THE FLEXIBILITY OF MORPHOMETRIC AND MERISTIC MEASUREMENTS OF *PERIOPHTHALMODON SEPTEMRADIATUS* (HAMILTON, 1822) IN HAU RIVER

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ABSTRACT

This study was contributed to supplement the data on morphology, and the flexibility of morphometric and meristic measurement of the mudskipper *Periophthalmodon septemradiatus*, a potential aquarium pet in the Mekong Delta. A total of 1,504 individuals (930 males and 574 females) were collected from August 2017 to July 2018 at five sites in Hau River, from An Giang to Soc Trang. The analysis result of 1,504 individual showed that the total length (TL) and the body weight (W) of this species varied with gender and site, but not season. The variations of TL and W of males and females depended on season but not site. The interaction of site and season influenced on the change of TL and W. External color of males varied with the environmental condition at different sites. The morphometric and meristic parameters of this mudskipper displayed a spatial variation based on the data analysis of 150 individuals (93 males and 57 females). The results supplied additional knowledge for fish identification and understanding the ecological adaptation of this fish in the study regions.

Keywords: *Hau River, morphometric flexibility, morphometry, mudskipper, Periophthalmodon septemradiatus*

INTRODUCTION

Morphometric and meristic parameters are important fish identification and classification [14]. These parameters are used to classify fish from the marine to the freshwater regions around the world [13], including Vietnam [15]. However, there is a few paper about external morphology and meristic parameters of mudskipper species living in the mudflats along the estuarine to riverine regions in the Mekong Delta. The mudskipper *Periophthalmodon septemradiatus* (Hamilton, 1822) is an amphibious fish and widely distributed mudflats and the mangrove swamps in the Asian regions [10]; [11]; [12]. The burrow morphology and utilization, and feeding activity of this fish species are described in the Navinal coast [1]. It lives from the estuary to the upstream of Hau River and is a potential aquarium pet in the Mekong Delta [15]. However, external morphology, morphometric and meristic characteristics of this species had fragmented. Have these parameters varied with different places along the Hau River, from the estuary (Soc Trang Province) to the upstream (An Giang Province)? Therefore, this study was conducted to answer this question. The results will contribute to knowledge on external morphology, morphometric and meristic parameters of this species; and the spatial variation of these characteristics along Hau River, being used for understanding fish ecological adaption in the study region.

MATERIALS AND METHODS

Fish collection and analysis

This study was carried out at five sites along Hau River from Long Duc, Long Phu, Soc Trang (LD); An Lac Tay, Ke Sach, Soc Trang (ALT); Phu Thu, Cai Rang, Can Tho (PT); Tan Hung, Thot Not, Can Tho (TH); and Binh Duc, Long Xuyen, An Giang (BD, Fig. 1). The fish specimens were monthly collected by fishing rods for a year-round from August 2017 to July 2018. An area of 30 m^2 (15 m along the river bank and 2 m from the river bank to the riverbed) in each study site was

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chosen for fishing. Every month, a field trip lasted for five days (one day per sampling site). There are two main seasons including the dry season (January to May) and wet season (June to December) in this study region. It rarely rain in the dry season but heavy rain in the wet season with 400 mm precipitation per month. The average annual temperature is ~27 °C and the tide of the study region is semi-diurnal [9]. The distance from the river bank to the riverbed of the mudflat was nearly 2.5 m at the lowest tide. Fish specimens were identification based on the external morphology described by Khaironizam & Norma-Rashid (2003) [8] and transported to the laboratory after collection.

The fish specimen, in the laboratory, was sexually differentiated using external morphology (males was more colorful than females) and genital papilla (genital papilla of males was smaller and whiter than females). Fish was then described external morphology such as the color of head, body, and fins. The morphometric and meristic parameters were followed the description of Murdy (1989) [10] and Daud et al. (2005) [2]. Accordingly, the total length (TL), standard length (SL), head length (HL), body depth (BD), eye diameter (ED), distance of two eyes (DE) and body weight (W) were measured to calculate some ratios such as HL/SL, BD/SL, ED/HL and DE/HL. The number of fin rays such as pectoral fin (PeF), pelvic fin (PF), anal fin (AF), dorsal fin 1 (D1F), dorsal fin 2 (D2F), and caudal fin (CF) was counted. The number of scales including longitudinal scales (LS), upper longitudinal scales (ULS), lower longitudinal scales (LLS), and the caudal scales (CS) was also counted.

