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SHORT COMMUNCATION

Length-weight relationships and Fulton's condition factors of two flatfishes, *Cynoglossus cynoglossus* and *Cynoglossus lingua*, from Cox's Bazar coast, Bay of Bengal

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Abstract. Length-weight relationships (LWRs) and Fulton's condition factor were estimated for two flatfishes, *Cynoglossus lingua* Hamilton, and *Cynoglossus cynoglossus* (Hamilton), from the Cox's Bazar coast of Bangladesh. Sampling was done from September to November 2022 from the landing center of Bangladesh Fisheries Development Corporation. In this study, the maximum total length of *C. cynoglossus* (34.0 cm) is a new record for this species. The length-weight relationships for these two species were highly significant ($P < 0.001$) with adjusted r^2 values of 0.918 and 0.927 for *C. lingua* and *C. cynoglossus*, respectively. The calculated growth coefficient (b) for *C. lingua* and *C. cynoglossus* was 2.873 and 3.359, respectively. The estimated Fulton's condition factor (Kn) was 0.42 ± 0.05 for *C. lingua* and 0.72 ± 0.11 for *C. cynoglossus*. No information about the population parameters of *C. lingua* from the Bay of Bengal has been reported previously in any scientific database. The maximum Kn value of *C. lingua* was observed in the 13.0–15.9 cm length class while that of *C. cynoglossus* was found in the 31.0–33.9 cm length class. Our estimated LWR and Fulton's condition factor values for these two flatfishes can be useful for management and conservation.

Keywords: *Cynoglossus cynoglossus, Cynoglossus lingua*, maximum length, population study

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Introduction

Bengal tongue sole, *Cynoglossus cynoglossus* (Hamilton), and long tongue sole, *Cynoglossus lingua* Hamilton, are commonly known as flatfish mainly found in shallow marine or brackish waters. Adults usually inhabit the muddy and sandy bottoms of estuaries, continental shelves, and tidal rivers (Rahman 2005, Kuiter and Tonozuka 2001). These flatfishes feed on benthic invertebrates (Rainboth 1996). Both flatfishes belong to the order Pleuronectiformes and the family Cynoglossidae (Hamilton, 1822). *C. cynoglossus* and *C. lingua* are mainly found in Bangladesh, Thailand, Myanmar, India, Vietnam,

western Indonesia, and the estuaries of Pakistan (Froese and Pauly 2022). In Bangladesh, these two flatfishes are primarily found inhabiting the muddy bottoms of shallow marine and brackish waters in coastal areas. While flatfishes are frequently found at fish markets in the coastal districts of Bangladesh, they are not widely consumed by locals. The market value of flatfish is comparatively lower (approximately 1 USD/ Kg) than that of other marine fishes.

Some features that can be used to distinguish between these two flatfishes are reported in FishBase (Froese and Pauly 2022). Dorsal and anal spines are absent in both species, but dorsal and anal soft rays are present in varying numbers. A total of 126–138 dorsal soft rays and 97–114 anal soft rays are found in *C. lingua*, while the number is lower in *C. cynoglossus* at 95–102 and 72–78, respectively (Froese and Pauly 2022). In the long tongue sole, the eyed side is reddish-brown, and occasionally there are large black blotches and brown-black areas on the gill cover (Munroe 2001). No dark blotches are observed on the body of *C. cynoglossus,* and the dorsolateral line usually undulating (Munroe 2001). Both species have very elongated bodies and eyes with a small interorbital space (Munroe 2001). The scales are comparatively large on *C. lingua* with ctenoid scales on the eyed side and cycloid ones on the blind side of the body (Munroe 2001).

