Chapter

Biological Characteristics of Some Fish Species in the Mekong Delta, Vietnam

Giang Van Tran and Quang Minh Dinh

Abstract

Vietnam, with a rich river system, many lagoons, and a long coastline, the fish fauna comprises both brackish and freshwater fish. The system of Mekong river is an extensive river located in the south of Vietnam. There are all kinds of brackish and freshwater fish in this river system. This chapter reveals data on the fish species composition and their roles in the Vietnamese Mekong delta. Moreover, the growth pattern and condition factor of some commercial fishes are also presented in this chapter. Their population structure and fishing status are also reported in this chapter.

Keywords: condition factor, goby, growth pattern, population structure, Vietnam

1. Introduction

Vietnam is one of the countries with a developed river system that comprises several extensive river systems, such as the Red river, the Ca river, the Dong Nai river, the Tien river, and the Hau river. Most of these rivers originate from other countries and flow into our country. According to statistics, about 2360 large and small rivers are widely distributed from the north to the south. With these characteristics, the fish system in Vietnam is very diverse and rich, with 1027 species classified into 427 genera, 98 families, and 22 orders. This fish system is considered diverse in species and high in biodiversity. The Mekong delta (VMD) is one of the two great deltas of Vietnam and is ranked 3rd globally [1]. The VMD is the last basin of the Mekong river with two main tributaries, the Tien and Hau rivers. This is an area with flat terrain and a dense system of rivers. On the other hand, VMD is also adjacent to the east sea and the Gulf of Thailand, with a coastline of nearly 700 km. Mekong river and rainfall mainly supply VMD's water source. The terrain in this area is favorable for the strong development of fishing and aquaculture from freshwater to brackish water [2]. The fish fauna in this area includes 332 species belonging to 77 families [3], including nearly 80 species of high economic value fish [4]. However, with the current exploitation of fish species, the number of some species is rapidly decreasing. Research on their biology is needed to supply appropriate data for the conservation and development of high-risk fish species. Therefore, the study "Biological characteristics of some fish species in the Mekong delta, Vietnam" provides these data.

2. Material and methods

This research was conducted at four sites covering a variety of aquatic environments. The first site has fresh water all year round in Cai Rang (Can Tho city, CRCT), the second site has brackish water due to saline intrusion in Long Phu (Soc Trang province, LPST); and year-round brackish water sites in Hoa Binh (Bac Lieu province, HBBL) and Dam Doi (Ca Mau province, DDCM). The biological characteristics of some investigated fish species include *G. aureus*, *G. giuris*, and *Glossogobius sparsipapillus*. The survey period lasted from January (2020) to March (2021). Fish samples were gathered using bottom nets with a net of $2a = 1.5$ cm. Collected fish were analyzed in the laboratory with the following steps: (1) classify founded on the outer morphological characterization [3], (2) sex discrimination based on genital spines [5], (3) measure morphological, and (4) anatomical parameters. Morphological parameters were estimated, including total length (TL, cm), and weight (W, g) (**Figure 1**).

Data on the TL and W of each fish sample was employed to specify the regression equation between length and weight of fish based on a formula: $W = a^{*}TL^{b}$ (a and b were the coefficients). The coefficient b was employed to determine the growth pattern of the fish, for example, homologous growth when $b \neq 3$; unequal growth when $b \approx 3$, based on the research method of Froese [7]. The CF coefficient was determined by a formula, specifically, $CF = W/TL^{b}$ [8]. Where b was the growth coefficient (from the regression equation between the TL and W of fish).

