FISHERIES & AQUATIC LIFE (2021) 29: 223 - 229
Archives of Polish Fisheries
DOI 10.2478/aopf-2021-0024

RESEARCH ARTICLE

Size frequency, LWRs, LLRs, and Fulton's condition factor of Burmese gobyeel, *Taenioides buchanani* (Day, 1873), collected from the Hatiya Island, Meghna River estuary, Bangladesh

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Received – 29 October 2021/Accepted – 16 December 2021. Published online: 31 December 2021; ©Inland Fisheries Institute in Olsztyn, Poland
Citation: Siddique M.A.M., Hossain M.S., Uddin A., Islam M.J. (2021). Size frequency, LWRs, LLRs, and Fulton's condition factor of Burmese gobyeel, *Taenioides buchanani* (Day, 1873), collected from Hatiya Island, Meghna River estuary, Bangladesh. Fisheries & Aquatic Life 29, 223-229.

Abstract. Size frequency, length-weight relationships (LWRs), length-length relationships (LLRs), and Fulton's condition factor (Kn) were studied in an estuarine fish, *Taenioides buchanani* (Day), from Hatiya Island in the Meghna River estuary. Specimens were caught with fixed purse nets of two mesh sizes (0.51–1.27 cm and 5.08–6.35 cm) from February to April 2021. The maximum total length of female *T. buchanani* (37 cm) is a new record for this species. The length-weight relationships (LWRs) for male, female, and unsexed *T. buchanani* was highly significant ($p<0.001$), and adjusted r^2 values were 0.929, 0.931, and 0.955 for males, females, and unsexed, respectively. The calculated growth coefficients (b) for male, female, and unsexed *T. buchanani* were 3.087, 3.342, and 3.253, respectively. The length-length equations were TL = 1.1034 SL + 0.8845 (r^2 = 0.977) for males and TL = 1.3728 SL + 0.9425 (r^2 = 0.975) for females. There were no significant variations in Fulton's condition factor among the specimens of different length classes (20–37 cm). To the best of our knowledge, no information regarding LWRs or length-length relationships (LLRs) for *T. buchanani* was previously reported either in the literature or on FishBase. The results from this study can be useful for management and conservation purposes of this mudskipper from the Hatiya Island.

Keywords: Population parameters, Gobiidae, mudskipper, Chewa, Bay of Bengal

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Introduction

Burmese gobyeel, *Taenioides buchanani*, belongs to the family Gobiidae and is regarded as a senior synonym of *Amblyopus buchanani* and *Gobioides buchanani* (Froese and Pauly 2021). The Burmese gobyeel is mainly found in Bangladesh, Myanmar, Japan, the Indian Ocean, and the Indo-Pacific Ocean (Rahman 2005, Kurita and Yoshino 2012, Froese and Pauly 2021). In Bangladesh, it is primarily found in fresh to brackish waters, inhabiting the muddy bottoms of estuaries or shallow areas at Nijhum Dweep (Island), Hatiya, Meghna River estuary, and Pasur River near the Sundarban (Latifa et al. 2015).

The Burmese gobyeel has a moderately long body that is sub-cylindrical anteriorly and flattened

posteriorly. The upper lip is fleshy and dense, with a fringed dorsal margin. The dorsal and anal fins join with a long, pointed caudal fin (Rahman 2005). On the chin, there are three pairs of small barbels. The body of the Burmese gobyeel is reddish inferiorly, and the pectoral and pelvic fins are yellowish in color. There are six canine teeth on each jaw in the mouth, and the peri-anal distance is more than 40% of standard length (Huda et al. 2003). There are a couple of rudimentary scales on the posterior part of the body, the eyes are rudimentary, but distinct and covered by skin (Latifa et al. 2015). The Burmese gobyeel is a medium-size fish species of moderate economic value. The consumption of this species is very low globally, but this goby is very popular in Bangladesh because of its distinct delicious taste, moderate price (1–3 USD per kg at local markets), fatty muscles, and few bones. Dried Burmese gobyeel is much favored by local consumers and sells at 7–8 USD per kg at local markets. From January to April, huge Burmese gobyeel are caught by anglers on Hatiya Island and in the Nijhum Dweep.