Length-weight relationships (LWRs) and Fulton's condition factors (Kn) are two of the main parameters used in fishery research (Froese 2006, Yedier x et al. 2021). The length-weight relationship is very useful for determining the weight of fishes based on their lengths (Baek et al. 2015, Siddique et al. 2015a, Bostanci et al. 2017, Yedier et al. 2020). Among other parameters, length-weight data can be used to estimate the total biomass of fish populations (Froese 1998, Moutopoulos and Stergiou 2002). Furthermore, LWRs are used to determine other aspects including fish health, age, and growth rates and to make regional comparisons and to assess the environmental suitability of particular species (Froese et al. 2011, Jellyman et al. 2013). The LWRs of various marine and estuarine fishes have been published in many regional journals based on a limited number of specimens and erroneous estimations, where intercept a and slope *b* of the regression for many species did not satisfy Bayesian length-weight predictions, which stemmed from inappropriate data collection methods and analysis (Siddique et al. 2021a, 2021b). Condition factor formulas have been developed to assist in assessing the state of fish health. Condition factor decreases with increased fish length and is influenced by the reproductive cycle. Fulton's condition factor is used widely to measure anthropogenic impacts on fishes (Morton and Routledge 2006). A mainstay of fishery research, Fulton's condition factor is also used as a gauge for recent eating behavior (Cone 1989). Therefore, the main objectives of the present study were to estimate the LWRs and Fulton's condition factor of two flatfish species collected from the Bay of Bengal.

Materials and Methods

Study area and sampling procedure

A total of 414 individuals of *C. lingua* and 139 individuals of *C. cynoglossus* were used to estimate LWR and Kn values. Specimens were collected from the Bangladesh Fisheries Development Corporation (BFDC) fish landing center, Cox's Bazar, Bangladesh (Fig. 1). Sampling was conducted from September to November 2022. The fish specimens collected were preserved in an icebox and length-weight measurements were performed immediately after collection at the sampling site. Species identification was made following Froese and Pauly (2022). Juveniles were discarded from this study and specimens of different sizes were collected to ensure accurate results (Siddique et al. 2014). The total lengths and body weights of 553 specimens were measured. The total length (TL) was measured to the nearest 0.1 cm with a Vernier caliper, and total wet body weight (W) was determined with a portable electronic balance (A&D Co. Ltd., Korea) to the nearest 0.01 g (Siddique et al. 2015a, 2015b).