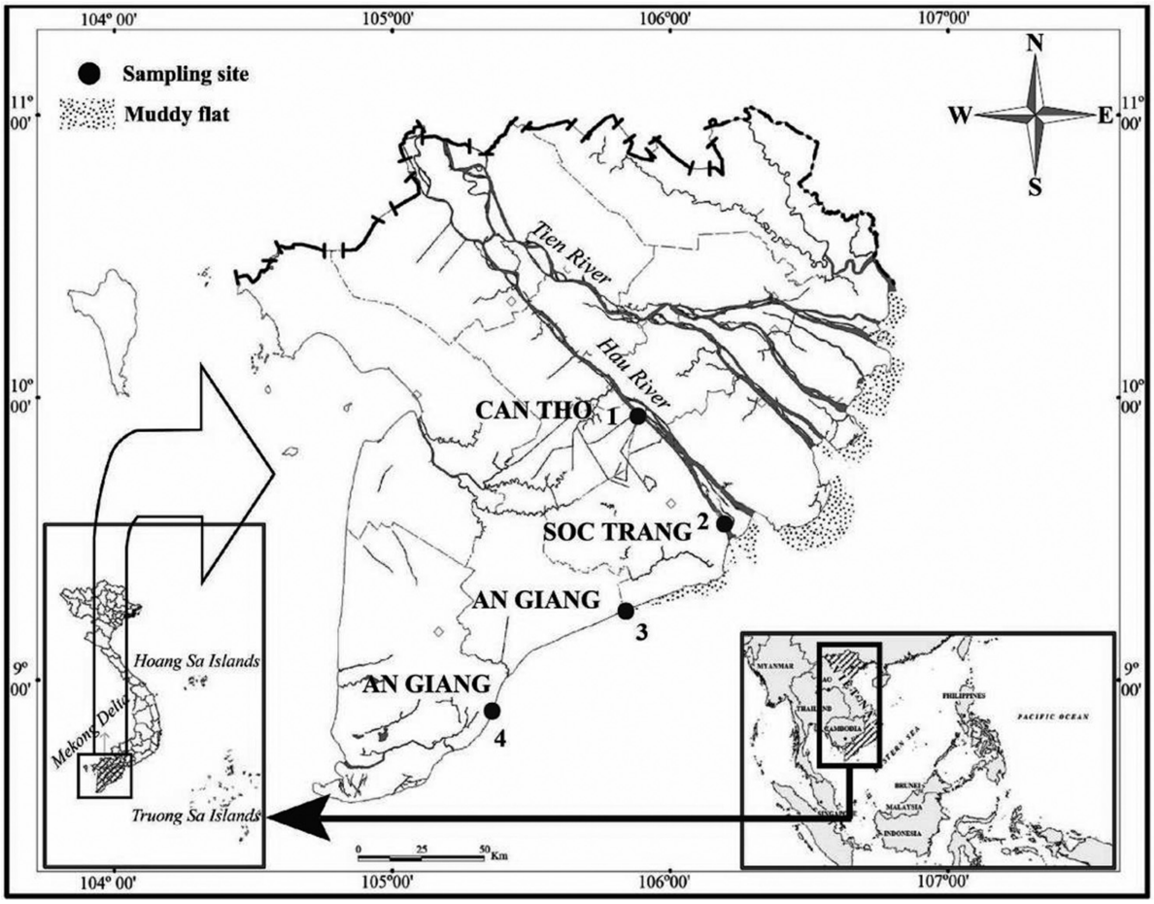

Figure 1.
Sampling location in the study area. 1: Cai RangCan Tho, 2: Long PhuSoc Trang, 3: Hoa BinhBac Lieu, 4: Dam DoiCa Mau (modified from Dinh [6]).

The collected length data were sorted into different length groups to determine the population parameters through the formula $L_t = L_\infty(1-e^{-K(t-t0)})$. Where L_∞ was the maximum asymptotic length that the fish could reach (cm), K was the growth rate of the fish, t was the age of the fish at time t; t_0 was the conjectural age at which the length of the fish was zero [9]. Length frequency data were included in the FiSAT II software to definite the L_∞ and K of the population using the ELEFAN I feature [10]. Length frequency data were normalized using the NORMSEP feature to serve as the basis for determining t_0 using the "Analysis of length-at-age" feature by [11].

The composite growth factor (Φ') was counted from the formula Φ'= logK +2*log L_∞ [12]. The longevity was determined by the formula $t_{max} = 3/K$, where was the growth rate [13, 14]. The total dead factor (Z) was specified by a yield curve converted from length-frequency data [15]. Natural mortality (M) was determined by Pauly's [13] formula $\text{Log}M = -0.0066–0.279^*\log L_\infty + 0.6543^*\log K + 0.463/\log T$, where L_∞ was the maximum asymptotic length that the fish can reach (cm), K was the growth rate of fish, and T was the average annual surface water temperature. Mining mortality (F) and extraction coefficient (E) were determined according to the formula $F = Z–M$ and $E = F/Z$ [16].

The first catch length (L_c) was the length at which 50% of fish were caught and was determined by the yield curve conversion equation [9]. The Beverton & Holt [17] model was used to analyze the yield-to-addition (Y'/R) and biomass-to-addition (B'/R) models as the basis for determining the maximum yield (E_{max}), the optimal mining factor ($E_{0.1}$), and the mining factor at which B'/R was reduced by 50% ($E_{0.5}$). In addition, the ratio between L_c and L_∞ (isopleths) of fish was also analyzed. This data (L_c/L_∞) and the catch coefficient (E) were combined to determine the fishing status of the fish population established on the research method of Pauly & Soriano [18].

A t-test determined the variation of b and CF by sex and season. The changes of b and CF by length group and sampling site were employed in a one-way ANOVA. The population parameters were analyzed with FiSAT II.

3. Overview of the river system in Vietnam

Vietnam has a dense system of rivers with a total length of more than 41,900 km. Due to the rainy conditions, several rivers and streams have formed up to 2360 rivers and large and small canals [19]. In which, there are many river systems with large basins, such as Red, Ky Cung, Thai Binh, Ma, Bang Giang, Vu Gia—Thu Bon, Ca, Ba, Dong Nai, and Mekong rivers [20]. In 2011, the Mekong and Thai river systems covered an area of more than 1,167,000 km^2, however, 72% of the surface discharge in these basins originated outside of Vietnam [19]. The topography is steep in Vietnam along the northwest and southeast axis, causing surface water to concentrate mainly in the east, where all the major river basins are located. Meanwhile, the western mountainous areas are much drier, mostly with streams and small rivers [21]. Almost all major rivers in Vietnam originate from outside. The vast majority of rivers here usually flow in the direction of northwest-southeast and empty into the sea. However, the exception is Ky Cung and Bang Giang rivers. These two rivers flow in the southeast-northwest direction. All rivers originate in high mountains, so upstream rivers are often very steep. Therefore, in the rainy season, the river water flows strongly; when returning to the river delta, it becomes winding and meandering. With the main water source of rivers originating from outside the territory, it is difficult to control the amount of water [22].

4. Overview of the fish in Vietnam

With a rich system of rivers and lagoons, the fish fauna of Vietnam is very diverse. According to Nguyen [23], Vietnam has 1027 species, classified into 427 genera, 98 families, and 22 orders. Vietnam is one of 16 countries that are assessed as having high biodiversity, species diversity, and fish species. Until 2016, 290 new fish species were announced in Vietnam. Today, with the strong development of molecular markers and morphological studies, the composition of fish species in Vietnam is increasingly being fully and accurately determined, including the Mekong river.

