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Otolith measurement and relationship with the size of *Butis butis* distributed in the Mekong Delta, Vietnam

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ABSTRACT

Butis butis is one of the economically valuable fish species in the Mekong Delta, Vitnam. This study provided data on otoliths and their relationship with morphological indices. Seven hundred fifteen individuals were used in this study. These individuals were collected from four sites from Tra Vinh to Ca Mau for six months, from March to August 2019. The otoliths of this fish were oval. The weight of the left otolith was equal to that of the right otolith. However, the length and width of the right otolith were more significant than that of the left otolith. Besides the size and weight of otoliths, this fish also varied by sex, season and location. The weight of otoliths could be considered a parameter to evaluate fish growth because it displayed a close relationship with the fish weight, total length, body height, and head length ($r^2 \geq 0.6$).

INTRODUCTION

Butis butis is a member of *Butis* genus widely distributed from freshwater to saltwater (the Indian Ocean to the Pacific Ocean) environments **(Nelson *et al.*, 2016; Tran *et al.*, 2020; Froese & Pauly, 2022)**. The species *B. butis* is a popular fish in the Mekong Delta (MD) **(Nguyen, 2005; Dinh, 2011; Le *et al.*, 2018)**. Some studies have been done on this fish, such as the relationship between length and weight **(Dinh, 2017)**, reproduction **(Dinh & Le, 2017)**, population structure **(Dinh, 2018a)**, digestive morphology, food and feeding habits **(Dinh *et al.*, 2020; Nguyen & Dinh, 2021; Nguyen & Dinh, 2022)** and morphological characteristics **(Phan *et al.*, 2021b)**. However, there is no information on otolith morphology and its relationship with fish size.

The otolith is a crucial structure of skeletal species, and it is a calcified structure located inside the skull of fish **(Popper & Lu, 2000; Campana, 2004)**. Otoliths can continuously grow in length and weight during the development of fish **(Rodríguez Mendoza, 2006)**. In some species of the family Cypriniformes, the otolith structure is divided into three parts: the lobe (Rostrum), the main track (Antirostrum), and the central groove (Sulcus) **(Hung & Loi, 2013)**. Otoliths have the function of receiving sound and balance of fish **(Popper *et al.*, 2005)**. In addition, the otoliths help in 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)**, the assessment of fishery reserves **(Stransky *et al.*, 2008)** . Moreover, they aid in identifying fish prey **(Waessle *et al.*, 2003; Tarkan *et al.*, 2007)**. Furthermore, according to **Dinh *et al.* (2015)**, the close relationships between the total length of fish (TL), otolith length (OL), otolith width (OW), and otolith weight (WO) can be used to determine the age of fish tropic. With the above essential roles, it is necessary to study the otolith morphology and the relationship with body morphological characteristics in *B. butis*. The study results would supplement the features of otoliths of this species in the study area.

MATERIALS AND METHODS

Fish collection and analysis

Fish samples in this study were collected continuously for 06 months, from 03/2019 to 08/2019. Trawl nets were the fishing gears used to collect samples at four sites: Duyen Hai - Tra Vinh (DHTV), Tran De - Soc Trang (TDST), Dong Hai - Bac Lieu (DHBL), and Dam Doi - Ca Mau (DDCM) (Fig. 1). Fish samples after catching were preserved with 5% formalin fluid and transported to the laboratory for further analyses. The fish samples were then identified using the morphology described by **Tran *et al.* (2013)** and sexed using criteria provided by **Dinh and Le (2017)**. Fish morphometric parameters, including weight (W, 0.01 g), total length (TL, 0.1 cm), body height (BH, 0.1 cm), and head length (HL, 0.1 cm), were determined before removing fish otoliths. The otoliths were then weighted (WO, 0.01 mg) before measuring length (OL, 0.01 mm) and width (OW, 0.01 mm).

