



## The Relative Gut Length and Gastro-Somatic Indices of the Mudskipper *Periophthalmodon septemradiatus* (Hamilton, 1822) from the Hau River

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**Abstract:** This study provides an understanding of the feeding habit and intensity of the mudskipper *Periophthalmodon septemradiatus*, which was a potential aquarium pet, by analyzing its relative gut length (RGL) and gastro-somatic (GaSI) indexes. Fish specimens were caught with fishing rods in an area from the Hau River's estuary in Soc Trang province to its upstream in An Giang province during a period of one year from August 2017 to July 2018. The analysis of 1,504 fish samples shows that RGL did not change by fish size, resulting in no change in the feeding habit of *P. septemradiatus* in relation to its size. By contrast, the feeding habit of this mudskipper varied by site, month and season of sample collection; accordingly, the RGL was also significantly different by site, month and season of sample collection; both the male and female fish fell into the carnivorous as the RGL was <1. Similarly, the feeding intensity of this species did not change by fish size, as the GaSI was not significantly different among the four fish size groups. Meanwhile, the mudskipper displayed spatial, temporal and seasonal variations in the feeding intensity since the GaSI significantly changed by site, month and season. The changes in the feeding habit and intensity of *P. Septemradiatus* were not regulated by the interaction between fish size and site, fish size and season, and site and season. These results provide new knowledge on the feeding habit and intensity of this fish species, which also helps understand the fish's adaption and conservation in the study area.

**Keywords:** Astro-somatic index, mudskipper, *Periophthalmodon septemradiatus*, relative gut length

### 1. Introduction

The mudskipper *P. septemradiatus* (Hamilton, 1822) is one of three species of the genus *Periophthalmodon*[1, 2, 3]. This gobiid species is an amphibious fish (Clayton 1993) widely distributed mudflats and the mangrove swamps in the Asian regions[1]. In India, the mudskipper creates I-, J- and Y-shapes and feed

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by grazing activity on the muddy flat in the Navinal coast [4]. The species *P. septemradiatus* lives from the estuary to the upstream and is a potential aquarium pet in the Mekong Delta. However, the fish population size has been declining because of deforestation, urbanization, and environmental pollution. There is no data on its feeding habit and intensity, and the variation of feeding habit and intensity with fish size, distribution area, season and month. These two characteristics are the basis for understanding the environmental condition influences on fish activity and fish interaction in the fish community. The relative gut length (RGL) index is helpful for feeding

habit determination [5], and gastro-somatic index (GaSI) one is used to examine the feeding intensity [6]. Therefore, this study aimed to provide new knowledge on RGL and GaSI, and the variation of RGL and GaSI with fish size, place, season and month of this mudskipper specie. The results will be helpful for understanding of the fish feeding habitat and intensity, being used for fish adaption in muddy habitat knowing.

