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Research Article

Some biological parameters of *Glossogobius aureus* population from the Mekong Delta

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Abstract

Glossogobius aureus is an important commercial fish for food supply and has been caught increasingly, but data on its population biology is limited. The present study was carried out along coastlines from Soc Trang to Bac Lieu, southern Vietnam to contribute new information on the biological characteristics of *G. aureus* population. Data analysis of length-frequency distribution of 666 individuals showed that the equation of von Bertalanffy curve of this species was $L_t = 27.97\left(1-e^{-0.72(t+0.12)}\right)$. The species displayed 4.47 y longevity and 2.75 in the growth performance. The length-converted catch curve analysis showed that the fishing, natural and total mortalities were 2.73 yr^{-1}, 1.52 yr^{-1} and 4.25 yr^{-1} respectively and fish exploitation rate was 0.64. There was one recruitment peak in July and the analyses of relative yield-per-recruit and biomass-per-recruit gave E_{max}=0.408, $E_{0.1}$=0.284 and $E_{0.5}$=0.404. This goby is potentially an aquaculture species due to its high growth rate. The fish stock has been overfished, so the gill net mesh size should be increased and fish should not be caught during the recruitment period for sustainable management.

Keywords: *Glossogobius aureus,* Mortality, Growth, Longevity, Exploitation rate, Mekong Delta

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Introduction

Fisheries management is strongly related to the exploitation rate that was estimated from the analysis of the yield-per-recruit, according to Beverton and Holt (1957). Ricker (1975) reported that the assessment of a fish population depends on the growth and mortality parameters. The growth performance obtained from the analysis of growth and asymptotic length relationship, additionally, are related to the variations of fish growth rate between genders and locations (Pauly and Munro, 1984). The understanding of gobiid population dynamics in the Mekong Delta is limited to some species such as *Pseudapocryptes elongatus* (Tran *et al*., 2007), *Parapcryptes serperaster* (Dinh *et al*., 2015b), *Glossogobius giuris* (Dinh *et al*., 2017) and *Boleophthalmus boddarti* (Dinh, 2017) whereas the rest of gobiid species have not been reported.

Glossogobius is a large genus with 29 species (Froese and Pauly, 2017), but only three species, *G. giuris*, *G. aureus* and *G. sparsipapillus*, are recorded in the Mekong Delta, Vietnam (Tran *et al*., 2013). *Glossogobius aureus* was described firstly by Akihito and Meguro (1975) and widely distributed in brackish and freshwaters in South Africa, Asia and Oceania regions, according to Rainboth (1996). This species is a native amphidromous fish to 13 countries (Froese and Pauly, 2017), including Vietnam (Tran et al., 2013). This goby is a zoobenthic predator feeding mainly on small fish and crustacean in Cambodia (Rainboth, 1996). In the Mekong Delta, this species lives from estuaries to upper stream of Hau and Tien River basins (Tran *et al*., 2013). This fish species spawns with a batch fecundity of 30,800–276,400 eggs/female during the late wet season from September to December and matures firstly at 13.02 cm in total length (Nguyen *et al*., 2014). The goby *G. aureus* shows negative allometric growth, according to the study of Dinh (2014). This goby plays an important role in food supply and is a target species for fishing in the Mekong Delta; however, the knowledge of this species is limited to morphology, environmental requirements, reproductive biology and growth pattern (Tran *et al*., 2013; Dinh, 2014; Nguyen *et al*., 2014; Froese and Pauly, 2017). Albeit *G. aureus* is a commercial fish and is being increasingly exploited (Diep *et al*., 2014), there is no information on the population biology of this goby, especially in the Mekong Delta. Therefore, this study aims to provide new data on the biological parameters to understand its stock and management.

Materials and methods

Study site

This study was carried out for a year-round from January 2016 to December 2016 in the mudflat and mangrove forests from Ganh Hao (9°06'12.9"N 105°29'47.8"E) and Nha Mat (9°12'15.8"N 105°43'51.8"E, Bac Lieu Province) to Tran De (9°28'47.41"N, 106°12'25.96"E, Soc Trang Province, Fig. 1), Vietnam. Both Soc Trang and Bac Lieu are fringed by large mangrove forests (*Avicennia marina* and

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Sonneratia caseolaris) with long coastlines and vast mudflats. Semi-diurnal tides with a range of ~1.2 m are typical for the tide of these two provinces. There are two seasons including the dry season (January–May) with little rain and the wet season (June–December) with monthly precipitation of 400 mm. With a mean annual temperature of ~27 °C, these provinces are typical for the natural environment condition in the Mekong Delta, according to Le *et al*. (2006).

