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Variation in Growth and Condition Factors of Three Commercial Fish Species in Habitats Associated with Rice Paddy Fields in An Giang Province, Vietnam

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Abstract: The assessment of the length-weight relationship and condition factors was carried out for three commercial fish species, *Esomus metallicus* Ahl, 1923, *Anabas testudineus* (Bloch, 1792) and *Trichopodus trichopterus* (Pallas, 1770). The survey was carried out in habitats influenced by human activities associated with rice paddy fields in three areas situated in An Giang Province, Vietnam: Luong Phi, islets in An Thanh Trung and Hau riverside in Vinh Thanh Trung. The relationship between length and weight showed the slope values (*b*) of the three species between 2.75 and 3.29; the growth patterns in them (negative allometry, positive allometry and isometry) varied depending on site and time of sampling. The *b* values in the three species were close to the critical isometric value (3), which could indicate that these species were highly fit for these conditions. No significant difference in the condition factors were observed in *Anabas testudineus* and *Trichopodus trichopterus* sampled from areas inside dike systems and outside them as well as from periods of the three consecutive rice crops produced annually in this region. Variations in this effect were more evident for *Esomus metallicus*. The condition factors of these species were close to the well-being value, showing the prospective for culturing them in rice paddy fields. The three species were impacted by the dike-site × crop interaction, showing that they are well adapted to the habitats and the seasonal conditions.

Key word: An Giang, commercial fishes, condition factor, dike, growth pattern, paddy crop

Introduction

Length-weight relationship (LWR) is a basic method for assessing the status of fish populations (Khaironizam & Norma-Rashid 2002, Mahmood et al. 2012, Dinh et al. 2016). The coefficient value (*b*) of LWR is applied for estimation of the fish growth pattern (Froese 2006). It is affected by the fish size and sex as well as by season and site variables (Dinh et al. 2016, Dinh 2017). The adaptation of fishes to their environment is quantified using the condition factor (*CF*) that varies across regions, seasons and genders (Abdoli et al. 2009a, 2009b). Data on LWR and condition factor, especially for commercial fish species in wetlands in the Mekong Delta, Vietnam, are fragmented.

Rice paddy fields and associated channels are suitable habitats for various fish species and are

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sometimes used for combined rice – fish cultures (Rothuis et al. 2008, Aditya et al. 2010). Paddy field channels contribute to the biodiversity conservation due to their function as a nursing ground for many fish species (Maltchik et al. 2011). An Giang is a Key Economic Zone and is favourable for rice and fish farming in the Mekong Delta. As it is located between the Tien and Bassac Rivers, fish diversity is affected by human activities such as intensive farming, agricultural chemicals application and utilization of dike systems (Dinh et al. 2020). There are no data on LWR, growth and environmental factors affecting the commercial fish species in the paddy fields, including *Esomus metallicus* Ahl, 1923, *Anabas testudineus* (Bloch, 1792) and *Trichopodus trichopterus* (Pallas, 1770).

Esomus metallicus (Cyprinidae) is a small indigenous fish inhabiting ponds, weedy ditches, streams, beels and inundated fields (Talwar & Jhingran 1991). This species, in fresh and dried form, is the main source of animal protein for rural people (Vishwanath et al. 1998). The changes in habitat have implications for the dynamics of fish life cycle, growth patterns and condition factors.

Anabas testudineus is a resident fish species, which is naturally found in many countries, from India to the Wallace Line (Tay et al. 2006, Mustakim et al. 2009). It inhabits predominantly lentic (swamps and lakes) as well as lotic habitats (rivers and canals). It has a high price due to its taste and soft meat texture (Helmizuryani & Muslimin 2016).

Trichopodus trichopterus is a freshwater and estuary tropical labyrinth species of the family Osphronemidae (Froese & Pauly 2019). It is considered an important target species for small-scale fishers (Rahman 2005) using a variety of traditional fishing gears. This species is used as a peaceful and beautiful aquarium fish; traditionally, people like its good taste (Talwar & Jhingran 1991).

The present study was conducted to test whether LWR, growth pattern and condition factor of these three species are regulated by human activities associated with maintaining conditions in paddy field habitats.