Hatiya Island is situated in the Meghna River estuary, in the northern Bay of Bengal. The Meghna River estuary possesses an extensive aquatic ecosystem that supports multitudes of fishes and other organisms (Siddique et al. 2021a). The fishery resources of this estuary are greatly diversified thanks to the influence of the maritime climate that supports a variety of commercially important fishes (Siddique et al. 2020). Burmese gobyeel is a native species in Bangladesh, but no study has been conducted on the size frequency, length-weight relationship (LWR), length-length relationship (LLR), or condition factor of this species.

The study of size-frequency in fishes reveals several ecological and life-history traits, such as stock conditions, aquatic health, and breeding periods of fishes (Beyer 1987). The size structure of a fish population can be considered a snapshot that reflects the interactions of the dynamic rates of recruitment, growth, and mortality (Beyer 1987). In fisheries science, LWRs are useful for calculating the total weight of fish based on length observations (Baek et al. 2015, Siddique et al. 2015a). Length-weight data are used as input parameters when estimating the total biomass of ecosystems (Froese 1998, Moutopoulos and Stergiou 2002, Siddique et al. 2015b). Moreover, this knowledge can be used for many biological investigations, i.e., health condition of fish (fatness, feeding and breeding state), age structure, growth rates among areas, regional comparisons of fish life-history traits and species-specific environmental suitability (Froese et al. 2011, Jenllyman et al. 2013). LWRs and LLRs for many estuarine fishes have been recorded and published in different regional journals without separating male from female individuals (Froese and Pauly 2021). Intercept, a, and slope, b, of the LWR equation for many species did not satisfy the Bayesian length-weight predictions because of inappropriate data collection and analysis (Siddique et al. 2021b). The abovementioned parameter is one of the main tools used in assessing and planning the sustainable exploitation and management of a vast spectrum of fish populations and for modelling marine ecosystems throughout the world (Anene 2005). Condition factor decreases with an increase in fish length and influences the reproductive cycle. Again, LWRs and LLRs for many estuarine fishes have not been recorded. A few studies on the Burmese gobyeel have been done on their distribution (Rahman 2005, Latifa et al. 2015), habitats (Huda et al. 2003), and morphometric and meristic characteristics from Meghna River and Pasur River (Latifa et al. 2015). Therefore, the aim of the current study was to estimate the size-frequency, LWRs, LLRs, and Fulton's condition factor (K_n) for *T. buchanani* from the Meghna River estuary, Noakhali coast, Bay of Bengal.

Materials and methods

Study area and sampling procedure

Fish were collected from the Meghna River estuary bounded between latitudes 22.064° N to 22.383° N and longitudes 90.982° E to 91.087° E, the Noakhali coast, Bangladesh. Sampling was conducted from February to April 2021, considering the highest capture of this species from four sampling points (Fig. 1).

