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Estimation of Relative Growth of *Anabas testudineus* through multiple linear dimensions

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ABSTRACT

This study provides scientific investigation on the relative growth pattern based on multiple linear dimensions and also observed the meristic characteristics of *Anabas testudineus* from the Gajner *Beel* northwestern (NW) Bangladesh from July to December 2018. A total of 454 individuals were collected and lengths and weight were noted up to 0.01 cm and 0.01g precision using a measuring board and digital weight balance, respectively. Fin rays and lateral line scales were counted by using a magnifying glass. Total length (TL) was ranged 7.40–14.50 cm while body weight (BW) ranged 7.90–64.00 g. Relationships of length-weight (LWRs) were highly significant (p<0.001) with r^2 values ≥ 0.823. TL *vs.* BW was one of the best models among ten equations based on r^2 value in LWR. In comparison, length-length relationships (LLRs) were extremely important (p<0.001) and most of the r^2 values were greater than 0.844. In LLR, SL *vs.* TL and PoAnL was the fitted model according to r^2 value among nine equations. Fin formula of *A. testudineus* was D. 26-28 (XVI-XVIII 1-2/7-10) P_1. 13-15 (1-2/11-14) P_2. 6 (I5) A. 18-21 (VIII-XI1 2/8-10) C. 15-17 (2/13-15).The results of this study will keep a vital contribution to stock assessment and sustainable management for *A. testudineus* in this wetland ecosystem and other world wide water bodies.

INTRODUCTION

Anabas testudineus (Bloch, 1792) is an exceedingly costly freshwater fish species belonging to the order Perciformes and the family Anabantidae **(Marimuthu *et al.*, 2009; Khatun *et al.*, 2019)**. This order comprises seven families containing at least 252 species **(Collins *et al.*, 2015; Nelson *et al.*, 2016)**. The family Anabantidae comprising about 33 species in 4 genera **(Froese and Pauly, 2019)** possess a labyrinth organ *i.e.*, accessory air-breathing organ **(Alleng, 1991; Khatun *et al*., 2019)** which allows it to breathe atmospheric oxygen **(Rahman, 1989)** and can survive out of water for a long period of time also make them able to resist poor water condition **(Atack, 2006)**. It is commonly called a climbing perch due to its ability to walk on land **(Talwar and Jhingran, 1991)**. *A. testudineus* locally known as 'koi' in Bangladesh and India, pla mor thai in Thailand, puyo in Philippine, kavaiya in Sri Lanka is a bottom dweller and insectivorous fish **(Foresee and Pauly, 2020)**. It is extensively distributed in Bangladesh, India, Pakistan, Sri Lanka, Burma, Singapore, Malay Archipelago, Philippines, Indonesia, southern China and Taiwan **(Rainboth, 1996; Wang *et al.*, 1999; Kottelat, 2001, Tan and Lim, 2004)**. This species inhabits both in fresh water and brackish water mostly found in *beels*, canals, lakes, ponds, swamps, *haors*, ditches, floodplains, *baors* and estuaries **(Talwar and Jhingran, 1991; Menon, 1999; Vidthayanon, 2002)**. *A. testudineus* is an omnivorous fish primarily dependent on organic debris algae, crustaceans, insects, worms, molluscs and soft plant parts **(Nagris and Hossain, 1987; Pandey *et al.*, 1992; Prasanth, 2006)**. The species contains a huge amount of iron and copper, which are essentially required for hemoglobin synthesis. It is a reasonable source of protein in Southeast Asian states like Bangladesh and Malaysia **(Alam *et al.*, 2010; Zalina *et al.*, 2011).** *Anabas* can survive in temperature fluctuations, low pH and low dissolved oxygen **(Kohinoor *et al.*, 2009; Sarma *et al.*, 2010; Be *et al.*, 2017)**.Overfishing, Pollution, and wetland conversion may possibly threaten to it **(Hossain *et al.*, 2015a)**. *A. testudineus* is listed as least concerned (LC) in Bangladesh **(IUCN Bangladesh, 2015)** and data deficient species according to **IUCN (2020)** for worldwide water bodies.