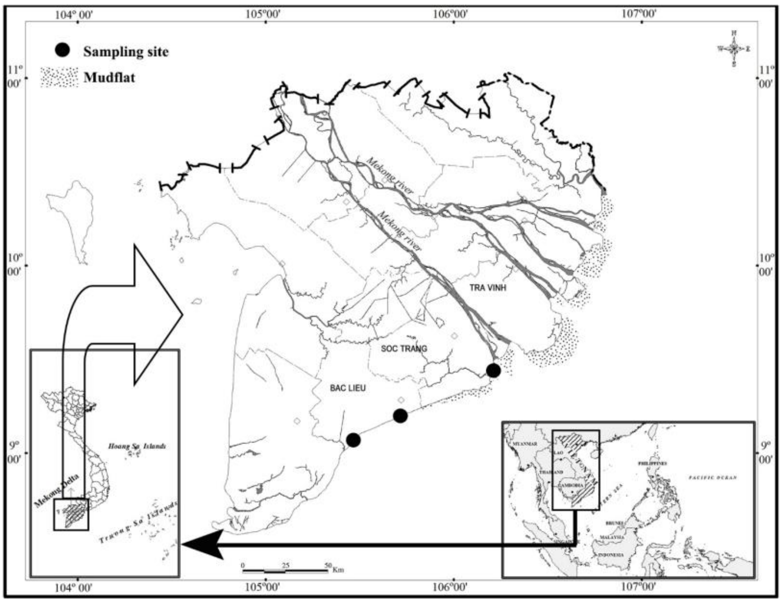

Figure 1: The sampling map in the Mekong Delta (•: Sampling sites).

Fish collection and analysis

A group of nine bottom gill nets (1.5 cm mesh aperture in the cod-end-size range of the gill-nets) was used to collected fish specimens. At the highest tide, a group of three gill nets were set along the mudflat and mangrove forest in each study site; and after 2–3 h during an ebb, gill nets were retrieved to collect fish specimens, according to Dinh *et al*. (2015a). Fish were identified using the external description given by Akihito and Meguro (1975), sexed according to the morphology of urogenital papilla shape (Dinh, 2014) and anaesthetized with benzocaine before storing in 5% formalin and transporting to the laboratory. Fish was then measured to the nearest 0.1 cm in total length and weighed to the nearest 0.01 g in fish body weight.

Data analysis

FiSAT II software was used to estimate the biological parameters of the fish population based on length frequency data, according to Gayanilo *et al*. (2005). The ELEFAN I procedure was performed to calculate the asymptotic length (L_∞) and the growth parameter (K) (Pauly and David, 1981; Pauly, 1982; Pauly, 1987) and the length-converted capture curve was used to determine the total mortality rate (Z) (Beverton and Holt, 1957; Ricker, 1975). Based on Pauly (1980), the natural mortality rate (M) was calculated from the equation

$$LogM = -0.0066 - 0.279 LogL_\infty + 0.6543 LogK + 0.463 LogT$$

(L_∞ and K were two parameters of the von Bertalanffy curve, T was the mean annual water temperature (^oC) in the study region). The fishing mortality (F) and exploitation rate (E) were finally calculated as $F = Z – M$ and the $E = F/Z$ respectively (Ricker, 1975).

The length-converted catch procedure was used to estimate the probability of capture for each size class and the fish length at first entry into the population for catching (L_c), and the time of recruitment was estimated from the recruitment pattern procedure (Pauly, 1987). The yield-per-recruit model of Beverton and Holt (1957) was used to calculate the goby stock and yield, according to Sparre and Venema (1992). The maximum yield exploitation rate (E_{max}), the exploitation rate with the minimal increase of 10% of yield per recruitment ($E_{0.1}$) and the exploitation rate with the reduction of stock to 50% ($E_{0.5}$) were computed from the knife-edge selection procedure (Beverton and Holt, 1966). Moreover, a combination analysis of isopleth (L_c/L_∞) and E was used to estimate the fishing status as described by Pauly and Soriano (1986). The growth performance was calculated as Φ'=Log$K$+2LogL_∞ (K and L_∞ are two parameters of the von Bertalanffy curve) and used to compare the von Bertalanffy growth parameters of *G. aureus* with other gobiid species in or different genus dwelling in the same or different habitat, according to Pauly and Munro (1984). The longevity (t_{max}) was calculated as $t_{\max} = \frac{3}{K}$ where K was the growth constant of the von Bertalanffy curve (Taylor, 1958).