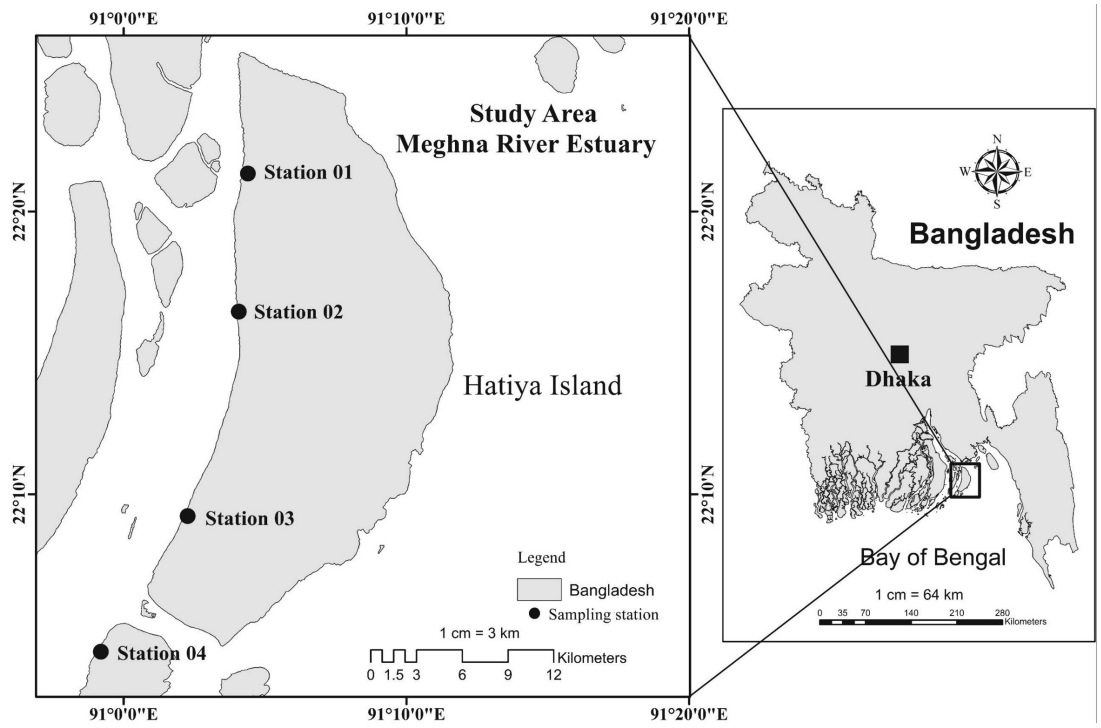

Figure 1. Sampling locations of Burmese gobyeel, *Taenioides buchanani*, from Hatiya Island, Meghna River estuary.

Specimens were caught with fixed purse nets of two mesh sizes (0.51–1.27 cm and 5.08–6.35 cm). The fish specimens were placed in a cooler and immediately transported to the laboratory at the Department of Oceanography, Noakhali Science and Technology University, Noakhali, for length and weight measurements. The species were identified following Rahman (2005) and Froese and Pauly (2021). Juveniles and anomalous fish were discarded. A total of 281 specimens were dissected to determine their sex. The total length (TL) and standard length (SL) were measured to the nearest 0.1 cm with a Vernier caliper, and total wet body weight (W) was determined with an electronic scale (A&D Co. Ltd., Korea) to the nearest 0.01 g (Siddique et al. 2014, 2016).

Data analysis

All the data were analyzed using PAST 4.01 software. Young juveniles and very old or anomalous specimens were excluded from the analysis (Siddique et al. 2020). Extreme values were excluded, and visual inspection of outliers for logarithmic length and weight values were performed before regression analysis according to Froese (2006).

The LWR of *T. buchanani* was established using linear regression analysis (least-squares method). Parameters of the LWRs were estimated using the equation proposed by Le Cren (1951): $W = a*TL^b$.

After logarithmic transformation of the length-weight data, this equation was expressed as $\log W = \log a + b \log TL$.

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* the regression coefficient (exponent indicating isometric growth, when b = 3). The allometric coefficient b>3 or b<3 showed hyper (+) or hypo (–) allometric growth, respectively. The coefficient of determination (r^2) was estimated as an indicator of the quality of linear regression (Scherrer 1984). The 95% confidence interval (CI) of *b* was computed to determine if the hypothetical value of isometry (3) fell between these limits (Froese 2006). Total length (TL) and standard length (SL)

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

			Total length (cm)		Total body weight (g)		Regression parameters					
Species	Sex	N	Min	Max	Min	Max	*a*	95% CL of *a*	*b*	95% CL of *b*	SE (*b*)	r^2
Burmese gobyeel	Male	68	20	33.7	23	133	0.0024	0.0012 - 0.0044	3.087	2.917 - 3.290	0.105	0.929
	Female	72	21.8	37	30	182	0.0012	0.0006 - 0.0019	3.342	3.159 - 3.523	0.109	0.931
Taenioides buchanani	Unsexed	141	20	37	23	182	0.0014	0.00098-0.00207	3.253	3.145-3.369	0.0865	0.955

relationships were established using TL = a + b SL linear regression analysis. Fulton's condition factor (Kn) was calculated from the following equation:

$$Kn = 100*W/TL^3$$

where W = observed total wet body weight (g) and TL = calculated total length of *T. buchanani*.