## 2. Materials and methods

### 2.1. Fish collection and analysis

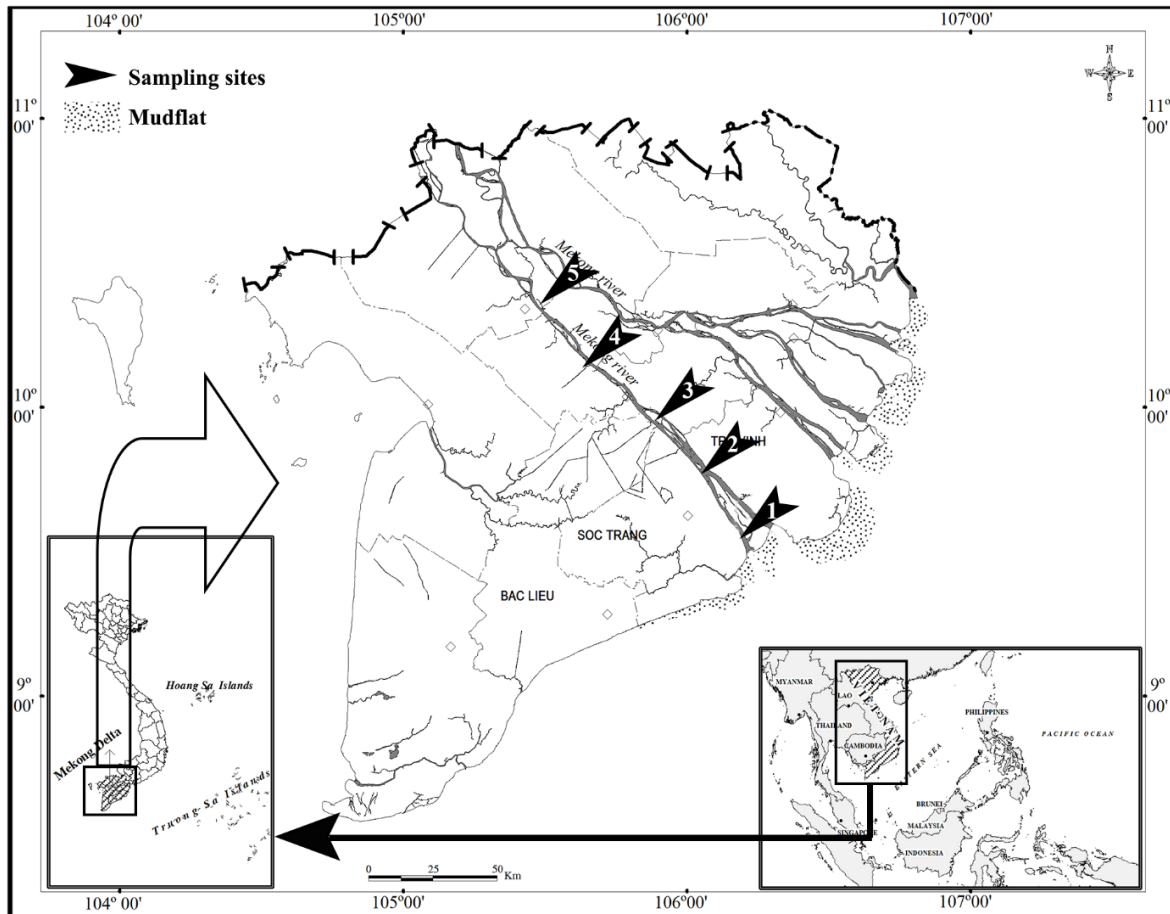


Figure 1. The sampling map in the Hau river.

(arrow head: 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)

Fish was collected monthly by fishing rods from August 2017 to July 2018 at five sites including 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). Each field trip lasted for five days (one day per sampling site). In each site, an area of 30 m<sup>2</sup> (15 m along the river bank and 2 m from the river bank to the riverbed) was chosen for fish collection. The dry season with little precipitation from January to May and the wet season from June to December with 400 mm precipitation per month are two main seasons in the study region. The average annual temperature is ~27 °C and the tide of the study region is semi-diurnal [7]. The distance from the river bank to the river bed of the mudflat was nearly 2.5 m at the lowest tide. After collection, fish was analyzed based on the external description of Khaironizam & Norma-Rashid (2003) [8], and then stored in 5% formal in fluid and transported to the laboratory.

In the laboratory, fish specimen was sexed using external morphology (males was more colorful than females) and genital papilla (genital papilla of males was smaller and whiter than females). Fish specimens were then measured the total length (TL) to the nearest 0.1 cm and body weight (W) to the nearest 0.01 g. After removing from fish specimen, the digestive tract was measured the length (Lg) to the nearest 0.1 cm and weight (Wg) to the nearest 0.01 mg in order to calculate the relative gut length (RGL) and gastro-somatic (GaSI) index. The RGL was calculated as  $Lg/TL$  (Lg: length of the gastrointestinal tract; TL: fish total length) and was used to determine feeding habit, e.g., carnivore (RGL < 1.0), omnivore (RGL = 1.0-3.0) or herbivore (RGL > 3.0) [5]. The GaSI was estimated as  $100 * Wg/W$  (Wg: weight of gut and W: fish body weight) and was used to estimate feeding intensity [6].

