Otolith morphology and its relationship with the fish size in *Butis humeralis* (Valenciennes, 1837) from Mekong Delta, Vietnam

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Abstract. This study provides information on the morphology and relationship of otoliths with the body morphology in *Butis humeralis* - a fish with high economic value in the Mekong Delta. In all, 1,439 pairs of otoliths were obtained from 580 females and 859 males from six coastal locations from Duyen Hai - Tra Vinh to Dam Doi - Ca Mau. Fish samples were collected continuously once a month by trawl nets from April 2019 to March 2020. The results showed no shape differences between the left and right otoliths; both sides were oval. Similarly, the weight of the left otolith was equal to that of the right otolith. Besides, the weight of *B. humeralis* changed with the fish size, season and location but did not change by sex. The relationships of otolith weight with body weight, total length, body height and head length, all had coefficients $r^2 \geq 0.6$. Thereby, the weight of the otoliths can be seen as an indicator of the growth of this fish. The study results add to the information about the otoliths of *B. humeralis* in the study area.

Key Words: coastal region, fish measurement, otolith shape, otolith size, growth indicator.

Introduction. The otolith of fish is a calcified structure located inside the skull of bony fish (Popper & Lu 2000; Campana 2004). Otolith has the function of receiving sound and keeping the balance of the fish (Popper et al 2005). In addition, otolith also helps determining the age of the fish (Pino et al 2004; Metin et al 2011; Dinh et al 2015), taxonomy (Tuset et al 2006; Bani et al 2013), assessment of fishery reserves (Stransky et al 2008) and identifying the fish prey (Waessle et al 2003; Tarkan et al 2007). According to the research of Rodríguez Mendoza (2006), during fish growth, the otolith continuously increases in size and weight. In the Cyprinidae, the otolith is classified into elliptical, oval and triangular forms. In particular, the parts of the otolith are pretty different, namely: the lobe (Rostrum), the main object (Antirostrum) and the central groove (Sulcus) (Hung & Loi 2013). The close relationships between the fish total length and otolith length, otolith width and weight can be used to determine the age of tropical fish (Dinh et al 2015).

Butis humeralis is a fish that lives in seas, from the Indian Ocean to the Pacific Ocean (Nelson et al 2016; Froese & Pauly 2021). This fish has a wide distribution and is well adapted to brackish and freshwater (Dinh et al 2018; Tran et al 2020; Dinh et al 2021a; Froese & Pauly 2021; Tran et al 2021a). According to Thacker (2003), *B. humeralis* is classified in the genus *Butis*, family Eleotridae, order Perciformes. Tran et al (2013) described that *B. humeralis* has a flattened head, with long and pointed snout; between the two orbits, there is a pair of sharp bones; small scales evenly covered; high caudal peduncle; and can grow to 10.7 cm standard length (SL). Currently, in Vietnam and around the world, studies on ear stones of this fish have not been done. Besides, according to Nguyen (2005), *B. humeralis* is a fish of high economic value in the Mekong Delta (MD). Therefore, studies on this fish, especially the characteristics of otoliths, need to be carried out in order to supplement the information on the characteristics and shapes of otoliths and their relationship with the morphology of fish. The results provide additional basic biological information for further studies on the adaptation of this fish to its habitat.

Material and Method

Fish collection and analysis. Fish samples used in this study were collected by trawl nets (mesh size in the codend: 1.5 cm) at six locations, including Duyen Hai - Tra Vinh (DHTV), Cu Lao Dung - Soc Trang (CLDST), Tran De - Soc Trang (TDST), Hoa Binh - Bac Lieu (HBBL), Dong Hai - Bac Lieu (DHBL), and Dam Doi - Ca Mau (DDCM) (Figure 1). From April 2019 to March 2020, fish samples were periodically collected once a month. After collecting, fish were fixed with a preservative (formalin 10%) to keep the fish condition when transported to the place of analysis. After that, the fish were measured for parameters such as weight (W, 0.01 g), total length (TL, 0.1 cm), body height (BH, 0.1 cm), head length (HL, 0.1 cm) before obtaining the fish otoliths. The otoliths were then weighed with an analytical balance (0.01 mg).

