Population biology of *Butis koilomatodon* in the Mekong Delta

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Abstract. A one-year study was conducted to assess the population of *Butis koilomatodon*, a target fish for food supply, based on a total of 1227 specimens (891 males and 336 females). The sample were collected from Tra Vinh to Ca Mau provinces, Mekong Delta, Vietnam. The ELEFAN I procedure and the model of Beverton & Holt about yield-per-recruit were used to analyze the fish population's biological parameters. Data analysis results showed that males outnumbered females in the population structure, with a sex ratio of 2.65:1. There were 4 classes of length frequency, with the highest values between 5-6 cm and 9-10 cm (accounting for 1204 fish, 98.13% out of the total number of samples). The von Bertalanffy curve of the goby showed a total length (L_t) value of 9.99 $(1-e^{-0.94(t+0.3)})$. The value of the longevity was 3.19 years, and the index of growth performance was 1.97. The total, natural, and fishing mortalities of the fish population were 2.91 $year^{-1}$, 2.37 $year^{-1}$, and 0.542 $year^{-1}$, respectively. The indices of relative yield and biomass of *B. koilomatodon* recruits were E_{max}=0.421, $E_{0.1}$=0.355, and $E_{0.5}$=0.278. As the exploitation rate (E=0.19) was lower than $E_{0.5}$, the fish stock was not overexploited. Overall, the fish stock has the potential for exploitation, and this mud sleeper goby could be a potential candidate for artificial aquaculture due to the high growth coefficient.

Key Words: exploitation rate, length-frequency, mortality, mud sleeper, sex ratio.

Introduction. The mud sleeper *Butis koilomatodon* (Bleeker, 1849) is a benthic and sedentary fish. It eats mostly crustaceans and small fish (https://www.fishbase.se/). *B. koilomatodon* is well adapted to the variations of water temperatures between 26 and 36°C and a salinity ranging from 3.8‰ to 37‰ (Miller et al 1989; Contente et al 2016). Thus, they are frequently found in the lower course of rivers, estuaries, and mangrove creeks (https://www.fishbase.se/). *B. koilomatodon* plays a critical intermediate unit in the food chain, feeding on crustaceans and small native fishes (Corrêa & Uieda 2007; Macieira et al 2012) or becoming food for larger predators. It is also considered as a food with high commercial and nutritional values. Although this gobiid fish is the most dominant fish in mangrove estuaries of the Indo-Pacific region (Robertson & Duke 1987; Blaber & Milton 1990), there is little information about population biology, especially in the Mekong Delta. Some of the main parameters of population biology were used to assess the population situation. For example, there was a close relationship between the exploitation rate from the yield-per-recruit analysis and the control catch in exploitive areas (Al-Husaini et al 2002). The fish population biology could be evaluated by growth parameters and mortality rates (Amezcua et al 2006). The growth and asymptotic length relationship affects the variations of fish growth rate between gender and location (Pauly & Munro 1984). Contextually, this study had two aims: primarily, to describe the mean length of maturation and gather data on the population structure of *B. koilomatodon* caught from the estuary from Tra Vinh to Ca Mau provinces in the Mekong Delta; and secondly, to supply the necessary knowledge for the development and sustainable management of this resource.

Material and Method

Study site, fish collection and analysis. Six coastal areas near the mouth of the Hau River were selected for the collection of fish specimens. The 6 sites were chosen to collect specimens monthly from April 2019 to March 2020, including Duyen Hai (Tra Vinh province), Cu Lao Dung and Tran De (Soc Trang province), Hoa Binh and Dong Hai (Bac Lieu province) and Dam Doi (Ca Mau province) (Figure 1). Estuarine mangroves were home for valuable fish species, including *B. koilomatodon*. *Avicennia marina* and *Sonneratia caseolaris* were dominant in the mangrove flora in the study regions. The tide was semi-diurnal. These provinces belong to the typical tropical region and monsoon climate. Thus, only two seasons were recorded: dry seasons (from January to May) and rainy season (from June to December). Monthly precipitation recorded in the rainy season was 400 mm per month and much higher than in the dry season, which rarely had rain. The average annual temperature fluctuated near 27°C (Le et al. 2006). Furthermore, these areas are affected by global climate change, leading to many extreme environmental phenomena, including coastal erosion (Nguyen et al 2013).

Bottom gill nets with 1.5 cm mesh size in the cod-end, 2.5 cm mesh size in the mouth, 5 m long and 10 m depth were used to catch fish. The nets were set up near the margin of the mangroves for 48 h continuously and retrieved four times at low tide to collect fish specimens. Then, the collected fish were identified based on external morphological characteristics according to the description of Akihito & Meguro (1976). The number of bands on the body from four to seven and the serrate snout were the characteristics differentiating between *B. koilomatodon* and its congeners (Yokoo et al 2006). All samples were fixed in 5% formalin buffer in the field before transportation to the laboratory. The gender was differentiated based on the urogenital papilla; the genital papilla of females was round, while it was narrow in males (Dinh et al 2016). The total length was determined with a precision of 0.1 cm.

Data analysis. The difference in sex ratio was tested using the χ^2 test. The SPSS v.21 software was used to perform these tests at 5% meaningful level. The data on length frequency was analyzed with the FiSAT II software to estimate the fish population's biological parameters (Gayanilo et al 2005). The ELEFAN I procedure was applied to find the asymptotic length ($L\infty$) and the growth parameter (K) (Pauly & David 1981; Pauly 1982; Pauly 1987). The following equation was applied to calculate the theoretical age parameter (t_0) (Pauly 1979):

$$\log_{10}(-t_0) = -0.3922 - 0.2752\log_{10}L_\infty - 1.038\log_{10}K$$

There are three types of mortality: total mortality rate (Z), natural mortality rate (M), and the fishing mortality rate (F). Z was estimated from the length-converted capture curve (Beverton & Holt 1957; Ricker 1975). M was calculated from the equation:

$$\text{Log}M = -0.0066 - 0.279\text{Log}L_\infty + 0.6543\text{Log}K + 0.463\text{Log}T$$

Where: L_∞ and K were obtained from ELEFAN I, and T was the average annual water temperature (°C) (Pauly 1980). After that, F was calculated as F=Z−M, and the exploitation rate (E) was determined as E=F/Z (Ricker 1975).