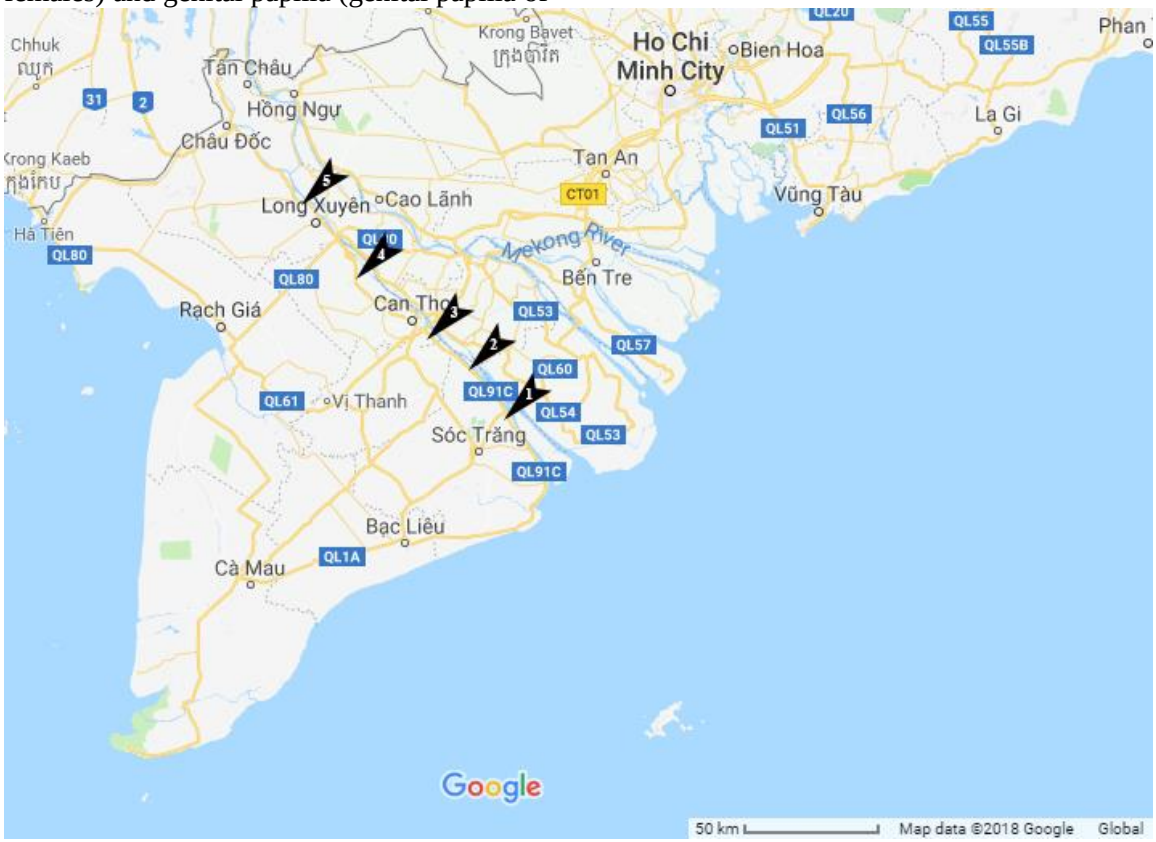

Figure 1. *The sampling map in the Hau River*
(arrowhead: sampling area; 1: Long Duc, Long Phu, Soc Trang; 2: An Lac Tay, Ke Sach, Soc Trang; 3: Phu Thu, Cai Rang, Can Tho; 4: Tan Hung, Thot Not, Can Tho; 5: Binh Duc, Long Xuyen, An Giang)

Data analysis

The Student t-test was used to examine the differences in TL and W between genders and seasons. One-way ANOVA was used to test the variation of TL and W among five sites. The influence of the interaction of three variables including gender × season, gender × site, season × site was examined by two-way ANOVA. The spatial variation of morphometric parameters (HL/SL, BD/SL, ED/HL, and DE/HL) and meristic parameters (PeF, PF, AF, D1F, D2F, CF, LS, LLS, and CS) were quantified by one-way ANOVA. The SPSS software v21 was used for data analysis. All tests were set at $P < 0.05$.