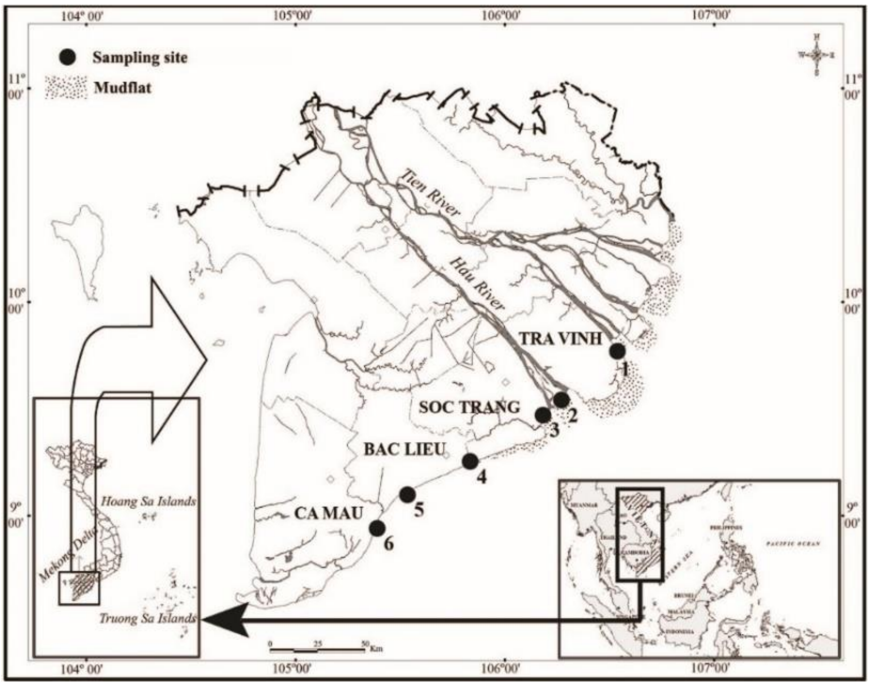

Figure 1. Sampling sites in the Mekong Delta (modified from Dinh 2018)
(1: Duyen Hai, Tra Vinh; 2: Cu Lao Dung, Soc Trang; 3: Tran De, Soc Trang; 4: Hoa Binh, Bac Lieu; 5: Dong Hai, Bac Lieu; 6: Dam Doi, Ca Mau).

Data analysis. The difference between the weight of left otoliths and right otoliths was tested by a t-test (Matic-Skoko et al 2011). A two-way ANOVA test determined the difference in the otolith weight between study sites. Besides, the mass of otolith has a proportional relationship to the allometric traits.

Results and Discussion

The analysis results of the otolith shape of 1,439 individuals *B. humeralis* showed that the outer shape of the right otolith was similar to that of the left otolith. The fish otoliths were located on the sides of the skull, behind the eye sockets. The general shape of the otolith of this fish was oval and slightly flat. The otolith side facing the interior of the skull has a rough structure. In contrast, the outward-facing side was flatter than the inner side. The front edge has a top deviated vertex. The rear edge was flat, with almost no peaks. The top edge was longer than the bottom edge (Figure 2).

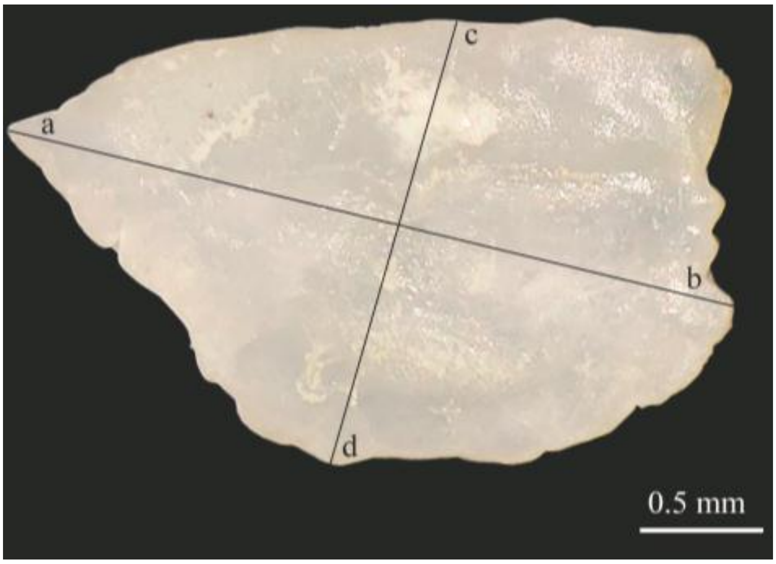

Figure 2. Dimension measurement of left otolith of *Butis humeralis* (ab: otolith length, cd: otolith width).