## 2.2. Data analysis

The variations of RGL and GaSI with fish size, place and month were quantified by one-way ANOVA. The changes RGL and GaSI between the dry and the wet season were examined by T-test. The interaction of fish size, season and place on changes of RGL and GaSI was tested by General Linear Model. The significant difference of RGL of male and female *P. septemradiatus* at different size, place, month and season from one was confirmed by using T-test. The fish size was divided using the function  $(TL_{max} - TL_{min}) / \log_{10} n$ , where,  $TL_{max}$  is the maximum fish total length,  $TL_{min}$  is the minimum fish total length; and n is number of fish collection [9]. Accordingly, fish size was categorized into four groups including group 1 (TL < 5.1 cm), group 2 (TL = 5.1-9.0 cm), group 3 (TL = 9.1-11.0 cm), and group 4 (TL > 11.0 cm). The SPSS software v21 was used for data analysis. All tests were set at  $P < 0.05$ .

## 3. Results and discussion

### 3.1. The relative gut length and feeding habit

A total of 1,504 fish specimens (930 males and 574 females) were collected from five sites during the dry and the wet season and recorded in Table 1.

Data analysis showed that the relative gut length index (RGL =  $0.60 \pm 0.01$  SE) of the mudskipper *P. septemradiatus* was significantly lower than one (t-test,  $P < 0.01$ ). It suggested that the species is a carnivorous fish that was also found in some gobiid species in the Mekong Delta, e.g., the goby *Oxyeleotris urophthalmus* [10], the broadhead sleeper *Eleotris melanosoma* [11]. By contrast, some other goby living in the Mekong Delta including the small scale goby *Pseudapocryptes elongatus* [12], the large scale goby *Parapocryptes serperaster* [13] and the goby *Stigmatogobius pleurostigma* [14] are omnivores.

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

Sampling time	1		2		3		4		5	
	M	F	M	F	M	F	M	F	M	F
Aug-17	41	10	23	37	28	11	11	16	6	7
Sep-17	12	7	28	3	10	4	13	5	8	7
Oct-17	22	4	14	5	14	6	5	3	3	2
Nov-17	13	13	13	9	4	8	4	4	12	12
Dec-17	15	16	10	16	19	10	15	13	16	7
Jan-18	11	11	7	10	14	13	8	2	14	10
Feb-18	13	7	16	6	19	10	12	9	9	5
Mar-18	12	10	25	10	11	3	9	3	20	19
Apr-18	18	12	24	12	12	20	15	7	24	11
May-18	30	2	20	9	30	3	17	11	6	6
Jun-18	28	7	14	17	17	10	20	13	13	6
Jul-18	19	13	18	12	18	23	18	7	10	10
Sum	234	112	212	146	196	121	147	93	141	102

Note: 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; M: males and F: females

The RGL of the mudskipper *P. septemradiatus* shared the same pattern among four fish size groups (ANOVA,  $P>0.05$ , Fig. 2), suggested that the feeding habit of this species did not show ontogenetic variation. Meanwhile, the feeding habit of the large scale goby *Parapocryptes serperaster* living in the Mekong Delta changed with fish size [13]. By contrast, the feeding habit of *P. septemradiatus* displayed a spatial variation, reaching the highest point in Tan Hung, Thot Not, Can Tho ( $0.61\pm 0.01$  SE; ANOVA,  $P<0.05$ , Fig. 3). The temporal change of the feeding habit was also found in this mudskipper species because the RGL displayed a significantly different during the 12-months study, reaching the highest point in April ( $0.70\pm 0.02$  SE) and the lowest point in December ( $0.51\pm 0.01$  SE; ANOVA,  $P<0.05$ , Fig. 4). The feeding habit of *P. Septemradiatus* changed with season, as RGL in the dry season ( $0.63\pm 0.01$  SE) was significantly higher than that in the wet season ( $0.59\pm 0.01$  SE, t-test,  $P<0.05$ ). However, both males and females fall into carnivorous fish since the RGL was significantly lower than one (t-test,  $P<0.05$  for all cases). The RGL was not influenced by the

interaction of the fish size and place, the fish size and season, and the place and season (ANOVA,  $P>0.05$  for all cases), showing that the variation of feeding habit of this fish species was not influenced by this variable interaction.

