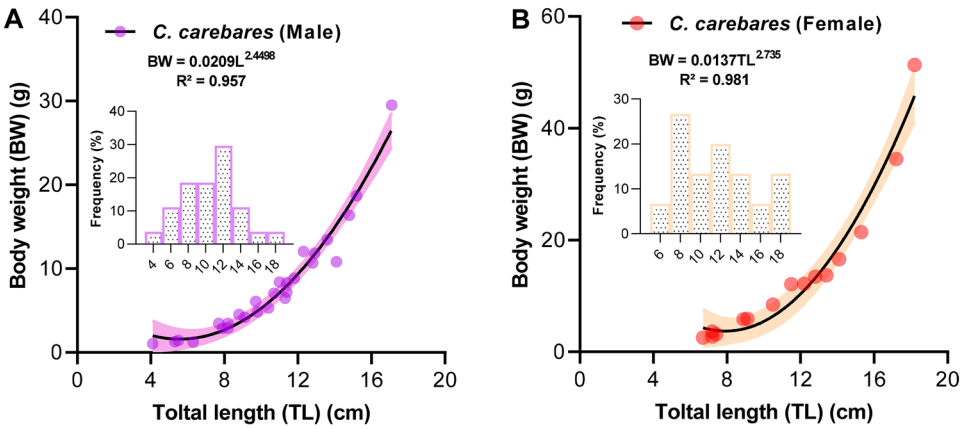

Fig. 2 Length frequency distribution and length–weight relationship and length frequency distribution of *C. carebares* from different sampling areas

class 12 was relatively higher for male while percentage of length class 8 individual was maximum for female (Fig. 2A, B). Whereas, large specimen was comparatively higher and specimen in length class 14 found maximum for male *C. profundus* while female in length class 9 and 10 found abundant (Fig. 3A, B). Table 1 summarizes the data, including sample size, total length (TL), body weight (BW), LWRs of 95% confidence intervals of *a* and *b*, coefficient of determination (r^2), and growth type for male and female of each species. The estimated *b* values of male and female were 2.4017 and 2.801 of *C. profundus* and 2.4498 and 2.735 for *C. carebares*. The coefficient of determination value (r^2) was above 0.95 for male and female both species. The maximum specimen (above 20%) was found in a 14 cm size group for both species; however, *C. carebares* was also abundantly found in an 8 cm size group. The calculated condition factor (K_F) ranged from 0.290–1.204 and 0.320–0.535 for male and female of C. profundus while in case of C. carebares it ranged from 0.386–1.509 and 0.569–0.973 for male and female respectively (Fig. 4).

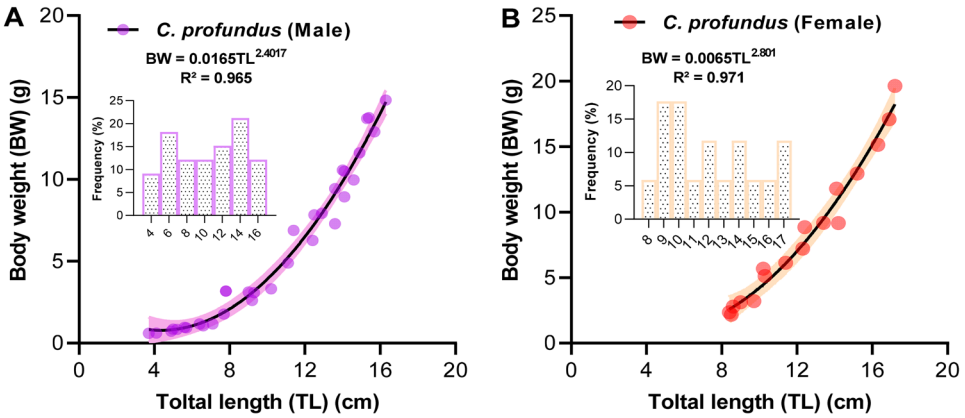

Fig. 3 Length frequency distribution and length–weight relationship and length frequency distribution of *C. profundus* from different sampling areas

Table 1 Statistical description for two dragonet fish from the Bay of Bengal, Bangladesh, between October 2020 and September 2021