5. Fishes in the Mekong Delta

Fisheries managers and scientists have updated info on fish diversity within the Mekong river delta [24, 25]. The dominance of marine characterizes fish composition in the western estuaries originated species with Engraulidae and fish family being dominant. In contrast, estuaries resident species (Pangasidae, Ariidae, Cyprinidae, Cynoglossidae, and Engraulidae) primarily contribute to fish composition in the Japanese estuaries. Spatio-temporal variations of species composition might be because of the hydrological regime powerfully influenced by the Mekong flows. There are 14, including inland protected areas (IPAs), with sizes varying from 500 hour angles to 14,605 ha. All of them are Melaleuca swamp forests or fresh marshes [26, 27]. The aquatic setting of those IPAs is variable and consistent with seasons, for example, nearly IPA's area is inundated in flooding season; however, canal systems within the IPAs contain water during the dry season. Therefore, environmental conditions amendment dramatically between two seasons. A recent study instructed that the dyke systems close to the IPAs cause poor quality of water in each season and, thus powerfully have an effect on aquatic life [28], which explains that solely black fishes, that is, genus *Anabas testudineus*, *Channa striata*, etc., survive such conditions, and that they are resident species. Within the flooding season, the inundated IPAs provide feeding and nursing ground for white and gray fishes (short and long migration fishes, such as Cyprinidae, Botiidae, Cobitidae, Siluridae, and Pangasiidae). Improving the dyke systems, that is, lowering the peak of the dyke system, enabling water exchangeably, enhancing water quality, and supplying migration routes for fishes. However, the inland protected areas (IPAs) presently target the protection of Melaleuca forest, grassland, and water birds [27, 29] and, consequently, the dyke systems and hydrological management operate to stop the fire, and going diversity of aquatic animals and migration routes being ignored. Surprisingly, data on fish diversity in these IPAs are poor or not available. Recently, our team created the assessment of fish diversity in two IPAs (Lang fractional monetary unit and U Minh Thuong), and knowledge has proven that the variability of fish from outside the IPAs (better water quality and migration routes) is way more extensive than that from within the IPAs for each season. Therefore, higher management practices of the IPAs might reach each readying and preserving fish diversity.

One of the prominent functions of the mainstream is to supply deep pools that provide vital shelters and spawning grounds for many indigenous and endangered species, that is, *Bosemania microlepis*, *Hypsibarbus malcolmi*, *Pangasianodon gigas,* etc. [30, 31]. Halls et al. [32] reported that deep pools in the VMD provide the dry season refuges for about 200 fish species. There are 23 deep pools in the VMD located mainly in Dong Thap and An Giang provinces and believed to be the refuges for many white fishes [33].

6. Fish growth, condition factor

In *Glossogobius aureus*, study results on the length and weight of 742 individuals in four study sites found a close relationship ($r^2 > 0.85$, in all cases). It was found that this was a fish with equal growth because, in most months, the growth coefficient *b* was equal to 3. However, in February, April, May, and June, there was a dominant growth pattern of a length overweight and 2 months November and December, which dominates mass over the span. This coefficient reached the highest value in Hoa Binh—Bac Lieu, while it was the lowest in Cai Rang—Can Tho. The environment and the food source in HBBL may be more suitable for fish growth than in the rest of the regions. This coefficient in the wet season is higher than in the dry season. This suggests that fish could have a higher growth rate in the wet season than in the dry season because of more abundant food sources. There were also statistically significant differences between mature and immature fish. Specifically, this value of the immature fish group was higher than the mature fish group. The growth coefficient *b* for males was 2.90 ± 0.04 SE, and for females was 2.82 ± 0.04 SE, and the whole population's coefficient was 2.85 ± 0.03 SE (**Figure 2**). This coefficient did not differ between males and females, showing that the growth of males and females was the same in the study sites. This coefficient for the whole population showed that this species belongs to the inequality growth group $b < 3$. The length of the fish tended to grow faster than the weight of the fish. This was similar to previous research on this species in the Con Tron area, Soc Trang province [35]. Also, there was a similar growth in *P. elongates* [36].

