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Morphometrics and Condition Factor Dynamics of the Goby *Stigmatogobius pleurostigma* (Bleeker 1849) During Dry and Wet Seasons in the Mekong Delta, Vietnam

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Abstract

This study provides useful knowledge on the morphometrics, growth pattern and body condition dynamics of *Stigmatogobius pleurostigma* (Bleeker 1849). Three hundred fish (190 females and 110 males) were collected at Tran De and Nha Mat in the Mekong Delta from November 2015 to October 2016. Data analysis showed mean length and weight of *S. pleurostigma* were similar in females and males but significantly different between the dry and wet seasons. The weights of female and male *S. pleurostigma* could be estimated from a fish given the length due to the high coefficient values of the fish length and weight relationship (LWR). The length and weight relationship of females was similar to males at different sites in the dry-wet season pattern. *Stigmatogobius pleurostigma* displayed a negative allometric growth as the slope of LWR was significantly lower than the standard threshold of 3 and its growth parameters were not significantly different between gender, season and habitat. This goby could adapt well to the study region as its condition factor (K) was close to the better well-being value of 1 and its K value did not vary within gender, season and month. The results indicate that this gobiid fish lives in a favourable environment and provide helpful information for the population management of this fish.

Key words: *Stigmatogobius pleurostigma*, goby, negative allometric growth, length-weight relationship, condition factor.

Introduction

Froese (1998) mentioned that fish length and weight relationship (LWR) is a fundamental indicator for fish stock assessment and fish weight estimate from a given length. The growth parameter, e.g., regression coefficient or slope value (*b*), obtained from LWR contributes to the knowledge of fish growth pattern estimation (Froese 2006).

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Furthermore, fish well-being variations between regions and species are examined by using fish body condition (K) (Abdoli et al. 2009). The condition factor is affected by fish size, season (Froese 2006) and reproductive cycle variables (Mahmood et al. 2012; Dinh et al. 2016). However, there is no information on LWR, K and growth pattern of numerous gobies in the Mekong Delta where 58 species were recorded in the Gobiidae family (Tran et al. 2013). *Stigmatogobius pleurostigma* (Bleeker 1849) (Gobiidae) is an estuarine goby with a small and elongated body (Larson 2005). It has a wide distribution and is found in brackish and freshwater environments in some Southeast Asian countries such as Vietnam, Thailand, Singapore, Malaysia and Indonesia (Larson 2005; Froese and Pauly 2016). This goby lives mainly at estuarine and coastline areas in the Mekong Delta (Tran et al. 2013) and has played a crucial role in providing food in the Mekong Delta, especially in the estuarine regions of Soc Trang Province. However, its morphometrics, LWR, growth pattern and K dynamics between fish gender during the dry and wet seasons are unknown. Therefore, this study aims to provide basic knowledge which can be useful for the population assessment of this gobiid species.

Materials and Methods

Study site and fish collection

Fish specimens were collected monthly using deep gill nets (1.5 cm mesh size in the cod end) and by hand from November 2015 to October 2016 along the mudflats and mangrove forests in Tran De (9°28'47.41"N, 106°12'25.96"E, Soc Trang Province) and Nha Mat (9°12'15.8"N 105°43'51.8"E, Bac Lieu Province), Vietnam. In the study region, no rain was recorded in the dry season (January–May) whereas heavy rain with roughly 400 mm of precipitation per month was recorded in the wet season (June–December), while the mean annual temperature was ~27 °C (Le et al. 2006). After collection, fish specimens were identified based on their external morphology described by Nguyen (2005) and Tran et al. (2013), they were then preserved in 5% formalin plastic cans and transported to the laboratory.

