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Population Biology of the Goby *Glossogobius giuris* (Hamilton 1822) Caught in the Mekong Delta, Vietnam

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Abstract

Glossogobius giruis (Hamilton 1822) is a commercial fish but there is no knowledge of its population biology. The present study was conducted along the coastlines from Soc Trang to Bac Lieu, Vietnam to contribute new information on population biological characteristics of *G. giuris* based on length-frequency distribution analysis of 673 individuals. The von Bertalanffy curve parameters of this goby were L_∞= 20.53 cm, K = 0.56 yr^{-1} and t_0 = –0.02 yr^{-1}. The longevity (t_{max}) and the growth performance (Φ') were 5.36 yrs and 2.37 respectively. The fishing, natural and total mortalities of this fish population were 1.77 yr^{-1}, 1.40 yr^{-1} and 3.17 yr^{-1} respectively and its exploitation rate was 0.56. There were two recruitment peaks in late April and in September, and the analyses of relative yield-per-recruit and biomass-per-recruit gave E_{max} = 0.633, $E_{0.1}$ = 0.515 and $E_{0.5}$ = 0.323. This goby is a potential aquaculture candidate due to its high growth parameters. The fish stock is subject to overexploitation and, as such, the deep gill net mesh size should be increased and the fish should not be caught during the recruitment period for sustainable fishery management.

Key words: *Glossogobius giruis*, mortality, growth, longevity, exploitation rate.

Introduction

The exploitation rate obtained from the yield-per-recruit analysis is essential for fishery management (Al-Husaini et al. 2002) and a fish population biology assessment depends on the growth parameters and mortality rates (Amezcua et al. 2006). Moreover, the variations of fish growth rate between gender and location are related to the growth performance that was retrieved from growth and asymptotic length relationship (Pauly and Munro 1984).

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However, the knowledge of fish population biology, especially of gobiid species in the Mekong Delta, where a diverse number of species exists (Tran et al. 2013), is little known. The goby *Glossogobius giuris* (Hamilton 1822) belonging to the family Gobiidae, is an elongated-bodied fish (Mahilum et al. 2013) and is widely distributed in coastal and estuarine waters in the Indo-Pacific regions (Talwar and Jhingran 1991; Riede 2004; Froese and Pauly 2016). This goby lives in brackish to freshwater in Bangladesh, India, Pakistan (Islam 2004) and the Mekong Delta (Tran et al. 2013). The goby *G. giuris* is one of twenty-nine species of *Glossogobius* genus (Froese and Pauly 2016) and some information on the eco-biology of this gobiid species has been documented by Islam (2004). In Bangladesh, *G. giuris* displays isometry in the Ganges (Hossain et al. 2009) but negative allometry in Mithamoin Haor, Kissorgonj (Hossain and Sultana 2014). The species spawns twice per year (in March and also from June to October) in Mithamoin Haor, Kissorgonj, Bangladesh (Hossain 2014) but a single spawning season was observed in October in Can Tho City, Vietnam (Pham and Tran 2013), in September in the Payra River, Patuakhali, Bangladesh (Roy et al. 2014) and in March in Pakistan (Qambrani et al. 2016).

This gobiid species is a carnivore feeding mainly on small fish and crustaceans in Mithamain Haor, Kishoreganj, Bangladesh (Hossain et al. 2016) and is an important target species for fishing (Hossain and Sultana 2014; Qambrani et al. 2016). Although this goby has played a major role in the food supply in the Mekong Delta, knowledge on this fish is limited to external morphology, environmental requirements and reproductive biology (Mahilum et al. 2013; Pham and Tran 2013; Tran et al. 2013). This goby is a commercially important fish and is being increasingly exploited (Diep et al. 2014) but there is no information on the population biology of this goby especially in the Mekong Delta. Therefore, this study aims to provide new information on the population biological parameters of this fish to improve its stock and fishery management.