The length-converted catch curve estimated the probability of capture for each size class (Pauly 1987). The fish whose length was calculated by charting the cumulative probability of capture compared to the mid-length class (Pauly 1987) appeared into the stock and was ready for catch (L_c). The model of Beverton & Holt (1957) about yield-per-recruit was used to estimate the goby stock and yield.

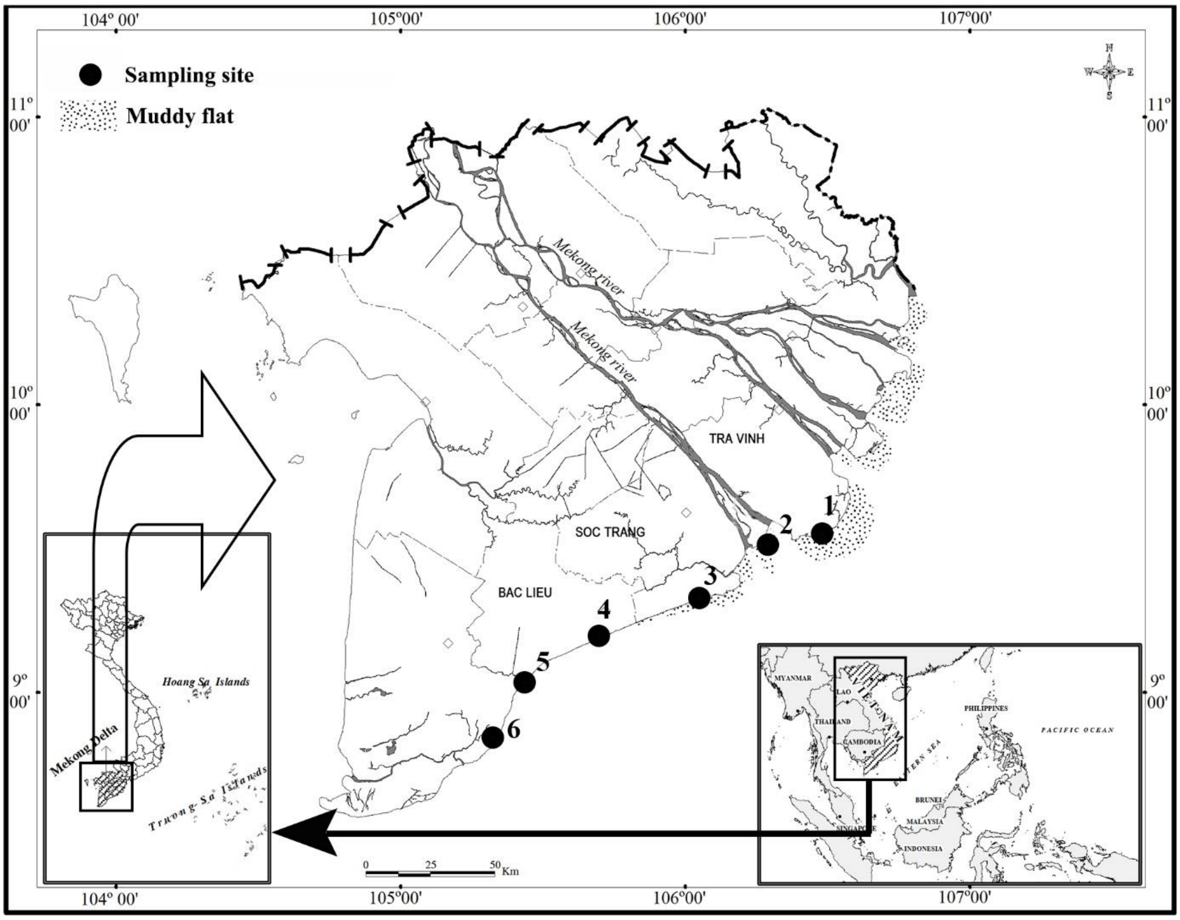

Figure 1. The sampling map in the Mekong Delta, modified from Dinh (2018a); 1 - Duyen Hai, Tra Vinh; 2 - Cu Lao Dung, Soc Trang; 3 - Tran De, Soc Trang; 4 - Hoa Binh, Bac Lieu; 5 - Dong Hai, Bac Lieu; 6 - Dam Doi, Ca Mau.

The maximum yield exploitation rate (E_{max}) was estimated from the knife-edge selection with a minimal increase of 10% of Y'/R ($E_{0.1}$) and the reduction of stock to 50% ($E_{0.5}$) (Beverton & Holt 1966). A combined analysis of exploitation rate and isopleth ratio (L_c/L_∞) was used to determine the fishing status (Pauly & Soriano 1986). Moreau et al (1986) compared the growth parameters of 100 populations of tilapia belonging to three genera, *Tilapia*, *Sarotherodon* and *Oreochromis* (Cichlidae), and realized that the growth performance index (Φ') was better than another growth index $\omega = K \times L_\infty$, because the degree of its variation was lower. Hence, in this research, the von Bertalanffy growth parameters of *B. koilomatodon* were compared with the growth performance ($\Phi' = LogK + 2LogL_\infty$) as described by Pauly & Munro (1984). The longevity (t_{max}) was calculated based on the next formula (Taylor 1958; Pauly 1980):

$$t_{max} = 3/K$$

Results and Discussion

Sex ratio. *B. koilomatodon* was found at all 6 studied areas along the river mouths. A total of 1227 specimens of *B. koilomatodon* (891 males and 336 females) were collected from April 2019 to March 2020 (Table 1). They were examined to determine the sex ratio and for population analysis. Table 1 reveals that the number of males was higher than that of females. The total male:female ratio was 2.65:1, differing significantly from 1:1 (χ^2, $p<0.05$). It was clear that males were more dominant than females.