Materials and Methods

Study site and fish collection

The study was carried out in three ecological regions of An Giang Province, including limestone mountain in Luong Phi (10°25’53,44”N, 104°56’45,45”E), islets in An Thanh Trung (10°25’53.2”N, 105°27’46.4”E) and Hau riverside in Vinh Thanh Trung (10°33’15.6”N, 105°12’28.5”E). To prevent floods during the wet season from August to October, An Giang authorities use dike systems. The fish were collected at both sides of the dike system. Like most of provinces in the Mekong Delta, there are three crops in An Giang Province, being Crop 1 (January – April), Crop 2 (July – November) and Crop 3 (November – January) (Le et al. 2006). Fishes were sampled during each of these periods.

Fish specimens of different size were collected using fishing tools such as fyke nets and weir nets; types of fish traps were cylindrical and rectangular, respectively. They were around 3.7 m in length and 15 mm in mesh size; cast net (350–500 m in length and 20–25 mm in mesh size) at six sampling sites (three ecological regions × two sides of the dike system), covering an area of 5,000 m^2 at each studied site. Fyke nets were set at high level in paddy channels and retrieved to collect fish after 20 hours. Fish was collected during the “rice making” period: Crop 1 (March 2019), Crop 2 (October 2018) and Crop 3 (December 2018). Fish specimens were stored in 4% formaldehyde.

Fish and data analysis

Totally, 330 fish specimens were collected. These were *E. metallicus* (200), *A. testudineus* (56) and *T. trichopterus* (74). Specimens were measured in the laboratory: total length (TL) up to accuracy of 0.1 cm and weigh (W) up to 0.01 g. The weight-length relationship was estimated using the formula

$$W = a \times TL^b,$$

where *a* is the regression intercept and *b* is the regression slope (Ricker 1973). The logarithm formulation ($LogW=Log a+b LogTL$) was used to estimate *a* and *b* parameters (Froese 2006). The fish body condition factor (CF) was calculated according to Le Cren (1951):

$$CF = \frac{W}{a \times TL^b}$$

The differences in TLs, Ws, *CFs* for areas inside and outside of the dike system were confirmed by t-test. The differences between the three crops and the three ecological regions were quantified by One-way ANOVA. The interaction of dike-sides and crop variations of TLs, Ws and *CFs* were simulated by two-way ANOVA. The quality of linear regression was confirmed using the determination coefficient (r^2) (Metin et al. 2011). The *b* value obtained from the LWRs was used to qualify growth patterns, e.g., negative allometry ($b<3$), positive allometry ($b>3$) and isometry ($b=3$) (Martin 1949). ANCOVA was

used to test if *b* values change with dike-side and crop (Dinh 2016). The t-test was used to verify if *b* and *CF* closed to the threshold of three and one respectively. Data analysis was performed using SPSS v21 at $p<0.05$.

Results

Morphometrics

Amongst the 330 fish individuals collected, *E. metallicus* had the highest number, with 200 sampled specimens, followed by *T. trichopterus* with 74 individuals and *A. testudineus* with 56 individuals. For *Esomus metallicus* (Table 1), the quantity of fish inside the dike (178) was much higher than outside (22); for the same species, the Crop 2 had the highest number of fish individuals (178) when compared to the other two crops (Crop 1 – 6; Crop 3 – 16). The number of *A. testudineus* (Table 2) was highest inside dike (29) and in the Crop 2 (40). The sample of *T. trichopterus* (Table 3) was dominated by specimens sampled inside dike (47) and during the Crop 2 period (47) (Table 3).

There was no weight difference between inside and outside dike at significant level 5% in three species (t-test, t_1 =2.325, t_2 = 0.693, t_3 = 3.453, p>0.05, Tables 1–3). About crop factor, only Ws of *A. testudineus* were undifferentiated (ANOVA, F = 2.078, p>0.05, Table 2). There was a weight difference between the two remaining species at a significant level of 5% (ANOVA, F_{W1} =3.539, F_{W3} = 5.692, p<0.05, Tables 1 and 3). For *E. metallicus* and *T. trichopterus*, Ws for Crops 1 and 3 were higher than for Crop 2 (Table 1 and 3).