RESULTS AND DISCUSSION

External morphological variation

The color of male *P. septemradiatus* varied with muddy color. The blue-purple of head and body fish was darker in PT than in BD, TH, ALT, and LD, as the mudflat in PT was darker than that in BD, TH, ALT, and LD. The pale red and pale blue spots on the snout, opercula and trunk were darker in PT than BD, TH, ALT, and LD. Likely, the margin of D1 and D2 was more reddish in PT than in BD, TH, ALT, and LD. The male color in BD and TH shared nearly the same pattern. But, the color of females did not vary with study sites (Fig. 2).

Data analysis 1,504 individuals (930 males and 574 females) showed that the mean TL of this species varied significantly with gender (t-test, t=11.50, $P<0.01$), but not season (t=0.79, $P>0.05$ Table 1). Likely, the average weight of males was significantly higher than that of females (t=10.90, $P<0.05$, Table 1), whereas this value in the dry season was similar to that in the wet season (t=1.50, $P>0.05$). It suggested that males grew quickly than females, and high precipitation in the wet season was not influenced on the TL and W of this mudskipper. Meanwhile, the TL and W of some gobiid species living in the Mekong Delta, e.g., the large scale goby *Parapocryptes serperaster* [6], the giant mudskipper *Periophthalmodon schlosseri* [4], the red goby *Trypauchen vagina* [5], and the boddart's goggle-eyed goby *Boleophthalmus boddarti* [3] and the goby *Stigmatogobius pleurostigma* [7], do not vary between dry season and wet season. The seasonal change in W was found in the large scale goby *P. serperaster* [6].

