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Burrow structure and utilization of *Periophthalmodon schlosseri* (Pallas, 1770) from Tran De coastal area, Soc Trang, Vietnam

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ABSTRACT

This study was conducted from October 2017 to March 2018 in Mo O territorial waters, Tran De district, Soc Trang province to contribute data of burrow morphology and utilization of the species *Periophthalmodon schlosseri* that was one of the important economical fish species in the Mekong Delta. The burrow morphology and dimensions were obtained by analyzing 30 casting burrows molded by polyester resin. The burrow utilization was determined by analyzing casting burrows and observing activities of fish in its habitats. The analysis result showed that burrows of this fish were various in shapes such as U, I, and J. The burrow had 1-2 opening with large mound made from mud pellets, and 0-1 bulbous chamber. Dimensions of the chamber did not display seasonal and spatial changes, however, they varied with burrow shape. Furthermore, the burrow dimensional variations did not change with the interaction of season, studied sites, and shape variables. This fish used burrows as a shelter for spawning and avoiding predators. The results can be used for further research on the artificial reproduction of this species.

INTRODUCTION

Many species of fish use burrows as a place for hunting food, spawning, and avoiding predators **(Atkinson and Taylor, 1990)**. The burrows have various shapes and sizes with several openings such as “U”, “J”, “Y” and “I” **(Atkinson and Taylor, 1990; Ishimatsu *et al.*, 1998; Ishimatsu *et al.*, 2007)**. For example, *Boleophthalmus dussumieri* builds U-shaped burrows **(Clayton and Wright, 1989)**, *Pseudapocryptes elongatus* digs Y-shaped burrows **(Tran, 2008)**, and *Boleophthalmus boddarti* digs I- and U-shaped burrows **(Dinh *et al.*, 2014a)**. While, other gobies dig burrow without clearly-defined shapes like *Taenioides cirratus* **(Itani and Uchino, 2003)** and *Odontamblyopus lacepedii* **(Gonzales *et al.*, 2008)**. However, little is known about morphological structures and utilization of burrow of fish living in the Mekong Delta.

Periophthalmodon schlosseri is a familiar fish species to coastal fishermen in the Mekong Delta. This fish is relatively large and has high economic value pricing between 7-12 USD/kg. This species belongs to the family of Gobiidae **(Murdy, 1989; Murdy, 2011; Murdy and Jaafar, 2017)** and it is a delicacy **(Tran *et al.*, 2019a; Tran *et al.*, 2019b)**. In the Malaysian water, this species digs burrows in J-shape and uses burrows as a place of spawning ground (**Ishimatsu *et al.*, 1998; Ishimatsu *et al.*, 2007)**. This fish inhabits mainly in the burrows on the coastal mudflats of the Mekong Delta, but no records of its burrow. Hence, this study aims to provide knowledge on

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morphology, structure, and utilization of *P. schlosseri*'s burrows, being used for further study on the artificial reproduction study of this fish.

MATERIALS AND METHODS

Burrow observation and collection

This study was conducted at three locations on the mudflats in Mo O territorial waters, Trung Binh commune, Tran De district, Soc Trang province (Site 1: 9°26'52.0"N 106°11'12.6"E; Site 2: 9°26'20.8"N 106°10'56.0"E; Site 3: 9°26'29.64"N 106°10'37.56"E; Fig. 1). Site 1 and 2 belonged to the natural habitat and site 3 was unnatural one that is near to the shrimp pond of local people. Burrow was molded during the receding tide period, from October 2017 to March 2018, within two seasons (three months in the wet season, from October to December, and three months in the dry season, from January to March). The salinity and vegetation were also recorded during the burrow casting period, which was then used to understand the spatial variation in the burrow dimensions.