Materials and Methods

Study site

This study was conducted along the mudflat and mangrove forests in Tran De (9°28'47.41"N, 106°12'25.96"E, Soc Trang Province) and Nha Mat (9°12'15.8"N 105°43'51.8"E, Bac Lieu Province), Vietnam from March 2015 to February 2016. Soc Trang and Bac Lieu Provinces which have long coastlines and extensive mudflats, are covered with mangrove forests. There is no rain in the dry season (January–May) in Soc Trang and Bac Lieu but these two provinces experience heavy rain with roughly 400 mm of precipitation per month in the wet season (June–December) and the mean annual temperature is ~27°C, which is typical for the natural environment in the Mekong Delta (Le et al. 2006).

Fish collection and analysis

Fish specimens were collected monthly using six deep gill nets with 1.5 cm mesh aperture in the cod-end. In each study site, a group of three gill nets was set at the highest tide along the mudflat and mangrove forest and retrieved after 2–3 h during an ebb tide in the study region based on the method described by Dinh et al. (2015a). After identification based on external description (Akihito and Meguro 1975; Mahilum et al. 2013; Tran et al. 2013), fish was sexed using external morphology of urogenital papilla shape (oval in female and triangle in male), stored in 5% formalin and transported to the laboratory. In the laboratory, the total length (to the nearest 0.1 cm) and weight (to the nearest 0.01 g) of the fish specimens were measured.

Data analysis

Data on length frequency were inputted to FiSAT II software to estimate the fish population biological parameters (Gayanilo et al. 2005). The ELEFAN I procedure was performed to determine the asymptotic length (L_∞) and the growth parameter (K) (Pauly and David 1981; Pauly 1982; Pauly 1987), and the length-converted capture curve was applied to estimate the total mortality rate (Z) (Beverton and Holt 1957; Ricker 1975).

The equation $\mathrm{Log}M = -0.0066 - 0.279\mathrm{Log}L_\infty + 0.6543\mathrm{Log}K + 0.463\mathrm{Log}T$ (L_∞ and K were two parameters estimated from the ELEFAN I, and T was the mean annual water temperature (^{o}C) in the study region) was used to estimate the natural mortality rate (M) (Pauly 1980). Thereafter, the fishing mortality (F) was calculated as $F = Z – M$ and the exploitation rate (E) was determined from equation $E = F/Z$ (Ricker 1975). The probability of capture for each size class and the seasonal recruitment pattern were estimated using the length-converted catch, and the fish length at first entry into the population for catching (L_c) was computed by plotting the cumulative probability of capture against the class mid-length (Pauly 1987). The goby stock and yield were estimated from the yield-per-recruit model of Beverton and Holt (1957) (Sparre and Venema 1992). The knife-edge selection was performed to estimate the maximum yield exploitation rate (E_{max}), the exploitation rate with the minimal increase of 10% of $^{Y'}\!/_R$ ($E_{0.1}$) and the exploitation rate with the reduction of stock to 50% ($E_{0.5}$) (Beverton and Holt 1966). A combination analysis of E and isopleth ratio (L_c/L_∞) was used to determine the fishing status based on the method of Pauly and Soriano (1986). When comparing growth parameters between different tilapia populations, Moreau et al. (1986) indicated the growth performance index (Φ') is the best growth index compared to another growth index $\omega = K \times L_\infty$ due to its small variation degree. Therefore, in the present study, the growth performance ($\Phi' = \mathrm{Log}K + 2\mathrm{Log}L_\infty$, where K and L_∞ are two parameters of the von Bertalanffy curve) was used to compare the von Bertalanffy growth parameters of *G. giuris* and other goby species dwelling in the same or different habitat (Pauly and Munro 1984). The longevity (t_{max}) of *G. giuris* was calculated as $t_{\max} = \frac{3}{K}$ where K was the growth constant (Taylor 1958; Pauly 1980).