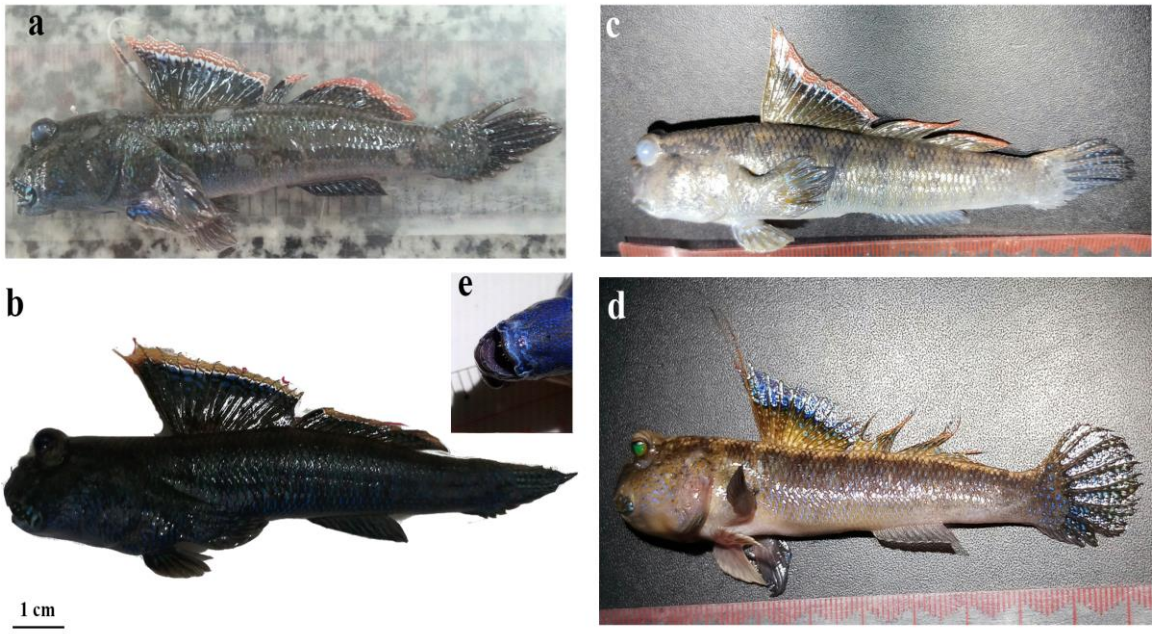

Fig. 2. *Variation in male P. septemradiatus at different sites*
(a: Binh Duc, Long Xuyen, An Giang and Tan Hung, Thot Not, Can Tho; b: Phu Thu, Cai Rang, Can Tho; c: An Lac Tay, Ke Sach, Soc Trang; d: Long Duc, Long Phu, Soc Trang; e: head of fish)

Table 1. *The number of Periophthalmodon septemradiatus was caught from five sites*

Morphometry	Category	Number of fish	Mean±SE
Fish total length	Male	930	8.70±0.10
	Female	574	7.80±0.10
Fish body weight	Male	930	6.19±0.10
	Female	574	4.57±0.11
Fish total length	Dry	617	8.40±0.10
	Wet	887	8.30±0.10
Fish body weight	Dry	617	5.71±0.13
	Wet	887	5.47±0.10

The mean TL of this species changed with study sites, reaching the highest point in BD (9.2±0.1 SE cm) and lowest point in ALT (7.6±0.1 SE cm, one-way ANOVA, F=62.60, *P*<0.05, Fig. 3). The spatial variation was also found in W of this fish with the highest point in BD (7.23±0.21 g) and the lowest point in ALT (4.17±0.12 g, F=55.03, *P*<0.05, Fig 4). It seems that the changes TL and W related to the environmental condition.

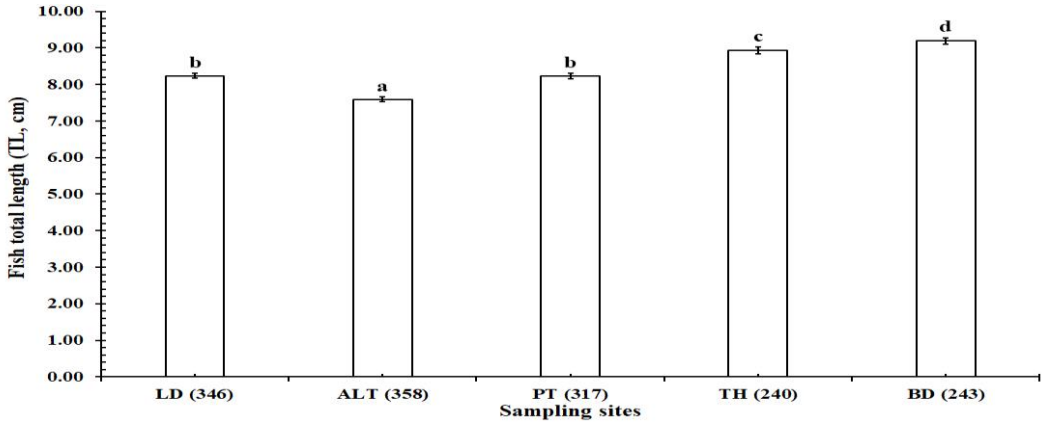

Fig. 3. *The variation in fish total length at five sites*

[LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang; number in parentheses: number of fish in each site; vertical bar was standard error of mean; different letters (a, b, c and d) represented the significant difference]