Table 1

Sex of Butis koilomatodon

Months	*Male*	*Female*	*Sex ratio (M:F)*
Apr-19	66	41	1.6:1
May-19	81	32	2.53:1
Jun-19	76	31	2.45:1
Jul-19	79	14	5.64:1
Aug-19	69	31	2.23:1
Sep-19	72	19	3.79:1
Oct-19	78	20	3.9:1
Nov-19	70	22	3.18:1
Dec-19	52	43	1.21:1
Jan-20	84	27	3.11:1
Feb-20	66	34	1.94:1
Mar-20	98	22	4.45:1
Total	891	336	2.65:1

Population parameters. The length-frequency analysis of 1227 *B. koilomatodon* samples was used to estimate the population parameters. Fish total length values ranged from 4 to 12 cm (Table 2) measured for length-frequency data for 12 months from April 2019 to March 2020. Overall, the length-frequency of the population was divided in 4 classes (Figure 2). The most common length classes were from 5 to 6 cm and from 9 to 10 cm (1204 individuals from 1227, or 98.13%). In the von Bertalanffy growth curve (Figure 2), black and white bars showed a positive and negative deviation of the length classes, respectively, and curves indicate the fish length over time. Figure 2 also reveals that there were 4 cohorts expressed by 4 growth curves labelled by dark lines

Table 2

The classes of length-frequency of *Butis koilomatodon* from April 2019 to March 2020

Month	*Total length (cm)*								*Total*
	4-5	*5-6*	*6-7*	*7-8*	*8-9*	*9-10*	*10-11*	*11-12*	
Apr-19	0	9	24	38	31	4	0	1	107
May-19	1	16	34	47	10	5	0	0	113
Jun-19	5	30	46	23	3	0	0	0	107
Jul-19	0	22	48	20	3	0	0	0	93
Aug-19	2	22	34	35	7	0	0	0	100
Sep-19	2	11	27	40	9	2	0	0	91
Oct-19	1	9	27	35	23	3	0	0	98
Nov-19	0	5	20	32	27	8	0	0	92
Dec-19	6	21	21	11	20	15	1	0	95
Jan-20	3	0	34	55	17	2	0	0	111
Feb-20	1	15	28	34	18	4	0	0	100
Mar-20	0	6	43	42	27	2	0	0	120
Total	21	166	386	412	195	45	1	1	1227

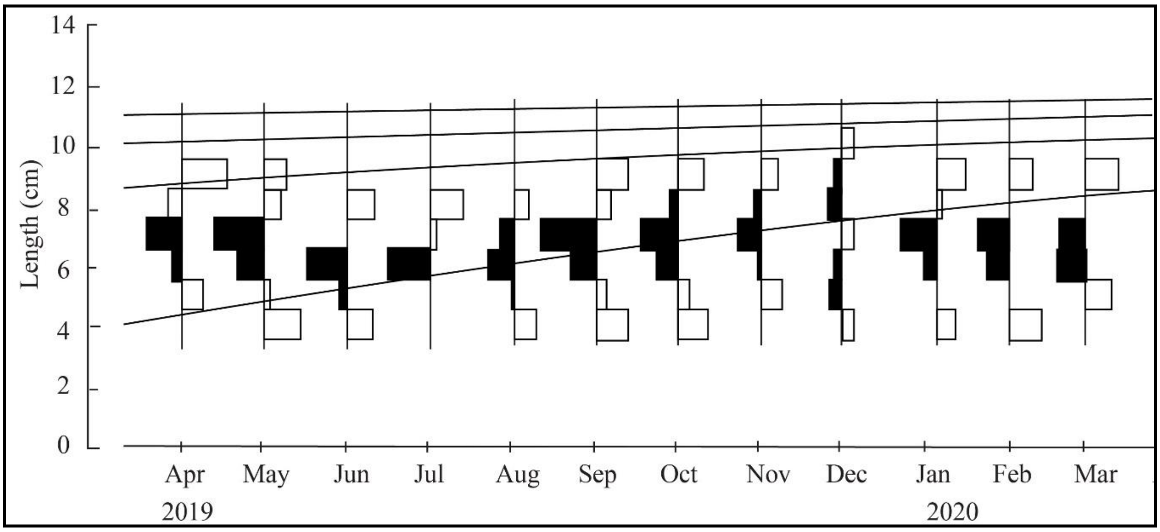

Figure 2. The von Bertalanffy growth curve of *Butis koilomatodon* (black and white bars indicate positive and negative deviation from the length classes, respectively; n=1227).

The von Bertalanffy growth curve of *B. koilomatodon* was L_t=9.99(1–$e^{-0.94(t+0.3)}$) (Figure 3). The maximum length, the growth coefficient, and t_0 were 9.99 cm, 0.94 year^{-1}, and -0.3 year^{-1}, respectively. Table 3 and Figure 4 displayed that the total, natural, and fishing mortalities were 2.91, 2.37, and 0.54, respectively.