Species	Sex	n	Total length (cm)		Weight (g)		Regression parameters					
			Min	Max	Min	Max	*a*	*b*	SE (b)	r^2	95% CI *a*	95% CI *b*
Callionymus profundus Fricke & Golani (2013)	Male	33	3.7	16.3	0.62	14.84	0.0165	2.4017	0.358	0.968	0.0097–0.0132	2.0.296–2.583
	Female	17	8.4	17.2	2.17	19.63	0.0065	2.801	0.046	0.971	0.0049–0.0092	2.707–2.924
Callionymus carebares Alcock 1890	Male	27	4.1	17.1	1.04	29.52	0.0209	2.4498	0.105	0.957	0.0106–0.0297	2.301–2.561
	Female	15	6.7	18.2	2.53	51.31	0.0137	2.735	0.084	0.981	0.0102–0.0217	2.607–2.845

Discussion

The biometric indices of two dragonets species studied here were found between September and April covering the season autumn to spring. Whilst no specimens availability in the months May to August (summer and rainy season) might be due to their habitat nature being normally occurred at a depth of 130–135 m where nets may not reach them because of a rise water level in the rainy season. The studied species were first reported from the Bay of Bengal two years ago which may be the probable cause for their low abundance in this new area. Thus the present study was conducted with very few specimens; however, Dulcic and Glamuzina (2006), Lei et al. (2018), Bok et al. (2011), Borges et al. (2003), Ozen et al. (2009), Gonçalves et al. (1997) and Veiga et al. (2009) also conducted their study on dragonets species with few ($n < 30$) individuals. Within the collected specimens, the abundance of male population were significantly higher (males were almost doubled than female) for both species indicating that female population may be naturally low in the study area. In general, the regression parameters *a* and *b* of LWRs reflect the environmental factors and rates of development and growth of the population (Wang et al. 2018). However, maximum lengths were recorded during the study period for both *C. profundus* (17.2 cm TL) and *C. carebares* (18.2 cm TL) compared to previous studies and available online data (fishbase) but the length could be bigger if fishing could be done in deeper water, as reported by fishermen. The values of parameter *b* in LWRs for female *C. carebares* fell within the recommended range (2.5 and 3.5) (Froese 2006), but it was lower for male. The similar result was observed for *C. profundus*. Several researchers i.e., Silva et al. (2013), Gonçalves et al. (1997),

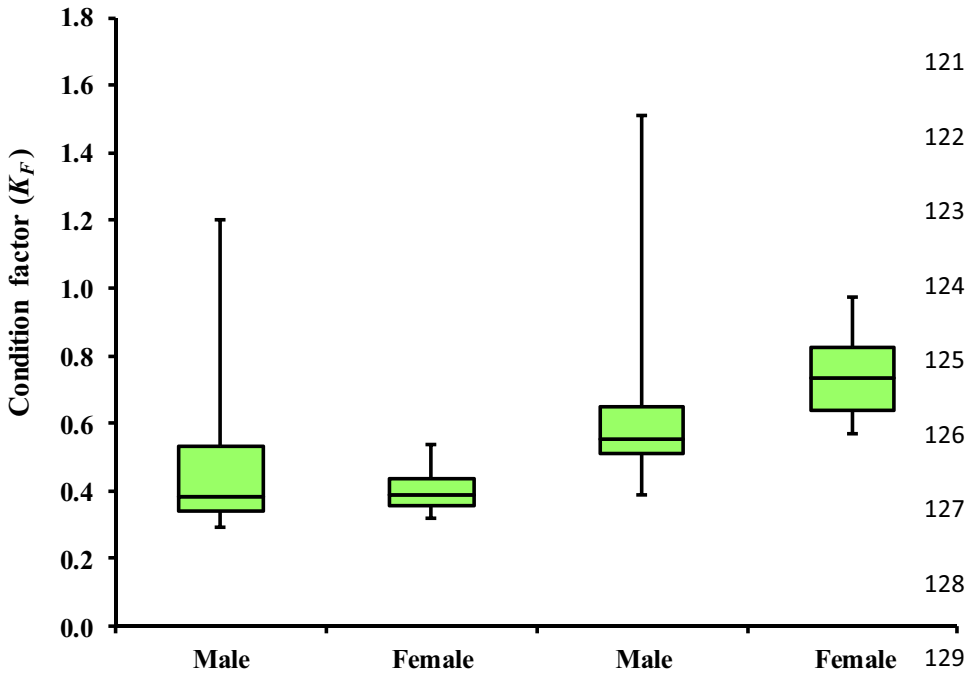

Fig. 4 Sex specific condition factor (K_F) of *C. carebares* and *C. profundus* from different sampling areas