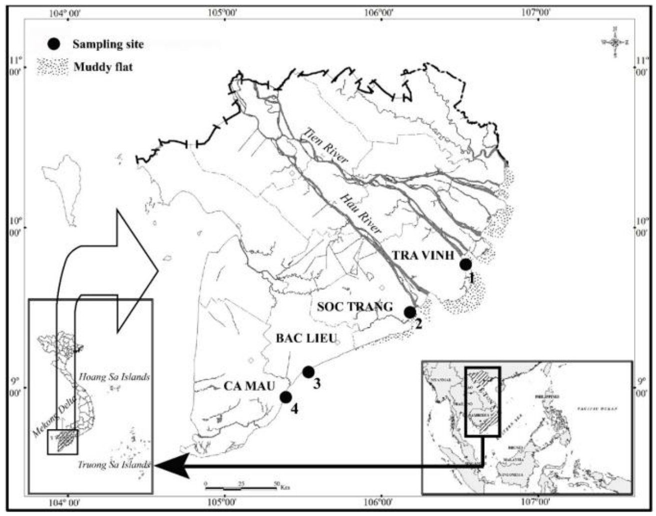

Figure 1. Sampling sites in the Mekong Delta. This figure was modified from Figure 1 produced by Dinh (2018b) with permission (•: sampling point; 1: Duyen Hai - Tra Vinh; 2: Tran De - Soc Trang; 3: Dong Hai - Bac Lieu and 4: Dam Doi - Ca Mau)

Data analysis. T-test was used to check the difference in weight, length, and width between the left and right otolith; between left or right otolith according to gender and season **(Matic-Skoko *et al.*, 2011)**. One-way ANOVA was used to test the difference in the otolith's weight, length, and width according to the study site. The tests were performed using SPSS v.21 software with 95% confidence.

RESULTS

The analysis results of the outer shape of *B. butis* otoliths showed that this fish displayed a similar structure between the right and left otoliths. Oval was the general otolith of this fish (Fig. 2). The front edge of the otolith had an upward slant, and the back edge had no obvious peak. The top edge was smooth, but the bottom edge was wavy. Otolith was observed to be a different two-sided structure; the outer surface was flat, and the inner surface was rough.

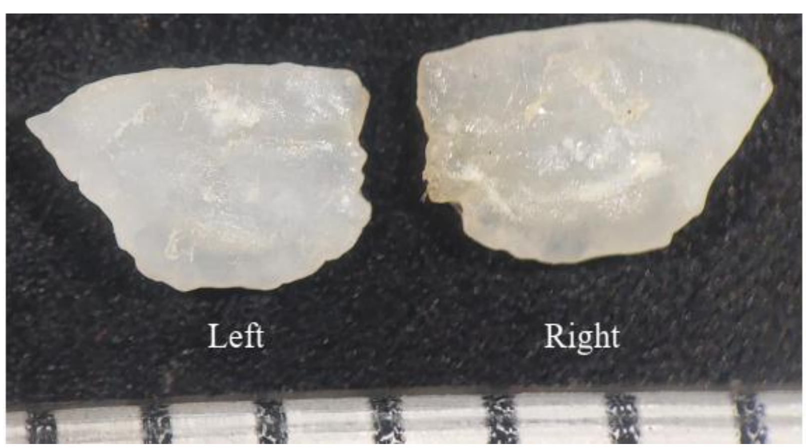

Figure 2. The shapes of left and right otoliths of *Buits butis*

Similar to the external appearance, the weight of the left otolith (4.12±0.07 SE mg) was similar to that of the right otolith (4.28±0.11 SE mg) (t-test, t=-1.90, p=0.06). However, the right otolith's length (t=-4.86, p=0.00) and width (t=-4.75, p=0.00) were significantly different from that of the left otolith. Specifically, the length of the right otolith (ROL=1.84±0.02 SE mm) was more significant than that of the left otolith (LOL=1.79±0.02 SE mm). Similarly, the width of the right otolith (ROW=1.38±0.02 SE mm) was more extensive than that of the left otolith (LOW=1.34±0.02 SE mm).