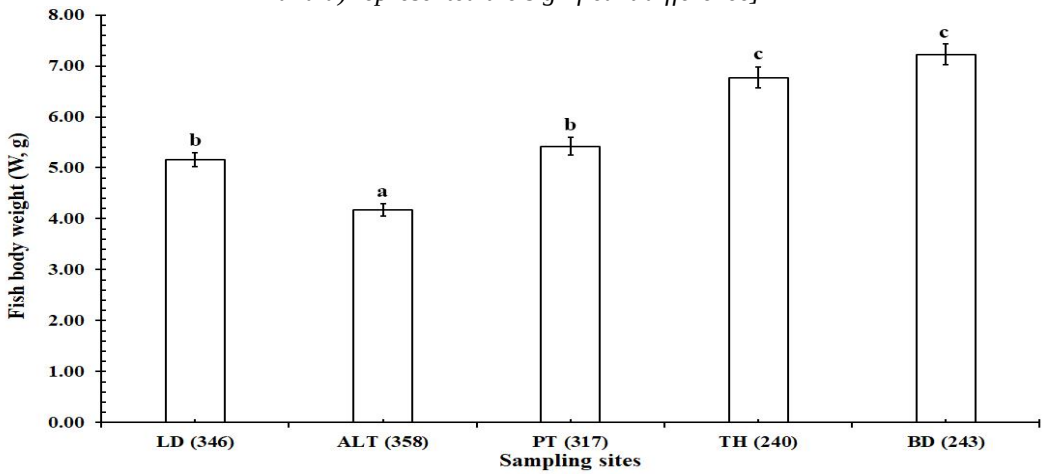

Fig. 4. *The variation in body weight at five sites*

[LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang; number in parentheses: number of fish in each site; vertical bar was standard error of mean; different letters (a, b, c and d) represented the significant difference]

The spatial variation in TL of this species did not depend on gender (two-way ANOVA, F=0.26, *P*>0.05), but depend on seasonal change (F=6.98, *P*<0.01, Fig. 5). However, the changed of TL of *P. septemradiatus* depend on the interaction of gender and season variables (F=8.72, *P*<0.01, Fig. 6). Similarly, the change W of *P. septemradiatus* depend on the interaction of site × season (F=10.31, *P*<0.01, Fig. 7), gender × season (F=10.16, *P*<0.01, Fig. 8) but not site × gender (F=0.62, *P*>0.05).

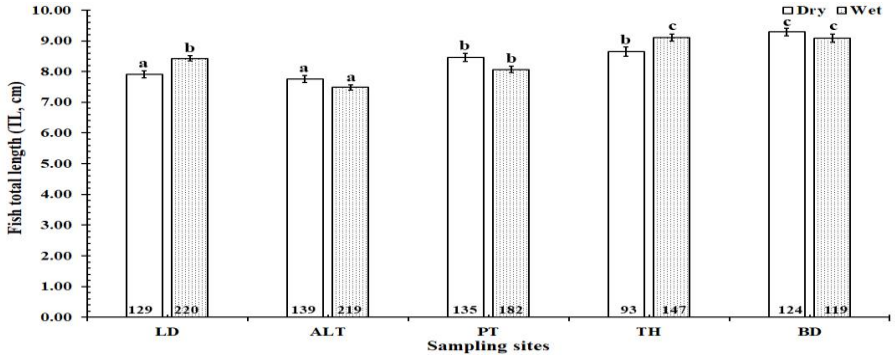

Fig. 5. *The interaction of season and site on the change of fish total length*
[LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang; the number in each column: number of fish in each site; the vertical bar was standard error of mean; different letters (a, b and c) represented the significant difference]

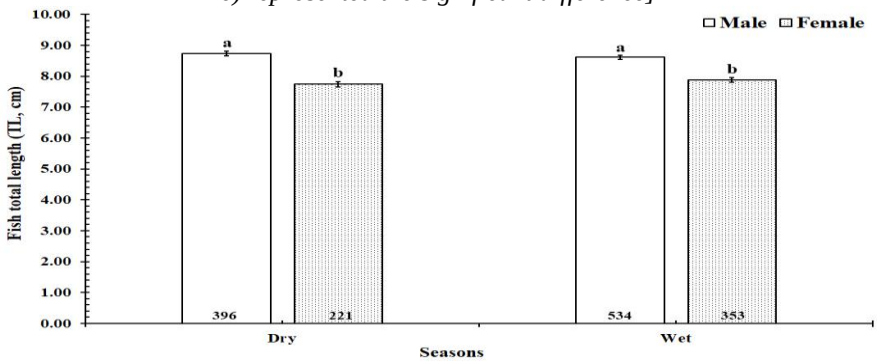

Fig. 6. *The interaction of season and gender on the change of fish total length*
[number in each column: number of fish in each season; the vertical bar was standard error of mean; different letters (a and b) represented the significant differences]