Results

There were five size groups (e.g., five growth curves or dark lines, Fig. 2) in the population of *G. aureus* based on the length-frequency analysis of 666 individuals (396 females and 270 males, Table 1, 6.0–20.0 cm in TL). The smaller fish grew slightly faster than the bigger fish due to a slight slope in the larger fish group. This species displayed the von Bertalanffy growth curve as $L_t = 27.97\left(1-e^{-0.72(t+0.12)}\right)$ based on the analysis of the growth increment data performed using the NORMSEP procedure (Fig. 3).

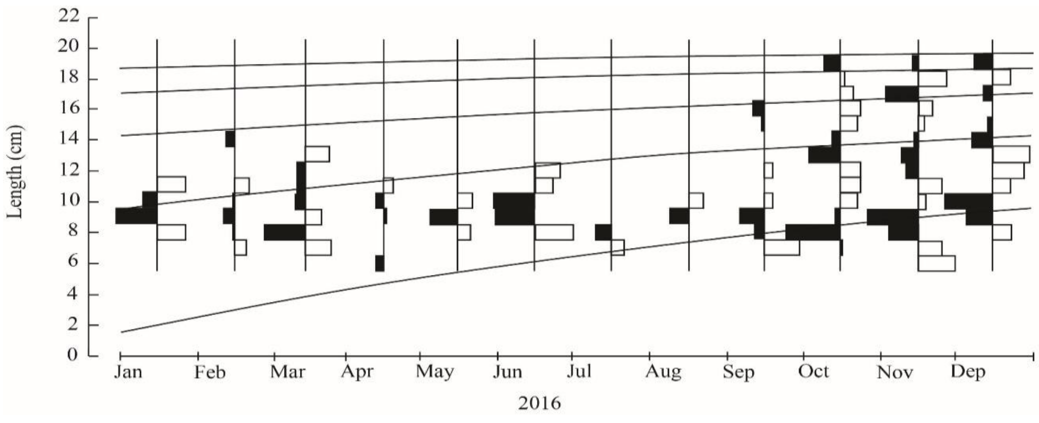

Figure 2: Length-frequency distribution of *Glossogobius aureus* (n = 666). The curves show the increase of fish length over time.

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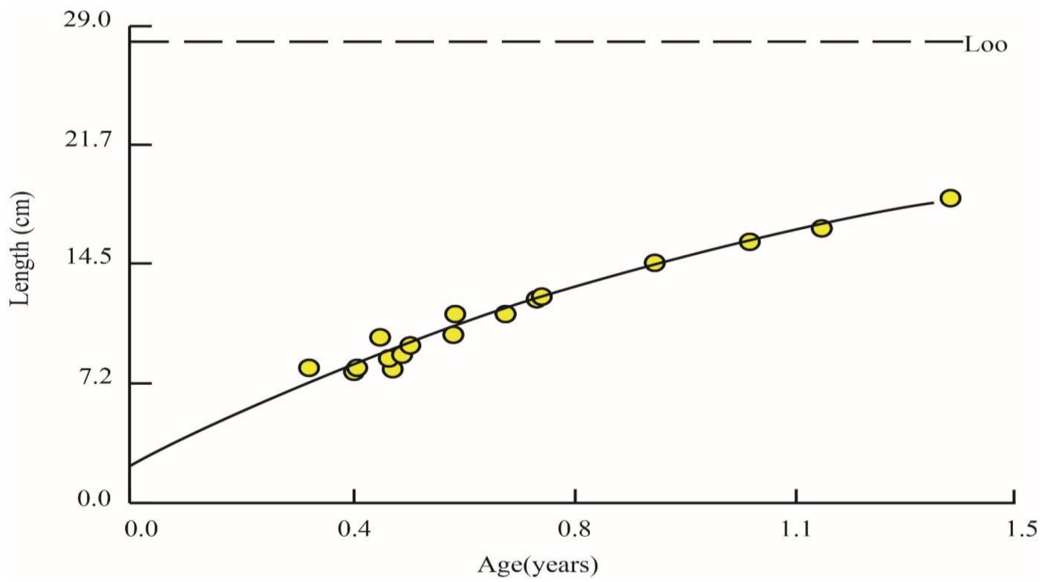

Figure 3: The von Bertalanffy growth curve of *Glossogobius aureus* based on growth increment analysis (L_∞ = 27.97 cm, t_0 = –0.12 yr^{-1}, K = 0.72 yr^{-1}).