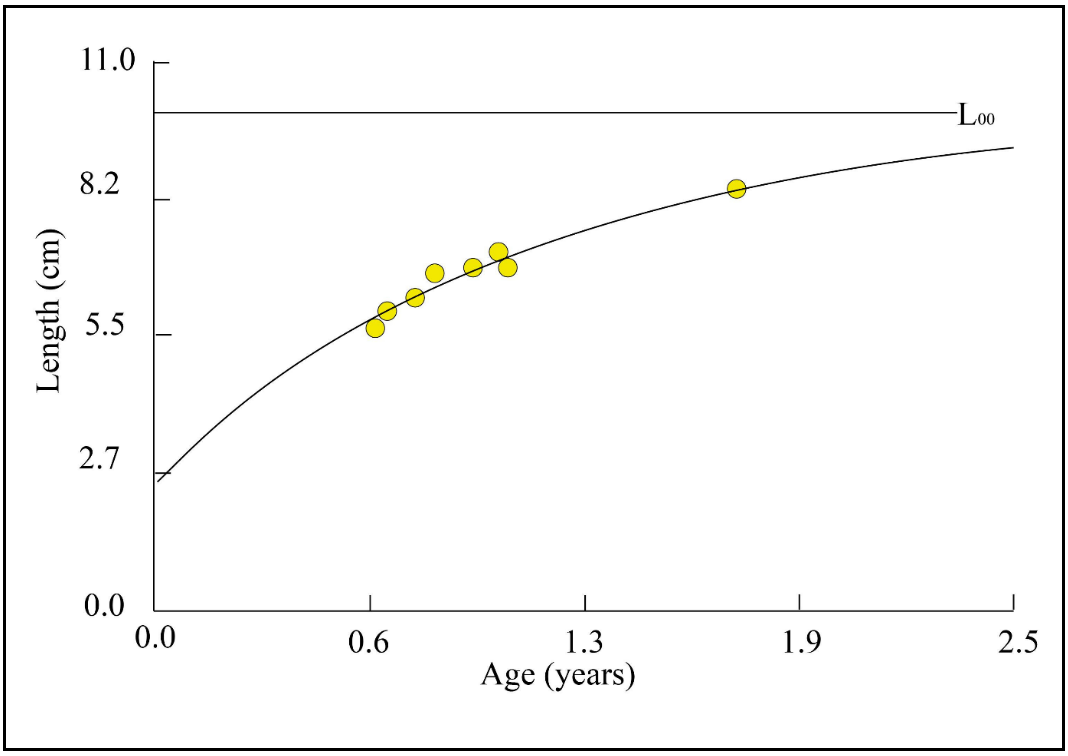

Figure 3. The von Bertalanffy growth curve of *Butis koilomatodon* (L_∞=9.99 cm, t_0=-0.3 year^{-1}, K=0.94 year^{-1}).

Table 3

Population parameters of *Butis koilomatodon* and some other gobiid species

Species	L_∞	*K*	t_0	t_{max}	*Z*	*F*	*M*	L_c	L_c/L_∞	*E*	*Φ′*	*Site*	*Source*
Periophthalmus barbarus	21.6	0.55	-0.32	5.45	4.21	2.86	1.35	10.2	0.47	0.68	2.41	Nigeria	Etim et al. (2002)
Pseudapocryptes elongatus	26.0	0.65	-0.26	4.35	2.91	1.47	1.44	11.8	0.45	0.51	2.64	Mekong Delta	Tran et al. (2007)
Periophthalmodon schlosseri	29.0	1.40	-0.11	2.14	-	-	-	-	-	-	3.10	Malaysia	Mazlan and Rohaya (2008)
Parapocryptes serperaster	25.2	0.74	-0.22	4.05	3.07	1.57	1.51	14.6	0.57	0.49	2.67	Mekong Delta	Dinh et al. (2015)
Trypauchen vagina	24.2	0.56	-0.03	5.56	2.73	1.29	1.44	13.8	0.57	0.53	2.50	Mekong Delta	Dinh (2018a)
Boleophthalmus boddarti	16.8	0.79	-0.24	3.55	2.13	0.30	1.83	13.0	0.77	0.14	2.35	Mekong Delta	Dinh (2017)
Butis butis	24.0	0.61	-0.04	4.92	3.40	1.98	1.42	10.5	0.44	0.58	2.55	Mekong Delta	Dinh (2018b)
Stigmatogobius pleurostigma	8.6	0.83	-0.07	3.61	3.48	1.17	2.31	3.8	0.44	0.34	1.79	Mekong Delta	Dinh and Nguyen (2018)
Butis koilomatodon	9.99	0.94	-0.30	3.19	2.91	0.54	2.37	6.16	0.62	0.19	1.97	Mekong Delta	The present study

Note: $L\infty$ - asymptotic length; K - growth parameter; t_0 - theoretical age parameter; t_{max} - longevity; Z - total mortality rate; F - fishing mortality rate; M - natural mortality rate; Lc - length at first capture; $Lc/L\infty$ - isopleth ratio; E - yield exploitation rate; Φ′ - growth performance index.

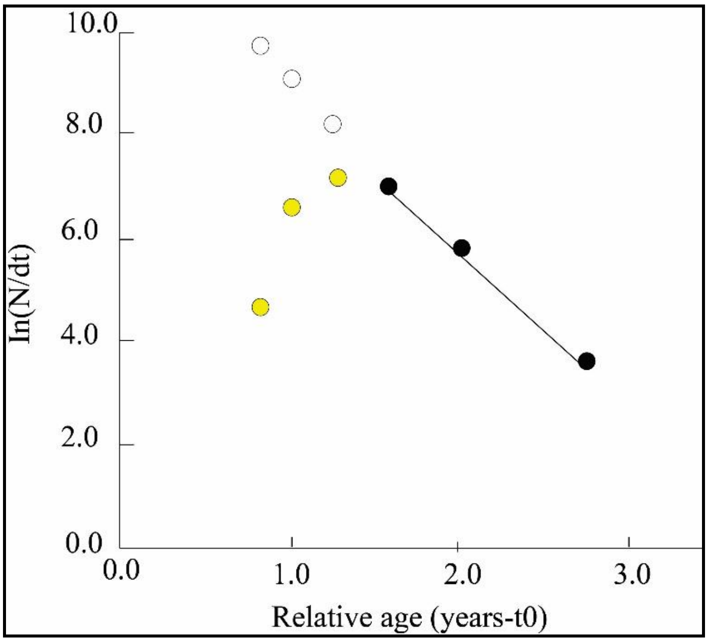

Figure 4. The length converted catch curve for *Butis koilomatodon* (n=1.227, Z=2.91, M=2.37, F=0.54 and E=0.19).