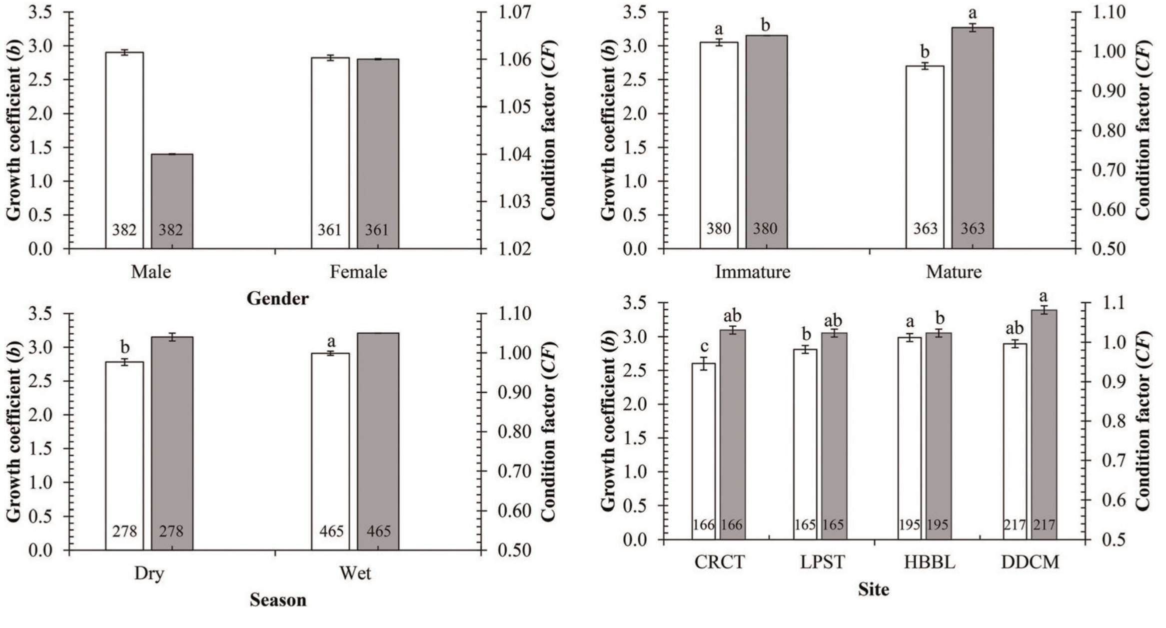

Figure 2.
Changed LWR and CF of sex, fish size, season, and sites in G. aureus. *(colorless columns: growth coefficient; gray columns: condition factor; number in each column: the number of individual fish; different letters (a, b and c) showed a significant difference; CRCT: Cai Rang—Can Tho; LPST: Long Phu—Soc Trang; HBBL: Hoa Binh—Bac Lieu; DDCM: Dam Doi—Ca Mau). Source: Phan et al. [34].*

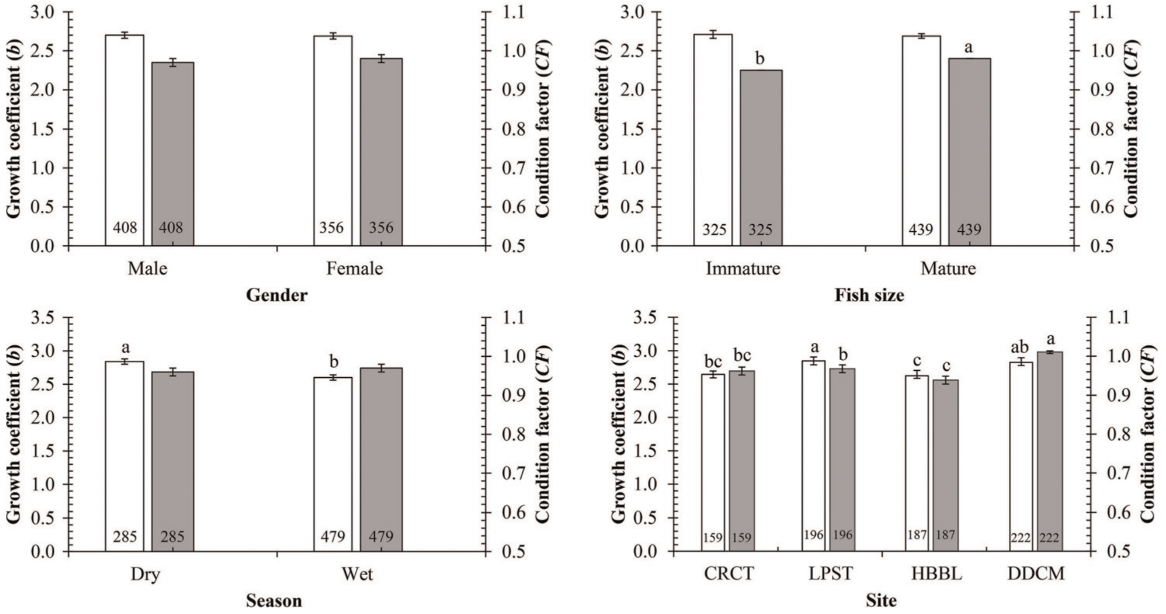

Figure 3.
Changed LWR and CF of sex, fish size, season, and sites in G. sparsipapillus (colorless columns: growth coefficient; gray columns: condition factor; number in each column: the number of individual fish; different letters (a, b and c) showed a significant difference; CRCT: Cai Rang—Can Tho; LPST: Long Phu—Soc Trang; HBBL: Hoa Binh—Bac Lieu; DDCM: Dam Doi—Ca Mau). Source: Truong et al. [37].

The study results on *G. sparsipapillus* showed a close relationship between fish length and weight in 764 individuals of this population at study sites ($r^2 > 0.7$, in all cases). Growth coefficient *b* in this species varied over the months. This was a species of an inequality growth group, and fish length grows faster than fish weight because, in most months, this coefficient was less than 3. The *b* value was highest in Long Phu—Soc Trang and lowest in HBBL. Similar to *Glossogobius aureus*, this species had *b* values difference that was not statistically significant (p > 0.05) in sex but was statistically significant between the dry season and the wet season (**Figure 3**). However, in terms of maturity, in *G. sparsipapillus*, there was no difference between mature and immature groups like fish below *G. aureus*. The growth coefficient *b* of the whole *G. sparsipapillus* population showed that this was a species of inequitable growth fish group, with the growing length faster than the fish weight with the mean value of 2.68 ± 0.03 SE. These results in two species were similar to many other fish species, such as *T. vagina* [38], *Boleophthalmus boddarti* [39], *Glossogobius giuris* [40], *Pseudapocryptes elongatus* [36], and the author's previous research on *G. aureus* [35] distributed in the Mekong delta.

Similar to *G. aureus* and *G. sparsipapillus*, *G. giuris* shows a positive relationship between fish weight and length ($p < 0.01$, $r^2 > 0.8$ for all cases). The growth coefficient of females was higher than that of males ($p < 0.05$), but this coefficient was not different between two groups of fish length ($p > 0.05$), as well as between wet and dry seasons ($p > 0.05$). Growth coefficients were similar across sex, fish size, and seasons ($b = 3$, $p > 0.05$). Unlike the two species above, the growth coefficient of this species (2.97 ± 0.04 SE) was equivalent to the equal growth value ($p > 0.05$) (**Figure 4**). This was similar to some other fish species, such as *B. boddarti* [39], *P. schlosseri* [42], *T. vagina* [38], *and Pd. elongatus* [36]. In the previous research of Phan et al. [41], *G. giuris* collected from Tra Vinh to Soc Trang and Bac Lieu also expressed the isometric growth pattern in most cases, except in October and

December 2016, the models of growth were negative allometry (2.79 ± 0.07 and 2.85 ± 0.07, respectively).