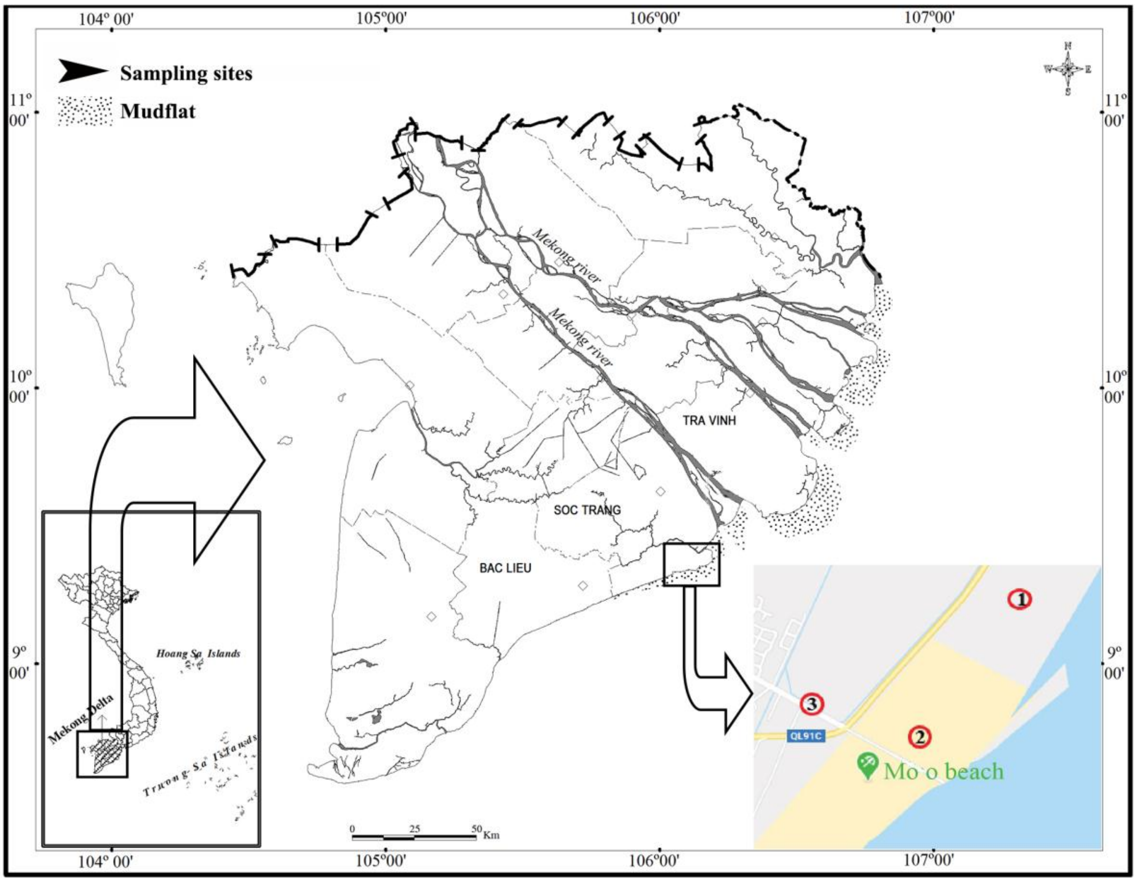

Fig. 1 The study site in Tran De, Soc Trang, Vietnam
(1: 9°26'52.0"N 106°11'12.6"E; 2: 9°26'20.8"N 106°10'56.0"E; 3: 9°26'29.64"N106°10'37.56"E)

The burrow of *P. schlosseri* was differentiated from other fish living in the same habitat by using criteria: "footprints" (Fig. 2a) imprinted nearby large opening, large mounds made from mud pellets surrounded opening (Fig. 2b), and fish occurred in the opening (Fig. 2c). The burrow cast was made using the method described by **Hamano (1990)**. Accordingly, burrows of *P. schlosseri* were molded by slowly pouring the mixed liquid of polyester resin and hardener (98% polyester resin and 2% hardener) into *in situ* the burrow opening (Fig. 3a). Casting burrows were removed and washed after 24 hours to 48 hours of molding (Fig. 3b). Then, they were transferred to the laboratory. The use of burrows for spawning was determined using the method described by **Dinh *et al.* (2014a)**. Indeed, if *P. schlosseri* caught inside burrows by hands had stage IV or V of the ovary, fish could use burrows as a place of breeding.