### 3.2. The gastrosomatic index and feeding intensity

The mudskipper *P. septemradiatus* displayed a high level in feeding intensity as gastro-somatic index (GaSI) was  $2.40\pm 0.03$  SE. The high feeding intensity was also found in the large scale goby *P. serperaster* [13] and the broadhead sleeper *E. melanosoma* [11].

The feeding intensity of this species did not show ontogenetic variation, as the GaSI did not significantly different among four fish size groups (ANOVA,  $P>0.05$ , Fig. 5). Likely, the feeding intensity of the large scale goby *P. serperaster* living in the Mekong Delta did not change with fish size [13]. On the other hand, the feeding intensity of *P. septemradiatus* displayed a spatial variation, reaching the highest point in An Lac Tay, Cai Rang, Can Tho ( $2.55\pm 0.06$  SE; ANOVA,  $P<0.05$ , Fig. 6). It seems that the feeding intensity of this mudskipper related with the environmental condition.

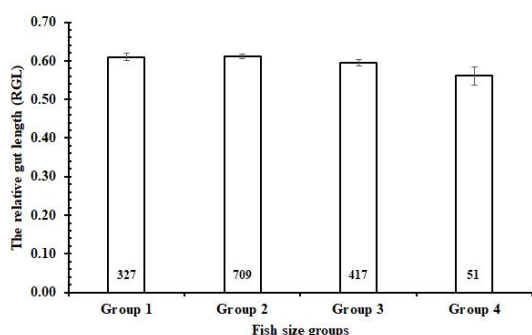


Figure 2. The variation in RGL of *P. septemradiatus* among four fish size groups. (group 1: TL<5.1 cm, group 2: TL=5.1-9.0 cm, group 3: TL = 9.1-11.0 cm, group 4: TL>11.0 cm; number in each column represented for number of fish in each fish size group; vertical bar was standard error of mean)

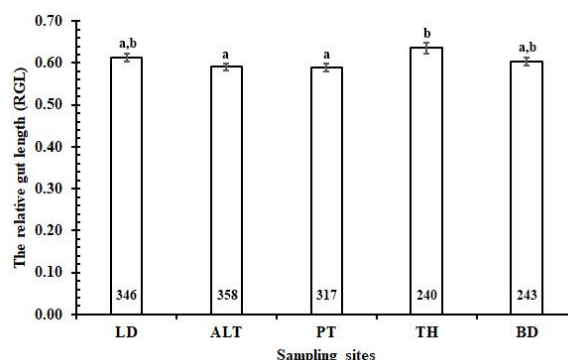


Figure 3. The variation in RGL of *P. septemradiatus* among five sampling sites. [LD: Long Duc, Long Phu, Soc Trang, ALT: An Lac Tay, Ke Sach, Soc Trang, PT: Phu Thu, Cai Rang, Can Tho, TH: Tan Hung, Thot Not, Can Tho, BD: Binh Duc, Long Xuyen, An Giang; number in each column represented for number of fish in each site; vertical bar was standard error of mean; different letters (a and b) represented the significantly different in RGL among five sites]

