Morphometrics variations of *Mystus mysticetus* Roberts, 1992 in the Mekong Delta, Vietnam

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Abstract. This study contributed to understanding the variation in morphometrics of *Mystus mysticetus*. In this study, 451 individuals were collected in two ecological regions, including the brackish region in Long Phu, Soc Trang, and the freshwater region in Cai Rang, Can Tho, Vietnam. Fish samples were collected continuously for nine months, from October 2020 to June 2021. Data analysis results showed that sex, season, and site variables regulated the variations of fish total length (TL) and weight (W). These two parameters were also affected by sex × season, sex × site, and season × site. Morphometrics of this fish, such as eye diameter (ED), eye distance (DE), body high (BH), head length (HL), HL/TL, BH/TL, DE/HL, and ED/HL fluctuated with the season, site but not sex. These parameters of the species were not affected by sex × season and sex × site but varied with season × site. The findings contribute to fish identification and support ecological adaptation measures in the studied regions.
Key Words: Can Tho, catfish, morphology, Soc Trang.

Introduction. Morphometrics, e.g., total length (TL), body height (BH), head length (HL), eye diameter (ED), and distance between the eye (DE), HL/TL, BH/TL, DE/HL and ED/HL are necessary to identify fish from saltwater to freshwater areas (Strauss and Bond 1990; Mai 1992). These morphological values were also commonly used in the biological analysis of fish (Grant and Spain 1977). According to research by Chaklader et al. (2016), fish growth and food sources strongly depend on their habitat conditions. These conditions were responsible for the changes in the development and morphological characteristics of the fish. Moreover, the relationship of TL with SL, BH, and HL can vary depending on where fish are caught and when fish reaches maturity (Dinh et al. 2021).

Mystus mysticetus Roberts, 1992 was one of the *Mystus* genus recorded in the Mekong Delta (Tran et al. 2013). This fish was distributed along the Chao Phraya and Mekong river basins. In this species, we observed three dark brown or black stripes along the body; a clear black spot was present behind the gill cover; and raised dorsal fin and adipose dorsal fin were quite far apart (Dinh et al. 2011; Tran et al. 2013). There is very little information on the morphological characteristics of this fish from the Hau River, so this study was conducted to examine whether the variation of different locations in the Mekong Delta affects the morphological parameters of this fish. In addition, the change of these parameters with sex and season was also provided in this study. The data in the study could contribute to the knowledge of fish identification and ecological adaptation in the studied regions.

Materials and Methods

Fish collection and analysis. Specimens of *M. mysticetus* (Figure 1) were collected in two ecological regions, comprising one site in the brackish region (Long Phu, Soc Trang) and another one in the freshwater (Cai Rang, Can Tho; Figure 2). In total, 451 fish samples were collected consecutively from October 2020 to June 2021. Fish was collected periodically every month by trawl nets (mesh size was 1.5 cm). Fish samples after catching were stored in 10% formalin solution and transferred to the laboratory for

further analysis. The sex of fish samples was determined based on the shape of the genital spines (Dinh et al. 2016a). The males had long genital spines; the tip of the genital spines was pointed and had a light red colour. The females had an oval-shaped genital opening and were pale pink. After sex determination, morphological indicators of the fish were determined, such as weight (W), total length (TL), standard length (SL), body height (BH), head length (HL), eye diameter (ED), and eye distance (DE).

Data analysis. The variations of TL (cm), W (cm), HL (cm), BH (cm), ED (cm), DE (cm), HL/TL, BH/TL, ED/HL and DE/HL between males and females, dry and wet seasons, and brackish and freshwater sites were confirmed by t-test. Impact of the interaction of indexes of sex × season, sex × sites and season × sites to the variation of TL, W, HL/TL, BH/TL, ED/HL and DE /HL and also checked by two-way ANOVA. SPSS v21 processed data. All tests were performed at the 5% significance level.