A land, which is inundated by water, annually or seasonally, permanently or temporarily that is called wetland **(Keddy, 2010)**. The wetlands can be freshwater, brackish, or saltwater **(Ramsar conservation, 1971)**. Gajner *Beel* is situated at Sujanagar, Pabna in the northwestern (NW) Bangladesh. This *Beel* used as an imperative feeding and spawning ground by many freshwater fish species. Near about 0.5 million people of surrounding villages of this *Beel* are directly or indirectly reliant on this wetland for their livelihood **(Mazid *et al.*, 2005)**.

Regression analysis is the one of the statistics analysis that used to explore and modeling the relationship between variables. Multiple linear regressions are the method of statistics in regression that used to analyze the relationship between single response variable (dependent variable) with two or more controlled variables (independent variables) **(Ghani and Ahmed, 2011)**.

Fish length is often considered more significant than fish age, as many ecological and physiological factors depend more on the length than the age **(Erzini *et al.*, 1997)**. Length-length (L-L) relationships of fishes are essential in management for relative growth studies **(Sandoval-Huerta *et al.*, 2015)**. In that case, where only lengths data are available we can easily estimate the weight and biomass by using **(Park and Huh, 2015)** and LWRs also help in conservation and control of wild populations and also for observing the well-being of fishes **(Hossain *et al.*, 2012a; Hassan *et al.*, 2020; Hasan *et al.*, 2020)** Further, the knowledge about growth pattern is essential for different studies in biology, physiology, and ecology of the natural and commercially exploited population of fishes **(Czerwinski *et al.*, 2008)**. Meristic study relates to count the quantitative characteristics of fish, such as the number of fins or scales **(Islam *et al.*, 2020)**. In addition, meristics and morphometrics features have been used to identify stocks of fish, differentiate the species taxonomically, and distinct various morpho types **(Lourie *et al.*, 1999; Doherty and McCarthy, 2004; Jayasankar *et al.*, 2004; Islam *et al.*, 2020)**. However, morphometric characters are less heritable than meristic characters **(Beacham, 1990; Islam *et al.*, 2020)** that's why morphometric features were the more preferred method to identifying intraspecific deviation within a stock **(Murphy *et al.*, 2007)**.

Therefore, a very few works have been dedicated on growth of *A. testudineus* from worldwide water bodies that were given in **Table 1**. There is no existing info on estimating relative growth of *A. testudineus* from the Gajner *Beel* on the basis of morphometric and meristic features. This study was therefore undertaken to investigate the relative growth of *A. testudineus* populations inhabiting the Gajner *Beel*, NW Bangladesh using multiple linear dimensions.

Table 1. Available literature on *Anabas testudineus* from worldwide water bodies.

Aspects	**Water body**	**Reference**
Length-weight relationship and condition factor	Kausalyaganga, Orissa, India	**Kumar *et al*. (2013)**
Length- weight relationship	Tetulia River, Bangladesh	**Hossain *et al*. (2015b)**
Morphometrical and gonadal studies	West Bengal, India	**Ziauddin *et al*. (2016)**
Length-weight relationship and relative condition factor	Deepar *Beel* (wetland), Assam, India	**Rahman *et al*. (2015)**
Length-weight relationship and Species composition	Candaba wetland, Philippines	**Garcia (2010)**
Growth and morphological development	Vientiane City, Laos	**Morioka *et al*. (2009)**
Length-weight and length-length relationships	Chi River, thailand	**Satrawaha and Pilasamorn (2009)**
Fecundity	Kedah, Malaysia	**Marimuthu *et al*. (2009)**
Stocking density, growth and production	Mymensingh, Bangladesh	**Jannat *et al*. (2012)**
Length weight relationships and condition factor	Semayang Lake, East Kalimantan, Indonesia	**Mustakim *et al*. (2019)**

MATERIALS AND METHODS

Fish sampling

A total number of 454 specimens of *A. testudineus* were collected occasionally from the Gajner *Beel*, a wetland ecosystem, NW Bangladesh **(Fig.1)** during July to

December 2018 through cast net (mesh size, 2.5 cm). These samples were stored as soon as possible with 10% buffered solution for the further process.

Fish measurements

Digital electronic balance was used to take body weight (BW) of the sample to the nearest 0.01g accuracy. The morphometric characters *i.e.*, ten different lengths **(Fig. 2)** were measured following **Hubbs and Lagler (1958)** with slight modification by digital slide calipers to the nearest 0.01cm accuracy.

Growth pattern

LWRs were estimated by the model; $W = a L^b$. LLRs were also assessed by linear regression analysis **(Le Cren, 1951)**.