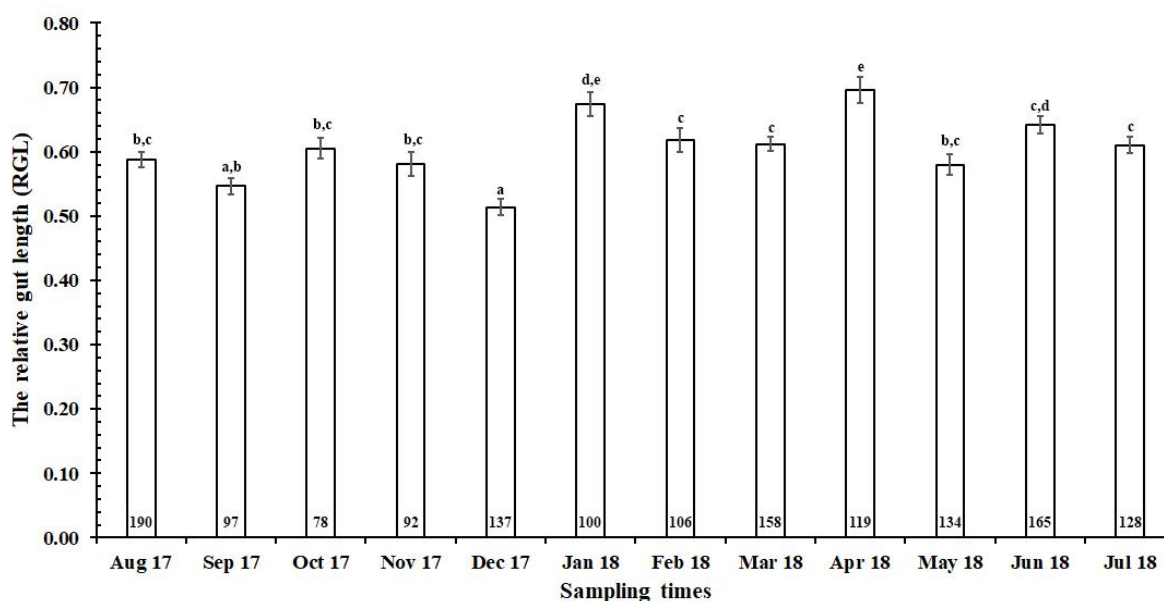


Figure 4. The variation in RGL of *P. septemradiatus* among 12 months [number in each column represented number of fish in each fish size group; the vertical bar was standard error of mean; different letters (a, b, c, d, and e) represented the significantly different in RGL among 12 months]

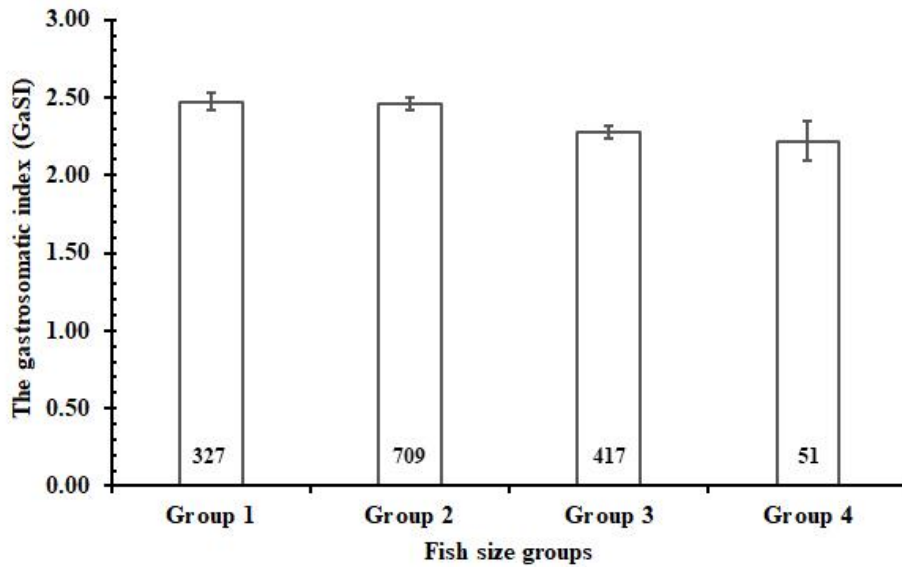


Figure 5. The variation in GaSI of *P. septemradiatus* among four fish size groups (group 1: TL<5.1 cm, group 2: TL=5.1-9.0 cm, group 3: TL = 9.1-11.0 cm, group 4: TL>11.0 cm; number in each column represented for number of fish in each fish size group; vertical bar was standard error of mean)