There were two different recruitment apexes, August and December (Figure 5). The analysis of the capture probability showed that the length at first capture (L_c or L_{50}) of the mud sleeper was 6.16 cm (Table 3 and Figure 6). The L_c/L_∞ ratio of this goby was 0.62. The growth performance index (Φ') of *B. koilomatodon* was 1.97, and the highest longevity (t_{max}) was 3.19 (Table 3). It seemed that Φ' and t_{max} had a close relationship and were regulated by the temporal-spatial factors. The analyses of relative yield-per-recruit and biomass-per-recruit by knife-edge selection revealed that the optimum yield $E_{0.1}$ was 0.515, the yield at stock reduction of 50% $E_{0.5}$ was 0.323 and the maximum sustainable yield E_{max} was 0.633 (Figure 7). Because the exploitation rates (E=0.19) of *B. koilomatodon* was lower than the permitted exploitation rates (E_{50}=0.278) (Figure 7), it suggested that the population had a reasonable exploitation rate, compatible with the food need of residents and mesh size of fishing nets in different regions.

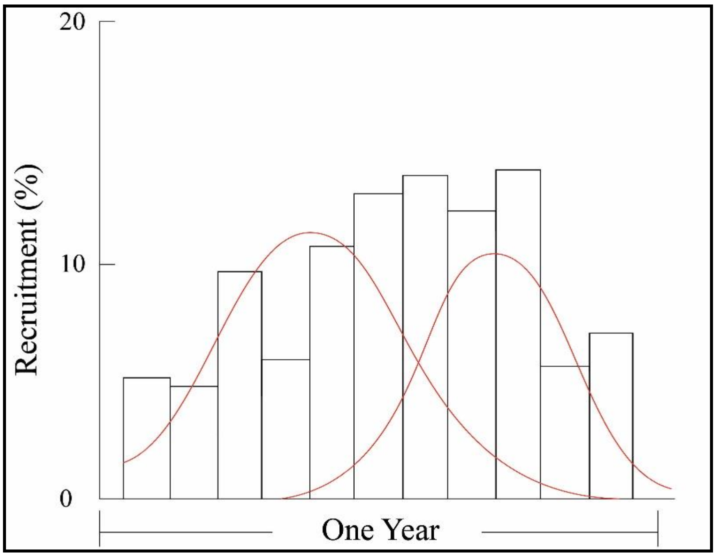

Figure 5. The recruitment pattern of *Butis koilomatodon* in the estuaries of Mekong delta obtained the length-frequency data from April 2019 to March 2020.

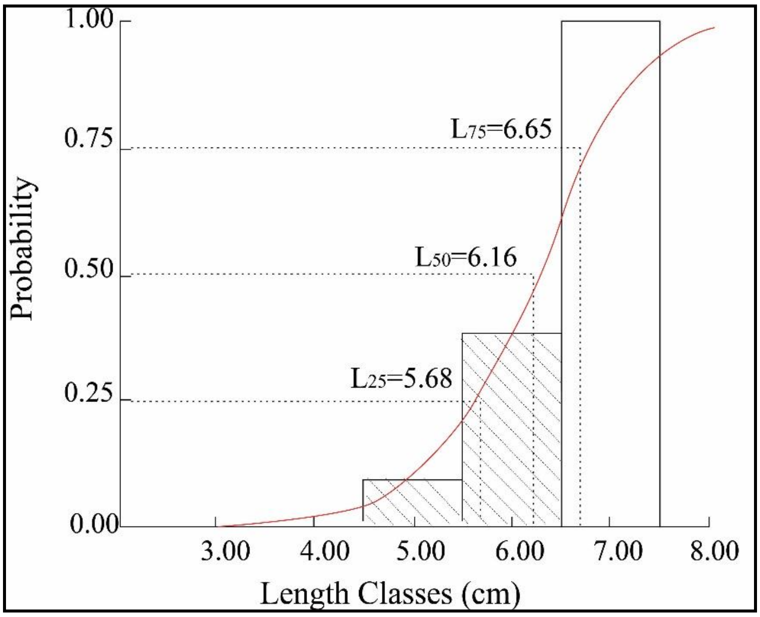

Figure 6. The probability of capture of *Butis koilomatodon* (L_{25}=5.68, L_{50}=6.16 and L_{75}=6.65 cm).

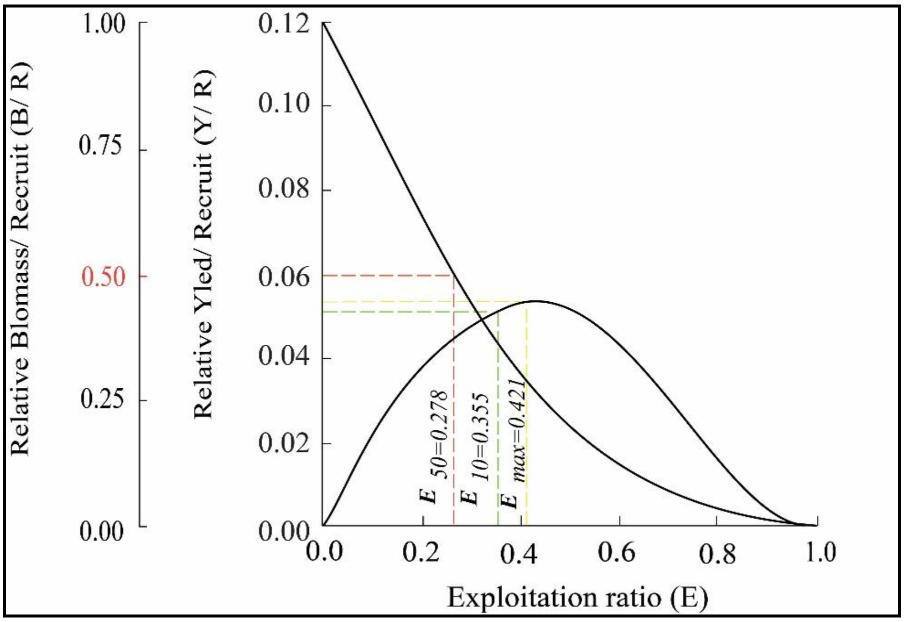

Figure 7. Relative yield-per-recruit and relative biomass-per-recruit of *Butis koilomatodon* (E_{max}=0.421, $E_{0.1}$=0.355 and $E_{0.5}$=0.278).