The mean weight of 1,439 left otoliths (LOW: 4.38±0.05 SE mg) was not significantly different from the right otolith weight (ROW: 4.35±0.05 SE mg, t-test, t=0.48, p=0.08). In *B. humeralis*, the weight of otoliths varied with the fish size (t_{LOW}=-22.26, p_{LOW}=0.00, t_{ROW}=-19.89, p_{ROW}=0.00) and season (t_{LOW}=-7.55, p_{LOW}=0.00, t_{ROW}=-7.95, p_{ROW}=0.00) (Table 1). Specifically, the otolith weight of mature fish (LOW=4.53±0.05 SE, ROW=4.51±0.05 SE mg) was higher than that of immature fish (LOW=2.70±0.07 SE, ROW=2.65±0.08 SE mg). Similarly, the otolith weight in the wet season (LOW=4.66±0.07 SE, ROW=4.65±0.07 SE mg) was higher than that in the dry season (LOW=3.97±0.06 SE, ROW=3.93±0.06 SE mg). However, the weight of otoliths did not change with sex (t_{LOW}=0.27, p_{LOW}=0.77, t_{ROW}=0.66, p_{ROW}=0.96) (Table 1).

Table 1

Variation in the otolith weight of *Butis humeralis* between sex, fish size, and season

Comparison	*Group*	*No.*	*Mean*	*SE*	*t*	*p*
Left otolith weight (mg)	Female	580	4.51	0.07	0.27	0.77
	Male	859	4.48	0.07		
Right otolith weight (mg)	Female	580	4.46	0.07	0.66	0.96
	Male	859	4.46	0.07		
Left otolith weight (mg)	Immature	123	2.70	0.07	-22.26	0.00
	Mature	1.316	4.53	0.05		
Right otolith weight (mg)	Immature	123	2.65	0.08	-19.89	0.00
	Mature	1.316	4.51	0.05		
Left otolith weight (mg)	Dry	611	3.97	0.06	-7.55	0.00
	Wet	828	4.66	0.07		
Right otolith weight (mg)	Dry	611	3.93	0.06	-7.95	0.00
	Wet	828	4.65	0.07		

In *B. humeralis*, the weight of otoliths varied according to the study site (One-way ANOVA, F=31.84, p=0.00). In six study sites, otoliths had the largest weight in the TDST region (LOW: 5.00±0.13, ROW: 4.98±0.13 SE mg) and the lowest in DHBL (LOW: 3.66±0.11, ROW: 3.58±0.10 SE mg) and DDCM (LOW: 3.38±0.08, ROW: 3.41±0.08 SE mg) (Figure 3).

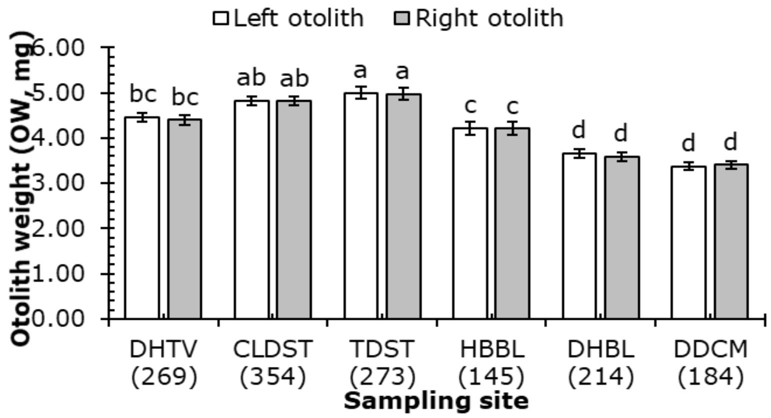

Figure 3. The change of otolith weight at the study sites (DHTV: Duyen Hai, Tra Vinh; CLDST: Cu Lao Dung, Soc Trang; TDST: Tran De, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau; number in the parenthesis: number of fish individuals).