Results

After separating 281 individuals by sex, 68 males and 72 females of *T. buchanani* were used to estimate size frequency, LWRs, LLRs, and Fulton's condition factor (Kn). In the present study, the maximum TL for female *T. buchanani* was 37 cm, which is a new record (Table 1). Male individuals from the 25 to 29 cm length classes (Fig. 2) and female individuals from the 25 to 32 cm length classes (Fig. 3) dominated the samples. This pattern was very close in both the male (n = 68) and female (n = 72) catch composition.

The mean total lengths and weights were 27.09 ± 0.34 cm and 66.35 ± 2.58 g for males and 28.69 ± 0.38 cm and 84.32±3.94 g for females, respectively. The descriptive statistics and estimated parameters of LWRs for *T. buchanani* are presented in Table 1. The LWRs for male and female *T. buchanani* were highly significant ($P < 0.001$), and adjusted r^2 values were 0.929 and 0.931 for males and females, respectively (Figs. 4 and 5). The growth coefficient (b) was 3.087 and 3.342 for male and female *T. buchanani*, respectively, and both values showed positive allometric growth ($b > 3$).

The total length (TL) vs. standard length (SL) relationships for male and female *T. buchanani* were TL = 1.1034 SL + 0.8845 (N = 68; r^2 = 0.977) and TL = 1.0706 SL + 1.7499 (N = 72; r^2 = 0.975) (Figs. 6 and 7). The Fulton's condition factor (Kn) values

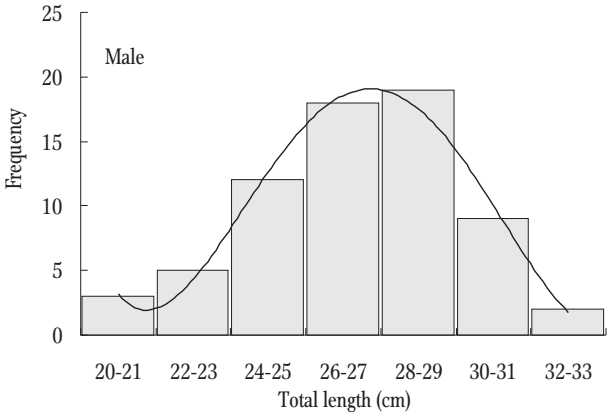

Figure 2. Length frequency of male *Taenioides buchanani* from Hatiya Island, Meghna River estuary.

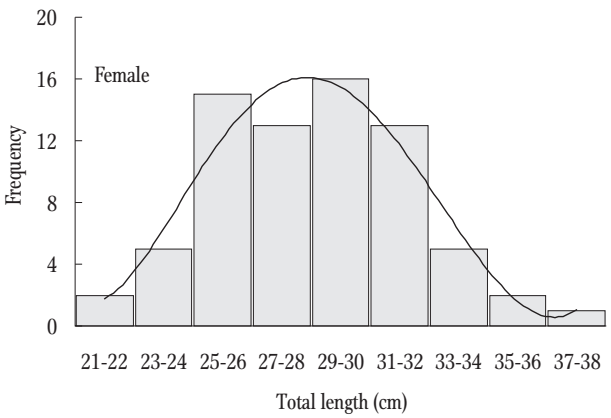

Figure 3. Length frequency of female *Taenioides buchanani* from Hatiya Island, Meghna River estuary.