Amongst three species, only the mean of TLs of *E. metallicus* indicated variations depending on the dike side, with the inner (4.69) being higher than the exterior (3.79) at 5% level (t-test, t=3.247, p<0.05, Table 1). However, there were no changes of TL value between inner and outer dike samples in *A. testudineus* (t-test, t= 1.585, p>0.05, Table 2) and *T. trichopterus* (t-test, t = 3.453, p>0.05, Table 3). Similarly, the TL value for the crops in *A. testudineus* was not significant (ANOVA, F = 2.706, p>0.05, Table 2). For in *E. metallicus*, TLs of Crops 1 and 3 were unchanged at the significant level of a 5% but differed from those for Crop 2 (ANOVA, F_{TLs}=7.292, p<0.05, Table 1). In *T. trichopterus*, the crop affected the TL value; e. g., they were highest in the Crop 1 (TL=7.54) when compared to two remaining crops (ANOVA, F_{TL} = 8.752, p<0.05, Table 3).

The TLs and Ws of all three species depended on the interactions of dike × crop (two-way ANOVA, F_{W1}=2.827; F_{TL2}=4.002 and F_{W2}=3.148; F_{TL3}=15.428 and F_{W3}=14.509, p<0.05).

Length-weight relationship and growth pattern

The LWRs coefficients were high for all cases (p<0.001, r^2 > 0.9, see Fig. 1, Tables 1–3). This made possible to infer the weight from the fish total length at different sizes with different conditions, i. e. sampling locations and seasons. The *b* value was used to identify the growth pattern.

For *E. metallicus*, the slope value (*b*) inside and outside dike were 2.86 and 3.07, thus growth models were negative allometric (N) and isometric (I), respectively (t-test, t_{inside}=40.345, $t_{outside}$=29.781, p<0.001, Table 1). To consider sampling seasons, the positive allometry (P) was predominant for Crop 1 and 3 (3.22, 3.29, t_{crop1}=7.382, t_{crop3}=11.625, p<0.01, Table 1). Crop 2 showed isometric growth pattern, with *b* value being c. 3 (2.96, t_{crop2}=47.414, p<0.001, Table 1).

The growth pattern in *A. testudineus* was isometric for all cases, with *b* value fluctuating around the threshold of 3 (except for Crop 3). E. g., both growth patterns were isometric for the inner and outer side of the dike (3.06, 2.99, t_{inside}=28.459, $t_{outside}$ = 25.866, p<0.001, Table 2). Similarly, Crop 1 and Crop 2 also exhibited isometric growth model (2.92, 3.03, t_{crop1}=20.807, t_{crop2}=33.899, p<0.001, Table 2). In Crop 3 only, the growth was positive allometric, with *b* value higher than 3 (3.38, t_{crop3}=12.264, p<0.001, Table 2).

The growth pattern of *T. trichopterus* showed variations. Based on *b* values, the growth models of this species inside and outside the dike were isometric and positive allometric (3.08 and 3.11, respectively, t_{inside}=56.684, $t_{outside}$=23.298, p<0.001, Table 3). Growth models across crops also had variations: negative allometry in Crop 1, positive allometry in Crop 2 and isometry in Crop 3 (2.75, 3.13 and 3.09, respectively; t_{crop1}=11.157, t_{crop2}=55.904, t_{crop3}=18.435, p<0.001, Table 3).

Condition factor

All condition factor (*CF)* values of the three species were close to 1, i.e. the standard well-being parameter (Tables 1–3). The condition factor of *E. metallicus* inside dike was higher than outside dike at a significant level of 5% (1.07 and 0.75, respectively, t=3.542, p<0.05, Table 1). However, this value did not change between Crop 1 and Crop 3 but higher than *CF* of Crop 2 (ANOVA, F=6.931, p<0.05, Table 1). This value was dependent on crop × dike interaction (ANOVA, F=7.549, p<0.05).

Comparing to the standard parameter (1), the *CF* value of *A. testudineus* did not vary by sampling site and crop. The values of *CF* within and outside dike were not different significantly at 5% (t-test, t=0.358, p>0.05, Table 2). ANOVA result showed

Table 1. Variations of growth pattern and condition factor of *Esomus metallicus*.