Table 2 Comparisons of length–weight relationship parameters of different dragonet species from different geographical location

Species	Source	n	Total length (cm)		Weight (g)		Regression parameters				References
			Min	Max	Min	Max	*a*	*b*	SE	r^2	
Callionymus lyra	Marmara Sea	345	6.0	22.2	1.07	60.40	0.019548	2.6136	0.0713241	0.7965	Daban et al. (2020)
	Sea of Marmara	87	6.4	22.6	1.65	66.53	0.0087	2.832	-	0.966	Bok et al. (2011)
	Sea of Marmara	99	6.5	22.5	-	-	0.021	2.554	0.077	0.918	Demirel and Dalkara (2012)
	France	38	-	-	-	-	0.0700	3.02	-	0.9953	Bauchot and Bauchot (1978)
	South coast, Portugal	24	17.5	26.9	-	-	0.11020	2.117	-	0.750	Gonçalves et al. (1997)
	Algarve coast, Portugal	235	16.2	29.6	-	-	0.10530	2.107	-	0.838	Santos et al. (2002)
	Algarve, Portugal	31	15.0	28.3	-	-	0.05630	2.310	-	0.864	Borges et al. (2003)
	Arade Estuary, Portugal	24	7.2	21.9	-	-	0.00780	3.020	-	0.993	Veiga et al. (2009)
	Cantabrico, Spain	56	8.0	27.0	-	-	0.01400	2.709	-	0.980	Pereda and Villamor (1991)
	North Sea and English channel	1226	2.0	24.0	1.00	99.00	0.0272	2.5574	-	0.9340	Silva et al. (2013)
	Celtic Sea	622	4.0	30.0	1.0	164.00	0.0199	2.6373	-	0.9665	
	North Sea	287	6.0	25.0	2.00	82.00	0.0218	2.5881	-	0.9022	
	Irish sea and Celtic Sea (BT)	1287	3.4	27.0	0.40	150.00	0.0187	2.7169	-	0.9436	
	Western English Channel	604	5.0	31.0	1.00	173.00	0.0188	2.6534	-	0.9574	
	Irish Sea and Celtic Sea (GOV)	806	5.0	31.0	1.00	173.00	0.0148	2.7707	-	0.9368	
Callionymus maculatus	Celtic Sea	124	7.0	16.0	3.00	21.00	0.0430	2.1697	-	0.7669	Silva et al. (2013)
	North Sea	206	6.0	16.0	1.00	18.00	0.0474	2.1387	-	0.8298	
	Western English Channel	135	5.0	16.0	1.00	18.00	0.0136	2.5930	-	0.9201	
	Irish Sea and Celtic Sea (GOV)	565	4.0	18.0	1.00	51.00	0.0351	2.3248	-	0.8341	
	British Isles	1041	4.0	18.0	1.00	14.00	0.0369	2.2653	-	0.8178	
	Central Aegean Sea	49	4.6	8.6	-	-	0.0066	3.13	-	0.975	Ilkyaz et al. (2008)
	Cantabrico, Spain	80	3.0	12.0	-	-	0.00674	2.846	-	0.940	Pereda and Villamor (1991)
	Alexandria, Egypt	37	4.5	17.0	-	-	0.00270	2.670	-	0.978	Abdallah (2002)
	Arade Estuary, Portugal	51	5.0	16.2			0.0094	2.93	-	0.994	Veiga et al. (2009)
Callionymus reticulatus	British Isles	141	4.0	15.0	1.00	14.00	0.0296	2.3367	-	0.8285	Silva et al. (2013)
	Arade Estuary, Portugal	37	2.5	7.2	-	-	0.01780	2.550	-	0.952	Veiga et al. (2009)
	North Aegean Sea, Greece	58	4.1	7.6	-	-	0.02060	2.379	-	0.800	Lamprakis et al. (2003)
Callionymus filamentosus	Northeastern Mediterranean	341	7.2	17.5	3.24	41.89	0.0142	2.792	-	0.987	Erguden et al. (2016)
	Eastern Mediterranean coast	92	5.8	10.2	-	-	0.0000265	2.835	0.016	0.96	Taskavak, and Bilecenoglu (2001)
Callionymus pusillus	Marmara region	20	3.8	10.7	-	-	0.03137	2.00	-	0.975	Ozen et al. (2009)
	Mar Menor lagoon, Spain	12	6.9	13.4	-	-	0.01309	2.572	-	0.960	Borges et al. (2003)