Information on the relationship between individuals and their population could be inferred from the sex ratio for each fish species. Similarly, the structure, reproductive potential, and size of population, can also be assessed based on sex proportion according to Stratoudakis et al (2006). In this population of *B. koilomatodon*, the sex ratio was male-biased. The may be caused by behavioral characteristics of mud sleeper males, which are responsible for burrowing, incubating and taking care of offspring during growth and reproduction (Berra 2001). Similarly, females of round goby (*Neogobius melanostomus*) in areas of an Ontario river were outnumbered by males because of their biological traits (e.g. role of males in aggression and paternal brood care) (Gutowsky & Fox 2011). Another possible reason was a tendency to seek new territory (e.g. "movers" versus 'stayers' or boldness; hence if the males were "movers", the females would be "stayers") (Fraser et al 2001).

Table 4 shows some of the reference sex ratios in some other goby species. For example, the *Periophthalmus papilio* males dominated over females (Lawson 2010). The same was observed for *Neogobius melanostomus* (Corkum et al 2004; Young et al 2010), *Trypauchen vagina* (Dinh 2018a), *Stigmatogobius pleurostigma* (Dinh & Tran 2018) and *Periophthalmodon septemradiatus* (Tran & Dinh 2020). Conversely, females were predominant for the species *Periophthalmus barbarous* (Chukwu et al 2010), *Proterorhinus semilunaris* (Valová et al 2015), and *Butis butis* (Dinh & Le 2017). The male to female ratio of 1:1 was found in *Periophthalmodon schlosseri* in Malaysia (Mazlan & Rohaya 2008), *Pseudapocryptes elongatus*, *Boleophthalmus boddarti*, and *Parapocryptes serpersater* in the Mekong Delta (Tran et al 2007; Dinh et al 2015a; Dinh et al 2015b).

Table 4

The sex ratio of some goby species

Species	*Sample size*	*Sex ratio (male:female)*	*Source*
Neogobius melanostomus	-	3:1	Corkum et al (2004)
Pseudapocryptes elongatus	1058	1:0.96	Tran et al (2007)
Periophthalmodon schlosseri	467	1:1.1	Mazlan & Rohaya (2008)
Periophthalmus barbarus	600	1:1.4	Chukwu et al (2010)
Periophthalmus papilio	1886	1:0.7	Lawson (2010)
Neogobius melanostomus	-	2:1	Young et al (2010)
Boleophthalmus boddarti	120	1:0.9	Dinh et al (2015a)
Parapocryptes serpersater	2506	1:0.96	Dinh et al (2015b)
Proterorhinus semilunaris	1075	1:1.54	Valová et al (2015)
Butis butis	604	1:1.32	Dinh & Le (2017)
Trypauchen vagina	701	1:0.67	Dinh (2018a)
Stigmatogobius pleurostigma	155	1:0.61	Dinh & Tran (2018)
Periophthalmodon septemradiatus	3436	1.36 to 1.87:1	Tran & Dinh (2020)
Butis koilomatodon	1227	2.65:1	The present study

Because the growth curves are not linear, and the growth rate varies with fish length and age, it is not biologically possible to compare population parameters directly with each other. Thus, the growth between fish species should be distinguished based on a multivariate perspective consisting of L_∞, K, and Φ' (Pauly & Munro 1984; Tran et al 2007). Ault et al (1998) stated that the main parameter was controlling whether several juveniles were enough to exploit the stock with the length at first capture (L_c or L_m). Also, L_c had a close relation to the asymptotic length (L_∞), and the L_c/L_∞ ratio, which would be useful in the assessment of the growth period of certain species before maturation (Pauly & Munro 1984). The L_c/L_∞ ratio usually fluctuates from 0.4 to 0.88 and does not vary with gender (Beverton 1992). In the present study, the L_c/L_∞ was 0.62 and belonged in the range mentioned above. So, the *B. koilomatodon* population was not overexploited and they had proper growth. The same results were found for *Periophthalmus barbarous* in Nigeria (Etim et al 2002), *Periophthalmodon schlosseri* in Malaysia (Mazlan & Rohaya 2008), *Trypauchen vagina* (Dinh 2018a), *Butis Butis* (Dinh & Le 2017), and *Periophthalmodon septemradiatus* (Table 4) in Mekong Delta (Tran & Dinh 2020).

The *B. koilomatodon* population had two recruitment peaks separately in August and December, like *Pseudapocryptes elongatus* (Tran et al 2007) and *Parapocryptes serperaster* (Dinh et al 2015b). It was likely that different geographical conditions affected the recruitment ability of goby. For example, *Glossogobius giuris* from Mekong Delta has two recruitment peaks that occur in April and September (Dinh et al 2017). Likewise, two recruitment peaks were also found for this species in Mithamoin Haor, Kissorgonj, Bangladesh (Hossain & Sultana 2014). However, there was only one in the

Payra River, Bangladesh (in September) (Roy et al 2014) and in Pakistan (in March) (Qambrani et al 2016).

The highest longevity of this goby was higher than that of *Periophthalmodon schlosseri* in Malaysia (Mazlan & Rohaya 2008) and *Periophthalmodon septemradiatus* in Tan Hung and Binh Duc, Mekong Delta (Tran & Dinh 2020), but lower than that of *Parapocryptes serperaster* (Dinh et al 2015b), *Boleophthalmus boddarti* (Dinh 2017), *Butis butis* (Dinh 2018b), *Trypauchen vagina* (Dinh 2018c), *Stigmatogobius pleurostigma* (Dinh & Nguyen 2018) and *Periophthalmus barbarus* (Etim et al 2002) (Table 3).

Conclusions. In conclusion, *B. koilomatodon* males were predominantly more in numbers compared to females. The mud sleeper stock has not been subjected to overfishing and seemed that it could recover quickly after exploitation because of having two recruitment peaks per year. Due to the high growth coefficient, this species could be a potential candidate for aquaculture. However, further research is needed in areas related to the reproductive behavior and artificial reproduction abilities. Nevertheless, appropriate strategies are required to develop a sustainable plan to protect this fish from overfishing.