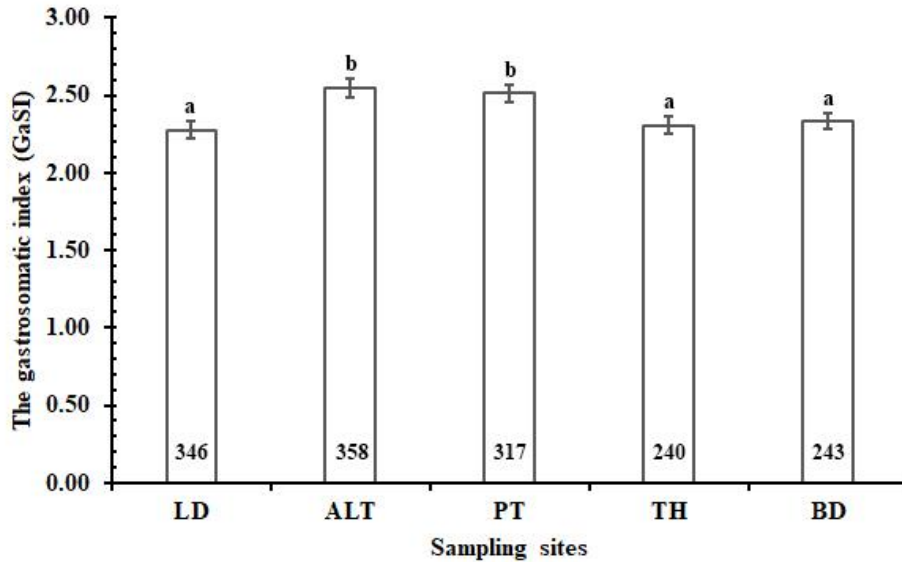


Figure 6. The variation in GaSI of *P. septemradiatus* among five sampling sites [LD: Long Duc, Long Phu, Soc Trang, ALT: An Lac Tay, Ke Sach, Soc Trang, PT: Phu Thu, Cai Rang, Can Tho, TH: Tan Hung, Thot Not, Can Tho, BD: Binh Duc, Long Xuyen, An Giang; number in each column represented for number of fish in each site; vertical bar was standard error of mean; different letters (a and b) represented the significantly different in GaSI among five sites]

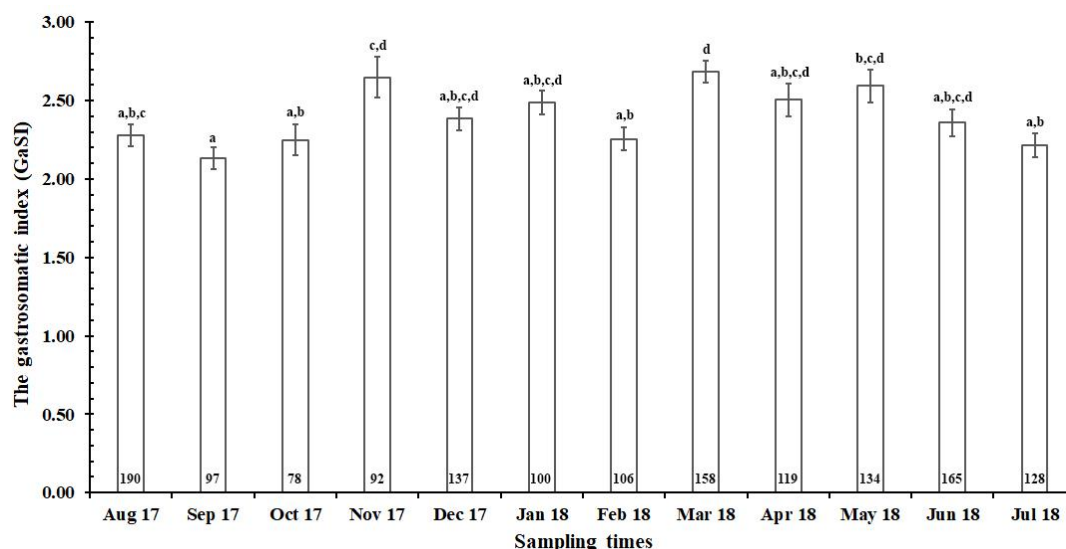


Figure 7. The variation in GaSI of *P. septemradiatus* among 12 months [number in each column represented number of fish in each month; the vertical bar was standard error of mean; different letters (a, b, c and d) represented the significantly different in GaSI among 12 months].