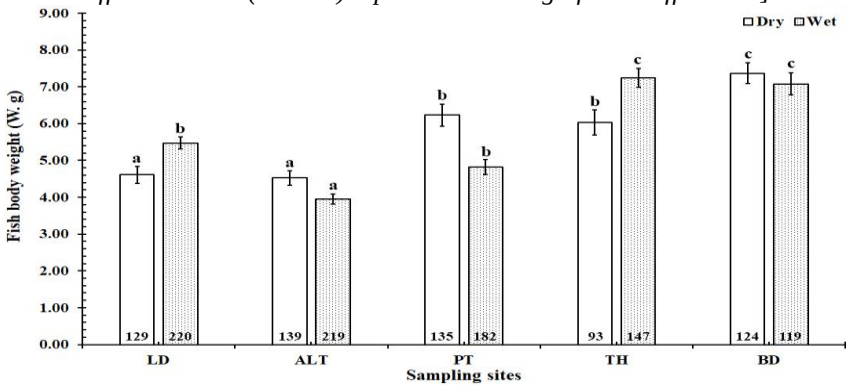

Fig. 7. *The interaction of season and site on the change of fish body weight*
[LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang; the number in each column: number of fish in each site; the vertical bar was standard error of mean; different letters (a, b and c) represented the significant differences]

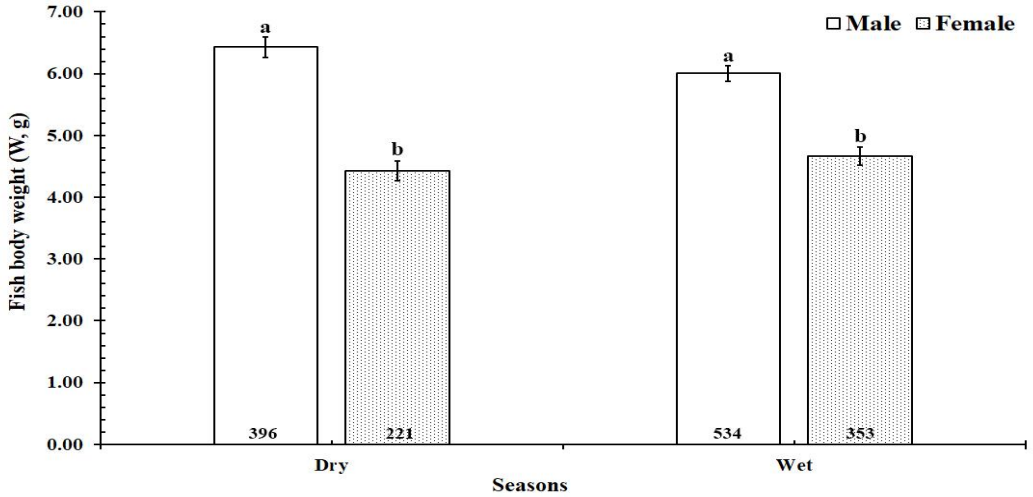

Fig. 8. *The interaction of season and gender on the change of fish body weight [number in each column: number of fish in each season; the vertical bar was standard error of mean; different letters (a and b) represented the significant differences]*

Morphometric and meristic variation

The morphometric parameters including HL/SL, BD/SL, ED/HL, and DE/HL of the mudskipper *P. septemradiatus* varied study sites (one-way ANOVA, $P<0.05$ for all cases) and recorded in Table 2.