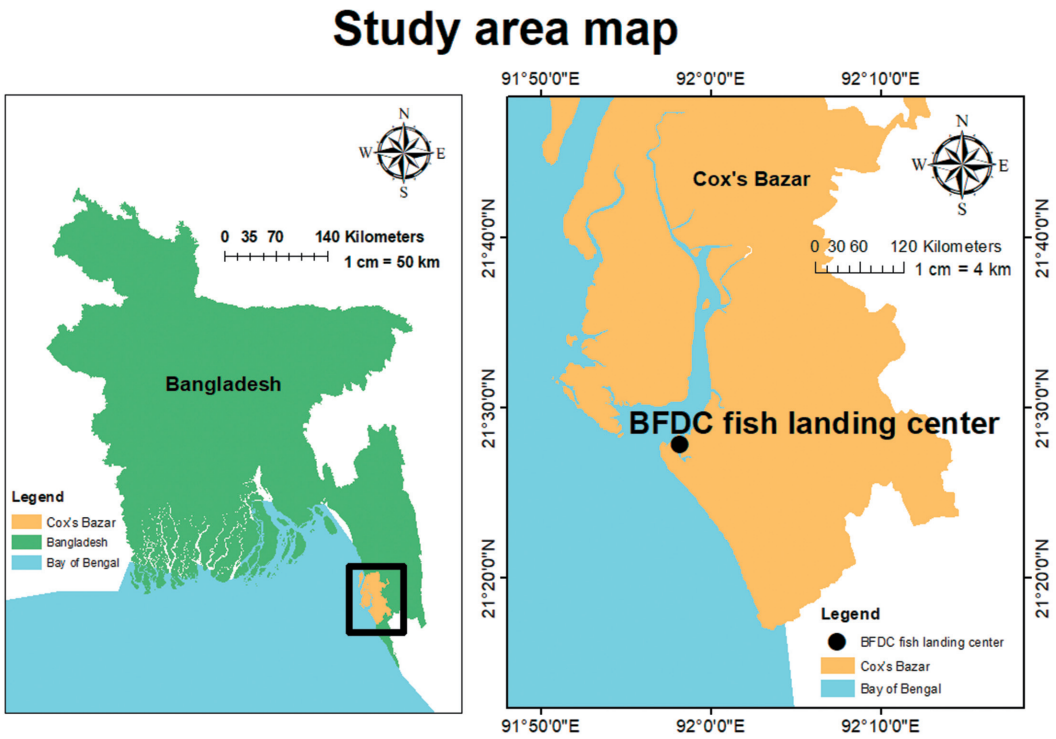

Figure 1. Sampling locations of *Cynoglossus lingua* and *Cynoglossus cynoglossus* collected from the BFDC fish landing center, Cox's Bazar, Bangladesh.

Data analysis

All the data collected were analyzed with PAST V4.11. In accordance with Froese (2006), the length-weight data for the two flatfishes were collected very carefully. Regression analysis outliers were inspected visually, and extreme values were eliminated.

Applying exponential regression analysis, the LWRs of these flatfishes were estimated (least-squares method). The parameters of the LWRs were estimated using the Le Cren (1951) equation:

$$W = aTL^b \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

After the length-weight values were logarithmically transformed, this equation was written as:

$$\log W = \log a + b \log TL \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where W is the total wet body weight of the fish (g), and TL is the total length of the fish (cm). Again, a is the intercept of the regression curve (coefficient related to body form), and *b* is the regression coefficient (exponent indicating isometric growth, when b = 3). The coefficient of determination (r^2) was estimated as an indicator of the quality of linear regression (Scherrer 1984). The hypothetical value of isometry (3) was calculated, and the 95% confidence interval (CI) of *b* was calculated to see if it fell within these bounds (Froese 2006). The following equation was used to compute Fulton's condition factor (Kn):

$$Kn = 100 \times W/TL^3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where W = wet body weight (g) and TL = the total length of fish.

Results and discussion

In the present study, the maximum TL values for *C. lingua* and *C. cynoglossus* were 30.4 cm and 34.0 cm, respectively, with that of *C. cynoglossus* being a new record. The maximum TL of *C. lingua was* recorded

Table 1
Descriptive statistics and length-weight relationships for two flatfishes from the Bay of Bengal. N – sample size, Min – minimum, Max – maximum, a and b parameters of length-weight relationship, CL – confidence limits, SE (b) – standard error of slope b, r^2 – coefficient of determination

		Total length (cm		Body weight (g)		Regression parameters					
Species	N	Min	Max	Min	Max	a	95% CL of a	b	95% CL of b	SE (b)	r^2
Cynoglossus lingua	414	13.2	30.4	11	130	0.0061	0.0045–0.0088	2.873	2.754–2.976	0.044	0.918
Cynoglossus cynoglossus	139	16.5	34.0	21	287	0.0023	0.0014–0.0038	3.359	3.201–3.521	0.081	0.927

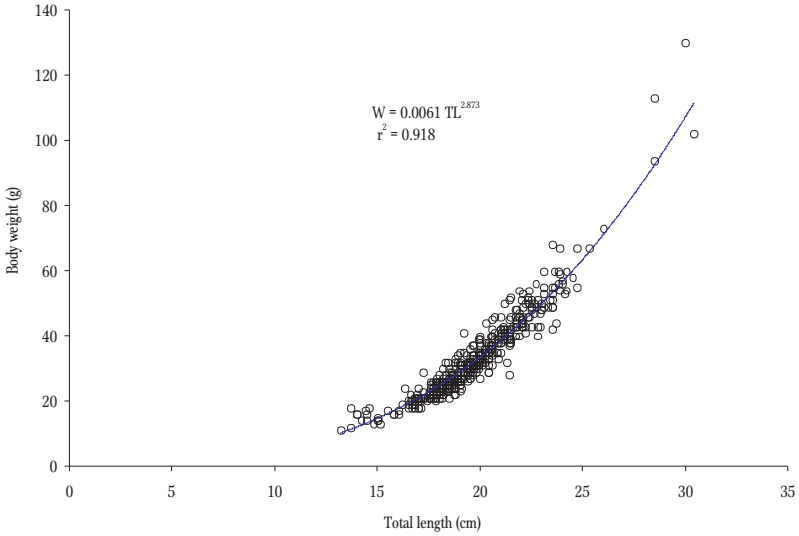

Figure 2. Total length-weight relationships of *Cynoglossus lingua* collected from the Bay of Bengal on an arithemetic scale.