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References

Akihito P., Meguro K., 1976 *Glossogobius sparsipapillus*, a new species of goby from Vietnam. Japanese Journal of Ichthyology 23(1):9-11.

Al-Husaini M., Al-Baz A., Al-Ayoub S., Safar S., Al-Wazan Z., Al-Jazzaf S., 2002 Age, growth, mortality, and yield-per-recruit for nagroor, *Pomadasys kakaan*, in Kuwait's waters. Fisheries Research 59(1-2):101-115.

Amezcua F., Soto-Avila C., Green-Ruiz Y., 2006 Age, growth, and mortality of the spotted rose snapper *Lutjanus guttatus* from the southeastern Gulf of California. Fisheries Research 77(3):293-300.

Ault J. S., Bohnsack J. A., Meester G. A., 1998 A retrospective (1979–1996) multispecies assessment of coral reef fish stocks in the Florida Keys. Fishery Bulletin - National Oceanic and Atmospheric Administration 96(3):395-414.

Berra T. M., 2001 Freshwater fish distribution. Academic Press, 604 p.

Beverton R. J. H., 1992 Patterns of reproductive strategy parameters in some marine teleost fishes. Journal of Fish Biology 41:137-160.

Beverton R. J. H., Holt S. J., 1957 On the dynamics of exploited fish populations. Chapman & Hall, London, 538 p.

Beverton R. J. H., Holt S. J., 1966 Manual of methods for fish stock assessment. Part II: Tables of yield function. FAO, Rome, 67 p.

Blaber S. J. M., Milton D. A., 1990 Species composition, community structure and zoogeography of fishes of mangrove estuaries in the Solomon Islands. Marine Biology 105:259-267.

Chukwu K., Deekae S., Gabriel U., 2010 Reproductive biology of *Perioptthalmus barbarus* (Linneaus 1766) in new Calabar River, Nigeria. Agriculture and Biology Journal of North America 1(6):1158-1161.

Contente R. F., Brenha-Nunes M. R., Siliprandi C. C., Lamas R. A., Conversani V. R., 2016 A new record of the non-native fish species *Butis koilomatodon* (Bleeker 1849) (Teleostei: Eleotridae) for southeastern Brazil. Biotemas 29(2):113-118.

Corkum L. D., Sapota M. R., Skora K. E., 2004 The round goby, *Neogobius melanostomus*, a fish invader on both sides of the Atlantic Ocean. Biological invasions 6:173-181.

Corrêa M. O. D. A., Uieda V. S., 2007 Diet of the ichthyofauna associated with marginal vegetation of a mangrove forest in southeastern Brazil. Iheringia. Série Zoologia 97(4):486-497.

Dinh Q. M., 2017 Population dynamics of *Boleophthalmus boddarti* in the Mekong Delta, Vietnam. The Journal of Animal and Plant Sciences 27(2):603-610.
Dinh Q. M., 2018a Aspects of reproductive biology of the red goby *Trypauchen vagina* (Gobiidae) from the Mekong Delta. Journal of Applied Ichthyology 34(1):103-110.
Dinh Q. M., 2018b Biological parameters of *Butis butis* (Hamilton, 1822) population from the Mekong Delta. Proceedings Scientific Research Results for Training, Science and Technics Publishing House, Kien Giang University, Vietnam, pp. 306-314.
Dinh Q. M., 2018c Population dynamics of the goby *Trypauchen vagina* (Gobiidae) at downstream of Hau River, Vietnam. Pakistan Journal of Zoology 50(1):105-110.
Dinh Q. M., Le T. T. M., 2017 Reproductive traits of the duckbill sleeper *Butis butis* (Hamilton, 1822). Zoological Science 34(5):452-458.
Dinh Q. M., Nguyen N. P. D., 2018 Population and age structure of the goby *Stigmatogobius pleurostigma* (Perciformes: Gobiidae) from the Mekong Delta. International Journal of Aquatic Science 9(1):23-29.
Dinh Q. M., Nguyen T. T. G., Nguyen T. K. T., 2015a Reproductive biology of the mudskipper *Boleophthalmus boddarti* in Soc Trang. Journal of Biology 37(3):362-369.
Dinh Q. M., Phan Y. N., Tran D. D., 2017 Population biology of the goby *Glossogobius giuris* (Hamilton 1822) caught in the Mekong Delta. Asian Fisheries Sciences 30:26-37.
Dinh Q. M., Qin J. G., Dittmann S., Tran D. D., 2016 Morphometric variation of *Parapocryptes serperaster* (Gobiidae) in dry and wet seasons in the Mekong Delta, Vietnam. Ichthyological Research 63(2):267-274.
Dinh Q. M., Qin J. G., Tran D. D., 2015b Population and age structure of the goby *Parapocryptes serperaster* (Richardson, 1864; Gobiidae: Oxudercinae) in the Mekong Delta. Turkish Journal of Fisheries and Aquatic Sciences 15:345-357.
Dinh Q. M., Tran T. T. N., 2018 Reproductive biological traits of the goby *Stigmatogobius pleurostigma* (Bleeker, 1849) from the Mekong Delta, Vietnam. Indian Journal of Fisheries 65(1):20-25.
Etim L., King R. P., Udo M. T., 2002 Breeding, growth, mortality and yield of the mudskipper *Periophthalmus barbarus* (Linneaus 1766) (Teleostei: Gobiidae) in the Imo River estuary, Nigeria. Fisheries Research 56(3):227-238.
Fraser D. F., Gilliam J. F., Daley M. J., Le A. N., Skalski G. T., 2001 Explaining leptokurtic movement distributions: intrapopulation variation in boldness and exploration. The American Naturalist 158(2):124-135.
Gayanilo F., Sparre P., Pauly D., 2005 FAO-ICLARM stock assessment tools II (FiSAT II): User's guide. FAO, Rome, 176 p.
Gutowsky L. F. G., Fox M. G., 2011 Occupation, body size and sex ratio of round goby (*Neogobius melanostomus*) in established and newly invaded areas of an Ontario river. Hydrobiologia 671(1):27-37.
Hossain M. S., Sultana N., 2014 Morphometric characters and length-weight relationship of Bele, (*Glossogobius giuris*) from Mithamoin haor, Kissorgonj, Bangladesh. Journal of the Bangladesh Agricultural University 12(2):389-395.
Lawson E. O., 2010 Aspects of reproductive biology in mudskipper, *Periophthalmus papilio* from mangrove swamps of Lagos Lagoon, Lagos, Nigeria. Journal of Fisheries International 5(2):36-43.
Le T., Nguyen M. T., Nguyen V. P., Nguyen D. C., Pham X. H., Nguyen T. S., Hoang V. C., Hoang P. L., Le H., Dao N. C., 2006 [Provinces and cities in the Mekong Delta]. Education Publishing House, Ha Noi, 575 p. [In Vietnamese].
Macieira R., Giarrizzo T., Gasparini J., Sazima I., 2012 Geographic expansion of the invasive mud sleeper *Butis koilomatodon* (Perciformes: Eleotridae) in the western Atlantic Ocean. Journal of Fish Biology 81(1):308-313.
Mazlan A. G., Rohaya M., 2008 Size, growth and reproductive biology of the giant mudskipper, *Periophthalmodon schlosseri* (Pallas, 1770), in Malaysian waters. Journal of Applied Ichthyology 24(3):290-296.