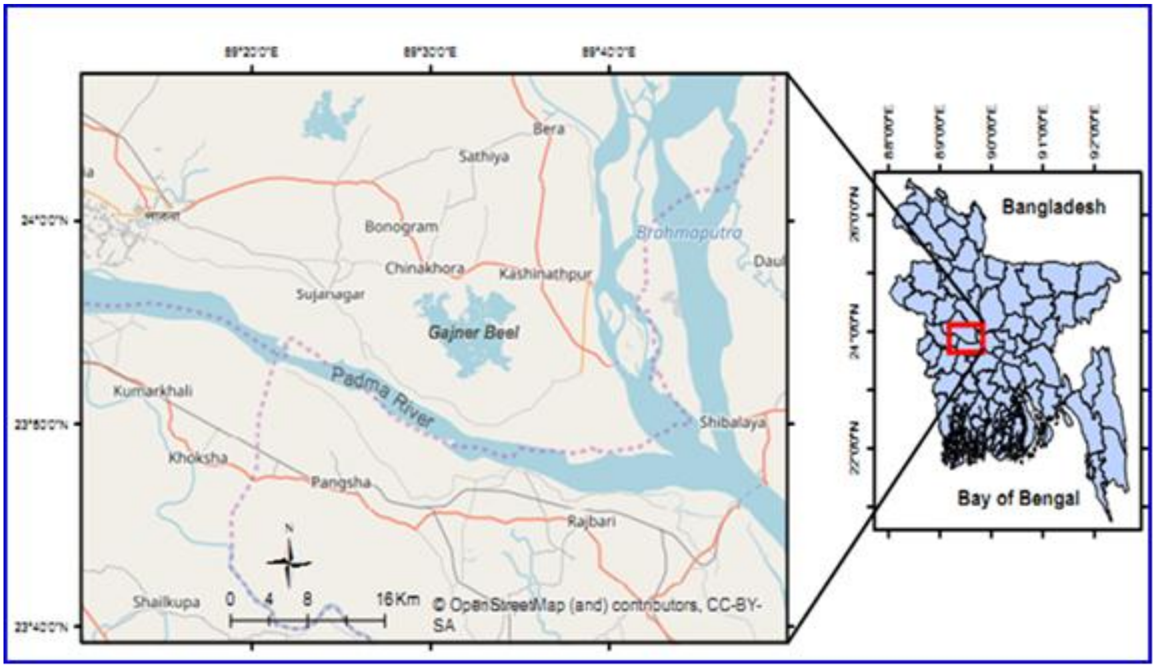

Fig. 1. Sampling sites in the Gajner *Beel* (indicated by red circle), northwestern Bangladesh.

Meristic counts

A magnifying glass was used to count the number of fin rays and scale (lateral line).

Statistical analyses

All statistical analyses were completed through the GraphPad Prism 6.5 software and Microsoft Excel program with consideration of 5 % significant level.

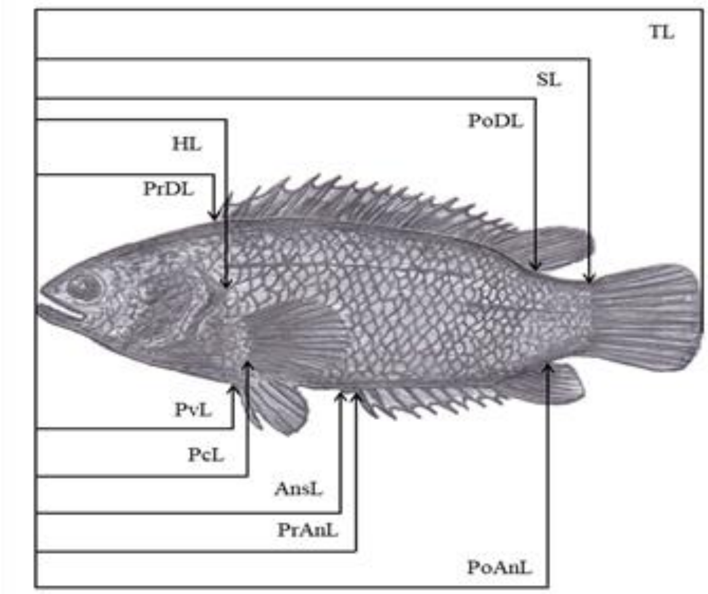

Fig. 2. Showing the morphometric measurements of *Anabas testudineus* from the Gajner *Beel*.