Santos et al. (2002), Borges et al. (2003), Lamprakis et al. (2003), and Ozen et al. (2009) found *b* values below the expected range for *C. lyra*, *C. maculatus*, *C. reticulatus* and *C. pusillus* during their surveys in the Irish Celtic Sea, North Sea, British Isles, South and Algarve coast of Portugal, Aegean Sea and Sea of Marmara (Table 2). While working on sex specific LWRs of dragonet species, Demirel and Dalkara (2012), and Erguden et al. (2016) found comparatively higher *b* value in female than male but not below expected range as like the present study. Except Bauchot and Bauchot (1978), Veiga et al. (2009), Ilkyaz et al. (2008), and Lamprakis et al. (2003), all other researchers found negative allometric growth ($b < 3$) for dragonet species (Table 2). The absence of specimens below 3 cm, less number of maximum length group and presence of majority middle length group could influence regression coefficient in the present study. In addition, the value of *b* might attributed by seasons, sex, stomach fullness, habitat, size range, type of length used and growth phase (Islam et al. 2017). However, the regression coefficient value ($0.9 \leq r^2 < 1$) indicates a normal growth pattern for both species (Hanif et al. 2022). The condition factor (K_F) of fish is normally found between $0 < K_F < 2$; its mean value should be near 1 for normal fish, but the low calculated result in this study indicated a really skinny and long fish. The value of the condition factor increases with improving nutritional status (Heincke 1908). But Clark (1928) found a correlation between the condition factor and the amount of fat content of a species. So, the condition factor is highly correlated with sex, size, season, and degree of gonad development and fat content of a particular species (Froese 2006). More detailed studies should be performed, especially on the basic biology, habitat suitability, food habits, and suitable water quality for these dragonet species in relation with biometry indices. Nevertheless, the present report provides baseline data which could provide some sense of directions for further studies to improve management plans and conservation of dragonet species in the Bay of Bengal.

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Data Availability Statement The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Competing/Conflict of Interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Table 2 (continued)

Species	Source	n	Total length (cm)		Weight (g)		Regression parameters				References
			Min	Max	Min	Max	*a*	*b*	SE	r^2	
Callionymus risso	Marmara region	42	2.4	6.4	-	-	0.01407	2.71	-	0.974	Ozen et al. (2009)
	Sea of Marmara	15	11.6	18.2	10.13	38.60	0.0079	2.929	-	0.999	Bok et al. (2011)
	Erdek Bay (Sea of Marmara)	13	3.2	7.0	-	-	0.0137	2.705	0.460	0.938	Keskin and Gaygusuz (2010)
	Arade Estuary, Portugal	134	2.5	6.9	-	-	0.00122	2.810	-	0.962	Veiga et al. (2009)
	Northwest Aegean, Greece	62	2.2	4.5	-	-	0.01710	2.536	-	0.937	Koutrakis and Tsikliras (2003)
	Adriatic, Croatia	12	2.5	8.4	-	-	0.00190	2.675	-	0.950	Dulcic and Glamuzina (2006)
	North Aegean Sea, Greece	22	4.3	14.7	-	-	0.00650	3.059	-	0.990	Lamprakis et al. (2003)
Callionymus curvicornis	Samniang Bay	29	7.3	17.4	2.0	20.6	0.00937	2.75	-	0.953	Lei et al. (2018)
Callionymus margaretae	Southwest coast of India	45	4.9	25.2	1.9	16.9	0.117	2.5020	-	0.9558	Kottappilly Surendran et al. (2020)

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