Fig 2. Burrow with “food prints” (a), large opening with mud pellet surrounded (b) and fish in burrow opening (c)

Fig. 3. Pouring the mixed liquid of polyester resin and hardener into in situ the burrow opening (a) and removing burrow casting from mud (b)

In February 2018 field trip, the activities of one fish were observed continuously for three hours to understand the burrowing behavior and utilization in the natural environment.

Burrow and data analysis

In the laboratory, the burrow dimensions including burrow length, burrow total length, burrow branch length, burrow depth, burrow opening distance, bulbous chamber diameter, and burrow branch diameter were measured to the nearest 0.1 cm. T-test was used to examine the variations of burrow length, burrow total length, and burrow depth between seasons and studied sites. One-way ANOVA was performed to test the variation of burrow length, burrow total length, and burrow depth among burrow shapes. Two-way ANOVA was used to examine the influence of the interaction of burrow shape × season, burrow shape × studied site, and season × studied site on burrow length, burrow total length and burrow depth. The SPSS software v21 was used for data analysis. All tests were set at a significant level of 5%.

RESULTS

Environmental condition

This area had the typical flora of mangroves like *Avicennia alba*, *Rhizophora apiculata*, *Sonneratia caseolaris, Excoecaria agallocha, Nypa fruticans*. Fish digs burrows in the area under the trees. The salinity in the studied sites was not significantly different between the dry (8.20±0.80 SE) and the wet seasons (8.73±1.07 SE, t-test, t=-0.40, p>0.05). Likely, the salinity in the natural habitat (9.0±0.72 SE) was not significantly different from the unnatural one (6.33±1.33 SE, t=1.67, p>0.05).

Burrow morphology and dimensions

The analysis results of 30 burrows (24 castings from natural habitat and 6 castings from unnatural habitat, Table 1) showed that the *P. schlosseri* burrow was less branched and had many different shapes in "I", the "J", and "U" (Fig. 4a, b, c). The *P. schlosseri* burrow had 1-2 openings. Each burrow had 0-1 bulbous chamber with 12.3-25.0 cm diameter. The burrow maximum length was 21.4-169.7 cm (66.01±7.05 SE cm) and the total length of burrows was 21.4-339.0 cm (88.63±12.37 SE cm). Burrow depth ranged from 18.5 cm to 82.3 cm (47.67±2.84 SE cm).

Table 1. Burrow dimensions of *Periophthalmodon schlosseri*

Number of burrow opening	The maximum length (cm)	Burrow total length (cm)	Number of bulbous chamber	Chamber diameter (cm)	Burrow height (cm)	Burrow shapes	Sampling time	Habitat
1	55.0	55.0	-	-	54.0	I	Oct 2017	N
1	77.0	77.0	-	-	59.5	J	Oct 2017	N
2	155	185	1	20.0	54.0	U	Oct 2017	N
1	50.5	60.1	-	-	36.0	I	Oct 2017	N
1	59.5	161.5	-	-	51.7	J	Oct 2017	N
1	35.0	90.3	-	-	30.0	I	Nov 2017	N
1	44.2	44.2	-	-	38.0	J	Nov 2017	N
1	44.5	44.5	-	-	41.0	I	Nov 2017	N
1	44.4	44.4	-	-	36.0	I	Nov 2017	N
1	89.6	120.6	1	21.3	82.3	I	Nov 2017	N
1	66.5	66.5	-	-	59.2	J	Dec 2017	N
1	61.1	61.1	-	-	54.5	I	Dec 2017	N
1	54.5	129.4	-	-	43.3	J	Dec 2017	N
2	169.7	339	1	25.0	67.7	U	Dec 2017	N
1	69.7	207.9	-	-	67.5	J	Dec 2017	N
1	97.4	97.4	-	-	68.3	J	Jan 2018	N
1	21.4	21.4	-	-	18.5	I	Jan 2018	N
1	79.2	79.2	-	-	55.2	J	Jan 2018	N
1	36.8	36.8	-	-	35.6	I	Jan 2018	N
1	31.8	31.8	-	-	30.5	I	Jan 2018	N
2	126.7	126.7	1	14.0	57.0	U	Feb 2018	N
1	35.2	35.2	-	-	33.0	I	Feb 2018	N