RESULTS

Growth pattern

In our study, total length (TL) was varied within 7.40-14.50 cm (mean ± SD, 10.88 ± 1.39) and BW was 7.89-64.00 g (26.52 ± 10.68) **(Table 2)**.

Table 2. Descriptive statistics of *Anabas testudineus* (*n* = 454) captured from the Gajner *Beel*, NW Bangladesh

Measurements	Min (cm)	Max (cm)	Mode (cm)	Mean ±SD	95% CL (cm)	% TL
TL (Total length)	7.40	14.50	9.80	10.88±1.39	10.70 to 11.05	100
SL (Standard length)	6.10	11.90	8.00	8.6 ±1.11	8.52 to 8.80	82.07
HL (Head length)	1.70	3.60	2.90	2.73±0.34	2.69 to 2.78	24.83
PrDL (Pre-dorsal length)	1.90	4.30	3.10	2.99±0.42	2.94 to 3.04	29.66
PoDL(Post-dorsal length)	5.20	10.40	8.10	7.81±1.02	7.68 to 7.94	71.72
PcL (Pectoral length)	2.10	4.00	3.00	2.98±0.33	2.94 to 3.02	27.59
PvL (Pelvic length)	2.30	4.60	3.20	3.28±0.43	3.23 to 3.34	31.72
AnsL (Anus length)	3.10	6.50	4.60	4.65±0.62	4.58 to 4.73	44.83
PrAnL (Pre-anal length)	3.20	6.60	4.70	4.81±0.64	4.73 to 4.89	45.52
PoAnL(Post-anal length)	5.70	11.00	8.20	8.13±1.07	7.996 to 8.6	75.86
BW(Body weight)*	7.89	64.00	13.14	26.52±10.68	25.18 to 27.87	-

n, sample size; Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean value; BW, body weight; *, weight in g.

The regression parameters *a* and *b*, 95% confidence limit and coefficients of determination (r^2) for LWRs of *A. testudineus* were documented in **Table 3 and Fig. 3**. All LWRs were highly significant (p< 0.0001) with r_s values ≥ 0.901. Based on $r^2$and r_s value, LWR by BW *vs.* TL was the best fitted model among the ten equations.

Table 3. Descriptive statistics and estimated parameters of length-weight relationships of *Anabas testudineus* (n = 454) captured from the Gajner *Beel*, NW Bangladesh

Equation	Regression parameter		95% CL of *a*	95% CL of *b*	r^2	r_s
	a	*b*				
BW= $\boldsymbol{a \times TL^b}$	0.0164	3.07	0.0136 to 0.0198	2.99 to 3.15	0.961	0.980
BW= $\boldsymbol{a \times SL^b}$	0.0353	3.04	0.0287 to 0.0434	2.94 to 3.13	0.941	0.969
BW= $\boldsymbol{a \times HL^b}$	1.4377	2.84	1.2180 to 1.6971	2.69 to 3.00	0.827	0.901
BW= $\boldsymbol{a \times PrDL^b}$	1.4242	2.62	1.2330 to 1.6450	2.49 to 2.76	0.864	0.910
BW= $\boldsymbol{a \times PoDL^b}$	0.0571	2.96	0.0474 to 0.0687	2.87 to 3.05	0.945	0.969
BW= $\boldsymbol{a \times PcL^b}$	0.6556	3.34	0.5462 to 0.7868	3.17 to 3.51	0.865	0.914
BW= $\boldsymbol{a \times PvL^b}$	0.8264	2.87	0.6979 to 0.9786	2.73 to 3.01	0.867	0.923
BW= $\boldsymbol{a \times AnsL^b}$	0.3032	2.87	0.2544 to 0.3614	2.76 to 2.99	0.909	0.958
BW= $\boldsymbol{a \times PrAnL^b}$	0.2741	2.88	0.2282 to 0.3294	2.76 to 2.99	0.906	0.950
BW= $\boldsymbol{a \times PoAnL^b}$	0.0487	2.98	0.0407 to 0.0583	2.89 to 3.07	0.950	0.973

n, sample size; *a* and *b* are the regression parameters of LWRs; CL, confidence intervals; r^2, co-efficient of determination.