Fish groups		No. of fish TL	Range		Mean±SE		*b*	*a*	r^2	t_s	Growth type Mean± SE	*CF*
			W	TL	W	Mean± SE	Mean± SE					
Dyke	Inside	178	2.60-8.50	0.24-5.15	4.69±0.07[a]	1.07±0.06[a]	2.86±0.07	0.011±0.001	0.90	-2	N	1.05±0.02[a]
	Outside	22	2.50-6.20	0.14-2.14	3.79±0.27[b]	0.64±0.14[a]	3.07±0.10	0.008±0.001	0.98	0.7	I	0.75±0.08[b]
Crop	Crop 1	6	4.80-6.20	0.93-2.06	5.37±0.20[a]	1.44±0.18[a]	3.22±0.44	0.006±0.005	0.93	0.5	P	1.22±0.08[a,b]
	Crop 2	178	0.30-8.50	0.14-5.15	4.50±0.08[b]	0.97±0.06[b]	2.96±0.06	0.010±0.001	0.93	-0.67	I	0.99±0.02[b]
	Crop 3	16	4.70-5.90	0.89-1.98	5.34±0.08[a]	1.46±0.07[a]	3.29±0.28	0.006±0.003	0.91	1.04	P	1.26±0.03[a]
Total		200	2.50-8.50	0.14-5.15	4.59±0.07	1.02±0.06	2.98±0.06	0.009±0.001	0.93	-0.33	I	1.02±0.02

Note: Different letters in each category show a significant difference.

Table 2. Variations of growth pattern and condition factor of *Anabas testudineus*.

Fish groups		No. of fish TL	Range		Mean±SE		*b*	*a*	r^2	t_s	Growth type Mean± SE	*CF*
			W	TL	W	Mean± SE	Mean± SE					
Dyke	Inside	29	4.50-12.10	1.66-60.89	7.04±0.36[a]	9.90±2.19[a]	3.06±0.11	0.019±0.004	0.97	0.54	I	1.01±0.03[a]
	Outside	27	3.80-11.00	1.08-34.31	7.79±0.30[a]	11.73±1.37[a]	2.99±0.12	0.022±0.005	0.96	-0.08	I	1.02±0.02[a]
Crop	Crop 1	8	6.10-11.30	5.02-32.33	8.54±0.68[a]	14.49±3.28[a]	2.92±0.14	0.024±0.007	0.99	-0.57	I	0.94±0.03[a]
	Crop 2	40	3.80-11.00	1.08-34.31	7.08±0.26[a]	9.13±1.09[a]	3.03±0.09	0.021±0.004	0.97	0.33	I	1.01±0.02[a]
	Crop 3	8	5.90-12.10	4.73-60.89	7.91±0.72[a]	15.34±6.62[a]	3.38±0.28	0.010±0.006	0.96	1.36	P	1.07±0.08[a]
Total		56	3.80-12.10	1.08-60.89	7.41±0.24	10.78±1.31	3.04±0.08	0.020±0.003	0.97	0.5	I	1.01±0.02

Table 3. Variations of growth pattern and condition factor of *Trichopodus trichopterus*.

Fish groups		No. of fish TL	Range		Mean±SE		*b*	*a*	r^2	t_s	Growth type Mean± SE	*CF*
			W	TL	W	Mean± SE	Mean± SE					
Dyke	Inside	47	3.00-9.10	0.37-12.30	5.62±0.23[a]	3.39±0.39[a]	3.08±0.05	0.013±0.001	0.99	1.6	I	1.03±0.02[a]
	Outside	27	4.90-8.50	1.64-11.67	6.98±0.24[a]	5.77±0.58[a]	3.11±0.13	0.012±0.003	0.96	0.85	P	1.02±0.02[a]
Crop	Crop 1	13	5.50-9.10	2.80-12.30	7.54±0.27[a]	6.62±0.69[a]	2.75±0.25	0.024±0.012	0.92	-1	N	0.98±0.03[a]
	Crop 2	47	3.00-8.50	0.37-11.67	5.65±0.24[b]	3.58±0.45[b]	3.13±0.06	0.012±0.001	0.99	2.17	P	1.04±0.02[a]
	Crop 3	14	4.90-8.20	1.64-10.03	6.36±0.29[b]	4.34±0.63[a,b]	3.09±0.17	0.013±0.004	0.97	0.53	I	1.03±0.03[a]
Total		74	3.00-9.10	0.37-12.30	6.11±0.19	4.26±.35	3.08±0.05	0.013±0.001	0.98	1.6	I	1.03±0.01

Note: Different letters in each category showed a significant difference.