Condition factor (*CF*) in *G. aureus* differed over the study months (ANOVA, $p < 0.05$). There was no difference in sex and seasons (**Figure 2**). This showed that sex and environmental conditions in different seasons do not affect the fish's condition coefficient. However, there was a significant difference between the two groups of mature and immature fish. Specifically, this coefficient was higher in mature fish than in immature fish (**Figure 2**). At Dam Doi—Ca Mau, this index was the highest, followed by CRCT and LPST, the lowest was HBBL (**Figure 2**). Condition factor in *G. sparsipapillus* also changed over the study months ($p < 0.05$). *CF* was higher than in the other months in June, July, August, and September. Similar to *G. aureus*, the coefficient of this species was highest in DDCM and lowest in HBBL. There was no difference between males and females between dry and wet seasons ($p > 0.05$). But the mature fish group was higher than the immature group (**Figure 3**). The *CF* of *G. giuris* fluctuated monthly, reaching the highest value in November and the lowest in June (ANOVA, $p < 0.01$). The *CF* coefficient of females was higher than that of males, and that of the mature group was higher than the immature group (**Figure 4**). However, the *CF* coefficient of this fish in the dry season was equivalent to that of the wet season. Similarly, in the study of Phan et al. [34], *CF* values of this species were near the value of 1. Although the *CF* coefficients of the three species fluctuated by month, sex, and fish size, it was close to one threshold ($p > 0.05$) when considering the population as a whole. This showed that these fish were well adapted to the habitats.

Research results showed that these two species had similar growth patterns, with the growth pattern being negative allometry. With this growth pattern, the weight of these two fish species grew better than the fish length. The condition coefficients of *G. aureus* and *G. sparsipapillus* were equivalent to 1. This showed that these two fish species were well adapted to the environment.

7. Population structure

Length-derivative data for *G. aureus*, *G. giuris,* and *G. sparsipapillus* were converted to growth curves. Black and white bars in the von Bertalanffy growth curve showed a change in the groups' length and number over the study months. This equation of *G. aureus* had the parameters $L_\infty = 30.44$ cm, $K = 0.51$/year, $t_0 = -0.09$, and the von Bertalanffy growth curve equation for this population was $L_t = 30.44$ $(1-e^{-0.51(t\,+\,0.09)}$$\mathrm{L_t} = 18.00\left(1 - \mathrm{e}^{-0.53(\mathrm{t}+0.10)}\right)$. The von Bertalanffy growth equation of *G. giuris* parameters was $L_\infty = 20.53$ cm, $K = 0.56$/year, *and* $t_0 = -0.02$, and the von Bertalanffy growth curve equation, respectively, of the entire population $\mathrm{L_t} = 20.53\left(1 - \mathrm{e}^{-0.56(\mathrm{t}+0.02)}\right)$. *G. sparsipapillus* distributed in CRCT had the parameters of the equation were $L_\infty = 16.53$ cm, $K = 0.78$/year, and $t_0 = -0.10$. Meanwhile, these parameters at lower LPST were equal to $L_\infty = 15.60$ cm, $K = 0.82$/year, *and* $t_0 = -0.09$. The von Bertalanffy growth curve of the population in CRCT and LPST were $L_t = 16.53$ $(1-e^{-0.78\ (t\,+\,0.10)})$ and $L_t = 15.60$ $(1-e^{-0.82\ (t\,+\,0.09)})$, respectively (**Figure 5**).

From the yield curve converted from the length frequency, the total death coefficient (*Z*), the natural death coefficient (*M*), the logging death coefficient (*F*), and the extraction rate (*E*) of the *G. aureus* populations were 3.38/year, 1.16/year, 2.22/year and 0.66, respectively. Similarly, *Z*, *M*, *F*, and *E* of *G. giuris* populations were