Table 1: The number of the goby *Glossogobius aureus* collected from the study site, from January to December 2016.

Fish total length (cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<6.0				1							1	
6.0-6.9		3	1				3		4	22	7	
7.0-7.9	2	9	7	0	0	1	10	12	11	55	30	9
8.0-8.9	14	11	3	3	5	11	6	21	18	31	41	26
9.0-9.9	12	9	7	5	1	12		5	8	11	19	35
10.0-10.9	2	2	5	2		4				6	8	10
11.0-11.9			5			2			2	3	17	4
12.0-12.9			1							9	15	1
13.0-13.9		1								5	11	5
14.-14.9									1	2	7	3
15.0-15.9									2	1	4	0
16.0-16.9										1	7	3
17.0-17.9										1	1	1
18.0-18.9										2	3	3
19.0-20.0												1

The length-converted catch curve analysis showed that the total, natural and fishing mortalities were 4.25, 1.52 and 2.73 respectively (Fig. 4a). This goby displayed a high exploitation rate of 0.64 and a recruitment peak in July (Fig. 4b). The species was firstly caught (L_c or L_{50}) at 6.77 cm in TL obtaining from the capture probability procedure (Fig. 4c).

The goby *G. aureus* showed that the optimum yield $E_{0.1}$=0.284, the yield at the stock reduction of 50% $E_{0.5}$ = 0.404 and the maximum sustainable yield E_{max}=0.482 based on the analyses of the yield-per-recruit and biomass-per-recruit procedure (Fig. 5a). The species

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displayed 0.24 in the yield isopleths, 2.75 in growth performance and 4.17 y in longevity.