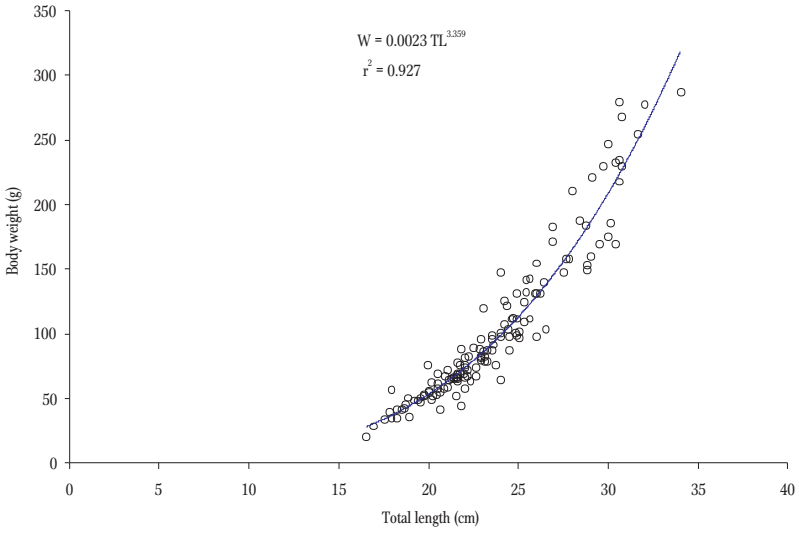

Figure 3. Total length-weight relationships of *Cynoglossus cynoglossus* collected from the Bay of Bengal on an arithmetic scale.

at 45 cm (male/unsexed) (De Bruin et al. 1995), while the maximum TL of *C. cynoglossus* was 20 cm (male/unsexed) (Munroe 2001).

The mean TL and weight values for for *C. lingua* were 19.8 ± 2.4 cm and 33.9 ± 13.6 g, and for *C. cynoglossus* they were 23. 7 ± 3.8 cm and 105.1 ± 61.6 g. The descriptive statistics and estimated parameters of LWRs for *C. lingua* and *C. cynoglossus* are presented in Table 1. Differences between *C. lingua* and *C. cynoglossus* in LWRs were highly significant ($P < 0.001$), and adjusted r^2 values were 0.918 and 0.927 for *C. lingua* and *C. cynoglossus*, respectively (Figs. 2 and 3). The estimated value of the growth coefficient (b) was 2.873 and 3.359 for *C. lingua* and *C. cynoglossus*, respectively. In terms of growth type, *C. lingua* exhibited hypo-allometric or negative allometric growth ($b < 3$), while *C. cynoglossus* exhibited hyperallometric or positive allometric growth ($b > 3$). The range of exponent *b* should normally fall between 2.5 and 3.5 (Carlander 1969, Froese 2006). When *b* values fall outside the acceptable range of 2.5–3.5, they are generally considered to be erroneous (Ricker 1975). However, the estimated b