The analysis showed that the weight of the left otolith was quite different by sex (t=0.62, p=0.00) and season (t=-3.59, p=0.00). However, right otolith did not differ by sex (t=0.57, p=0.10) and season (t=-1.14, p=0.26) (Table 1). In *B. butis*, the left otolith (t_{LOL}=-4.53, p_{LOL}=0.00, t_{LOW}=-4.52, p_{LOW}=0.00) and the right (t_{ROL}=-3.38, p_{ROL}=0.00, t_{ROW}=-3.38, p_{ROW}=0.00) of males were all larger than that of females (Table 1). In the wet season, the otolith of this fish has a length (t_{LOL}=-4.41, p_{LOL}=0.00, t_{ROL}=-4.43, p_{ROL}=0.00) and width (t_{LOW}=-4.41, p_{LOW}=0.00, t_{ROW}=-4.42, p_{ROW}=0.00) was larger than that in the dry season (Table 1).

Table 1. The variations in otolith dimensions between sexes and seasons

Comparison	**Group**	**No.**	**Mean**	**SE**	***t***	***p***
Left otolith weight	Dry	372	3.89	0.09	-3.59	0.00
	Wet	343	4.37	0.10		
Right otolith weight	Dry	372	4.16	0.18	-1.14	0.26
	Wet	343	4.40	0.10		
Left otolith weight	Female	303	3.87	0.11	0.62	0.00
	Male	412	4.31	0.09		
Right otolith weight	Female	303	4.08	0.19	0.57	0.10
	Male	412	4.43	0.12		
Left otolith length	Dry	372	1.69	0.03	-4.41	0.00
	Wet	343	1.90	0.03		
Left otolith width	Dry	372	1.27	0.02	-4.41	0.00
	Wet	343	1.42	0.02		
Right otolith length	Dry	372	1.74	0.03	-4.43	0.00
	Wet	343	1.96	0.03		
Right otolith width	Dry	372	1.31	0.03	-4.42	0.00
	Wet	343	1.47	0.03		
Left otolith length	Female	303	1.67	0.03	-4.53	0.00
	Male	412	1.88	0.03		
Left otolith width	Female	303	1.25	0.03	-4.52	0.00
	Male	412	1.41	0.02		
Right otolith length	Female	303	1.74	0.04	-3.88	0.00
	Male	412	1.92	0.03		
Right otolith width	Female	303	1.30	0.03	-3.88	0.00
	Male	412	1.44	0.02		

At four study sites, it was found that otolith has a change in weight (One-way ANOVA, F_{OL}=23.21, p_{OL}=0.00, F_{OR}=10.53, p_{OR}=0.00, Fig. 3), length (F_{LOL}=23.95, p_{LOL}=0.00, F_{ROL}=21.16, p_{ROL}=0.00, Fig. 4) and width (F_{LOW}=23.94, p_{LOW}=0.00, F_{ROW}=21.17, p_{ROW}=0.00, Fig. 5).

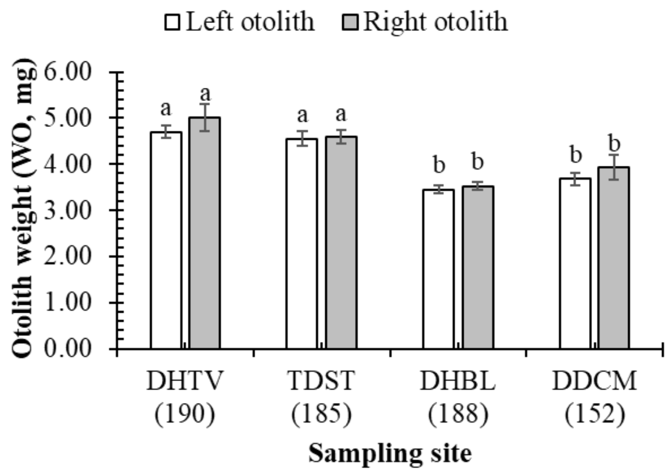

Figure 3. Weight of otoliths at four study sites (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau; number in bracket: number of fish individuals)