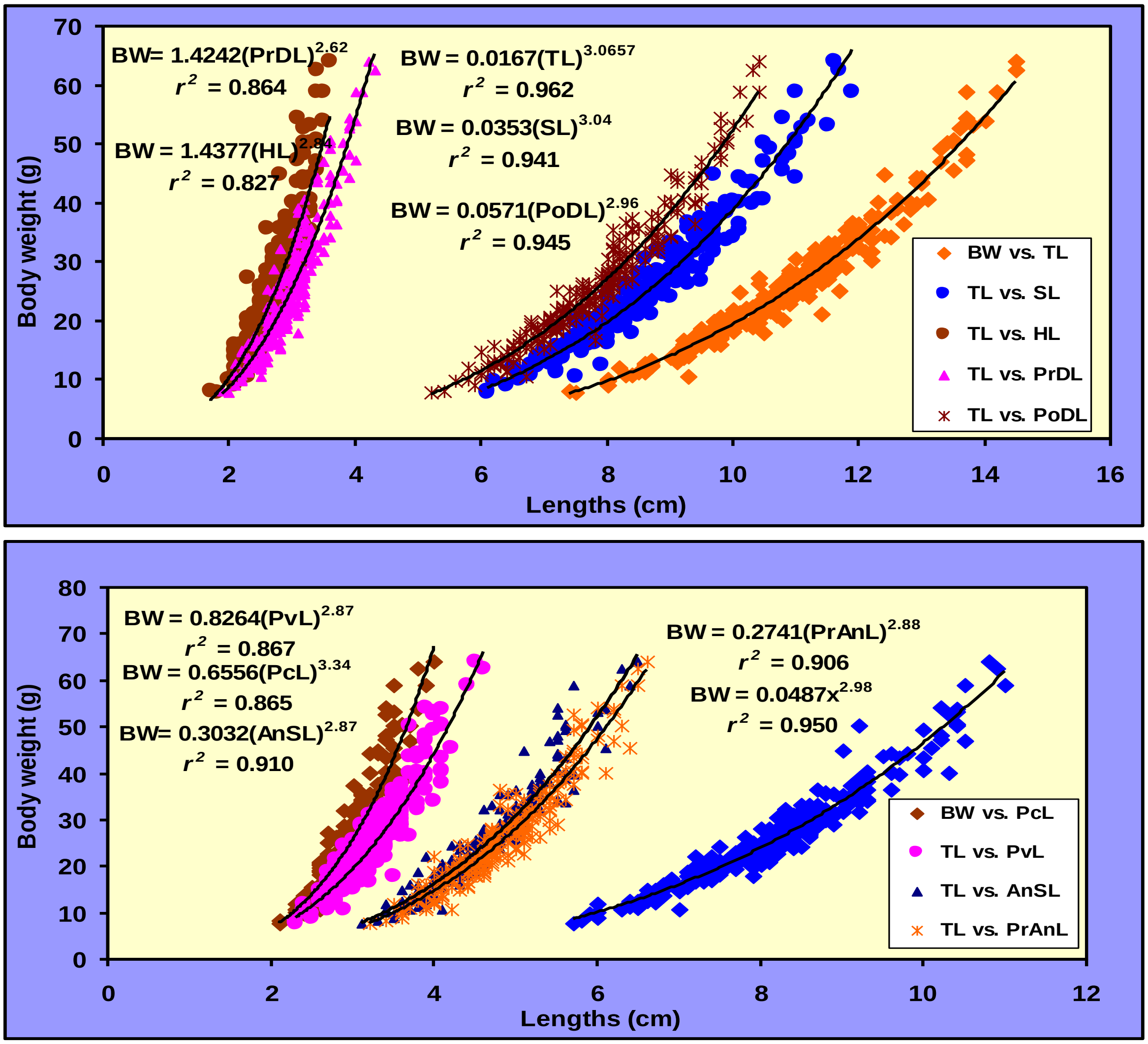

Fig. 3. Relationships (BW = a × L^b) between lengths *vs.* body weight of male (lower) and female (upper) *Anabas testudineus* in the Gajner *Beel.*

The LLRs were shown in **Table 4** and **Fig. 4**. All relationships were also highly correlated (p<0.0001) with r_s values ≥0.909 (Spearman rank test). On the basis of maximum $r^2$and r_s value, LLR by TL *vs.*SL and TL *vs.* PoAnL was the best fitted model among nine equations.