Number of burrow opening	The maximum length (cm)	Burrow total length (cm)	Number of bulbous chamber	Chamber diameter (cm)	Burrow height (cm)	Burrow shapes	Sampling time	Habitat
1	70.6	70.6	-	-	64.0	I	Feb 2018	N
1	64.0	97.0	1	23.9	63.0	I	Feb 2018	N
1	52.7	59.4	-	-	49.8	I	Feb 2018	U
1	31.2	31.2	-	-	26.0	I	Mar 2018	U
2	149.5	149.5	1	12.3	56.0	U	Mar 2018	U
1	40.9	69.7	-	-	37.0	I	Mar 2018	U
1	29.6	29.6	-	-	25.6	I	Mar 2018	U
1	37.0	37.0	-	-	35.8	I	Mar 2018	U

N: Natural habitat; U: Unnatural habitat

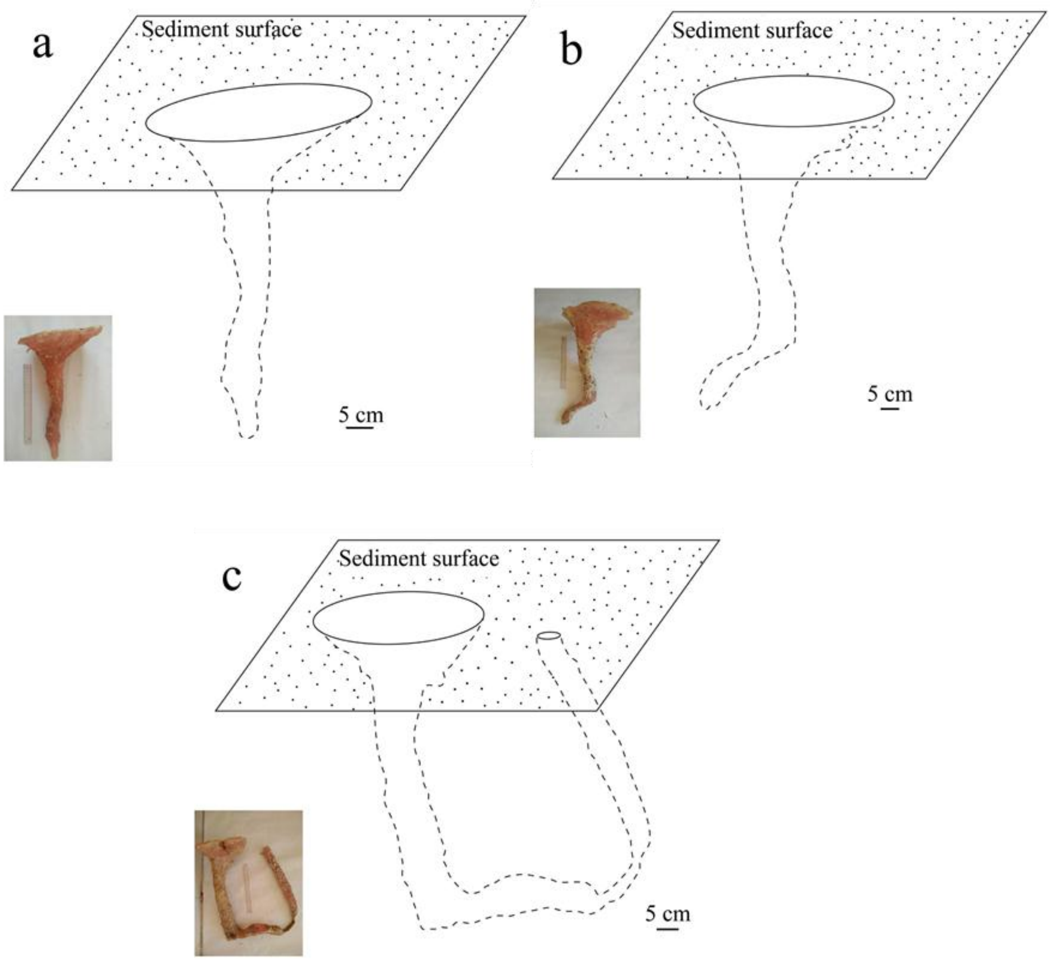

Fig. 4. The burrow shapes of "I" (a); "J" (b), and "U" (c)

The burrow dimensions did not vary between natural and unnatural habitats. The mean of maximum burrow length in the natural habitat (68.30±7.61 SE cm) was not significantly longer than that in the unnatural one (56.82±18.84 SE cm, t-test, t=0.645, p>0.05). Likely, the average total length of the burrow in the natural habitat (95.11±14.60 cm SE) was not significantly longer than that in the unnatural one (62.73±18.57 cm SE, t=1.05, p>0.05). The average burrow depth in the natural environment - 49.99±3.18 cm SE - was not also significantly longer than the unnatural environment (38.37±5.05 SE cm, t=1.69, p>0.05) (Table 1).

Likewise, the burrow dimensions did not display seasonal change. In the dry season, the maximum length of burrows (71.75±10.19 SE cm) was not significantly longer than that in the wet season (60.27±9.88 SE cm, t=0.809, p>0.05). The total length of burrows in the dry season was 112.43±21.26 SE, which was not significant from that in the wet one (64.83±10.04 SE cm, t=2.03, p>0.05). Likely, burrow depth in the dry season (51.65±3.73 SE cm) was closed to that in the wet season (43.69±4.15 SE, t=1.43, p>0.05).

However, the burrow dimensions change significantly among three burrows shape. The maximum length of burrow reached the highest value in the "U" shape (150.23±8.93 SE cm) and the lowest in "I" shape (47.92±4.18 SE cm), followed by "J" one (66.97±6.48 SE cm, one-way ANOVA, F=53.77, p<0.05). Similarly, the total length of burrow displayed