Figure 1. Specimen of *M. mysticetus* collected in Cai Rang, Can Tho.
(Source: This figure was taken by authors)

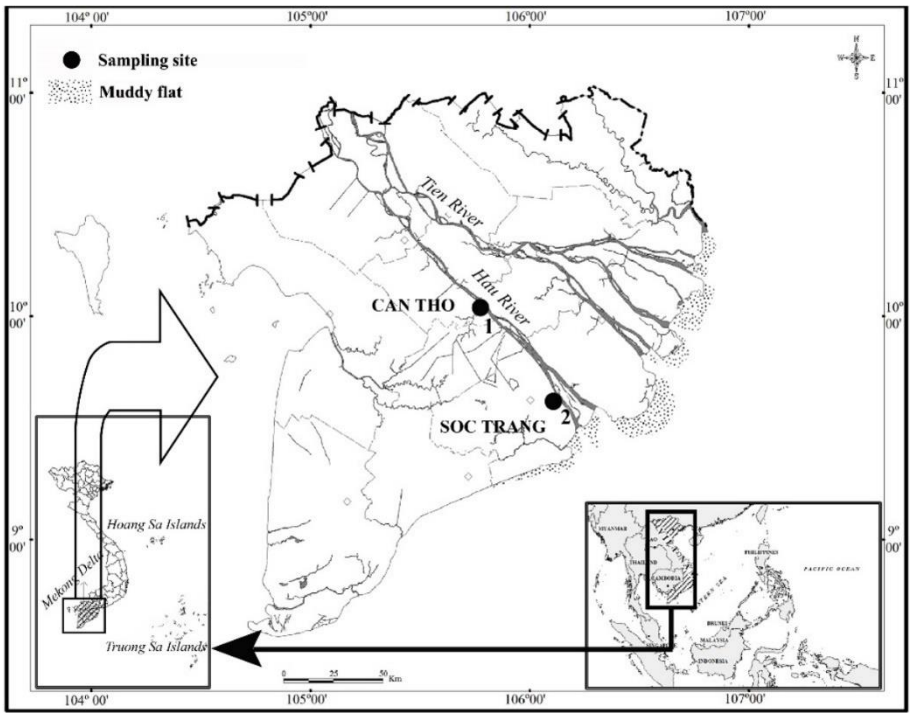

Figure 2. Map of the Mekong Delta showing the sampling locations (1: Cai Rang, Can Tho; 2: Long Phu, Soc Trang).
Source: modified after Dinh (2018)

Results and discussion

Variation in fish length and weight. The study of 451 *M. mysticetus* individuals collected in Cai Rang - Can Tho (CT) and Long Phu - Soc Trang (ST), showed that study location significantly influenced the average total length. The mean TL reached the longest value in Long Phu, Soc Trang (11.21±0.09 SE cm) and the smallest in Cai Rang, Can Tho (t=5,70; P<0.05). Additionally, the location significantly impacted the fish weight (W) value. Specifically, the highest W value was in Long Phu, Soc Trang (15.62±0.28 SE g), and the lowest was in Cai Rang, Can Tho (14.19±0.33 SE g) (t-test; t=-3.30; P<0.05). This showed that the length and weight of this species fluctuated according to the study site. Environmental factors such as pH, temperature and salinity, at different study sites did not affect this fish's total length and weight. The morphological change of striped pinnacles at separate study sites from Can Tho to Soc Trang showed that this fish was morphologically flexible and widely distributed in different habitats. Like *M. mysticetus*, total length of *Boleophthalmus boddarti* (Dinh 2017a), *Glossogobius sparsipapilus* (Nguyen et al. 2020), and *Periophthalmus chrysospilos* (Le et al. 2021), also vary with the site. The weight change was seen in *Mystus cavasius,* and the variation in TL was found in *Mystus nigriceps* (Latif et al. 2018).

Sex also caused the total length of *M. mysticetus* to change significantly (t=6.82; P<0.05). Specifically, this value reached 11.47±0.08 SE cm in females and was 10.92±0.13 SE cm higher than in males. Similarly, the weight of fish also varied by sex. Specifically, the weight of females reached 16.61±0.23 SE g and was significantly higher than that of males with a weight of 12.29±0.34 SE g (t=10.84; P<0.05). Besides, the influence of seasonal factors also changed the weight of fish (t=10.54; P<0.05). In the dry season (15.57±0.23 SE g), fish weight differed significantly compared to the wet season (14.16±0.37 SE g). Unlike W, in the dry and wet seasons, the TL was 15.57±0.25 SE cm and 14.16±0.37 SE cm, respectively. This difference of TL showed that the seasonal factor did not affect the total length of fish (t=1.62; P>0.05). Therefore, factors such as water source or food source change depending on the season, leading to the difference in total length. Results showed that this fish's environmental conditions, water sources, and food sources were more favorable in the dry season, resulting in its total length and weight being significantly higher than in the wet season. Changes of these values were also observed in other fish species distributed in the Mekong Delta, such as *Parapocrytes serperaster* (Dinh et al. 2016b), *Glossogobius sparsipapilus* (Nguyen et al. 2020), *Butis Koilomatodon* (Lam and Dinh 2020), *G. giuris* (Nguyen and Dinh 2021), and *G. aureus* (Phan et al. 2021a) distributed in the Mekong Delta.