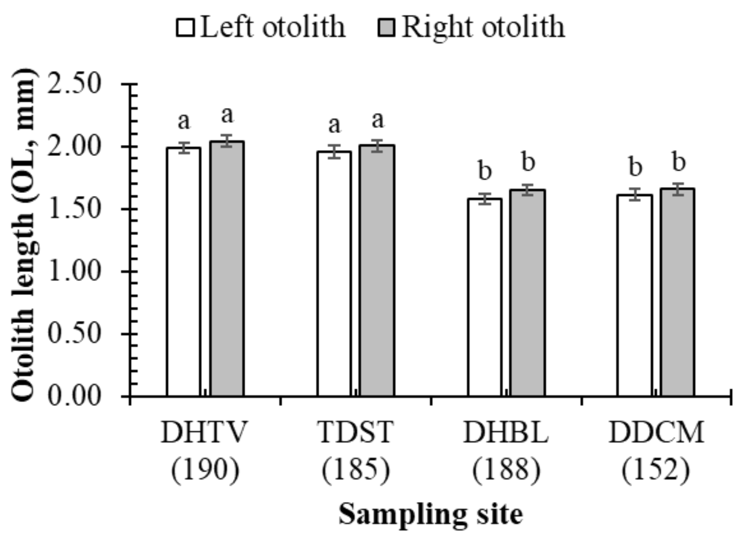

Figure 4. Length of otoliths at four study sites (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau; number in bracket: number of fish individuals)

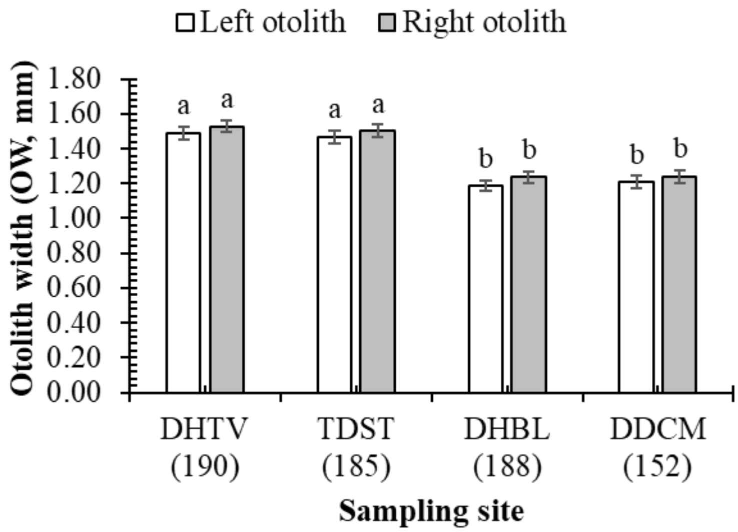

Figure 5. Width of otoliths at four study sites (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau; number in bracket: number of fish individuals)

The analysis of the relationship of otolith weight with body morphological parameters showed a close relationship ($r^2 \geq 0.60$, Fig. 6-9). In the relationship between WO with W, TL, BH, and HL, the relationship between WO and TL was the highest with $r^2 \geq 0.63$ (Fig. 7).