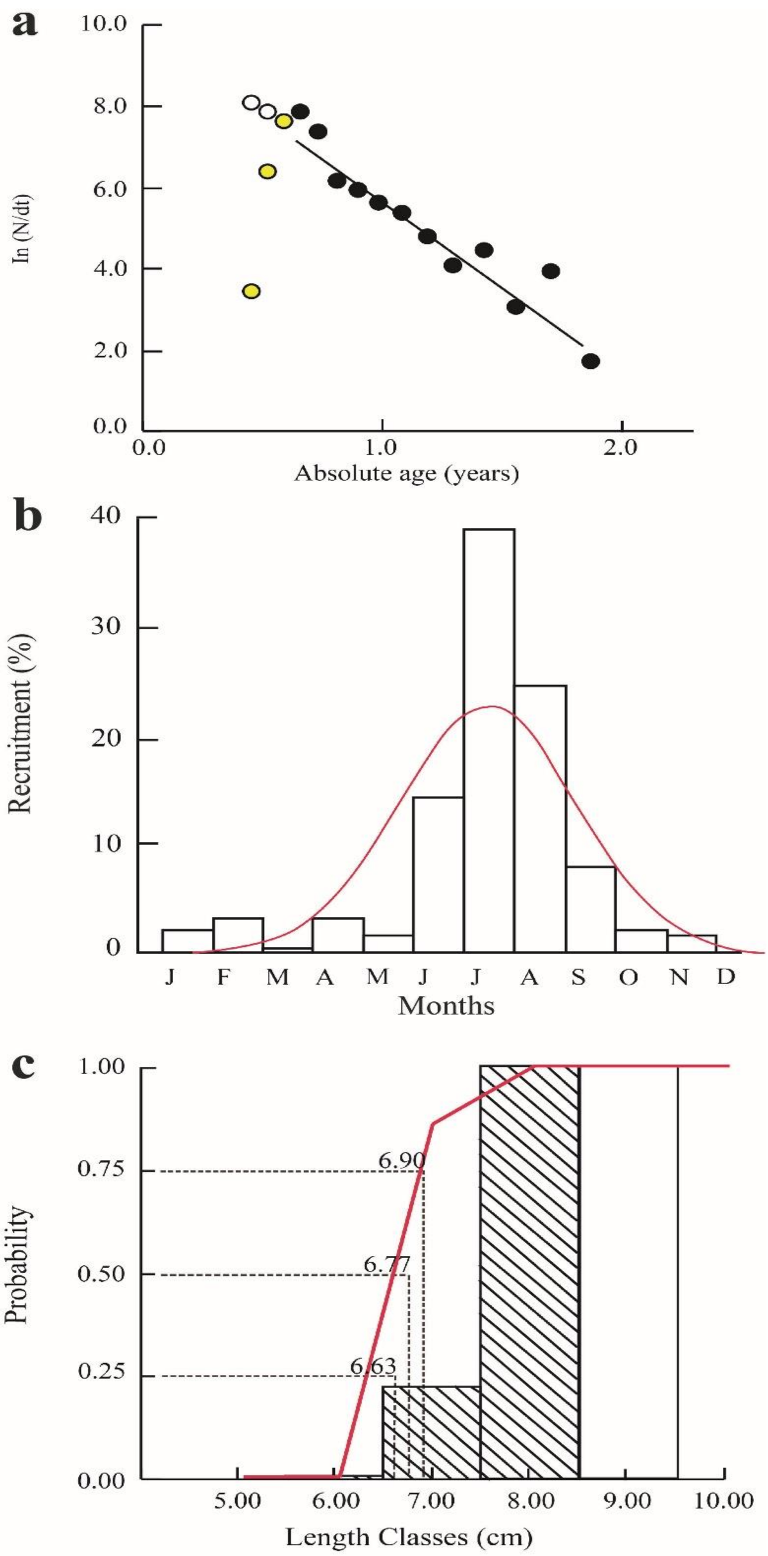

Figure 4: The length converted catch curve (a), recruitment pattern (b), and the probability of capture of *Glossogobius aureus* (c, L_{25} = 6.63, L_{50} = 6.77 and L_{75} = 6.90 cm which was estimated from the logistic transform curve, e.g., red line).

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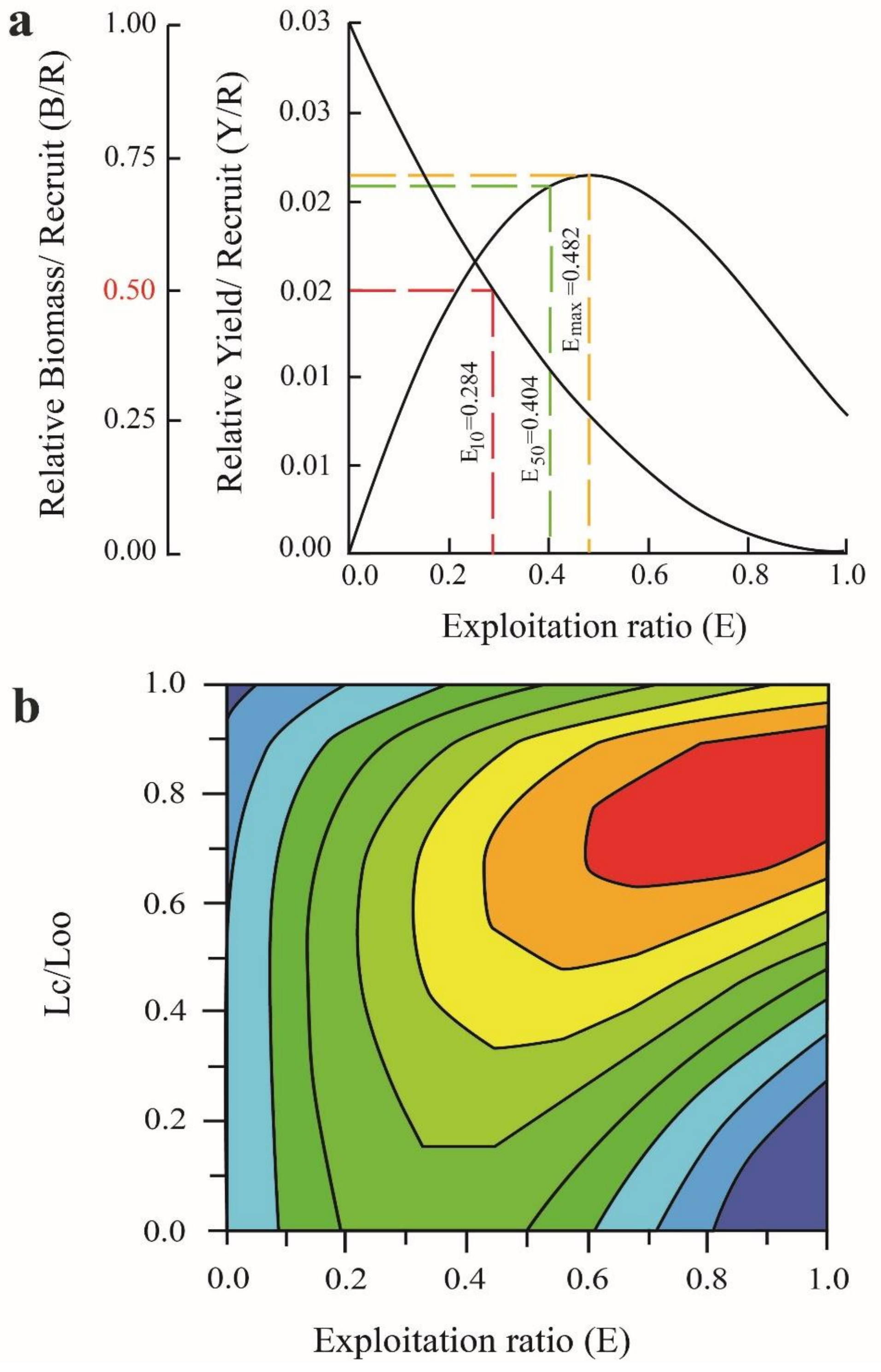