Season × sex (one-way ANOVA; F=0.32; P>0.05; Figure 3) and sex × sites (F=0.33; P>0.05; Figure 4) did not affect on total length, but this parameter was affected by the season × sites (F=20.56; P<0.05; Figure 5). Similar to the total length, the season × sex (F=0.17; P>0.05; Figure 6) and sex × sites (F=0.19; P>0.05; Figure 7) did not affect the weight of fish; conversely, it was affected by the season × sites (F=17.54; P<0.05; Figure 8). However, each factor such as sex, season or area impacted the variation of TL and W, but the growth of fish was entirely independent of the interaction of these two factors. According to the study sites with different salinity, the change in length and weight was also found in *Glossogobius sparsipapillus* (Nguyen et al., 2020). The variation of weight by sex and season was also observed in species *Mystus cavasius* of the same Genus *Mystus* (Latif et al. 2018).

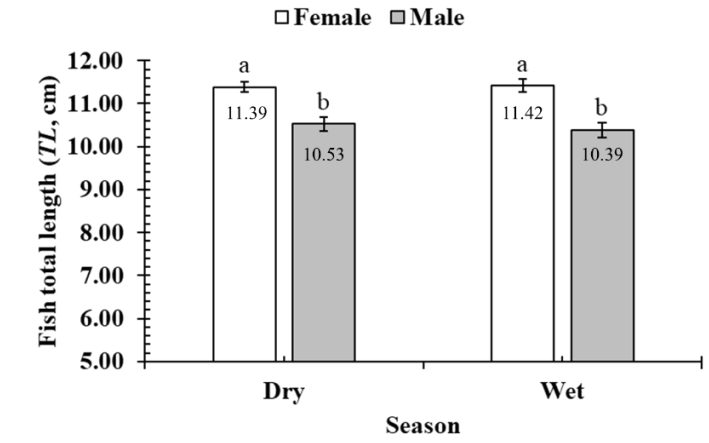

Figure 3. The fish total length variation with the interaction of sex and season
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance).

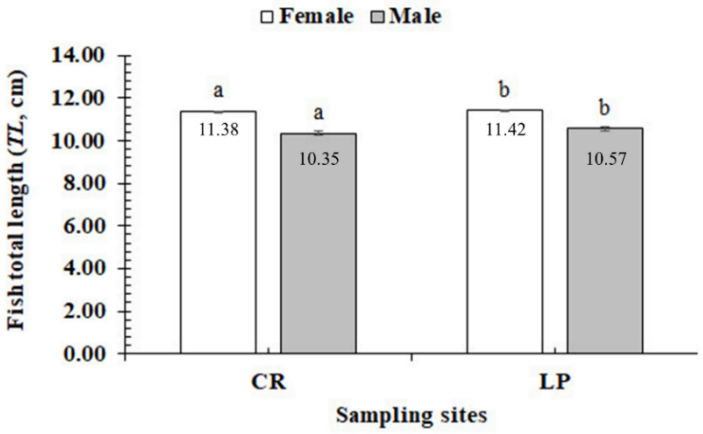

Figure 4. The fish total length variation with the interaction of sex and site
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance;
CR: Cai Rang, Can Tho; LP: Long Phu, Soc Trang).