The monthly change in feeding intensity was found in this mudskipper species due to the significantly different in GaSI during 12-month study, reaching the highest point in March ( $2.68 \pm 0.07$  SE) and the lowest point in September ( $2.13 \pm 0.07$  SE; ANOVA,  $P < 0.05$ , Fig. 7). Similarly, the change of feeding intensity with month was also found in the large scale goby *P. serperaster* in the Mekong Delta [13]. The GaSI of *P. septemradiatus* in the dry season ( $2.52 \pm 0.04$  SE) was significantly higher than that in the wet season ( $2.32 \pm 0.03$  SE, t-test,  $P < 0.05$ ), suggested that feeding intensity of this goby changed with season. It seems that the difference in precipitation between the dry and the wet season regulated the feeding intensity of this mudskipper. This assumption was also found in the large scale goby *P. serperaster* in the Mekong Delta [13], but not in the broadhead sleeper *E. melanosoma* [11] and the goby *S. pleurostigma* [14]. The change of feeding habit of this fish species was not influenced by the interaction of the fish size and place, the fish size and season, and the place and season since GaSI did not change

with the interaction of these variables (ANOVA,  $P > 0.05$  for all cases).

#### 4. Conclusion

The feeding habit of *P. septemradiatus* did not change with the fish size, but varied with place, month and season. Both males and females at different size, place, month and season fall into carnivorous fish. Likely, the feeding intensity of this species did not change with fish size, whereas displayed spatial, temporal and seasonal variation. The changes of feeding habit and intensity of *P. Septemradiatus* were not regulated by the interaction of the fish size and place, the fish size and season, and the place and season. These results were based for understanding of fish adaption and conservation in the study region.

#### Acknowledgments

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## Chỉ số sinh trắc ruột và cường độ bắt mồi của cá thòi lòi *Periophthalmodon septemradiatus* (Hamilton, 1822) ở Sông Hậu

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**Tóm tắt:** Nghiên cứu này đã cung cấp những hiểu biết về tính ăn và cường độ bắt mồi của cá thòi lòi *Periophthalmodon septemradiatus*, một loài cá cánh tiềm năng, bằng việc phân tích chỉ số sinh trắc ruột (RGL) và hệ số no (GaSI). Mẫu cá được thu bằng cần câu từ vùng cửa sông ở tỉnh Sóc Trăng đến thượng nguồn ở tỉnh An Giang của sông Hậu trong suốt một năm từ tháng 8 năm 2017 đến tháng 7 năm 2018. Kết quả phân tích 1.504 mẫu cá cho thấy RGL không thay đổi theo chiều dài cá. Điều này cho thấy tính ăn của loài này không thay đổi theo thời gian phát triển của cá. Tuy nhiên, tính ăn của loài cá này thay đổi theo địa điểm nghiên cứu, tháng và mùa thu mẫu vì RGL khác biệt có nghĩa về mặt thống kê giữa các điểm, tháng và mùa thu mẫu. Cả cá đực và cá cái đều thuộc nhóm cá ăn động vật vì RGL nhỏ hơn một. Tương tự, cường độ bắt mồi của loài cá này như nhau ở bốn nhóm chiều dài cá vì GaSI không khác biệt có nghĩa thống kê giữa các nhóm chiều dài cá. Trái lại, cường độ bắt mồi loài cá này thay đổi theo điểm, tháng và mùa thu mẫu do GaSI thay đổi theo những nhân tố này. Sự thay đổi của tính ăn và cường độ bắt mồi của *P. septemradiatus* không phụ thuộc vào sự tương tác của các cặp nhân tố như nhóm chiều dài và điểm thu mẫu, nhóm chiều dài và mùa thu mẫu, điểm thu mẫu và mùa thu mẫu. Những kết quả này đã cung cấp kiến thức mới về tính ăn và cường độ bắt mồi của loài này ở khu vực nghiên cứu. Đây là cơ sở cho những hiểu biết về sự thích nghi và sự bảo tồn loài này ở khu vực nghiên cứu.

**Từ khóa:** Cá thòi lòi, chỉ số sinh trắc ruột, hệ số no, *Periophthalmodon septemradiatus*.