Miller P., Wright J., Wongrat P., 1989 An Indo-Pacific goby (Teleostei: Gobioidei) from West Africa, with systematic notes on *Butis* and related eleotridine genera. Journal of Natural History 23(2):311-324.
Moreau J., Bambino C., Pauly D., 1986 A comparison of four indices of overall growth performance based on 100 tilapia populations (Fam. Cichlidae). In: The first Asian fisheries forum. Maclean J. L., Dizon L. B., Hosillo L. V. (eds), Asian Fisheries Society, Philippines, pp. 201-206.
Nguyen V. T., Vu M. T., Nguyen A. D., Nguyen V. T., Zheng J. H., 2013 Overview of estuary research and waterway engineering in Vietnam. Proceeding of the 35th IAHR World Congress, Curran Associates, Chengdu, China, 13 p.
Pauly D., 1979 Theory and management of tropical multispecies stocks: A review with emphasis on Southeast Asian dermersal fisheries. ICLARM, Philippines, 35 p.
Pauly D., 1980 On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. ICES Journal of Marine Science 39(2):175-192.
Pauly D., 1982 Studying single-species dynamics in a tropical multi-species context. In: Theory and management of tropical fisheries. Pauly D., Murphy G. I. (eds), ICLARM, Philippines, pp. 33-70.
Pauly D., 1987 A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates. The International Conference on the Theory and Application of Length-Based Methods for Stock Assessment, ICLARM, Mazzara del Vallo, pp. 7-34.
Pauly D., David N., 1981 ELEFAN I, a BASIC program for the objective extraction of growth parameters from length-frequencies data. Meeresforschung 28:205-211.
Pauly D., Munro J. L., 1984 Once more on the comparison of growth in fish and invertebrates. Fishbyte 2(1):1-21.
Pauly D., Soriano M. L., 1986 Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In: The first Asian fisheries forum. Maclean J. L., Dizon L. B., Hosillo L. V. (eds), Asian Fisheries Society, Manila, pp. 491-496.
Qambrani G. R., Soomro A. N., Palh Z. A., Baloch W. A., Tabasum S., Lashari K. H., Qureshi M. A., 2016 Reproductive biology of *Glossogobius giuris* (Hamilton), in Manchar Lake Sindh, Pakistan. Journal of Aquaculture Research & Development 7(1):392-394.
Ricker W. E., 1975 Computation and interpretation of biological statistics of fish populations. Department of the Environment, Fisheries and Marine Service, Canada, 401 p.
Robertson A., Duke N., 1987 Mangroves as nursery sites: comparisons of the abundance and species composition of fish and crustaceans in mangroves and other nearshore habitats in tropical Australia. Marine Biology 96:193-205.
Roy A., Hossain M. S., Rahman M. L., Salam M. A., Ali M. M., 2014 Fecundity and gonadosomatic index of *Glossogobius giuris* (Hamilton, 1822) from the Payra River, Patuakhali, Bangladesh. Journal of Fisheries 2(2):141-147.
Stratoudakis Y., Bernal M., Ganias K., Uriarte A., 2006 The daily egg production method: recent advances, current applications and future challenges. Fish and Fisheries 7(1):35-57.
Taylor C. C., 1958 Cod growth and temperature. ICES Journal of Marine Science 23(3):366-370.
Tran D. D., Ambak M. A., Hassan A., Nguyen T. P., 2007 Population biology of the goby *Pseudapocryptes elongatus* (Cuvier, 1816) in the coastal mud flat areas of the Mekong Delta, Vietnam. Asian Fisheries Sciences 20(2):165-179.
Tran T. L., Dinh M. Q., 2020 Population dynamic of *Periophthalmodon septemradiatus* (Hamilton, 1822) living along the Hau River, Vietnam. Egyptian Journal of Aquatic Biology and Fisheries 24(3):97-107.
Valová Z., Konečná M., Janáč M., Jurajda P., 2015 Population and reproductive characteristics of a non-native western tubenose goby (*Proterorhinus semilunaris*) population unaffected by gobiid competitors. Aquatic Invasions 10(1):57-68.

Yokoo T., Kanou K., Moteki M., Kohno H., Tongnunui P., Kurokura H., 2006 Juvenile morphology and occurrence patterns of three *Butis* species (Gobioidei: Eleotridae) in a mangrove estuary, southern Thailand. Ichthyological Research 53: 330-336.
Young J. A., Marentette J. R., Gross C., McDonald J. I., Verma A., Marsh-Rollo S. E., Macdonald P. D., Earn D. J., Balshine S., 2010 Demography and substrate affinity of the round goby (*Neogobius melanostomus*) in Hamilton Harbour. Journal of Great Lakes Research 36(1):115-122.
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