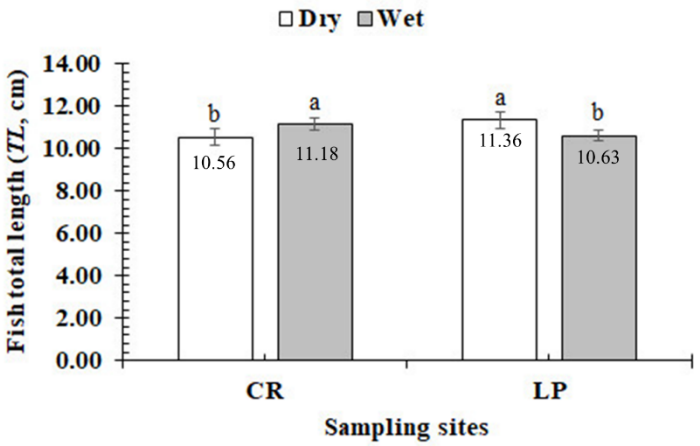

Figure 5. The fish total length variation with the interaction of season and site
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance;
CR: Cai Rang, Can Tho; LP: Long Phu, Soc Trang).

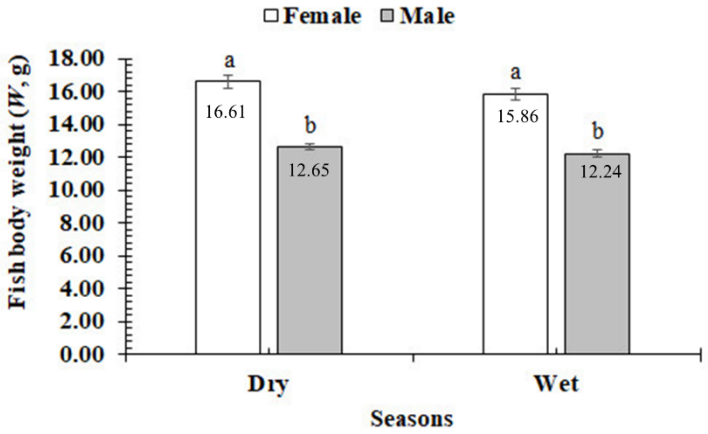

Figure 6. The fish body weight variation with the interaction of season and sex
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance)

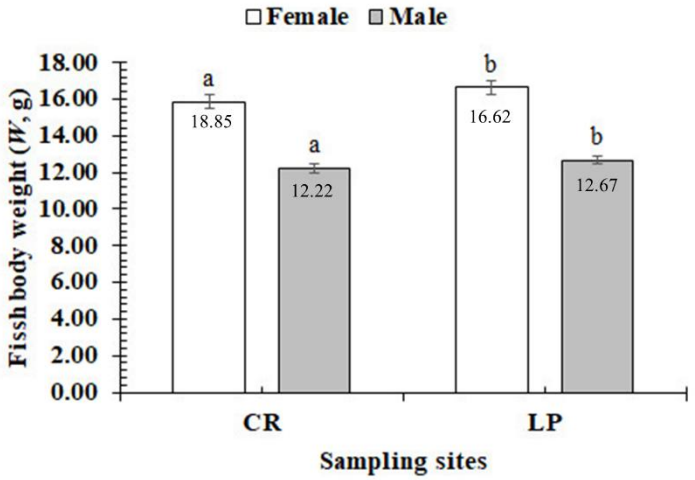

Figure 7. The fish body weight variation with the interaction of site and sex
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance; CR: Cai Rang, Can Tho; LP: Long Phu, Soc Trang).

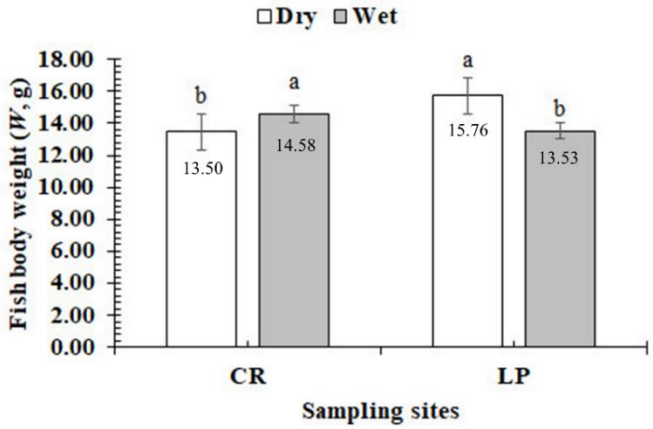

Figure 8. The fish body weight variation with the interaction of season and site
(value in column: Mean; vertical bar: standard error; the letters a and b represent a statistically significant difference at the 5% level of significance; CR: Cai Rang, Can Tho; LP: Long Phu, Soc Trang).