Results

The length-frequency analysis of 673 individuals (412 females and 261 males, Table 1, 3.0–17.0 cm in TL) showed that there were five fish size groups, i.e., five growth curves represented by five dark lines (Fig. 1) in the population of *G. giuris* in this study area. The small fish grew slightly faster than the bigger fish because of the slight slope in the larger fish group compared to the small group. The analysis of the growth increment data obtained from the NORMSEP procedure showed that the von Bertalanffy growth curve of *G. giuris* was $L_t = 20.53\left(1 - e^{-0.56(t+0.02)}\right)$ (Fig. 2).

Table 1. The number of the goby *Glossogobius giuris* collected from the study site.

Sampling time	Female	Male	**Sum**	Season
3/2015	26	25	51	Dry
4/2015	16	25	41	Dry
5/2015	17	15	32	Dry
6/2015	33	39	72	Wet
7/2015	4	1	5	Wet
8/2015	31	31	62	Wet
9/2015	64	23	87	Wet
10/2015	169	57	226	Wet
11/2015	9	15	24	Wet
12/2015	16	16	32	Wet
1/2016	6	10	16	Dry
2/2106	21	4	25	Dry

The total, natural and fishing mortalities of this fish were 3.17, 1.40 and 1.77 respectively based on the length-converted catch curve analysis (Fig. 3a). This goby displayed high exploitation rate of 0.56 and there were two separate recruitment peaks which occurred in April and September (Fig. 3b). This goby was first caught (L_c or L_{50}) at 7.41 cm (TL), and this length was estimated from the capture probability analysis (Fig. 3c).

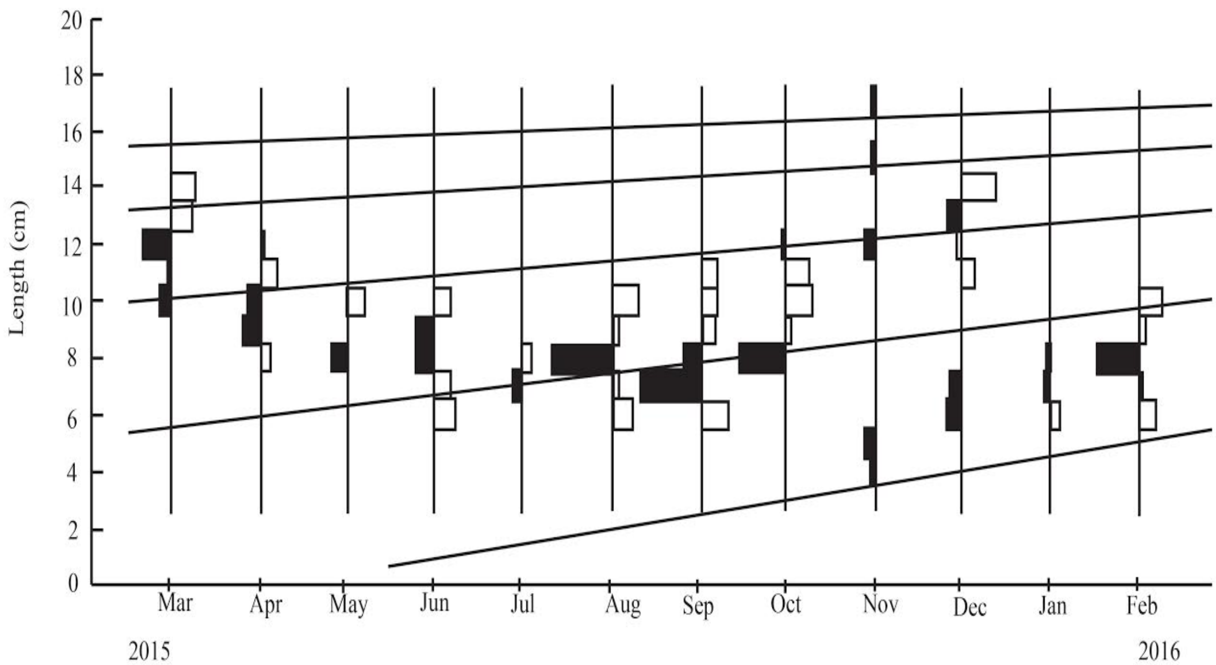

Fig. 1. Length-frequency distribution of *Glossogobius giuris* (n = 673). The curves show the increase of fish length over time.