Table 2. *The variation in morphometric parameters of P. septemradiatus among five sites*

Morphometric parameter	Site	Number of fish	Mean	Standard deviation	Minimum	Maximum	F	*P*
Head length/Standard length	LD	30	21.44	3.25	13.33	29.51	18.69	0.001
	ALT	30	23.95	3.77	17.74	34.55		
	PT	30	26.12	1.68	23.40	29.23		
	TH	30	22.74	2.09	16.67	26.67		
	BD	30	26.04	1.26	23.53	28.38		
Body depth/ Standard length	LD	30	13.02	1.70	10.42	15.73	34.25	0.001
	ALT	30	14.72	2.01	10.29	17.14		
	PT	30	17.48	1.65	14.19	20.63		
	TH	30	15.40	1.35	13.04	18.67		
	BD	30	16.47	1.10	14.29	18.24		
Eye diameter/Head length	LD	30	15.87	2.99	11.43	25.00	15.88	0.001
	ALT	30	14.45	3.73	7.14	27.27		
	PT	30	19.83	3.27	15.91	30.30		
	TH	30	19.41	3.20	14.29	26.67		
	BD	30	16.57	2.68	11.36	22.22		
Distance of two eyes/Head length	LD	30	13.97	2.10	11.11	18.75	10.42	0.001
	ALT	30	11.04	2.97	6.67	18.18		
	PT	30	14.59	2.06	11.76	20.00		
	TH	30	12.44	2.74	7.14	16.67		
	BD	30	12.04	2.29	7.14	16.67		

Note: LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang

Likely, the change in meristic parameters including PeF, PF, AF, D1F, D2F, CF, LS, LLS, and CS was recorded in Table 3. PeF, D1, CF, and CS of *P. septemradiatus* varied study sites (ANOVA, $P<0.05$ for all cases, Table 3).

Table 3. *The variation in meristic parameters of P. septemradiatus among five sites*

Meristic parameters	Sites	Number of fish	Mean	Standard deviation	Minimum	Maximum	F	*P*
Pectoral fin ray (PeF)	LD	30	12.3	0.9	10.0	14.0	3.80	0.001
	ALT	30	12.5	1.2	10.0	16.0		
	PT	30	12.0	1.5	10.0	15.0		
	TH	30	13.1	1.3	10.0	16.0		
	BD	30	13.0	1.4	11.0	16.0		
Pelvic fin ray (PF)	LD	30	6.2	0.5	6.0	8.0	1.89	0.115
	ALT	30	6.1	0.4	6.0	8.0		
	PT	30	6.0	0.2	6.0	7.0		
	TH	30	6.0	0.0	6.0	6.0		
	BD	30	6.0	0.0	6.0	6.0		
Anal fin ray (AF)	LD	30	10.6	1.2	8.0	13.0	2.36	0.056
	ALT	30	10.1	1.3	8.0	14.0		
	PT	30	10.5	1.0	8.0	12.0		
	TH	30	11.1	1.2	8.0	13.0		
	BD	30	10.5	1.5	8.0	14.0		
Dorsal one fin ray (D1)	LD	30	12.1	3.1	4.0	16.0	7.78	0.001
	ALT	30	6.8	3.7	3.0	14.0		
	PT	30	11.3	3.9	4.0	16.0		
	TH	30	10.0	4.4	4.0	17.0		
	BD	30	10.3	4.7	4.0	21.0		
Dorsal two fin ray (D2)	LD	30	13.4	1.8	10.0	18.0	1.41	0.235
	ALT	30	12.5	2.1	9.0	20.0		
	PT	30	12.9	1.2	11.0	16.0		
	TH	30	12.7	1.2	10.0	16.0		
	BD	30	12.7	1.6	7.0	15.0		
Caudal fin ray (CF)	LD	30	13.5	2.2	10.0	21.0	9.99	0.001
	ALT	30	14.8	1.7	12.0	20.0		
	PT	30	16.2	1.6	14.0	19.0		
	TH	30	15.6	2.0	10.0	18.0		
	BD	30	15.7	1.5	12.0	18.0		
Longitudinal scale (LS)	LD	30	50.0	2.7	43.0	55.0	1.39	0.239
	ALT	30	50.1	3.0	45.0	55.0		
	PT	30	50.3	4.5	47.0	73.0		
	TH	30	51.7	3.4	46.0	62.0		
	BD	30	50.2	2.8	43.0	55.0		
Upper longitudinal scale (ULS)	LD	30	7.0	0.7	6.0	9.0	1.65	0.165
	ALT	30	7.3	0.6	6.5	9.0		
	PT	30	7.1	0.4	6.5	8.0		
	TH	30	7.0	0.5	6.0	8.0		
	BD	30	7.2	0.6	6.0	8.0		
Lower longitudinal scale (LLS)	LD	30	5.0	0.7	4.0	7.0	1.65	0.165
	ALT	30	5.3	0.6	4.5	7.0		
	PT	30	5.1	0.4	4.5	6.0		
	TH	30	5.0	0.5	4.0	6.0		
	BD	30	5.2	0.6	4.0	6.0		
Caudal scale (CS)	LD	30	8.8	1.4	6.0	13.0	5.62	0.001
	ALT	30	10.0	1.3	8.0	12.0		
	PT	30	8.8	0.9	8.0	12.0		
	TH	30	8.8	1.2	7.0	13.0		
	BD	30	8.7	1.3	7.0	13.0		