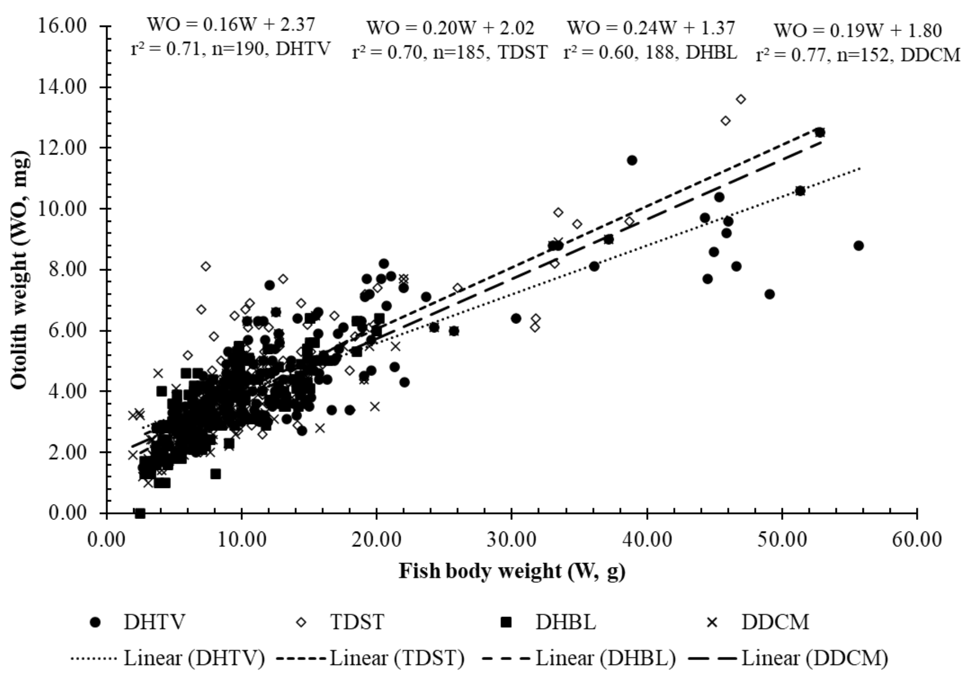

Figure 6. Relationship between otolith weight and body weight (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau)

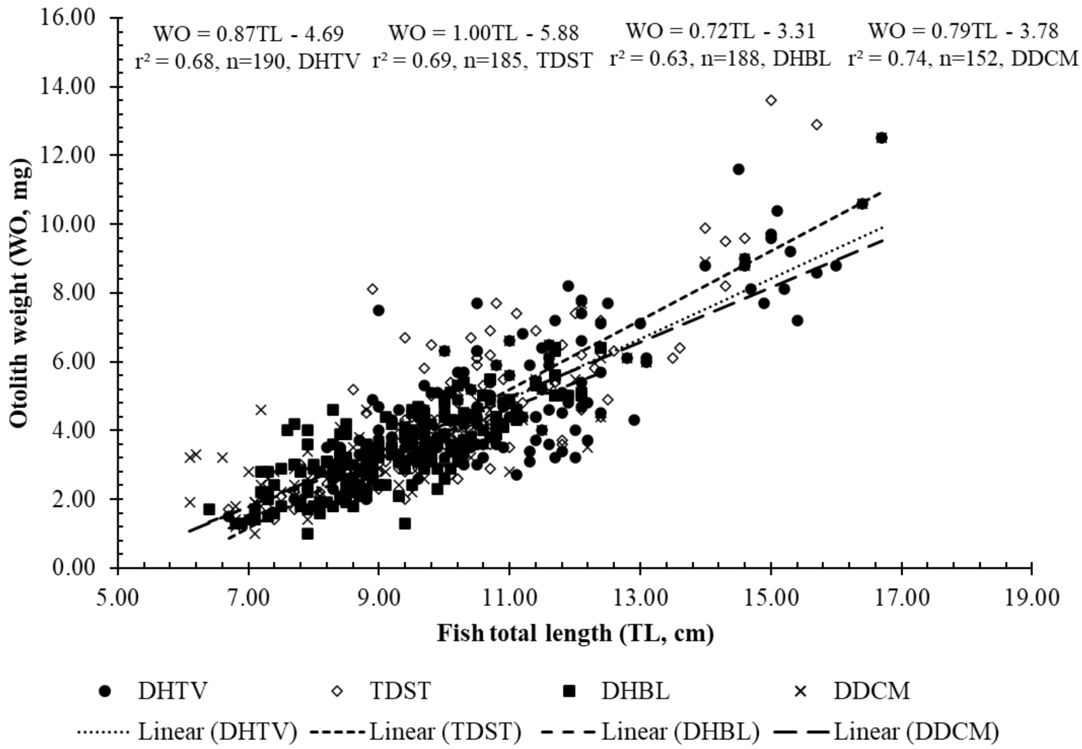

Figure 7. Relationship between otolith weight and total length (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau)