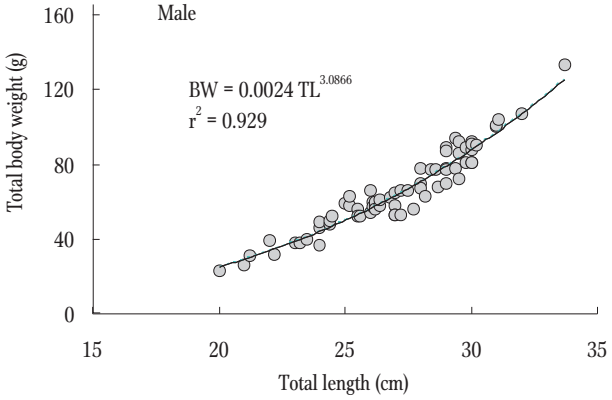

Figure 4. Total length-weight relationships of male *Taenioides buchanani* collected from the coastal waters of Hatiya Island, Meghna River estuary on an arithmetic scale.

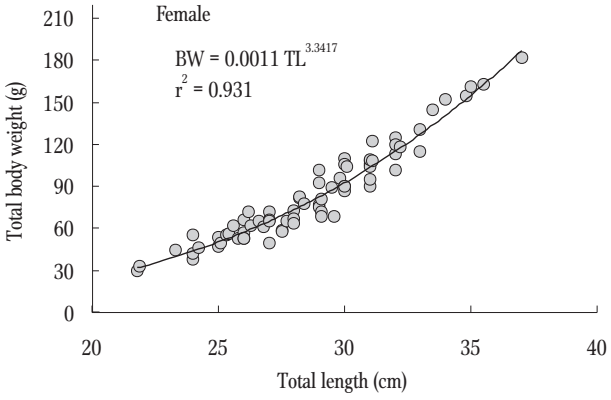

Figure 5. Total length-weight relationships of female *Taenioides buchanani* collected from the coastal waters of Hatiya Island, Meghna River estuary on an arithmetic scale.

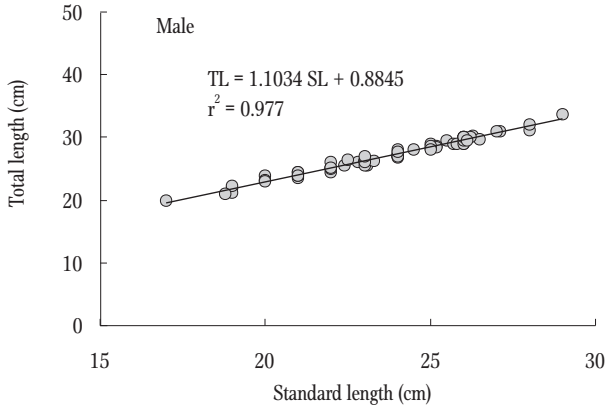

Figure 6. Length-length relationships of male *Taenioides buchanani* collected from the coastal waters of Hatiya Island, Meghna River estuary on an arithmetic scale.

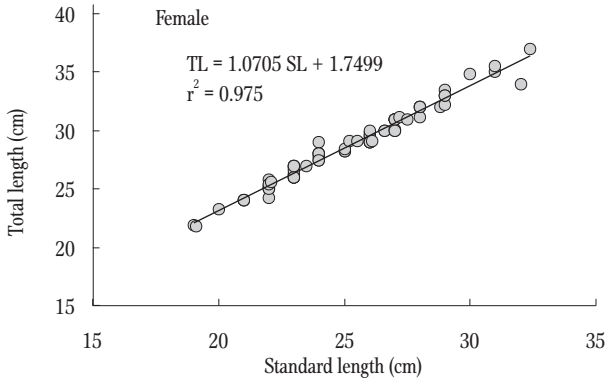

Figure 7. Length-length relationships of female *Taenioides buchanani* collected from the coastal waters of Hatiya Island, Meghna River estuary on an arithmetic scale.

were calculated separately for male and female *T. buchanani* from the study area. The mean Kn value for *T. buchanani* was 0.339±0.042 for males and 0.369±0.007 for females. The maximum Kn value of *T. buchanani* was observed in the 22–23 cm length class for males and the 35–36 cm length class for females (Fig. 8). However, no significant differences in Kn were noted among different length classes ($P > 0.05$) for males or females.