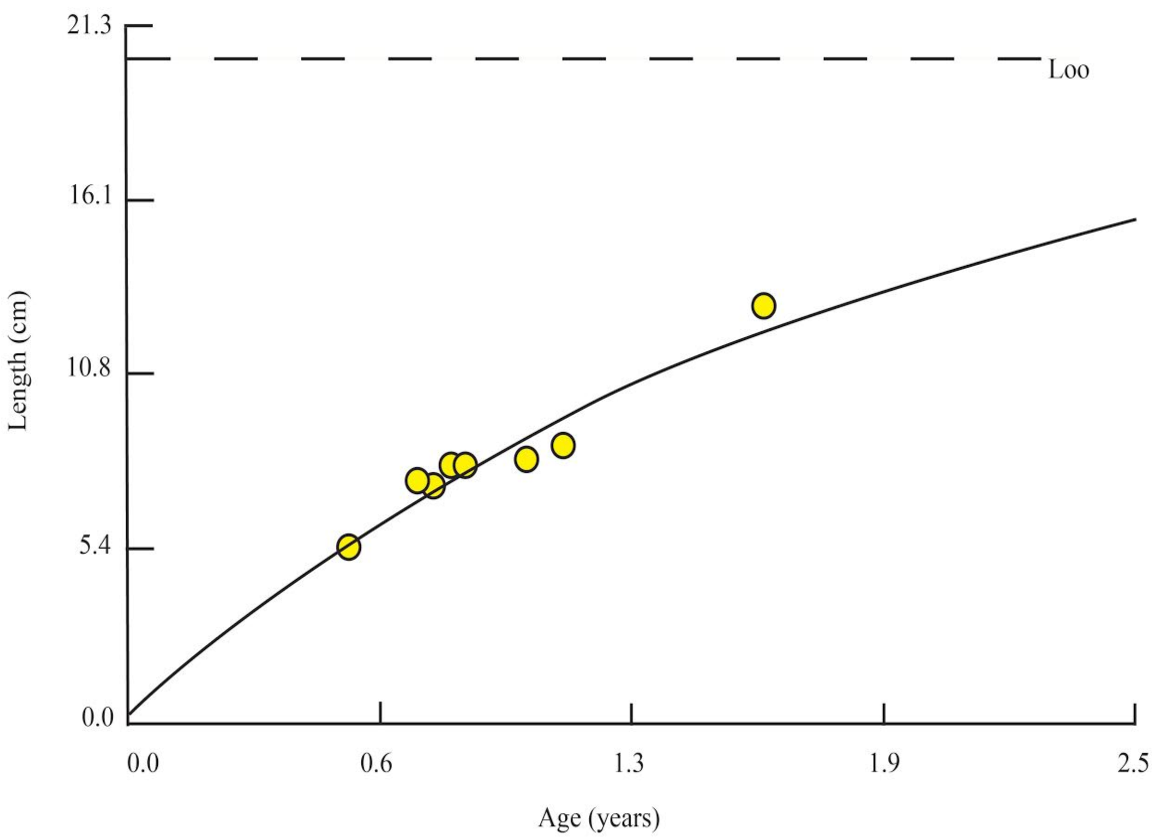

Fig. 2. The von Bertalanffy growth curve of *Glossogobius giuris* based on growth increment analysis (L_∞ = 20.53 cm, t_0 = –0.02 yr^{-1}, K = 0.56 yr^{-1}).