Fish analysis

After sex-differentiation based on external genital morphology (e.g., oval shape in females and triangle shape in male), fish specimens were measured for total length (TL, to the nearest 0.1 cm) and weighed (W, to the nearest 0.01 g) in the laboratory. Fish length and weight relationship was estimated using the function $W = a \times TL^b$, where, W is fish weight (g), TL is fish total length (cm), *a* is the regression intercept and *b* is the regression slope (Ricker 1973). The transformation of fish length and weight as LogW = log*a* + *b*×LogTL was used to determine *a* and *b* (Froese 2006). The fish body condition factor was estimated using the function $K = \frac{W}{a \times TL^b}$, where, W is fish weight (g), TL is total length (cm), *a* is the regression intercept and *b* is the slope as described by Le Cren (1951).

Data analysis

The dynamics in morphometric measurements (TL and W) between gender and season were quantified using t-test, and the impact of gender and season interaction on the changes of TLs and Ws was tested using ANOVA. The variations in LWRs and growth pattern between females and males during the dry (January-May) and the wet (June-December) seasons at different sampling sites were examined using ANCOVA and t-test respectively based on the method of Dinh (2016b). The growth pattern of this species, e.g., allometric or isometric growth, was tested using t-test as described by Froese (2006). The variations in K within gender and season and the significant difference of K from the favourable condition value (i.e., 1) were quantified using t-test. Monthly variation in K and the influence of the interaction of gender and season on the changes of K were tested using ANOVA (Mahmood et al. 2012). The level of significant difference for all tests was set at $p<0.05$ and the SPSS v21 was used to perform these tests.

Results

Morphometric measurements

The mean length of females (4.57±0.07 cm, n = 190) was not significantly longer than males (4.41±0.11 cm, n = 110, t-test, $p>0.05$, Fig. 1A), and the average body weight of females (1.28±0.06 g) was similar to males (1.14±0.08 g, $p>0.05$, Fig. 1B). Female and male lengths were significantly greater in the dry (5.44±0.16 cm) compared to the wet (4.32±0.06 cm) seasons ($p<0.05$, Fig. 1A). Similarly, the weight of *S. pleurostigma* was significantly different between the dry (2.11±0.13 g) and the wet (1.05±0.05 g) seasons ($p<0.05$, Fig. 1B). However, fish length and weight variations were not affected by gender and season interaction (ANOVA, $p>0.05$, Figs. 1A and 1B).

Length-weight relationships and growth parameter

Both female and male weights of *S. pleurostigma* could be estimated from a caught length during the dry and wet seasons due to high coefficients of determination ($p<0.001$ for all cases, Table 1). The growth parameter of females (b = 2.88±0.05, $p>0.05$) was similar to males (b = 2.61±0.09, ANCOVA, $p>0.05$). Likely, fish growth coefficients in the dry season (2.58±0.15, n = 7) were not significantly different from the wet season (2.79±0.12, n = 5, t-test, $p>0.05$). The slope values obtained from the LWRs of females and males in the dry-wet season pattern were lower than the isometric value of 3. Overall, the regression slope value of this goby was 2.70±0.10 (all fish) and was significantly lower than the isometric value of 3 (t-test, n = 12, $p<0.05$), showing that this gobiid species displayed a negative allometric growth.