Like most Osteichthyes, the otolith in this fish is similar and symmetrical between the left otolith and the right otolith. Some fish species distributed in MD with this characteristic have been studied, such as *Glossogobius sparsipapillus* (Nguyen & Dinh 2020), *Glossogobius aureus* (Phan et al 2021a), *Glossogobius giuris* (Phan et al 2021a), *Periophthalmodon septemradiatus* (Dinh et al 2021b), *Butis koilomatodon* (Tran et al 2021b). Similarly, some other fish species distributed in the world also have this feature, such as *Kurtus gulliveri* and *Thunnus thynnus* (Megalofonou 2006), *Pagrus auratus* (Hamer & Jenkins 2007), *Neogobius caspius*, *Ponticola bathybius* and *Ponticola gorlap* (Bani et al 2013), *Trachinus draco* (Fatnassi et al 2017), *Ctenosciaena gracilicirrhus*, *Macrodon ancylodon*, *Menticirrhus americanus*, *Haemulon steindachneri*, *Pellona harroweri* and *Polydactylus virginicus* (Oliveira et al 2019).

Because the mass of the left otolith and right otolith did not have a statistically significant difference, the weight of the left otolith was used to examine the relationships with the body morphological parameters of *B. humeralis*. The results show that the otolith weight had a close relationship with weight (W), total length (TL), body height (BH) and head length (HL). The coefficients r^2 of all relationships were ≥0.6 (Figures 4-7).

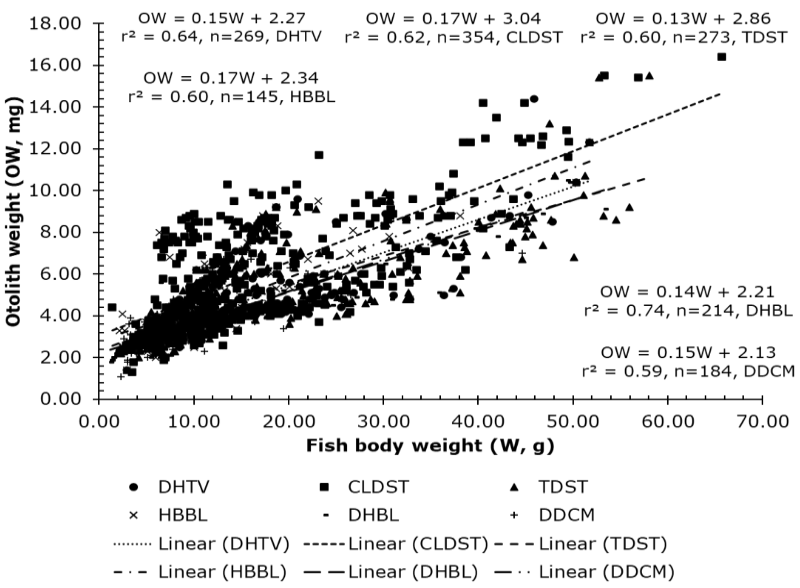

Figure 4. Relationship between otolith weight and body weight at the six sampling locations (CLDST: Cu Lao Dung, Soc Trang; DHTV: Duyen Hai, Tra Vinh; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau; HBBL: Hoa Binh, Bac Lieu; TDST: Tran De, Soc Trang).