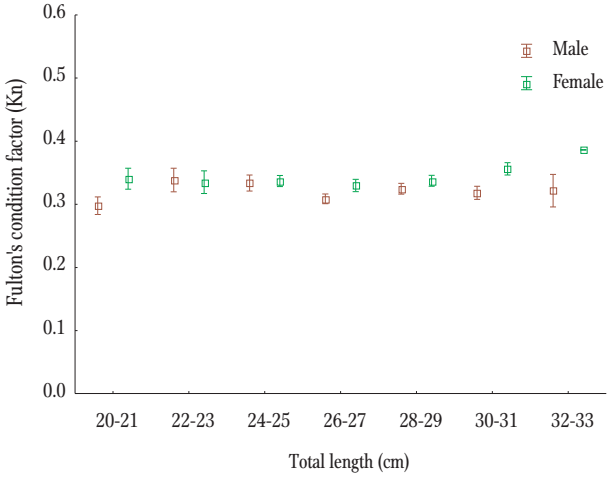

Figure 8. Variation of Fulton's condition factor (Kn) in different size classes of male and female *Taenioides buchanani* collected from the coastal waters of Hatiya Island, Meghna River estuary on an arithmetic scale.

Discussion

In the present study, the maximum total length for female *T. buchanani* (37 cm) is a new record, where the previous TL was 30 cm for males on FishBase

(Froese and Pauly 2021). The maximum length of *Taenioides cirratus,* which belongs to the same genus, from the Noakhali Coast, Bay of Bengal, was 36.2 cm (Siddique et al. 2021b). Although LWRs are not currently considered interesting data by fisheries scientists (Froese 2006), they are essential in modeling aquatic ecosystems since they are only known for a restricted number of species (Kulbicki et al. 2005). The exponents (b = 3.087 for males and 3.342 for females) estimated in the present study were higher than the isometric value and were very close to the Bayesian LWR predictions for b = 3.04 (range 2.81–3.27) for this species with this body shape on FishBase (Froese et al. 2014). The regression parameter b for *T. buchanani* also fell within the expected range of 2.5 < b < 3.5 (Froese 2006). No information regarding the LWR of *T. buchanani* is available in either the literature or on FishBase (Froese and Pauly 2021). Previous studies on the LWRs of *T. cirratus* reported b = 2.546 (r^2 = 0.967) for males and b = 2.948 (r^2 = 0.922) for females from the Noakhali Coast, Bay of Bengal (Siddique et al. 2021b). However, the intercept of LWRs of male and female *T. buchanani* obtained from the present study was very close to the Bayesian LWR predictions (a = 0.00244–0.04107) based on LWR estimates for this (Sub) family-body shape (eel-like).

The condition factor of any fish species reflects interactions among all abiotic and biotic factors of the aquatic environment (Liao et al. 1995). Moreover, the condition factor indicates the well-being of any fish population in various stages of their life cycles. The condition factor of a species is assumed to reflect biological characteristics such as health, well-being, reproductive state, and growth and environmental conditions such as habitat quality, water quality, and food availability (Anderson and Gutreuter 1983, Ney 1993). In the present study, Fulton's condition factor did not vary among different length classes of male and female *T. buchanani.* Generally, the condition factor of all fishes decreases after the spawning season. Several studies showed that sudden fluctuations in condition indices could be associated with attaining sexual maturity. During physical examinations after the dissection of females, no gametes were observed, which could have be attributed to these individuals having a similar pattern of Kn among different length classes.

Author contributions. M.A.M.S. conceptualization, methodology, investigation, writing original draft, reviewing and editing, supervision; M.S.H. methodology, investigation, writing original draft; A.U. methodology, investigation, writing original draft; M.J.I. methodology, investigation.

Acknowledgments. The authors thank the Ministry of Science and Technology, The People's Republic of Bangladesh (Grant no. 39.00.0000.009.14.004.19/BS-148/159 and Grant no. 39.00.0000.009.06.024.19/BS-222/238) for funding this study.

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