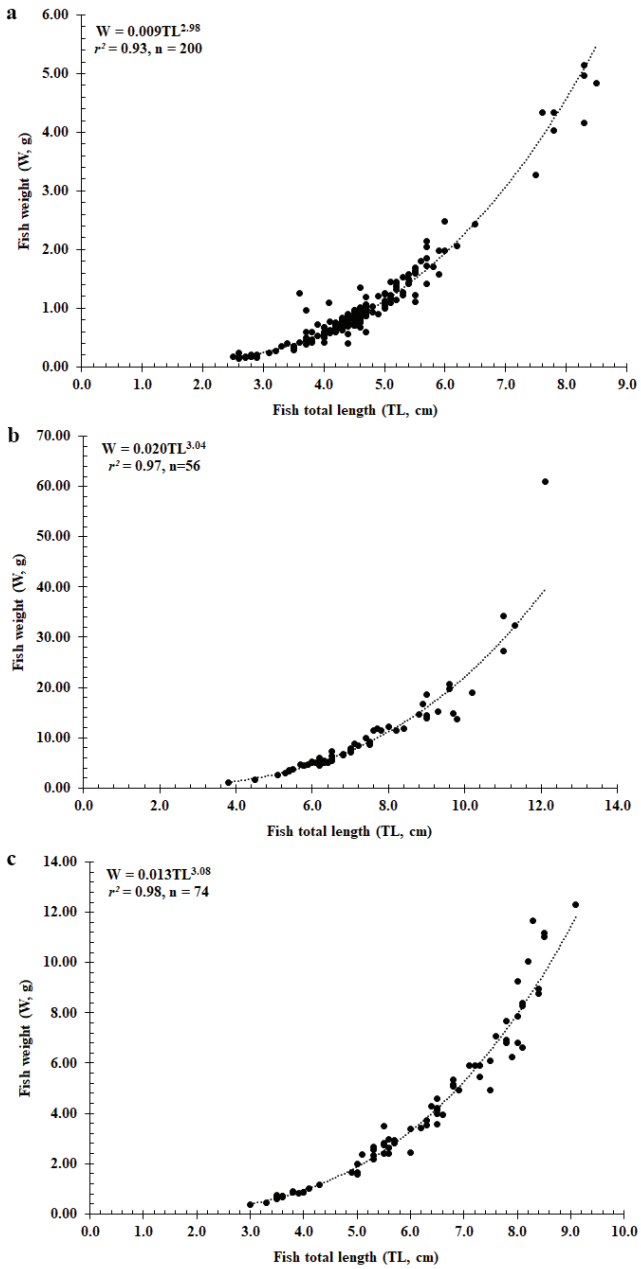


Fig 1. The relationship between fish weight and total length of *Esomus metallicus* (a), *Anabas testudineus* (b) and *Trichopodus trichopterus* (c).

that *CF* of this species did not change with the Crops (ANOVA, F=1.764, p>0.05, Table 2). The *CF* of this species was not dependent on crop × dike interaction (ANOVA, F=0.921, p>0.05).

Similarly, *CF* of *T. trichopterus* was unchanged under the different temporal and spatial conditions. Analysed by t-test, *CF* values were not different between inside and outside dike at a significant level of 5% (t-test, t=0.239, p>0.05, Table 3). *CF* values of this species across crops did not vary (ANOVA, F=1.049, p>0.05, Table 2). The *CF* value was not affected by the interaction between crop and dike (ANOVA, F=1.164, p>0.05).

Discussion

It is apparent that spatiotemporal factors (the crop season and habitat types) affect the numbers of *E. metallicus*, *A. testudineus* and *T. trichopterus* (Tables 1–3). The quantification of fish inside dike is sharply higher than outside, especially for *E. metallicus* (178 and 22, respectively; Table 1), followed by *T. trichopterus* (47 and 27, Table 3). *Anabas testudineus* was less affected relative to the numbers of indivuduals (inside 29, outside 27). Complete dike systems have been constructed in many provinces along the Mekong Delta, including in An Giang Province. These systems prevent the annual sediment deposition on lands protected by full dikes. According to Bui et al. (2017), the average weight of sediments outside diked area (22.5 tons/ha) is five times higher (4.4 tons/ha) than that in the inside area. The quantities of the total phosphorus and organic matter in sediments outside dike are higher than those inside. The environment inside the dike, with its low levels of dissolved oxygen, poor food sources, high turbidity and organic humus, is favourable for species such as *E. metallicus* and *T. trichopterus*.

The number of fish is also impacted by the temporal factor such as season and crop. Crop 2 is associated with the highest fish numbers (*Esomus metallicus* – 178, *Anabas testudineus* – 40 and *Trichopodus trichopterus* – 47) when compared to two other crops. Crop 2 (July – November) coincides with the annual wet season resulting into substantial amount of water and alluvium, mild climate, suitable light and temperature, which are suitable for rice development. Thus, paddy fields in this season provide more abundant food (duckweed, zooplankton and benthic invertebrates) for the studied fish species than the other crops (Tsuruta et al. 2011).