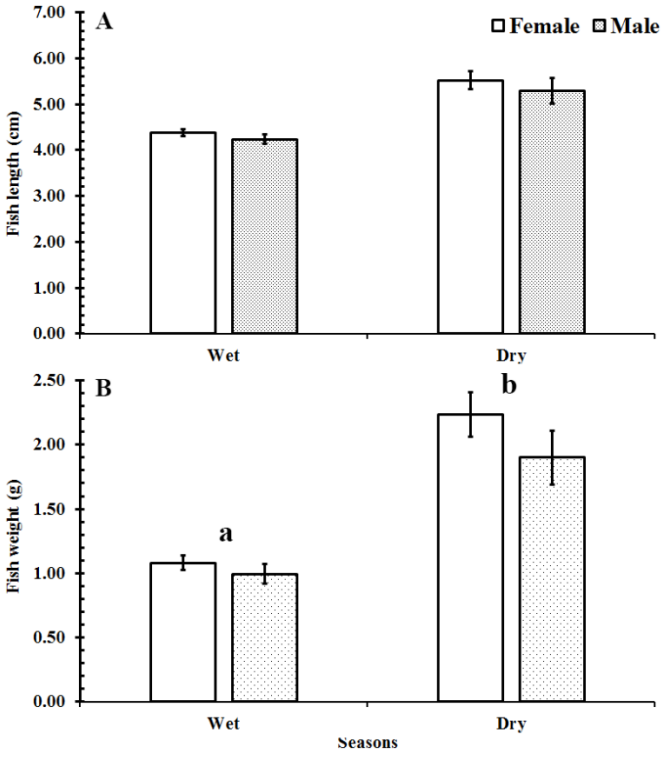

Fig. 1. Variations in length (A) and weight (B) in *Stigmatogobius pleurostigma* according to gender and season. Different letters (a and b) show significant differences between seasons. Vertical lines represent standard error.

Table 1. Morphometrics and regression slope (*b*) of *Stigmatogobius pleurostigma* in the study site over time.

Months	No. of fish (n)		*b*	*a*	r^2
	Tran De	Nha Mat			
Nov-15	26	-	2.60	0.0187	0.8046
Dec-15	19	-	3.21	0.0077	0.5652
Jan-16	11	-	2.57	0.0227	0.7573
Feb-16	8	-	2.53	0.0317	0.9868
Mar-16	9	-	2.54	0.0315	0.9878
Apr-16	12	4	3.10	0.0093	0.8390
May-16	7	-	2.18	0.0442	0.6498
Jun-16	16	7	2.26	0.0421	0.9527
Jul-16	56	10	2.95	0.0122	0.9207
Aug-16	68	-	2.85	0.0137	0.9397
Sep-16	11	-	2.57	0.0227	0.7573
Oct-16	36	-	3.06	0.0098	0.7284

The condition factor

The condition factors of both females (1.02±0.01) and males (0.97±0.02) were close to the standard threshold of 1 (t-test, $p>0.05$). This parameter in the dry (1.01±0.02) and wet (1.01±0.01) seasons was not significantly different from 1 ($p>0.05$, Fig. 2). Overall, the K value of this goby (1.01±0.01) was close to the standard well-being parameter of 1 ($p>0.05$). Fish body condition factor was similar in both gender and season ($p>0.05$) and the impact of season variables on the changes of body condition of this goby did not depend on gender ($p>0.05$, Fig. 2). Moreover, the fish condition factor was not significantly different between months (ANOVA, $p>0.05$, Fig. 3).

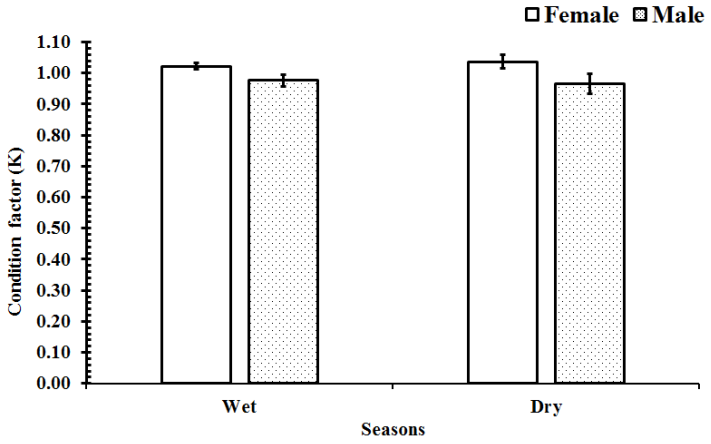

Fig. 2. The variation of condition factors between gender and season of *Stigmatogobius pleurostigma*. Vertical lines represent standard error.