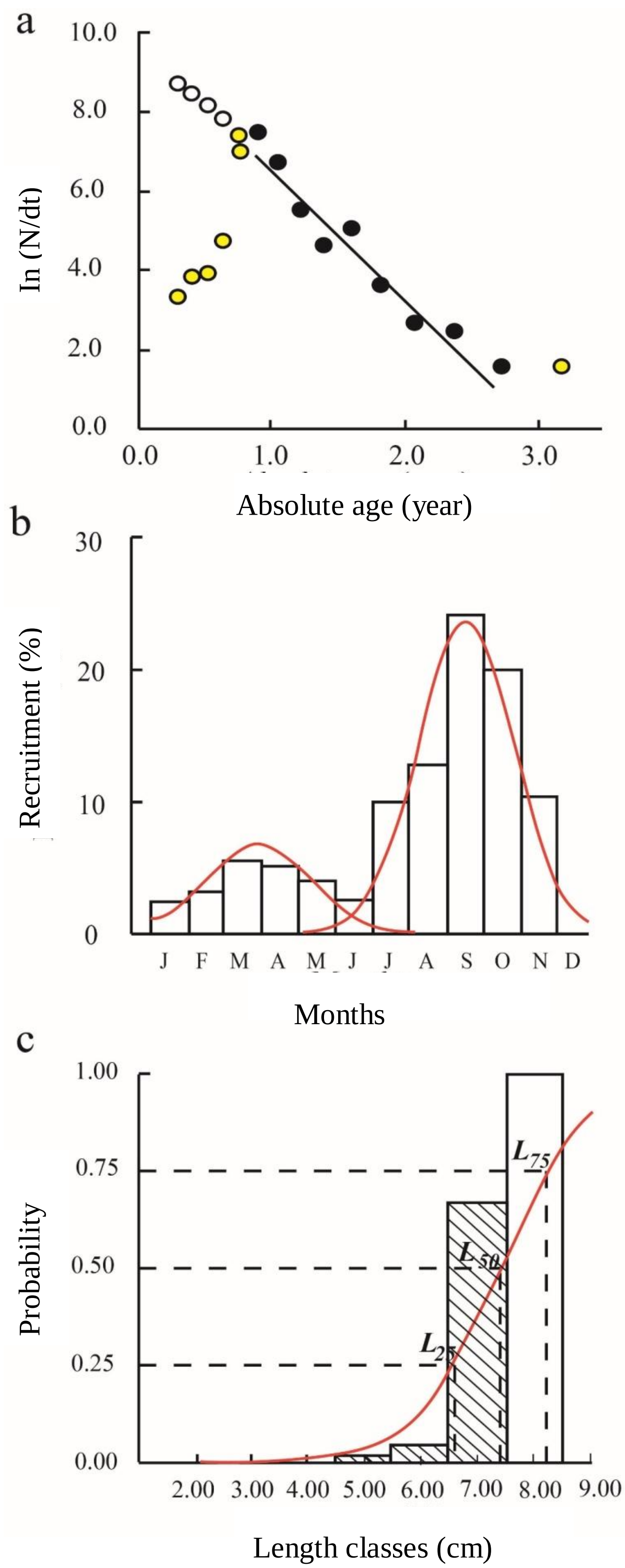

Fig. 3. The length converted catch curve (a), recruitment pattern (b), and (c) the probability of capture of *Glossogobius giuris* (L_{25} = 6.60, L_{50} = 7.41 and L_{75} = 8.22 cm, estimated from the logistic transform curve, e.g., red line).

The analyses of the yield-per-recruit and biomass-per-recruit of *G. giuris* showed that the optimum yield $E_{0.1}$ = 0.515, the yield at the stock reduction of 50% $E_{0.5}$ = 0.323 and the maximum sustainable yield E_{max} = 0.633 (Fig. 4a). The ratio of the length at first capture and the asymptotic length (e.g., the yield isopleths, Fig. 4b) of this fish was 0.36; its growth performance was 2.37 and the longevity was 5.36.