Table 4. Descriptive statistics and estimated parameters of length-length relationships of *Anabas testudineus* (n = 454) captured from the Gajner *Beel*, NW Bangladesh

Equation	Regression parameter *a*	Regression parameter *b*	95% CL of *a*	95% CL of *b*	r^2	r_s
TL = *a* + *b*× SL	0.2744	1.22	0.0163 to 0.5325	1.19 to 1.25	0.965	0.981
TL = *a* + *b*× HL	0.7320	3.71	0.1755 to 1.2886	3.51 to 3.91	0.844	0.909
TL = *a* + b× PrDL	1.7268	3.06	1.2857 to 2.1680	2.92 to 3.21	0.876	0.918
TL = *a* + b× PoDL	0.4787	1.33	0.2150 to 0.7423	1.30 to 1.37	0.962	0.975
TL = *a* + b× PcL	-0.7796	3.92	-1.3440 to -0.2150	3.73 to 4.11	0.874	0.920
TL = *a* + b× PvL	0.9472	3.02	0.4637 to 1.4307	2.88 to 3.17	0.873	0.924
TL = *a* + b× AnsL	0.8670	2.15	0.4842 to 1.2499	2.07 to 2.23	0.918	0.957
TL = *a* + b× PrAnL	0.9007	2.07	0.5139 to 1.2876	1.99 to 2.15	0916	0.953
TL = *a* + b× PoAnL	0.4844	1.28	0.2429 to 0.7260	1.25 to 1.31	0.968	0.983

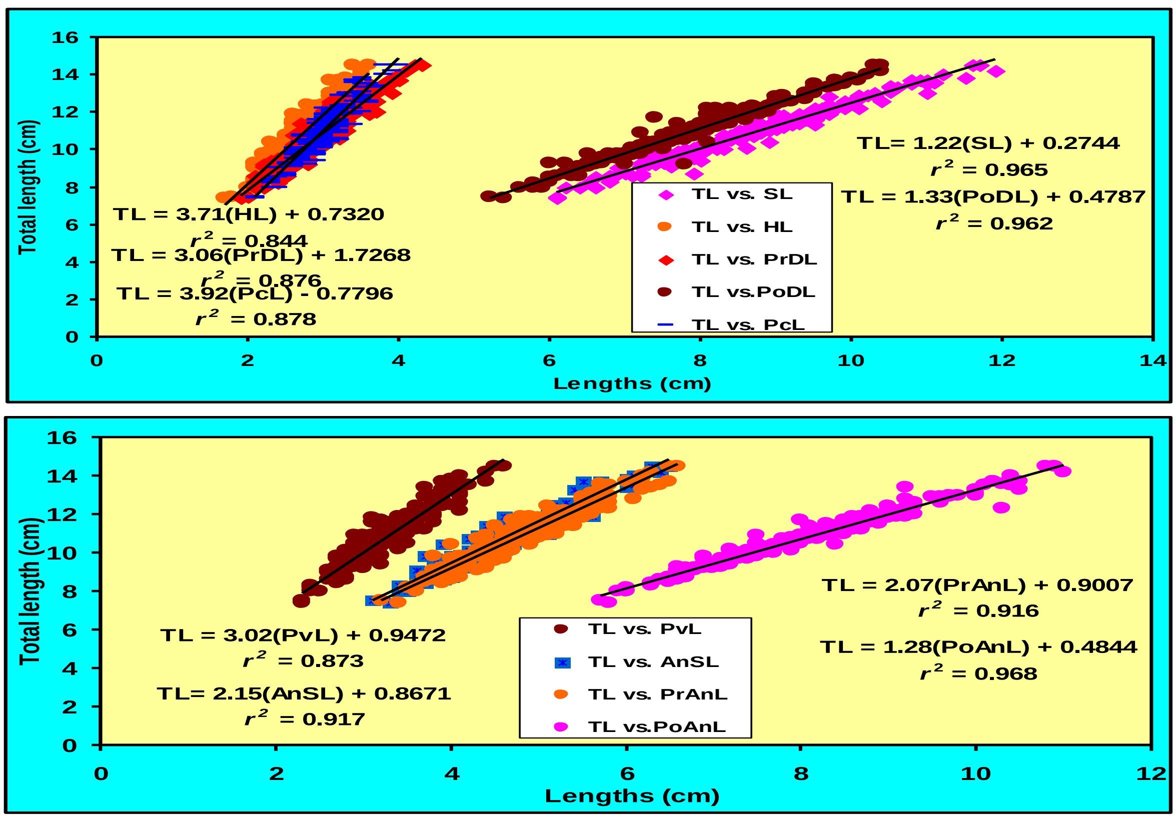

Fig. 4. Relationships (TL = a +*b**L) between length *vs.* length of male and female *Anabas testudineus* Gajner *Beel*.