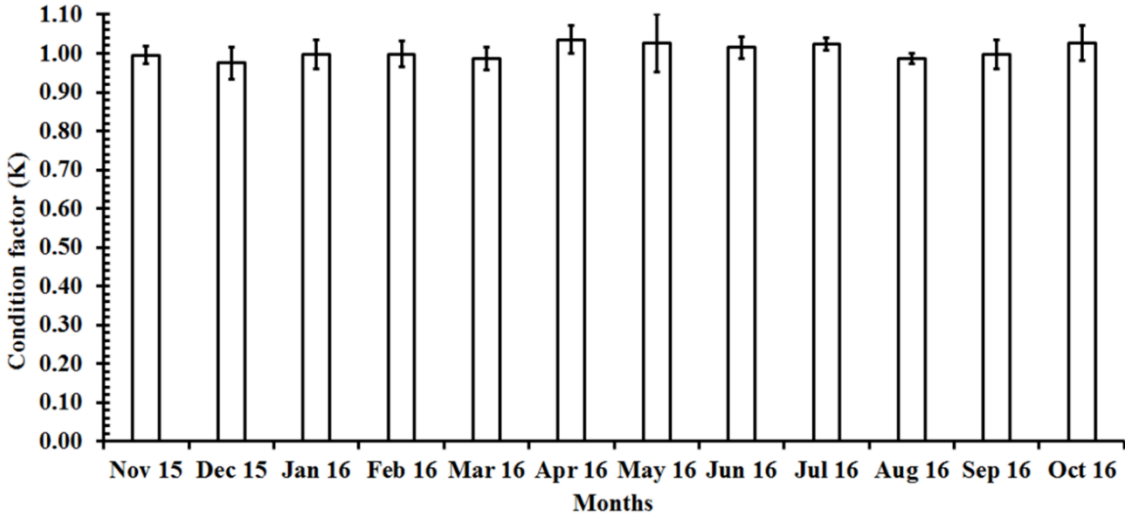

Fig. 3. Monthly variation of K values of *Stigmatogobius pleurostigma*. Vertical lines represent standard error.

Discussion

The male and female *S. pleurostigma* can reach marketable size at the same age as their TLs and Ws are not significantly different during the dry and the wet seasons. This was also found in some co-occurring gobies such as *Pseudapocryptes elongatus* (Cuvier 1816) (Tran 2008), *Boleophthalmus boddarti* (Pallas 1770) (Dinh 2014), *Parapocryptes serperaster* (Richardson 1846) (Dinh et al. 2016), *Trypauchen vagina* (Bloch & Schneider 1801) (Dinh 2016b). Likely, the morphometric measurements of *Periophthalmus barbarus* (Linnaeus 1766) (Chukwu and Deekae 2011) and *Parachaeturichthys ocellatus* (Day 1873) (Panicker et al. 2013) are not significantly different between the genders. The goby *S. pleurostigma* displayed positive relationships between length and weight in both gender and season, suggesting that fish weight could be estimated from fish length regardless of fish developmental stages. Likely, some other co-occurring gobies like the goby *P. elongatus* (Tran 2008), *B. boddarti* (Dinh 2014), *P. serperaster* (Dinh et al. 2016) and *T. vagina* (Dinh 2016b) show positive relationships between length and weight. Besides, the Atlantic mudskipper *P. barbarus* (Chukwu and Deekae 2011) and the goby *P. ocellatus* (Panicker et al. 2013) also display a positive relationship in LWRs.

In some gobies, their slope values retrieved from LWRs were regulated by gonadal developmental stage. For instance, *b* values of *P. serperaster* (Dinh et al. 2016) and *T. vagina* (Dinh 2016b) were higher in females compared to males during the spawning period. Similarly, *b* value of female *Gobius niger* (Linnaeus 1758) caught in Turkey was also significantly different from males (Kalaycı et al. 2007). However, in some other gobies, their slope values were not affected by gonadal development such as *P. barbarus* (King and Udo 1998; Chukwu and Deekae 2011). The present study also shows that slope values of *S. pleurostigma* were not impacted by gonadal development. The environmental condition (e.g., temperature and precipitation) in this study did not influence the *b* values of *S. pleurostigma* as *b* did not vary with season, which was also found in other co-occurring gobies like *P. elongatus* (Tran 2008) and *P. serperaster* (Dinh et al. 2016) but this was not the case in *T. vagina* (Dinh 2016b).