The average total length and total weight of *E. metallicus* are 4.69±0.07 cm and 1.07±0.06 g inside dike and 3.79±0.27 cm and 0.64±0.14 g outside dike. These values are similar in the study of Sanjay et al. (2015) on *Esomus danricus* in India (body weight 0.82–1.02 g and length 3.6–4.1 cm). Interestingly, the total length of *E. metallicus* inside dike is higher than outside at a significant level of 5% (Table 1), while total weights are not different. The reason may be that areas inside dike have less food source, thus *E. metallicus* inside dike is slimmer than outside. For *A. testudineus* and *T. trichopterus*, TLs and Ws do not differ at both dike sides (Tables 2 and 3). This indicates that the growth of the two species is not

affected by the different conditions on the two dike sides. Kumar et al. (2013) have found that the TLs and Ws recorded for *A. testudineus* varies from 1.80 to 17.50 cm, and 0.15 g to 135.00 g, which differs from our results. In the study for *Trichogaster fasciata* (Bloch & Schneider, 1801) in a wetland ecosystem from Northwestern Bangladesh, TLs and Ws have shown values of 5.3-19.2 cm and 2.5-121.37 g (Rahman et al. 2019), also differing from the result of the present study. A possible explanation is that the habitats at the two sides of the dike I our study are not sufficiently different to influence the body size of the samples.

In respect to the different crops, the total length and weight of *A. testudineus* do not change. In contrast, *E. metallicus* and *T. trichopterus* show length and weight in Crops 1 and Crop 3 significantly higher than those in Crop 2. Probably, due to the large density of fish during the period of Crop 2, individuals have competed for food, resulting into TLs and Ws lower than in other seasons. Although Crop 2 is characterised by higher rainfall than the other seasons, which coincides with other favourable conditions, it may indicate that the seasonal change of environmental factors cannot influence the body size of these species. All three species are affected by the crop × dike interaction, which means that their growth pattern depends on the combination of the habitat type and seasonal conditions. If these environmental factors change, these species may have other growth patterns.

The fish weight increases logarithmically with fish length and *b* value is 2.5–3.5 but usually close to 3.0 (Froese 2006). The *b* often remains constant (c. 3) in an "ideal" fish (Carlander 1997) but, under natural conditions, *b* usually ranged between 2.5 and 4.0 (Allen 1938). The isometric growth (b=3.0) is associated with a constant proportional change of body. The negative allometric growth (b<3) means that the fish becomes thinner as it increases in length while positive allometric growth (b>3) indicates relatively higher-bodied individuals when increasing in length.

When the coefficient determination value (r^2) for length-weight relationship is high, this indicates an increase in weight, with growth in every unit of length with a positive correlation in the length group as well as during the season (Sanjay et al. 2015). It can be stated that the relationship between length and weight has a positive correlation when r^2 is close to one, with each length increase followed by a weight increase (Mustakim et al. 2019). All LW relationships of the three studied species are highly significant (p<0.05), with all r^2 values being higher than 0.90. The r^2 value of *E. danricus* near 1 has been found in studies by Hossain et al. (2016a) (r^2 >0.97). A value of *A. testudineus* near to 1 has also been found in several studies (Mustakim et al. 2019). This positive relationship is also found in recent studies on *Trichogaster trichopterus* (Rahman et al. 2019) and *Trichogaster lalius* (see Awasthi et al. 2015). The value of the coefficient of determination, in general, is near 100%; this can be interpreted that the influence of other factors such as sex, disease or food availability is small.

In the present study, the *b* value range is 2.86–3.29, indicating all the three growth pattrens in *E. metallicus*. E.g., growth pattern inside dike is negative isometric (b = 2.86) while isometric outside. This means that the outside conditions are better for growing ofn *E. metallicus*. The morphometric relationships between length and weight can be used to assess the well-being of individuals and predict weight on the basis of length measurements when making a yield assessment. Because TLs was increased with Ws in Crops 1 and 3, the slope value was significantly higher than critical isometric value (3) in *E. metallicus*, indicating a positive allometric growth, i.e. individuals become plumper when increasing in high. The *b* value during the period of Crop 2 is close to the isometric threshold (3) suggesting that individuals are growing without changing their body proportions. In recent studies, *E. danricus* from the Ganges River, NW Bangladesh, have shown negative allometric growth due, with *b* values ranging 2.5–2.6 (Hossain et al. 2016b). Mercy et al. (2008) have recorded the isometric growth of *E. danricus* from the Western Ghats, India. Sanjay et al. (2015) have studied the growth of *E. danricus* in Assam, India, and have shown a negative allometric growth. The present results are not in accordance with the above-cited studies.