Figure 5: The relative yield-per-recruit and relative biomass-per-recruit (a, E_{max}=0.482, $E_{0.1}$=0.284 and $E_{0.5}$=0.404), and the yield isopleths (b) for *Glossogobius aureus.*

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Discussion

The growth performance (*Φ'*) obtained from the growth parameter (*K*) and asymptotic length (L_∞) varies with some gobiid species, according to the study on the population structure of *P. serperaster* of Dinh et al. (2015b). Similarly, *Φ'* of *G. aureus* was lower than other gobiid species living in the same or different habitat such as *P. schlosseri* in Malaysia (Mazlan and Rohaya, 2008), *Glossogobius matanensis* in Indonesia (Mamangkey and Nasution, 2014) but higher than *P. barbarrus* in Nigeria (Etim *et al*., 2002), *P. elongatus* (Tran *et al*., 2007), *P. serperaster* (Dinh *et al*., 2015b), *G. giruris* in the Mekong Delta (Dinh *et al*., 2017) and *B. boddarti* (Dinh, 2017) (Table 2). It could be because *K* and L_∞ of *G. aureus* were lower than *P. schlosseri* (Mazlan and Rohaya, 2008), *G. matanensis* (Mamangkey and Nasution, 2014) but higher than *P. barbarrus* (Etim *et al*., 2002), *P. elongatus* (Tran *et al*., 2007), *P. serperaster* (Dinh *et al*., 2015b) and *G. giruris* (Dinh *et al*., 2017) (Table 2).

Table 2: Population parameters of some gobiid species.

Species	L_∞	K	t_{max}	Z	F	M	L_c	E	Φ'	Fishing gears	Study site	Sources
Periophthalmus barbarus	21.60	0.55	5.45	4.21	2.86	1.35	10.2	0.68	2.41	Non-return valved basket traps	Nigeria	Etim *et al.* (2002)
Pseudapocryptes elongatus	26.00	0.65	4.35	2.91	1.47	1.44	11.75	0.51	2.64	Fixed-bag nets	Mekong Delta	Tran *et al.* (2007)
Periophthalmodon schlosseri	29.00	1.40	2.14	-	-	-	-	-	3.10	Hook, cast net and traps	Malaysia	Mazlan and Rohaya (2008)
Glossogobius matanensis	46.20	1.20	-	3.73	1.94	1.79		0.52	3.42	Salue/Rawai (long line hook)	Indonesia	Mamangkey and Nasution (2014)
Parapocryptes serperaster	25.52	0.74	4.05	3.07	1.57	1.51	14.6	0.49	2.67	Gill nets	Mekong Delta	Dinh *et al.* (2015b)
Boleophthalmus boddarti	16.80	0.79	3.55	2.13	0.30	1.83	12.97	0.14	2.35	Gill nets	Mekong Delta	Dinh (2017)
Glossogobius giuris	20.53	0.56	5.36	3.17	1.77	1.40	7.41	0.56	2.37	Gill nets	Mekong Delta	Dinh *et al.* (2017)
Glossogobius aureus	27.97	0.72	4.17	4.25	1.52	2.73	6.77	0.64	2.75	Gill nets	Mekong Delta	Present study