Morphometric variations. Besides changes in TL and W, in this study other morphological parameters of fish such as eye diameter (ED), eye distance (DE), body height (BH), and head length (HL) were also recorded to play an essential role in determining the morphological variation of *M. mysticetus.* Gender played a role in morphometric variations. Thus, a statistical significant difference between *M. mysticetus* males and females was found regarding all tested parameters ($P<0.05$; Table 1) except for ED.

Table 1

Changes in morphological indicators of *M. mysticetus* by sex

Parameters	Sex	Number of fish	Mean	SE	*t*	*P*
ED	Female	285	0.50	0.04	1.66	0.09
	Male	166	0.48	0.08		
DE	Female	285	1.02	0.12	7.97	0.00
	Male	166	0.85	0.17		
BH	Female	285	2.04	0.02	11.99	0.00
	Male	166	1.68	0.02		
HL	Female	285	2.65	0.02	9.35	0.00
	Male	166	2.30	0.03		
HL/TL	Female	285	0.18	0.00	5.05	0.00
	Male	166	0.17	0.00		
BH/TL	Female	285	0.23	0.00	4.23	0.00
	Male	166	0.22	0.00		
ED/HL	Female	285	0.19	0.00	-6.48	0.00
	Male	166	0.21	0.00		
DE/HL	Female	285	0.39	0.00	2.21	0.03
	Male	166	0.37	0.00		

ED: eye diameter, DE: eye distance, BH: body height, and HL: head length.

The season was also one of the factors influencing the development of some morphological parameters of *M. mysticetus*. There was a statistically significant difference between the values of DE, BH, HL/TL, and DE/HL in dry compared to wet season ($P<0.05$; Table 2). This change was also found in *Mystus vittatus* (Chattopadhyay et al. 2014).

Table 2

Changes in morphological indicators of *M. mysticetus* by season

Parameters	*Season*	*Number of fish*	*Mean*	*SE*	*t*	*P*
ED	Dry	276	0.50	0.00	1.78	0.07
	Wet	175	0.49	0.01		
DE	Dry	276	0.98	0.01	3.20	0.01
	Wet	175	0.92	0.02		
BH	Dry	276	1.96	0.02	3.89	0.00
	Wet	175	1.82	0.03		
HL	Dry	276	2.55	0.02	1.90	0.06
	Wet	175	2.47	0.03		
HL/TL	Dry	276	0.18	0.00	3.01	0.00
	Wet	175	0.17	0.00		
BH/TL	Dry	276	0.23	0.00	0.38	0.70
	Wet	175	0.23	0.00		
ED/HL	Dry	276	0.20	0.00	0.33	0.73
	Wet	175	0.20	0.00		
DE/HL	Dry	276	0.39	0.00	3.01	0.03
	Wet	175	0.37	0.00		

ED: eye diameter, DE: eye distance, BH: body height, and HL: head length.

Sampling location influenced some of the parameters of *M. mysticetus*. Thus, a statistically significant difference between the two sampling sites was found for DE, BH, HL, and HL/TL ($P<0.05$, Table 3). This site adaptation was almost identical to *Glossogobius sparsipapillus* (Nguyen et al. 2020), a goby of the same Gobiidae living in the Mekong Delta. In addition, this morphological change also found some goby species distributed in this area, such as *Stigmatogobius pleurostigma* (Dinh 2017b) and *Butis butis* (Phan et al. 2021b).