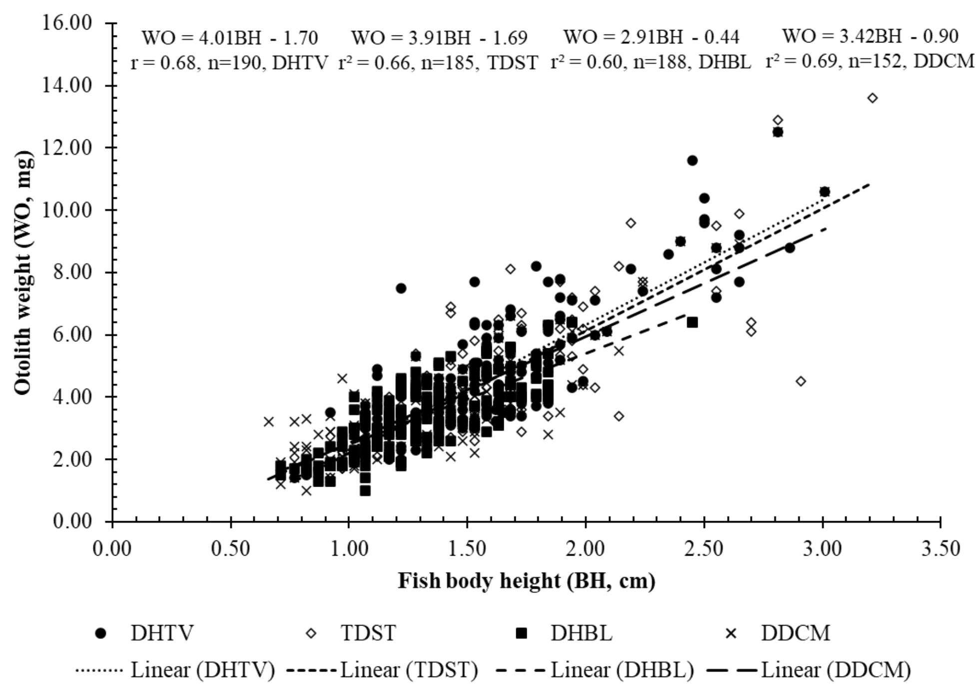

Figure 8. Relationship between otolith weight and body height (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau)