Meristic characteristics

The body shape of *A. testudineus* was oblong, moderately deep and compressed. Body color was greenish brown or blackish brown. Mouth was anterior with villiform teeth on jaws and the lower jaw was slightly longer. Dorsal and anal fin were long, pectoral and caudal fin is rounded. Dorsal fin, pelvic fin and anal fin rays were modified to spine. Lateral line was interrupted; the first lateral line contained 14-17 scales and the second 10-13 scales. Body covered with ctenoid large scales arranged regularly. The observed fin formula of *A. testudineus* was dorsal, D. 26-28 (XVI-XVIII 1-2/7-10); pectoral, P_1. 13-15(1-2/11-14); pelvic, P_2. 6 (I5); anal, A. 18-21 (VIII-XI1 2/8-10); caudal, C.15-17(2/13-15) respectively **(Table 5 & Fig. 5)**.

Table 5. Meristic counts of *Anabas testudineus* (*n* = 454) captured from the Gajner *Beel*, NW Bangladesh

Meristic data	Numbers	Spine	Unbranched	Branched
Dorsal fin rays	26–28	XVI–XVIII	1–2	7–10
Pectoral fin rays	13–15	-	1–2	11–14
Pelvic fin rays	6	I	-	5
Anal fin rays	18–21	VIII–XI	1–2	8–10
Caudal fin rays	15–17	-	2	13 – 15
1st lateral line scale	14 – 17	-	-	-
2nd lateral line scale	10 – 13			
Scale above the lateral line to dorsal fin base	3 – 4	-	-	-
Scale below the lateral line to pelvic fin base	6 – 7	-	-	-

n, sample size; Unbranched, single fin ray; Branched, upper portion of fin is divided into several rays; Spine, upper portion of unbranched fin ray is pointed.