Table 3

Changes in morphological indicators of *M. mysticetus* by site

Parameters	*Site*	*Number of fish*	*Mean*	*SE*	*t*	*P*
ED	Cai Rang, Can Tho	188	0.50	0.08	0.37	0.71
	Long Phu, Soc Trang	263	0.49	0.08		
DE	Cai Rang, Can Tho	188	0.90	0.23	-4.51	0.00
	Long Phu, Soc Trang	263	1.00	0.22		
BH	Cai Rang, Can Tho	188	1.81	0.33	-4.67	0.00
	Long Phu, Soc Trang	263	1.97	0.40		
HL	Cai Rang, Can Tho	188	2.45	0.41	-3.02	0.00
	Long Phu, Soc Trang	263	2.57	0.39		
HL/TL	Cai Rang, Can Tho	188	0.17	0.03	-2.72	0.01
	Long Phu, Soc Trang	263	0.18	0.04		
BH/TL	Cai Rang, Can Tho	188	0.23	0.02	-1.60	0.11
	Long Phu, Soc Trang	263	0.23	0.03		
ED/HL	Cai Rang, Can Tho	188	0.21	0.03	3.19	0.00
	Long Phu, Soc Trang	263	0.19	0.04		
DE/HL	Cai Rang, Can Tho	188	0.37	0.06	-3.63	0.00
	Long Phu, Soc Trang	263	0.39	0.07		

ED: eye diameter, DE: eye distance, BH: body height, and HL: head length.

The variation of ED, DE and HL was not influenced by sex × sites at the same time (two-way ANOVA; $F_{ED}=0.91$; $F_{DE}=0.05$; $F_{HL}=0.01$; $P>0.05$ for all cases), sex × season ($F_{ED}=0.19$; $F_{DE}=0.02$; $F_{BH}=1.04$; $F_{HL}=1.00$; $P>0.05$ for all cases) and season × sites ($F_{ED}=1$,47; $P>0.05$ for all cases). BH was affected by sex × sites ($F_{BH}=5.85$; $P<0.05$ for all cases) along with DE, BH, HL affected by season × sites ($F_{DE}=46.45$; $F_{BH}=48.20$; $F_{HL}=48.78$; $P<0.05$ for all cases). Except for BH affected by sex × sites ($F_{BH}=5.85$; $P<0.05$ for all cases) along with DE, BH, HL affected by season × sites ($F_{DE}=46.45$; $F_{BH}=48.20$; $F_{HL}=48.78$; $P<0.05$ for all cases). Similar to *M. mysticetus, Periophthalmus chrysospilos* was also unaffected by sex × season ($P>0.05$) (Le et al. 2021) but differs from *M. mysticetus* in that it changed these parameters when influenced by sex × sites ($P<0.05$) and season × sites ($P<0.05$).

In addition, ratios such as HL/TL, BH/TL, ED/HL and DE/HL were not affected by sex × sites ($F_{HL/TL}=6.33$; $F_{BH/TL}=0.76$; $F_{ED/HL}=0.44$; $F_{DE/HL}=0.41$; $P>0.05$ for all cases), sex × season ($F_{HL/TL}=1.50$; $F_{BH/TL}=3.51$; $F_{ED/HL}=2.14$; $F_{DE/HL}=0.65$; $P>0.05$ for all cases). In contrast, all ratios of HL/TL, BH/TL, ED/HL and DE/HL were affected by sites × season ($F_{HL/TL}=4.75$; $F_{BH/TL}=10.56$; $F_{ED/HL}=24.60$; $F_{DE/HL}=9.97$; $P<0.05$ for all cases). Comparing this result with the research results of *Glossogobius giuris* (Nguyen and Dinh 2021), we saw that the factors of sex × sites, sex × season and season × sites had an opposite effects with *M. mysticetus*.

Conclusions. The sex, season and site variables and their interactions affected TL and W variations. Some morphometrics, e.g., ED, DE, BH, HL, HL/TL, BH/TL, DE/HL and ED/HL varied with season, sites but not sex. These parameters of the species were not affected by sex × season and sex × site, but varied with season × site. The findings contribute to fish identification and extends the knowledge on the *M. mysticetus* adaptation in two different environments.

Acknowledgements. We are grateful to Can Tho University for funding support (Grant number: TSV2021-137) and Ton Huu Duc Nguyen for assisting in fish collection and data analysis.

Conflict of interests: The authors declare no conflict of interest.

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Received: 8 September 2021. Accepted: 30 November 2021. Published online: 4 December 2021.
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How to cite this article: Vo L. T. T., Tran A. N., Phan T. Q, Dinh Q. M., 2021 Morphometrics variations of *Mystus mysticetus* Roberts, 1992 in the Mekong Delta, Vietnam. AACL Bioflux 14(6):3423-3431.