With regard to *A. testudineus*, isometric is the predominant growth pattern. Only during the period of Crop 3, b values are higher than 3, i.e. the type of growth pattern is positive allometric. This proves that *A. testudineus* is easily adaptable to different habitat and weather conditions. For *A. testudineus* in the Semayang Lake, East Kalimantan, Indonesia, the growth pattern is negative allometric, where growth in length is faster than weight growth (Mustakim et al. 2019). Actually, *A. testudineus* has a body shape combining characteristics of rover-predator and bottom-rover, being slightly elongated (Moyle & Cech 2004). Kumar et al. (2013) has studied the length-weight relationship and condition factor of *A. testudineus* under different culture systems such as tanks, cages and ponds; the attained slope is significantly lower than

the critical isometric value, with the highest slope in ponds when compared to that in cages or tanks.

Concerning *T. trichopterus*, the *b* value fluctuates from 2.75 to 3.13, i.e. exhibiting a diversity of growth model. E. g., the growth pattern during the Crop 1 is negative allometric. Inside dike and in the period of Crop 3, the growth pattern is isometric. Outside dike and in the period of Crop 2, it is positive allometric. In contrast, the growth model of *Trichogaster fasciata* in a wetland ecosystem from NW Bangladesh is negative allometric (*b*=2.72) (Rahman et al. 2019). Similar findings are documented in the Nitai Beel (*b*= 2.58) (Kalita et al. 2016) and the Deepor Beel, India (*b*=2.78) (Borah et al. 2017). However, Hossain et al. (2017) has reported a positive allometric growth (*b*= 3.29) in the Gajner Beel. The *b* value of the same species may vary from one study to another due to the application of different fishing gears (with different mesh sizes) or variations of the number of specimens examined (Ahamed et al. 2018). Furthermore, such differences between studies may be influenced by the differences between habitats or seasonal differences.

The condition factor (*CF*) of a fish reflects recent physical and biological circumstances. It can fluctuate as a result of influences caused by the feeding conditions, parasitic infections and physiological factors (Le Cren 1951). *CF* indicates the changes in food reserves and, therefore, it is an indicator of the fish general condition. When the *CF* factor value is high, it means that the fish is in better condition. *CF* can also vary depending on the stress, sex, season, availability of food and water quality parameters. The different values of *CF* are indicative for the status of food source available in the habitat (Khallaf et al. 2003). All condition factor in this study fluctuated close to the threshold 1, indicating that the three studied species are fitted to the habitat and seasonal conditions. The condition factors of *A. testudineus* and *T. trichopterus* are not impacted by habitat and seasonal crops in the present study. The differences in the values of *CF* of *A. testudineus* is due to sexes (Lorenzoni et al. 2015, Mustakim et al. 2019). In *Trichogaster lalius*, *CF* has been used to evaluate the condition or fatness of fish, which has shown that the growth in the sub-populations of this species is satisfactory (Awasthi et al. 2015).

In *E. metallicus*, *CF* inside dike is higher than outside, which means that this inner dike is a favourable habitat for this species. Crop 1 and Crop 2 are reasonable periods for growing this species. Recently, Sanjay et al. (2015) have used the condition factor, demonstrating that its values for males are the highest (1.34) in pre-monsoon period and the lowest (0.95) in winter; in females, *CF* fluctuates from 0.88 (post-monsoon) to 1.24 (pre-monsoon). In the present study, *CF* values of all studied species have been impacted by the combination of site and crop.

In conclusion, both factors in this study, dike-side and crop, have influenced *E. metallicus* than *T. trichopterus* but not *A. testudineus*. The numbers of the three species were higher in areas inside dike as well as during the period of Crop 2. Based on the length-weight relationship, slope value and condition factor, *A. testudineus* is in good condition in the studied habitats. The growth patterns of *E. metallicus* than *T. trichopterus* vary depending on the habitats and seasonal factors.

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