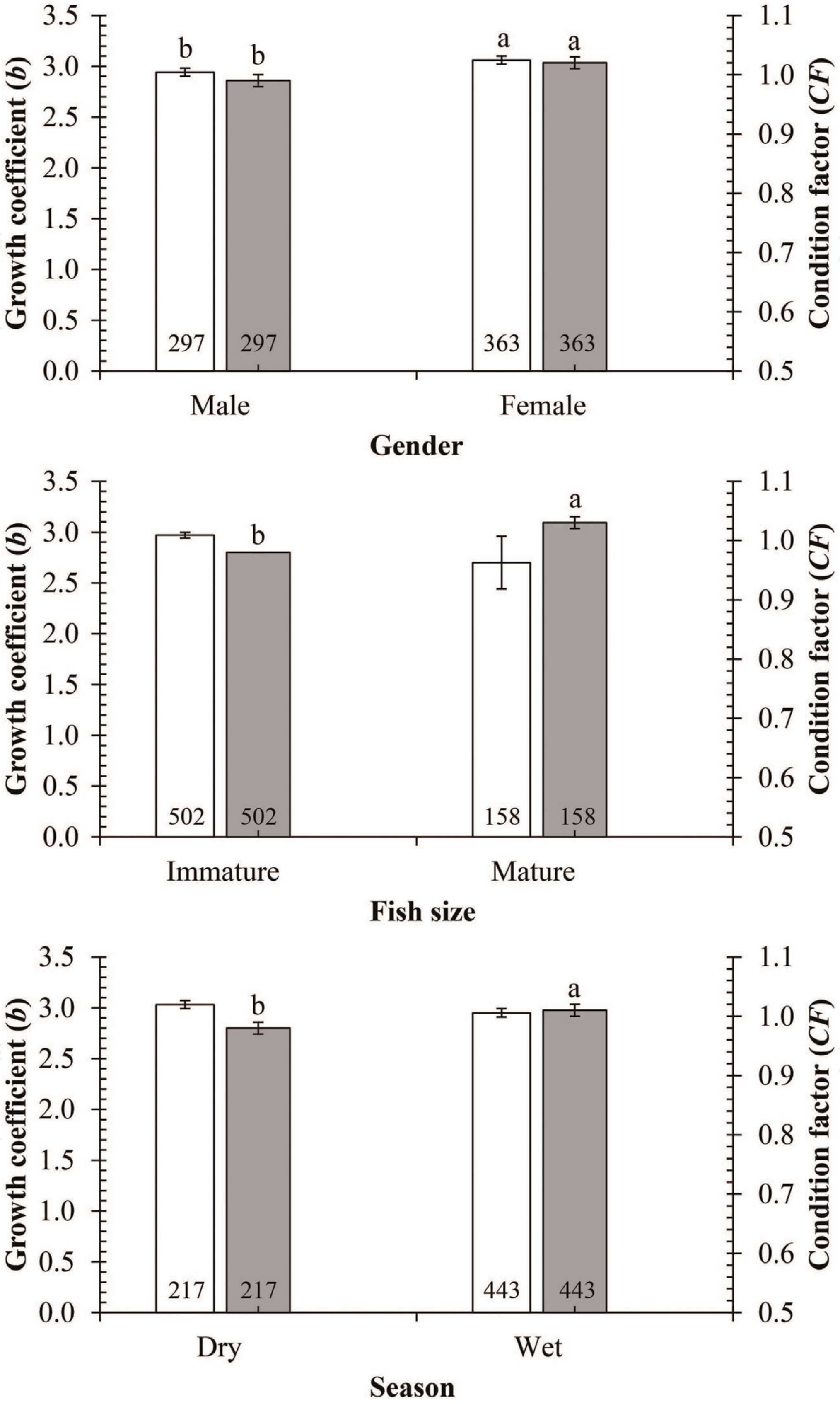

Figure 4.
Changed LWR and CF of sex, fish size, season, and sites in G. giuris. *(colorless columns: growth coefficient; gray columns: condition factor; number in each column: the number of individual fish; different letters (a and b) showed a significant difference). Source: Phan et al. [41].*