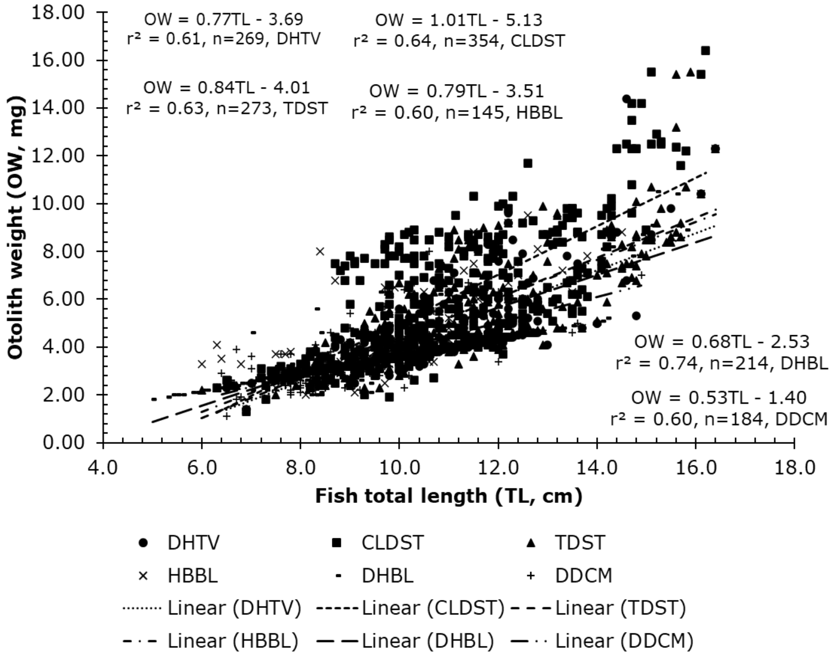

Figure 5. Relationship between otolith weight and total length at the six sampling locations (CLDST: Cu Lao Dung, Soc Trang; DHTV: Duyen Hai, Tra Vinh; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau; HBBL: Hoa Binh, Bac Lieu; TDST: Tran De, Soc Trang).

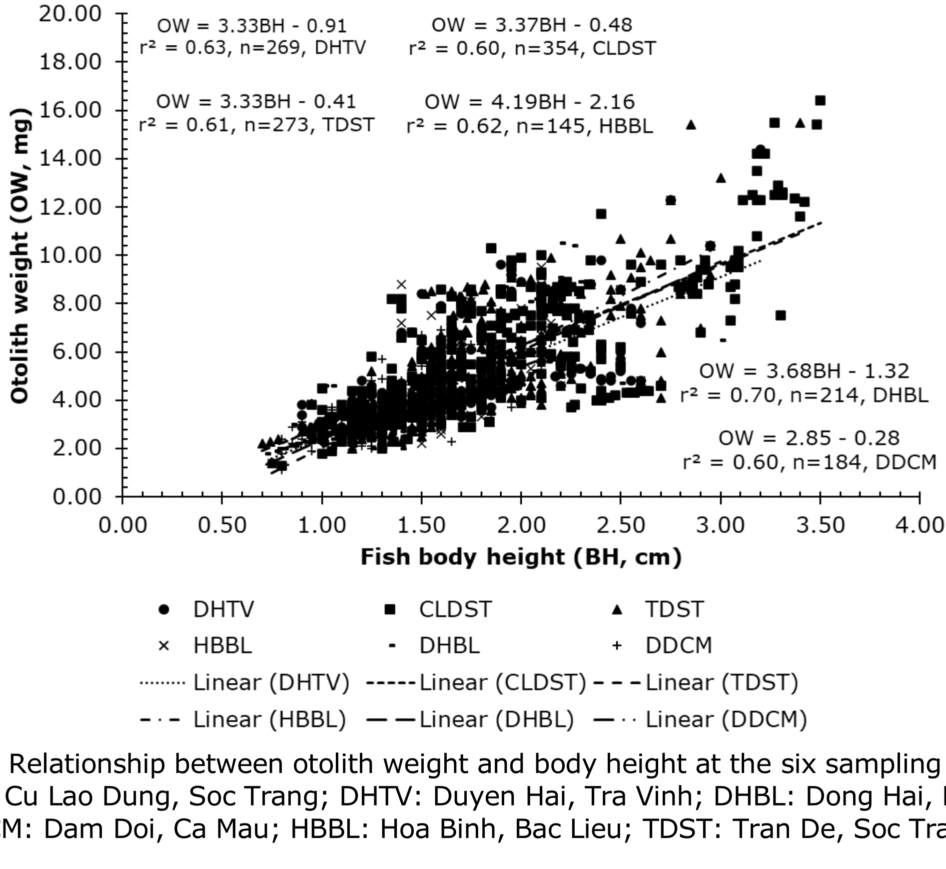

Figure 6. Relationship between otolith weight and body height at the six sampling locations (CLDST: Cu Lao Dung, Soc Trang; DHTV: Duyen Hai, Tra Vinh; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau; HBBL: Hoa Binh, Bac Lieu; TDST: Tran De, Soc Trang).