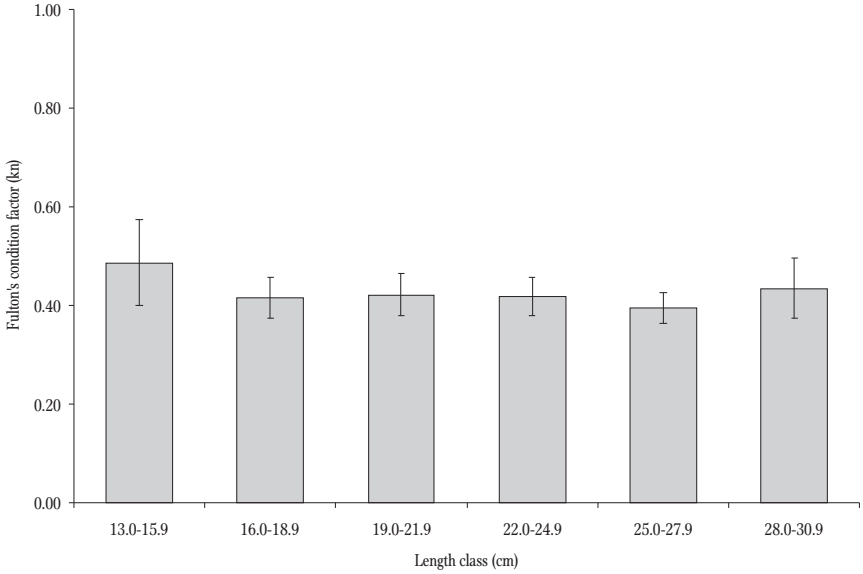

Figure 4. Fulton's condition factor (Kn) of *Cynoglossus lingua* collected from the Bay of Bengal. Data presented as mean ± SD.

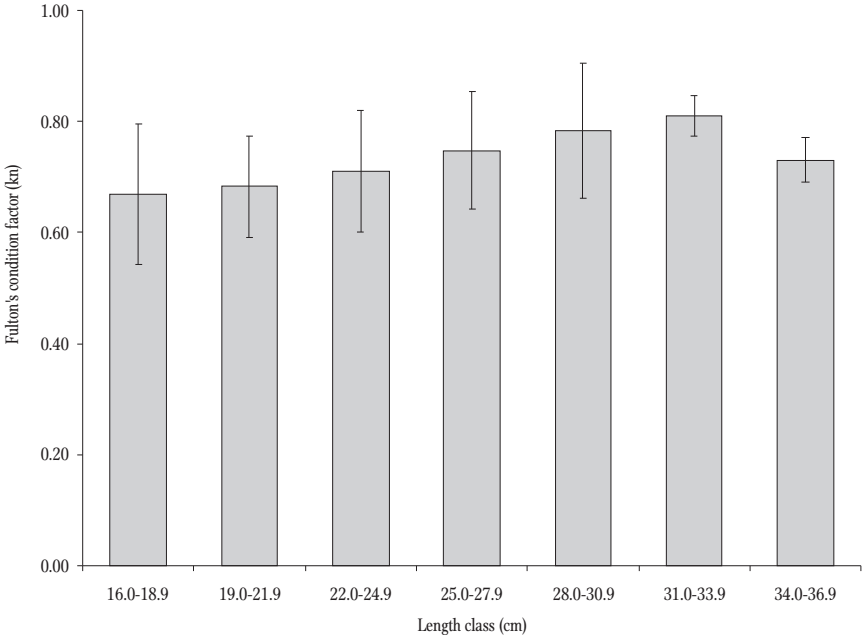

Figure 5. Fulton's condition factor (Kn) of *Cynoglossus cynoglossus* was collected from the Bay of Bengal. Data presented as mean ± SD.

values for *C. lingua* and *C. cynoglossus* were within the acceptable range of 2.5 < b < 3.5. No information regarding the LWRs of *C. lingua* from the Bay of Bengal has ever been reported or documented in FishBase. The a and *b* values calculated for *C. cynoglossus* from Cochin Coast, India were reported as a = 0.0040 and b = 3.155, which are close to those in the present study.

The Fulton's condition factor values were calculated separately for *C. lingua* and *C. cynoglossus* from the area studied. The mean Kn value of for *C. lingua* was 0.42 ± 0.05, and for *C. cynoglossus* it was 0.72 ± 0.11. The maximum Kn value of *C. lingua* was observed in the 13.0–15.9 cm length class, while for *C. cynoglossus* it was in the 31.0–33.9 cm length class (Figs. 4 and 5). However, no significant

differences in Kn were observed among the different length classes (P > 0.05) for either *C. lingua* or *C. cynoglossus*.

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Declaration of competing interests. The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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