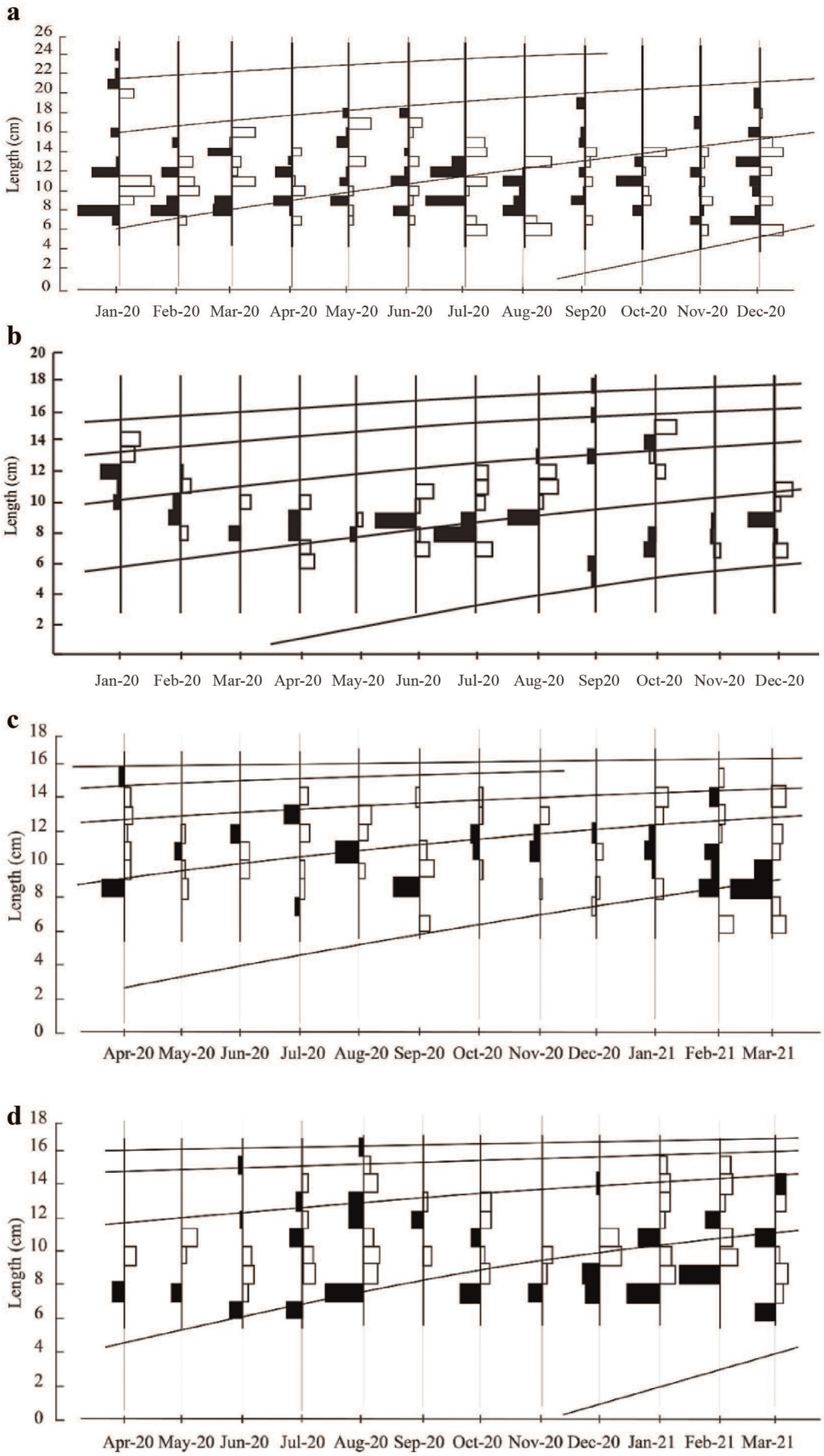

Figure 5.
The von Bertalanffy fish growth curve of G. aureus (a, n = 742, source: Dinh et al. [43]), G. giuris (b, n = 673, source: Dinh et al. [44]), and G. sparsipapillus (c: Cai Rang—Can Tho, n = 717, d: Long Phu—Soc Trang, n = 662, source: Nguyen et al. [45]) (the curves show the increase of fish length over time).

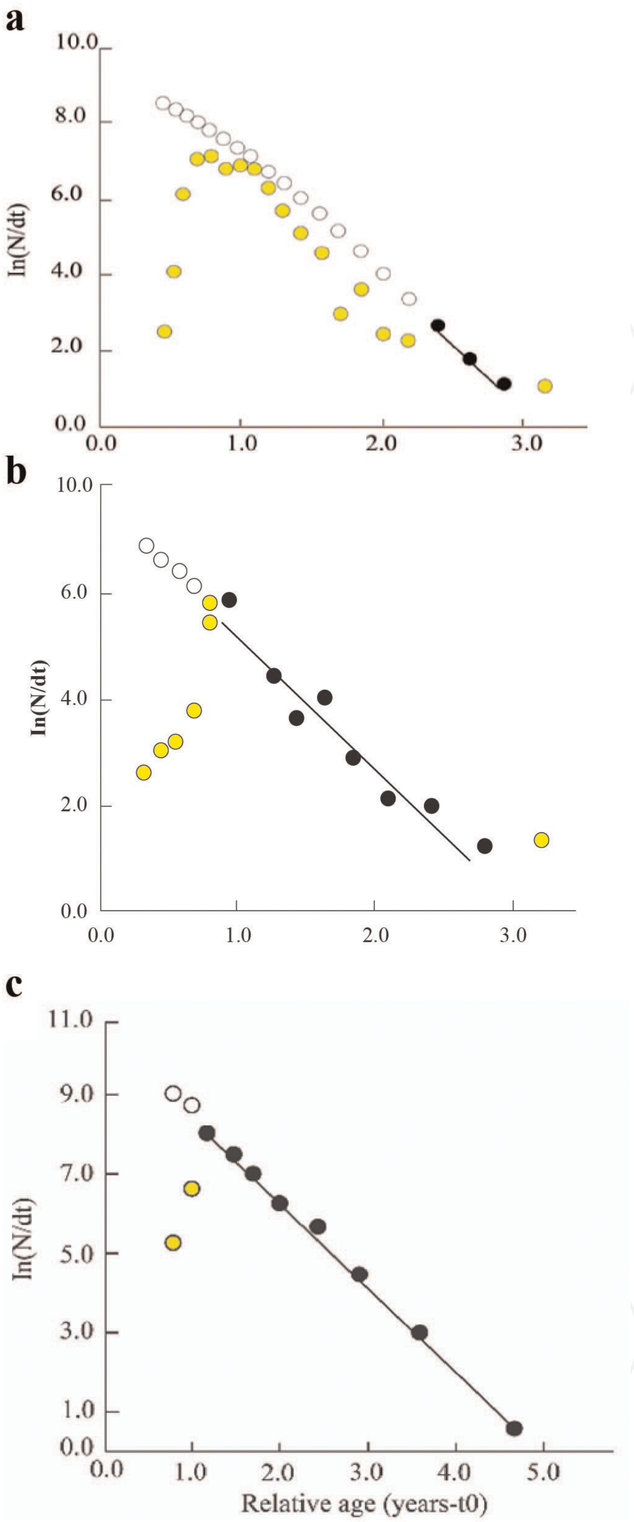

Figure 6.
The length converted catch curve G. aureus (a, source: Dinh et al. [43]), G. giuris (b, source: Dinh et al. [44]), and G. sparsipapillus (c: Cai Rang—Can Tho, d: Long Phu—Soc Trang, source: Nguyen et al. [45]).

3.17/year, 1.40/year, 1.77/year, and 0.56, respectively. In *G. sparsipapillus*, these coefficients were lower in CRCT (2.17/year, 1.49/year, 0.68/year, and 0.31/year) than in LPST (3.46/year, 1.68/year, 1.78/year, and 0.51/year). Similarly, the length at first capture in the CRCT population (5.07 cm) was shorter than in the LP population (8.01 cm) (**Figure 6**).