the highest value in the "U" shape of 200.05±47.84 SE cm, followed by "J" one with 111.99±21.85 SE cm, and the lowest value in the "I" shape of 56.57±6.06 SE cm (F=16.41, p<0.05). Like the burrow length, the burrow depth of this goby also reached the highest value in "U" shape (58.68±3.07 SE cm) and the lowest value in "I" shape (42.52±3.70 SE cm), followed closely by the value in the "J" one (55.36±4.38 SE, F=3.38, p<0.05).

Burrow dimensions mostly did not impact the interaction of season, studied site, and burrow shape variables. The maximum length of burrows was not regulated by the interaction shape × studied site (two-way ANOVA, F=1.70, p>0.05), but by shape × sea interaction (F=3.68, p<0.05). The variation of the total length of burrow did not change with the interaction of shape × studied site (F=0.21, p>0.05) and shape × sea (F=2.15, p>0,05). Likewise, the change of burrow depth was not regulated by the shape × studied site interaction (F=0.09, p>0.05) and shape × sea interaction (F=0.63, p>0.05).

Burrowing behavior and utilization

The results of the field survey indicated that this goby dug burrows by opening excavation during the low tide period, and uses the burrow as a shelter and avoids the predators (Fig. 2c). The burrow was also a place where they could be used for breeding. During the sampling period, the species had been caught the ovaries at stage V, so it was initially possible to conclude that the mudskippers used the burrows to breed.

DISCUSSION

The J-shaped burrow of *P. schlosseri* was similar to the study done in Malaysian water **(Ishimatsu *et al.*, 1998)**, suggesting that this goby can adapt well to a wide range of environmental conditions. The "I" and "J" shaped burrows of this species were also found in *Boleophthalmus boddarti* **(Dinh *et al.*, 2014a)**. While, the "U" shaped burrow was similar to species such as *Parapocryptes serperaster* in the Mekong Delta **(Dinh *et al.*, 2014a)** and the goby *Boleophthalmus boddarti* in India and Mekong Delta **(Clayton and Wright, 1989; Dinh *et al.*, 2014a)**.