The variation in slope values, in the present study, was not regulated by the interaction of gender and season, implying that this fish species could adapt well to the study area during the study period. The good adaptation of the fish to the habitat was also found in some gobiid species such as *P. serperaster* (Dinh et al. 2016), *T. vagina* (Dinh 2016b) caught in the Mekong Delta and *P. barbarus* caught in Nigeria (King and Udo 1998). The goby *S. pleurostigma* showed a negative growth pattern as defined by Froese and Binohlan (2000) as its *b* value was significantly lower than the isometric threshold (e.g., 3), suggesting that this goby was slim in body shape as the fish grew. This assumption was also found in *Ilisha melastoma* (Mahmood et al. 2012) but not in *Periophthalmus argentilineatus* (Valenciennes 1837) and *Periophthalmus spilotus* (Murdy & Takita 1999) (positive allometric growth) (Khaironizam and Norma-Rashid 2002) and *P. serperaster* (isometric growth) (Dinh et al. 2016).

The growth pattern is not only species-specific but also regulated by environmental condition due to different growth patterns in this goby and other gobies. For example, the *b* value of *Periophthalmodon schlosseri* (Pallas 1770) is close to 3 in Malaysia (Khaironizam and Norma-Rashid 2002) and Vietnam (Dinh 2016a) but lower than 3 in Bangladesh (Saha 2013). The fish developmental stage is a factor relating to fish body condition. Indeed, the K of female *P. serperaster* was lower than male during the wet season (spawning season) (Dinh et al. 2016), which was also found in *I. melastoma* (Mahmood et al. 2012). However, like *P. barbarus* (King and Udo 1998; Chukwu and Deekae 2011), the body condition of *S. pleurostigma* in the present study was not affected by gender. Like other gobiid species such as *P. serperaster* (Dinh et al. 2016) and *T. vagina* (Dinh 2016b), the K value of *S. pleurostigma* did not vary with month and season. The condition factor was used as an indicator for fish adaptation to habitat, and when fish live in a favourable environment, the K is close to 1. In this study, *S. pleurostigma* adapted well to its habitat as K was close to the well-being threshold of 1. Similarly, the gobies distributed at the same area, i.e., *P. elongatus* (Tran 2008), *P. serperaster* (Dinh et al. 2016) and *T. vagina* (Dinh 2016b) lived well in their habitats as their condition factors are close to 1. This implied that the study area possessed favourable nutritional conditions for fish growth. The K of *S. pleurostigma* shared the same pattern in between gender and season, suggesting that the study site was nutritionally favourable for this species. This assumption was also found in other gobies such as *P. serperaster* (Dinh et al. 2016) and *T. vagina* (Dinh 2016b) caught in the Mekong Delta and *P. barbarus* collected in Nigeria (King and Udo 1998; Chukwu and Deekae 2011). The change of K of male and female *S. pleurostigma* did not depend on season, implying the variation of food resources in the study site could not influence the growth of *S. pleurostigma*. Likely, the seasonal environmental changes did not impact the condition factor of *T. vagina* (Dinh 2016b), *I. melastoma* (Mahmood et al. 2012) and *P. barbarus* (King and Udo 1998; Chukwu and Deekae 2011). On the other hand, the condition factor of *P. serperaster* varied with gender and season interaction, because of the variation of food resource in the environment between the dry and wet seasons (Dinh et al. 2016).

Conclusion

The mean length and weight of *S. pleurostigma* were not significantly different between gender and season. It was a negative allometric growth as its slope value was lower than three and the *b* value shared the same pattern between gender and season. This goby lived in a favourable condition for growth because its K value was near to 1, falling into the good well-being category. These values of female and male were not significantly different between the dry and wet seasons, indicating that *S. pleurostigma* could adapt well to the variation of precipitation between the dry and the wet seasons.

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