L_∞: asymptotic length, *K*: growth parameter, t_{max}: maximum age; *Z*: total mortality, *F*: fishing mortality, *M*: natural mortality, L_c: length at first capture, *E*: exploitation rate and *Φ'*: growth performance

The goby *G. aureus* had only one recruitment peak in July whereas other gobiid species living in the same habitat show two distinguished recruitment peaks such as *P. elongatus* (Tran *et al*., 2007) *P. serperaster* (Dinh *et al*., 2015b), *G. giuris* (Dinh *et al*., 2017) and *B. boddarti* (Dinh, 2017). Moreover, *G. aureus* displayed one spawning period in Ben Tre during the late wet season from September to December, according to the study of Nguyen *et al*. (2014). It seems that the recruitment time of *G. aureus* varied with geographical regions. Similarly, a neighbour goby *G. giuris* spawns twice a year in Mithamoin Haor, Bangladesh (Hossain, 2014), but only once in September in the Payra River, Bangladesh (Roy *et al*., 2014), in March in Pakistan (Qambrani *et al*., 2016) and in September in Can Tho City, Vietnam (Pham and Tran, 2013). The goby *G. aureus* could spawn many

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times during its life cycle due to its high longevity. The longevity and growth parameter of *G. aureus* were respectively higher and lower than other species in the Gobiidae family such as *P. elongatus* (Tran *et al*., 2007), *P. serperaster* (Dinh *et al*., 2015b), *G. giuris* (Dinh *et al*., 2017) and *B. boddarti* (Dinh, 2017) in the Mekong Delta, *P. barbarus* in Nigeria (Etim *et al*., 2002) and *P. schlosseri* (Mazlan and Rohaya, 2008) in the mud flats in Malaysia (Table 2). The growth constant of this fish could be positively related to the fish longevity.

The natural mortality of *G. aureus* was higher than that of co-occurring gobies such as *P. elongatus* (Tran *et al*., 2007), *P. serperaster* (Dinh *et al*., 2015b), *G. giuris* (Dinh *et al*., 2017) and *B. boddarti* (Dinh, 2017) (Table 2). The goby *G. aureus* was more expensive than other gobiid species like *P. serperaster* (Dinh *et al*., 2015b), *G. giuris* (Dinh *et al*., 2017) and *B. boddarti* (Dinh, 2017) in the Mekong Delta which may lead to the higher fishing mortality of *G. aureus* than others (Table 2). Moreover, the difference in fishing gear may lead to the differences in length at first capture of *G. aureus* and other gobiid fishes (Table 2).

This fish was overfished as its E was higher than E_{50}. Moreover, the combination of yield isopleths and exploitation rate analysis showed this gobiid species failed into overfishing quadrant (quadrant D) as described by Pauly and Soriano (1986). This assumption was supported by the short length at first capture. Similarly, the stock of the neighbour goby *G. giuris* has been overfished, according to the study of Dinh *et al*. (2017). On the contrary, other co-occurring gobiid populations such as *P. elongatus* (Tran *et al*., 2007), *P. serperaster* (Dinh *et al*., 2015b) and *B. boddarti* (Dinh, 2017) have not been overexploited. It could be the fact that *G. aureus* had higher economic value than *B. boddarti* (Dinh, 2017) and its L_∞ and L_c were shorter than *P. elongatus* (Tran *et al*., 2007) and *P. serperaster* (Dinh *et al*., 2015b).

In conclusion, this species had a potential aquaculture resource because of high growth constant. The goby stock was overexploited in the study region so that fish gear mesh size should be increased and fish should not be caught during the recruitment period for future sustainable management.

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