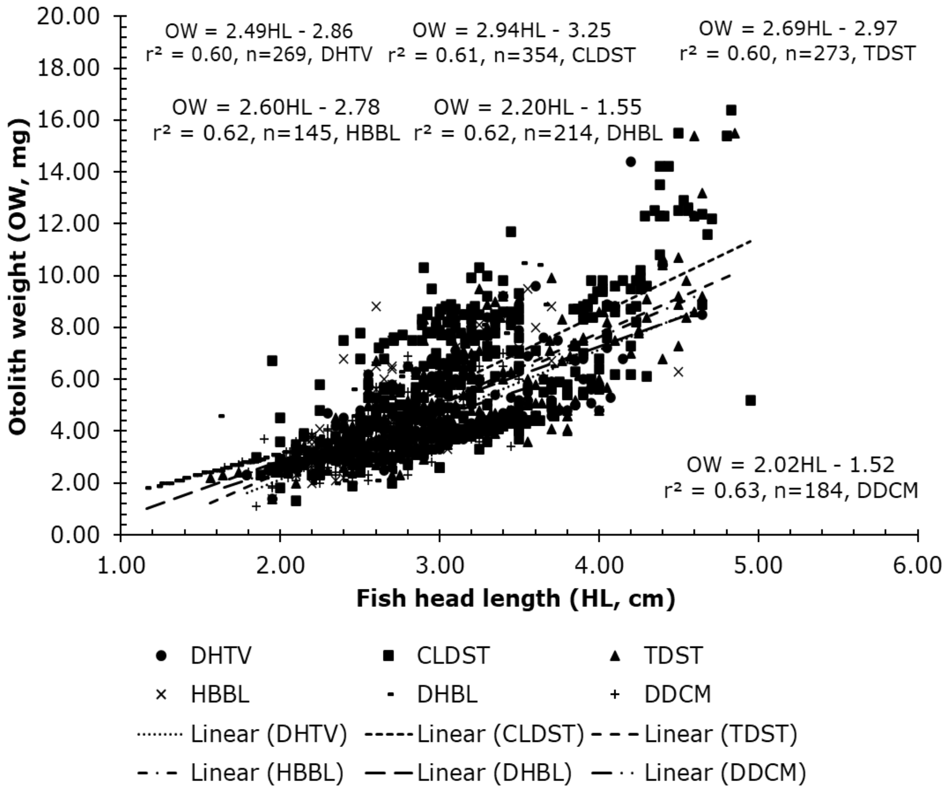

Figure 7. Relationship between otolith weight and head length at the six sampling locations (CLDST: Cu Lao Dung, Soc Trang; DHTV: Duyen Hai, Tra Vinh; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau; HBBL: Hoa Binh, Bac Lieu; TDST: Tran De, Soc Trang).

The close relationship between otolith weight and fish size shows that the otolith plays an essential role in determining the growth of the fish. This has been proven in some other studies on certain fish species distributed in MD and around the world, such as *Kurtus gulliveri* and *Thunnus thynnus* (Megalofonou 2006), *Pagrus auratus* (Hamer & Jenkins 2007), *Neogobius caspius*, *Ponticola bathybius* and *Ponticola gorlap* (Bani et al 2013), *Trachinus draco* (Fatnassi et al 2017), *Ctenosciaena gracilicirrhus*, *Macrodon ancylodon*, *Menticirrhus americanus*, *Haemulon steindachneri*, *Pellona harroweri* and *Polydactylus virginicus* (Oliveira et al 2019). *Glossogobius sparsipapillus* (Nguyen & Dinh 2020), *Glossogobius aureus* (Phan et al 2021a), *Glossogobius giuris* (Phan et al 2021b), *Periophthalmodon septemradiatus* (Dinh et al 2021b), *Butis koilomatodon* (Tran et al 2021b).

Conclusions. *B. humeralis* had a similar structure in shape and weight between the left otolith and the right otolith. The otolith weight did not change by sex but varied by fish size, season and location. The otolith weight was closely related to the fish weight, total length, body height and head length. The findings indicated that otolith weight could be seen as an indicator of fish growth.

Acknowledgements. This study was funded by the Ministry of Education and Training under grant number B2019-TCT-02. The authors are grateful to Mr. Nguyen Huu Duc Ton for their support in the fish collection and experimental process.

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

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Received: 04 January 2022. Accepted: 21 March 2022. Published online: 05 April 2022.
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How to cite this article:
Vo T. T., Dinh Q. M., 2022 Otolith morphology and its relationship with the fish size in *Butis humeralis* (Valenciennes, 1837) from Mekong Delta, Vietnam. AACL Bioflux 15(2):788-795.