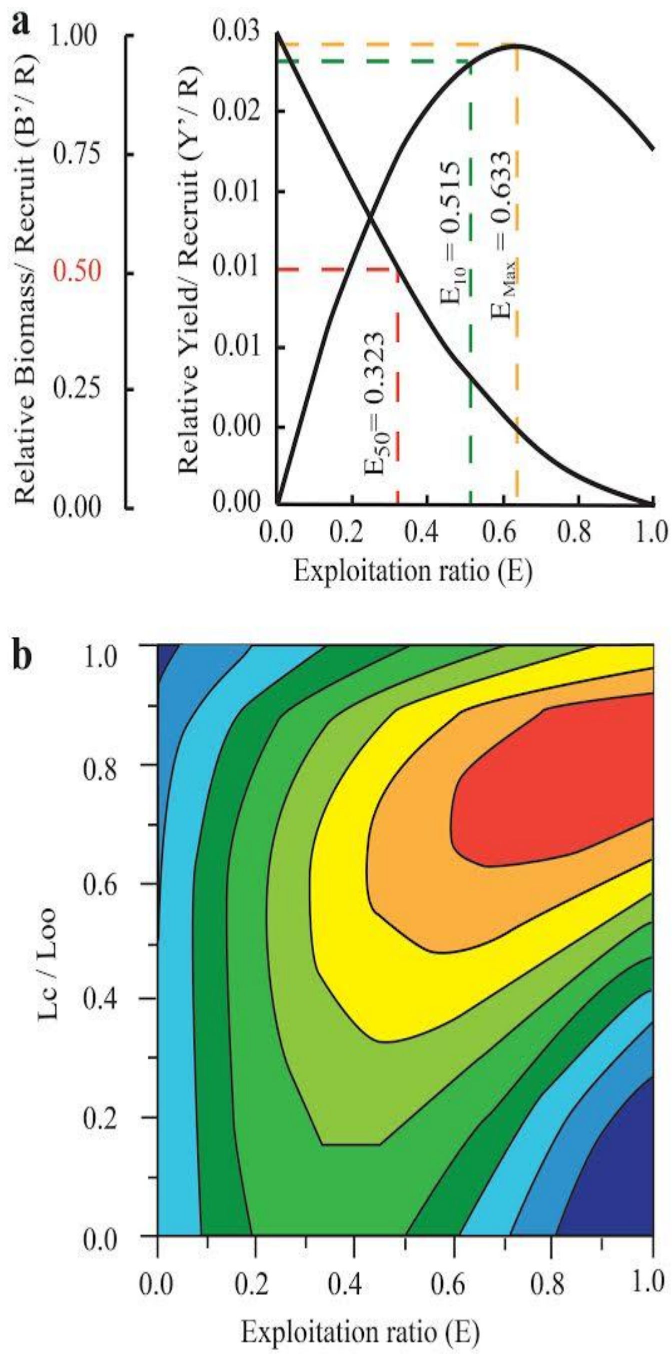

Fig. 4. The relative yield-per-recruit and relative (a) biomass-per-recruit and (E_{max} = 0.633, $E_{0.1}$ = 0.515 and $E_{0.5}$ = 0.323), and the yield isopleths (b) for *Glossogobius giuris.*

Discussion

When studying the population structure of *Parapocryptes serperaster* (Richardson 1846), Dinh et al. (2015b) indicated that variation in the growth parameter (K) and asymptotic length (L_∞) might exist in some gobiid fishes. Similarly, Φ' of *G. giuris* was lower than other gobiid species living in the same or different habitat such as *Pseudapocryptes elongatus* (Cuvier 1816) in the Mekong Delta (Tran et al. 2007), *Periophthalmodon schlosseri* (Pallas 1770) in Malaysia (Mazlan and Rohaya 2008), *Glossogobius matanensis* (Weber 1913) in Indonesia (Mamangkey and Nasution 2014) and *P. serperaster* in the Mekong Delta (Dinh et al. 2015b) but higher than that of *Periophthalmus barbarrus* (Linneaus 1766) in Nigeria (Etim et al. 2002) (Table 2). This could be due to the fact that K and L_∞ of *G. giuris* were lower than *P. barbarrus* (Etim et al. 2002), *P. elongatus* (Tran et al. 2007), *P. schlosseri* (Mazlan and Rohaya 2008), *G. matanensis* (Mamangkey and Nasution 2014) and *P. serperaster* (Dinh et al. 2015b) (Table 2).