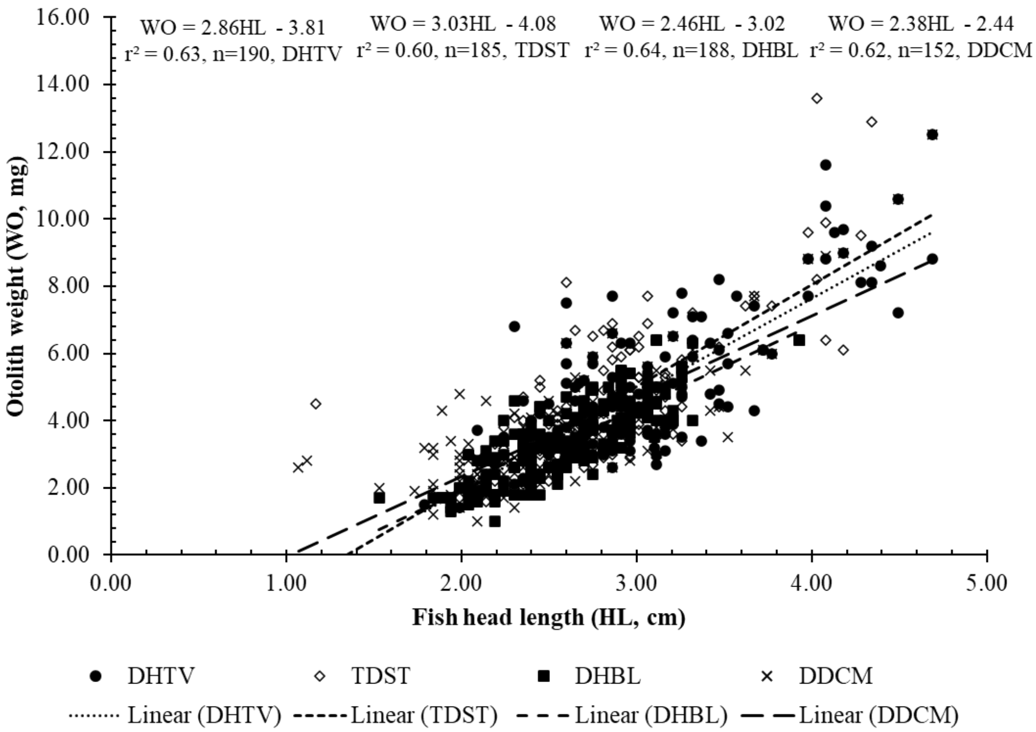

Figure 9. Relationship between otolith weight and head length (DHTV: Duyen Hai - Tra Vinh; TDST: Tran De - Soc Trang; DHBL: Dong Hai - Bac Lieu; DDCM: Dam Doi - Ca Mau)

DISCUSSION

Research results show that the size of otoliths was relatively uniform on the left and right sides of the fish. Otoliths with no difference between the left and right sides were also found in the species *Parapocryptes serperaster* **(Dinh *et al.*, 2015)**, *Glossogobius sparsipapillus* **(Nguyen and Dinh, 2020)**, *G. aureus* **(Phan *et al.*, 2021a)**, *G.giuris* **(Phan *et al.*, 2021c)**, *Periophthalmodon septemradiatus* **(Dinh *et al.*, 2021)**, *B. koilomatodon* **(Tran *et al.*, 2021)** in MD, and some other fish like *Kurtus gulliveri* in the North Australia **(Berra and Aday, 2004)**, *Thunnus thynnus* in the Mediterranean Sea **(Megalofonou, 2006)**, *Pagrus auratus* và *Platycephalus* in Southeast Australia **(Hamer and Jenkins, 2007)**, *Neogobius caspius, Ponticola bathybius,* and *Po. gorlap* in Iran **(Bani *et al.*, 2013)**. In addition, the size and weight of the otoliths varied markedly in different locations. This variation was related to the size of fish living in different environments, showing that the otolith size was continuously growing and proportional to the fish size.

The change in otolith size was related to fish size because of the close relationship between otolith size and fish size, which shows that otolith size was constantly growing and was directly proportional to fish size. Similarly, a close relationship between otoliths and fish size was also found in *Pa. serperaster* **(Dinh *et al.*, 2015)** and *G. sparsipapillus* **(Nguyen and Dinh, 2020)**. The close relationship between fish size and otolith was also found in other species such as *N. caspius, Po. Bathybius* and *Po. gorlap* in Iran **(Bani *et al.*, 2013)**. The larvae of Japanese anchovies and sardines such as *Engraulis japonicus* and *Sardinops melanostictus* caught from the western North Pacific Ocean also showed a strong relationship between fish size and otolith **(Takasuka *et al.*, 2008)**. Besides, the Indian mackerel *Rastrelliger kanagurta* obtained from the Sea of Oman had a close relationship between fish length and otolith length, otolith width, and fish weight **(Jawad *et al.*, 2011)**; that relationship was also found in nine species of devilfish caught from the waters northeast of Tasmania, Australia, including *Trachurus declivis*, *Parequula melbournensis, Neosebastes scorpaenoides*, *Pl. aurimaculatus*, *Pl.bassensis*, *Pl. conatus*, *Lepidotrigla mulhalli* and *L. vanessa* **(Park *et al.*, 2018)**. The results showed that the otolith weight could be used as an indicator of fish growth.

CONCLUSION

Butis butis showed oval-shaped otoliths. There was no difference between left otolith and right otolith. The length and weight of otoliths varied by sex, season, and site. The otolith weight was closely related to TL, W, BH, and HL, suggesting that it could be seen as an indicator of the growth rate of this fish.

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