In *Pseudapocryptes elongatus*, the openings of the burrow were smooth and streakless. This proved that they did not use the pectoral fins to move, but bent their body to enter the burrow **(Tran, 2008)**. However, for *P. schlosseri*, the burrow was recognized by the traces left on the mud, as they move in and out of the burrow using their pectoral fins. Also, a long streak left specific marks between the pectoral fins when they used to lift their head and chest, as their abdomen and tail still touched the mud. Furthermore, the main burrow opening of *P. schlosseri* was surrounded by mounds. This characteristic was similar to the opening of some other goby species such as *Odontamblyopus lacepedii* **(Gonzales *et al.*, 2008)**, *Taenioides rubicundus* **(Itani and Uchino, 2003)**. However, the burrow opening of *Parapocryptes serperaster* was not surrounded by mounds **(Dinh *et al.*, 2014b)**. The soil mounds formed as a result of burrowing by "land scooping" (active excavation) (Fig. 2b). The mound used as a place to store and exchange oxygen **(Ishimatsu *et al.*, 1998; Itani and Uchino, 2003; Ishimatsu *et al.*, 2007)**.

The similar in salinity and vegetation could lead to the similar in burrow dimensions of *P. schlosseri* between season and studied sites. Burrows of *Periophthalmodon schlosseri* had fewer openings than other gobies such as *Pseudapocryptes elongatus* **(Tran, 2008)**, *Boleophthalmus boddarti* **(Dinh *et al.* 2014a)**, *Parapocryptes serperaster* **(Dinh *et al.* 2014b)**, *Odontamblyopus lacepedii* **(Gonzales *et al.* 2008)** and *Taenioides cirratus* **(Itani & Uchino, 2003)**. The burrow depth of *P. schlosseri* was greater than that of these five species. The total length of burrows of *P. schlosseri* was also larger than *Pseudapocryptes elongatus* **(Tran, 2008)**, *Boleophthalmus boddarti* **(Dinh *et al.***

2014a), *Parapocryptes serperaster* **(Dinh *et al.*, 2014b)**, but smaller than that of *Odontamblyopus lacepedii* **(*Gonzales et al.*, 2008)** and *Taenioides cirratus* **(Itani & Uchino, 2003)**.

The goby *P. schlosseri* dug burrows by mouth excavation, while *Parapocryptes serperaster* in the Mekong Delta dug burrows by twisting body **(Dinh *et al.*, 2014a)**. With "U" shape burrows, *P. schlosseri* could easily move in and out of burrows, especially for the escape of predators. The burrows of this species had 1 to 2 openings with the largest diameter was in the main opening and a smaller diameter for the second opening had. This fish used the burrow as a shelter and avoided predators, which was similar to *Boleophthalmus boddarti* **(Dinh *et al.*, 2014a)**, *Parapocryptes serperaster* **(Dinh *et al.*, 2014b)** and *T. cirratus* **(Itani and Uchino, 2003)**. The burrow was also a place for spawning as, during the sampling period, *P. schlosseri* with stage V ovary was caught inside its burrow. Likely, the use of burrows as reproducing round was found in some other gobiid species including *Boleophthalmus boddarti* **(Dinh *et al.*, 2014a)** and *Periophthalmus modestus* **(Ishimatsu *et al.*, 2007)**. Contratly, *Pseudapocryptes elongatus* **(Tran, 2008)** and *Parapocryptes serperaster* **(Dinh *et al.*, 2014b)** did not use burrows for breeding.

CONCLUSION

The burrow of *Periophthalmodon schlosseri* is made up of diverse shapes composing "U", "I" and "J" formation. The burrow structure of this fish has one to two openings with the large mound made from mud mullets. It was found that the number of bulbous chambers was not higher than 1. This fish was found to use its burrows as a shelter for spawning and avoiding predators.

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