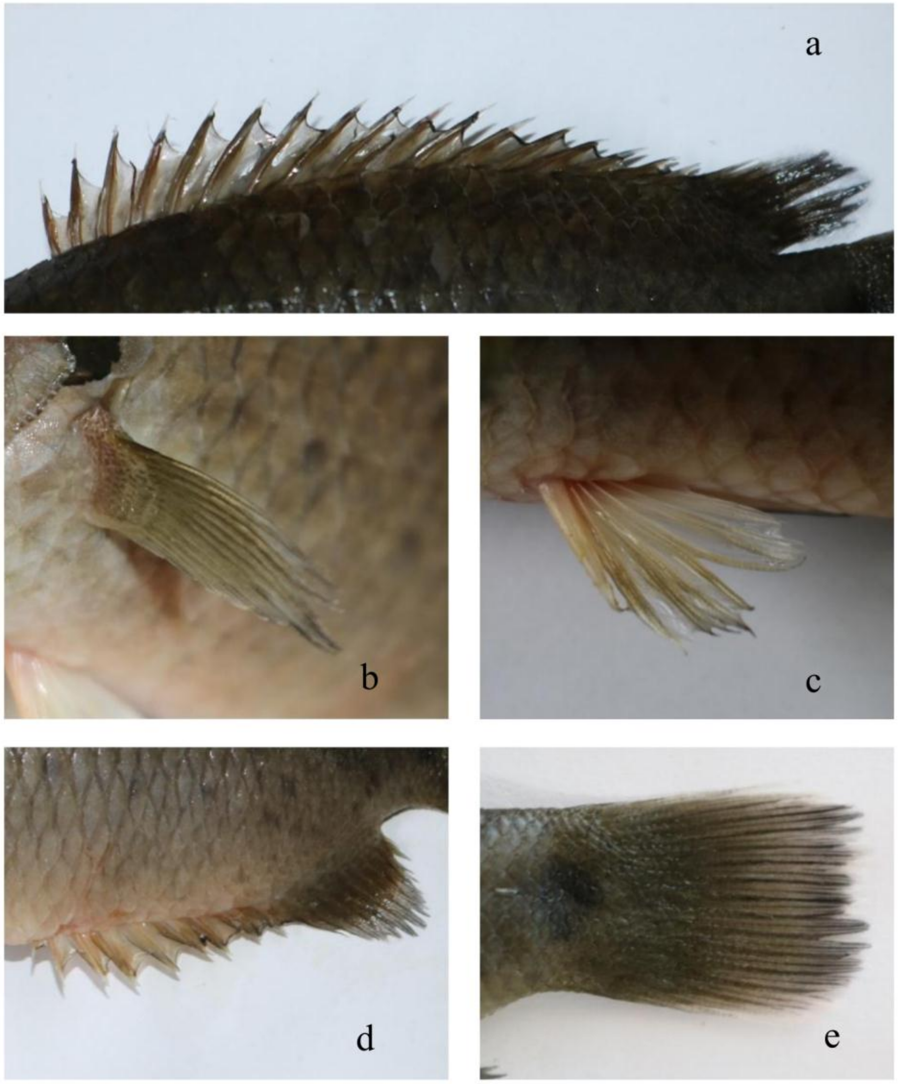

Fig. 5. Different fins such as (a) Dorsal, (b) Pectoral, (c) Pelvic, (d) Anal and (e) Caudal of *Anabas testudineus* from the Gajner *Beel*.

DISCUSSION

Although some authors have been working on some biological aspects **(Hubbs and Lagler, 1958; Hassan *et al.,* 2005; Alam *et al.,* 2007)** of *A. testudinesus* but this is the first study which estimates the relative growth using ten linear dimensions and also studies the meristic features. A total of 244 individuals comprised altered body sizes were used for the current study and the recorded maximum length was 14.50 cm TL, which is moderately similar with **Hassan et al. (2005)** who recorded TL as 14.20 cm in the Chittagong region but is lower than the maximum length reported by **Shafi and Quddus (1982)**, **Talwar and Jhingran (1991)** and **Rahman (2005)** (22.00 cm, TL 25.00 cm and 17.60 cm , respectively). Maximum length is helpful for the estimation of growth parameters that is needed for planning of fisheries capital and sustainable management **(Ahmad *et al.*, 2012)**.

In our present study, the allometric co-efficient, *b* value was ranged from 2.62-3.34 which is in the limit reported by Froese (2006) (2.50-3.50) and Carlender (1969) (2.00-4.00). According to Tesch (1971), *b*=3, means the growth isometric and *b*>3, means the growth is positive allometric and *b*<3, means the growth is negative allometric. **Shafi and Mustafa (1976)** and **Hossain *et al.* (2015b)** reported *b* value as 2.72 and 2.9 from Dhaka Bangladesh and Tetulia River, southern Bangladesh, respectively. However, the values of *b* may divers because of differences growth of organs, sex and preservation process and variation in the physiology **(Hossain *et al.*, 2012b; 2015b)**, which were not observed in the current study. Furthermore, LLRs were highly correlated ($P < 0.001$).

In the current study, the observed spine fin rays (16-17) in dorsal fin rays were similar to **Shafi and Quddus (1982)**, **Talwar and Jhingran (1991)** and **Rahman (2005)** as well as soft fin rays (7-10) is similar with **Shafi and Quddus (1982)**, pectoral fin contained 13-15rays and pelvic fin **(Riede, 2004)** that was more or less similar to the findings of **Bhuiyan (1964)**, **Shafi and Quddus (1982)**, **Talwar and Jhingran (1991)** and **Rahman (2005)**. Anal fin (18-21) is disparate with their study Caudal fin is somewhat similar to the number reported **Shafi and Quddus (1982)**. However, no one mentions spine and unbranched fin rays separately but the present study does that. First lateral line containing 14-17 scales was similar (16-17) with the results of **Rahman (2005)** and the second (10-13 scales) deviated from **Rahman (2005)**. Meristic counts of the current study were done in pictorial form which helps to easily identify this species and comparable with the future study. Above lateral line (3–4) scales was similar to the findings of **Rahman (2005)** but the below lateral line scales (6–7) differ with the findings **Rahman (2005)**.

CONCLUSION

These findings will help to more accurately understand the growth pattern of *Anabas testudines* and serve as baseline data for this species, a wetland ecosystem Gajner *Beel*, and nearby ecosystem for evaluation with future studies of this fish.

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