Note: LD: Long Duc, Long Phu, Soc Trang; ALT: An Lac Tay, Ke Sach, Soc Trang; PT: Phu Thu, Cai Rang, Can Tho; TH: Tan Hung, Thot Not, Can Tho; BD: Binh Duc, Long Xuyen, An Giang

The variation in morphometric and meristic parameters at different sites along the Hau River resulted in the wide distribution and the morphometric flexibility of this mudskipper in the Mekong Delta.

CONCLUSIONS

The study was contributed to add knowledge on external morphology, morphometric and meristic parameters of this species. The external morphology, morphometric and meristic parameters of the mudskipper *P. septemradiatus* changed with environmental conditions. The results supplied additional knowledge for fish identification and understanding the ecological adaptation of this fish in the study regions. Further DNA barcoding assessments should be done to confirm whether genetic variation of this species.

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TÓM TẮT

TÍNH MỀM DẺO CỦA ĐẶC ĐIỂM HÌNH THÁI CỦA CÁ THÒI LÒI *PERIOPHTHALMODON SEPTEMRADIATUS* (HAMILTON, 1822) PHÂN BỐ Ở SÔNG HẬU

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Nghiên cứu bổ sung đặc điểm hình thái cơ thể và sự mềm dẻo của các chỉ số đo và đếm của cá thòi lòi *Periophthalmodon septemradiatus*, một loài cá cảnh tiềm năng ở Đồng bằng sông Cửu Long. Tổng số 1.504 mẫu cá (930 cá đực và 574 cá cái) thu được tháng 08 năm 2017 đến tháng 7 năm 2018 tại năm điểm dọc theo tuyến sông Hậu, từ An Giang đến Sóc Trăng. Kết quả phân tích 1.504 mẫu cá cho thấy chiều dài tổng (TL) và khối lượng cơ thể (W) của loài cá này thay đổi với tính biệt và điểm thu mẫu nhưng không thay đổi theo mùa. Sự thay đổi của TL và W của loài này phụ thuộc vào sự tương tác của mùa và điểm thu mẫu, mùa và tính biệt nhưng không phụ thuộc vào sự tương tác của điểm thu mẫu và tính biệt. Màu sắc cơ thể của cá đực thay đổi phụ thuộc vào sự thay đổi điều kiện của môi trường. Các chỉ số đo và đếm của loài cá này cũng thay đổi theo điểm thu mẫu dựa trên kết quả phân tích 150 mẫu cá (93 cá đực và 57 cá cái). Kết quả bổ sung thêm thông tin cho công tác định loại cá và những hiểu biết về thích nghi sinh thái của loài này với môi trường sống.

Từ khóa: *cá thòi lòi, đặc điểm hình thái, Periophthalmodon septemradiatus, sông Hậu, tính mềm dẻo kiểu hình*

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