Table 2. Population parameters of various gobiid species.

Species	L_∞	K	t_{max}	Z	F	M	L_c	E	Φ'	Sources
Periophthalmus barbarus	21.60	0.55	5.45	4.21	2.86	1.35	10.2	0.68	2.41	Etim et al. (2002)
Pseudapocryptes elongatus	26.00	0.65	4.35	2.91	1.47	1.44	11.75	0.51	2.64	Tran et al. (2007)
Periophthalmodon schlosseri	29.00	1.40	2.14	-	-	-	-	-	3.10	Mazlan and Rohaya (2008)
Glossogobius matanensis	46.20	1.20	-	3.73	1.94	1.79		0.52	3.42	Mamangkey and Nasution (2014)
Parapocryptes serperaster	25.52	0.74	4.05	3.07	1.57	1.51	14.6	0.49	2.67	Dinh et al. (2015b)
Glossogobius giruis	20. 53	0.56	5.36	3.17	1.77	1.40	7.41	0.56	2.37	Present study

Like *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b), *G. giuris* had two separate recruitment peaks but the main peak was in September. In contrast, this species had only one spawning period in the river in Can Tho city, according to the study of Pham and Tran (2013). The time limitation of 9 months in the earlier survey could have contributed to this difference. Similarly, this species also spawns twice a year in Mithamoin Haor, Kissorgonj, Bangladesh (Hossain 2014), but only once in September in the Payra River, Patuakhali, Bangladesh (Roy et al. 2014) and in March in Pakistan (Qambrani et al. 2016). It seems that the recruitment times of this goby could be related to geographical regions. The goby *G. giuris* could spawn many times during its life cycle due to its high longevity value. This fish has greater potential for artificial spawning breakthrough compared to other co-occurring gobies such as *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b) as its t_{max} was higher than others.

The longevity and growth parameters of *G. giuris* in the present study were respectively higher and lower than other species in the Gobiidae family such as *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b) in the Mekong Delta, *P. barbarrus* in Nigeria (Etim et al. 2002) and *P. schlosseri* (Mazlan and Rohaya 2008) in the mud flats in Malaysia (Table 2). The constant growth of this fish could probably be related to the fish longevity. The goby in this study was able to avoid predators, use natural food resources and reproduce more effectively than other co-occurring gobiid fish including *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b) as the natural mortality of *G. giuris* was lower than *P. elongatus* and *P. serperaster* (Table 2). The fishing mortality of *G. giuris* was higher than that of *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b) (Table 2) due to the higher price of *G. giuris* compared to other gobiid species. The differences in economic value or fishing gears may result in the differences in fishing mortality between *G. giuris* in the present study region and *P. barbarus* in Nigeria (Etim et al. 2002) and the differences in length at first capture of *G. giuris* and other gobiid fishes (Table 2). This fish stock was overfished in the present study region as its exploitation rate was higher than that of E_{50}. Moreover, the combination of yield isopleths (L_c/L_∞) and exploitation rate (E) analysis showed this gobiid species falls in the overfishing quadrant (quadrant D) as described by Pauly and Soriano (1986). This assumption was supported by the short length at first capture of this goby.

Meanwhile, other co-occurring gobiid populations such as *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b) have not been subjected to overfishing. It could result from the fact that this goby had a higher economic value than the others and its L_∞ and L_c were shorter compared to *P. elongatus* (Tran et al. 2007) and *P. serperaster* (Dinh et al. 2015b). Therefore, the mesh size of the fishing gears should be increased to avoid fishing during the recruitment period for sustainable fishery management.

Conclusion

This species had high population recruitment and is a potential candidate for future aquaculture production due to its high growth constant. Its stock was subjected to overexploitation in the study region and, as such, the mesh size of deep gill nets should be increased and fish should not be caught during the recruitment period for future sustainable fishery management.

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