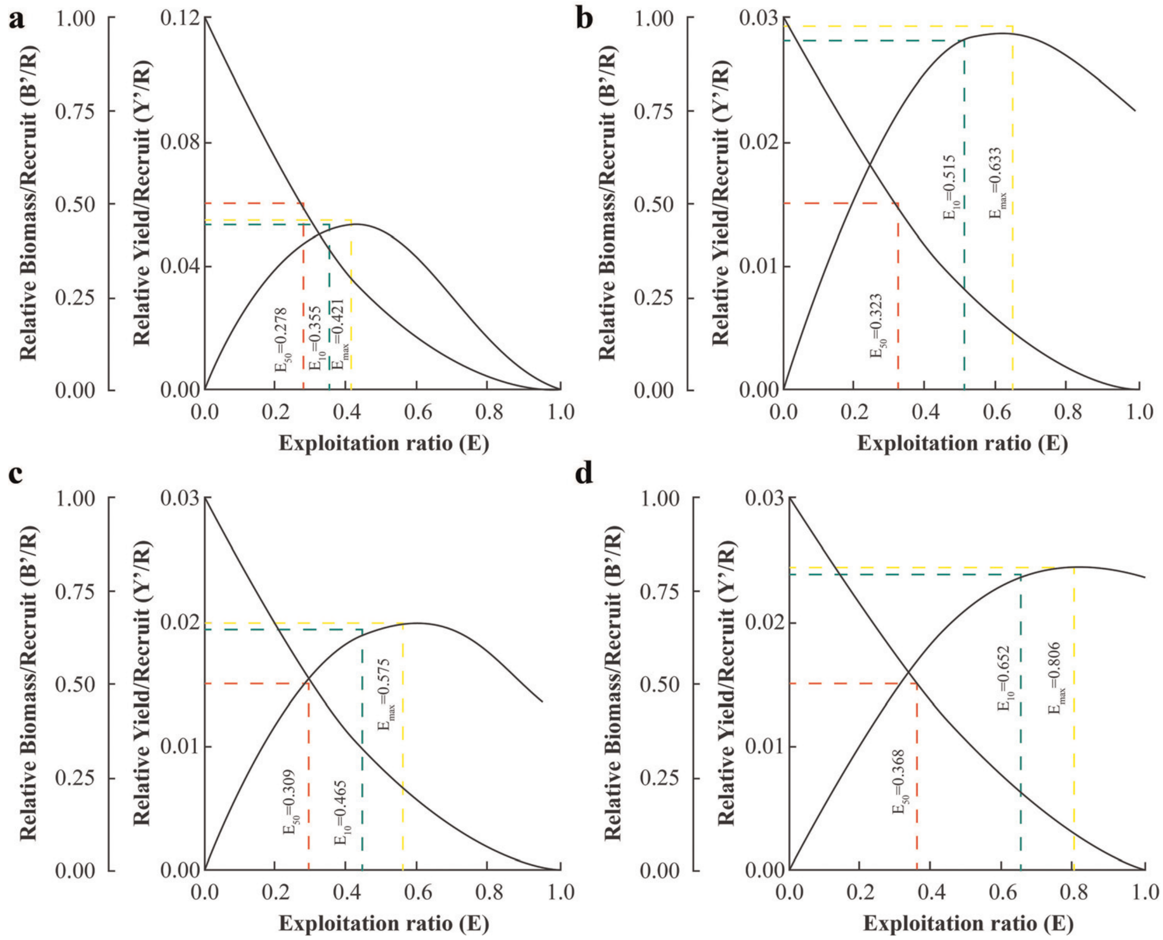

Figure 7.
The relative yield-per-recruit and relative biomass-per-recruit for G. aureus *(a, source: Dinh et al. [43]), G. giuris (b, source: Dinh et al. [44]), and G. sparsipapillus (c: Cai Rang—Can Tho, d: Long Phu—Soc Trang, source: Nguyen et al. [45]).*

After analyzing the results of analyzing the biomass and additional yield of two goby populations *G. aureus* at the four study sites, the maximum extraction coefficient (E_{max}) and the extraction rate were found optimal exploitation ($E_{0.1}$) and the exploitation coefficient that the population decreases by 50% ($E_{0.5}$) are 0.421, 0.355, and 0.278, respectively. Meanwhile, these coefficients in the *G. giuris* goby population were higher than those of the *G. aureus*, with these coefficients of 0.633, 0.515, and 0.323. These coefficients in *G. sparsipapillus* at the CRCT were 0.575; 0.465, 0.309, and at the LPST were 0.806, 0.652, and 0.368, respectively (**Figure 7**).

The growth coefficient (Φ') of the *G. aureus* population was estimated from the formula $\Phi' = \log K + 2\log L_\infty$ was 2.23 and the maximum lifespan of the population was 5.66 years. The rate of L_c/L_∞ in this species was 0.32. Similarly, in *G. giuris*, this rate was 0.36; its Φ' was 2.37 and t_{max} was 5.36. In *G. sparsipapillus,* the Φ' and t_{max} in the CRCT population were 2.19 and 4.81 yrs., respectively, and in the LPST population, they were 2.32 and 3.61 yrs., respectively. The L_c/L_∞ of this species was 0.43 in CRCT and 0.51 in LPST.

G. aureus, *G. sparsipapillus,* and *G. giuris*, had a higher growth rate than the other two species. However, all three species of goby had lower growth ratios than some other fish species in the same area, such as *Boleophthalmus boddarti* [46], *Parapocryptes serpersater* [47], *Stigmatogobius Pleurostigma* [48], *Pd. elongatus* Tran et al. [49],*Trypauchen vagina* [50]. Coefficient Φ' of *G. aureus*, *G. sparsipapillus,* and *G. giuris* was lower than other species, such as *Pd. elongatus* in the Mekong delta [49], *Glossogobius matanensis* in Indonesia [51] and *Pa. serperaster* in the Mekong delta [52]. It could be because the K and L_∞ of *G. giuris* were smaller than *Pd. elongatus* [49], *G. matanensis* [51] and *Pa. serperaster* [52].

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