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Using the Otolith Mass in Growth Determining of *Glossogobius giuris* in the Mekong Delta

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ABSTRACT

Otoliths played essential roles in fish growth determination but were limited to gobies living in the Mekong Delta, Vietnam (VMD). This study consequently lasted for one year from January to December 2020 in order to provide knowledge of morphology and mass of otoliths and their roles in growth determining for a commercial goby *Glossogobius giuris* in VMD. Samples were monthly collected using trawl nets in four locations from the fresh to brackish waters, including Cai Rang, Can Tho (0‰); Long Phu, Soc Trang (24.9‰); Hoa Binh, Bac Lieu (30.4‰) and Dam Doi, Ca Mau (30.8‰). Data analysis results of 1,291 individuals showed that the otolith mass was similar between left and right sides, but varies with gender, fish size, season and site. Due to high determination parameters, the otolith mass had positive relationships with fish dimension measurements such as weight, total length, eye diameter, body height, and head length. The findings showed otolith mass could be used as a growth indicator for this species.

INTRODUCTION

Most of the bonefish have otoliths located inside of the head **(Popper *et al.*, 2005)**. The otolith plays as a balance apparatus **(Popper and Lu, 2000; Campana, 2004)**. According to **Rodríguez and Villamizar (2006)**, fish otolith sizes increase as fish grow **(Tuset *et al.*, 2006; Reichenbacher *et al.*, 2009; Bani *et al.*, 2013; Dinh *et al.*, 2015; Polgar *et al.*, 2017; Lam *et al.*, 2021)**. It is possible to estimate the size of fish from otolith size based on their relationships **(Granadeiro and Silva, 2000; Dehghani *et al.*, 2016)**. Additionally, the otoliths are used in fishery stock assessment **(Stransky *et al.*, 2008)** and prey determination in the stomach of fishes **(Waessle *et al.*, 2003; Tarkan *et al.*, 2007)**. But little is known on the morphology and mass of otoliths and their

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relationships with fish sizes in the fish, especially gobies in VMD, where they diversify **(Tran *et al.*, 2013; Diep *et al.*, 2014; Tran *et al.*, 2020a; Tran *et al.*, 2020b; Tran *et al.*, 2021)**.

Glossogobius giuris is one of three species of the genus *Glossogobius* distributed in VMD **(Dinh, 2008; Dinh *et al.*, 2009; Dinh, 2011; Tran *et al.*, 2013; Diep *et al.*, 2014; Le *et al.*, 2018; Tran *et al.*, 2020b)**. It is a commercial goby, distributing from fresh to brackish waters **(Talwar and Jhingran, 1991; Riede, 2004; Froese and Pauly, 2021)**. There have been some studies on reproduction **(Pham and Tran, 2013; Dinh *et al.*, 2021b; Dinh *et al.*, 2021c)**, growth pattern and condition factor **(Dinh and Ly, 2014; Phan *et al.*, 2021)**, morphometric-meristic variation and population structure **(Dinh *et al.*, 2017; Nguyen and Dinh, 2021)** of this species. However, the shape and mass of otoliths and their relationships with fish sizes are unknown. Therefore, this study aims to provide knowledge on these gaps being used for fish growth indicators.

MATERIALS AND METHODS

Study sites and fish collection. Samples were collected at two sites along Hau River comprising Cai Rang, Can Tho (CRCT), Long Phu, Soc Trang (LPST) and two coastal areas including Hoa Binh, Bac Lieu (HBCL), Dam Doi, and Ca Mau (DDCM) (Fig. 1). CRCT was a freshwater site all year round. In contrast, HBBL and DDCM were saltwater regions, with 10‰ in the months of the year. Especially in the LPST, in the wet season, there was almost freshwater but was a saltwater intrusion in the dry season. Fish samples were caught monthly using trawl nets with a mesh of 1.5 cm in each site from January 2020 to December 2020. Fish samples were stored in a 10% formol solution and then analyzed in the laboratory by weight (*W*), total length (*TL*), body height (*BH*), head length (*HL*), and eye diameter (*ED*). The otoliths were obtained by following steps (1) making a ~1.0 cm line from top-middle head forward to tail; (2) making a T-shape by cutting another ~1.0 cm line which was perpendicular at the first line end; (3) using one pen to separate two skull pieces and two sides of otoliths were visible near to fish brain; (4) using another pen to pick up otoliths that were then determined mass by an electronic balance.

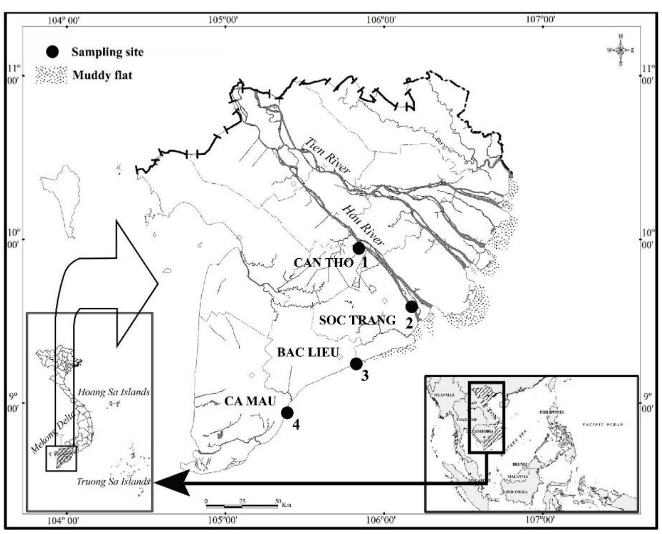

Figure. 2 The sampling location in the Vietnamese Mekong Delta modified from **Dinh (2018)** (1: Cai Rang, Can Tho; 2: Long Phu, Soc Trang; 3: Hoa Binh, Bac Lieu; 4: Dam Doi, Ca Mau)

Data analysis. The difference in mass of left otolith and right otolith was quantified by t-test **(Matics, 2000; Matic-Skoko *et al.*, 2011)**. The variation of otolith mass between gender, size and season was confirmed by t-test, and among four sites was tested by one-way ANOVA. Two-way ANOVA confirmed the interaction of these variables affecting the otolith mass. The relationship between otolith mass and fish sizes was calculated as $WO = a \times TL + b$; $WO = a \times W + b$; $WO = a \times ED + b$; $WO = a \times HL + b$ and, $WO = a \times BD + b$ (*WO*: mass of otolith; a and b: the coefficients of the equation; *TL*: total length; *W*: fish weight; *HL*: fish head length; *BD*: fish body height).

RESULTS

Otolith shape. Analysis results of 1,291 individuals (659 males and 632 females) showed that the otolith of *Glossogobius giuris* was oval-like in shape (Fig. 2). It had a round bulbous end, and the other end was slightly protruding and deviating to one edge of the otolith. The upper edge was rippled, while the bottom edge was flatter. The otolith face facing the fish body had an uneven rough shape due to the structure that matched the skull bones of the fish (Fig. 2).

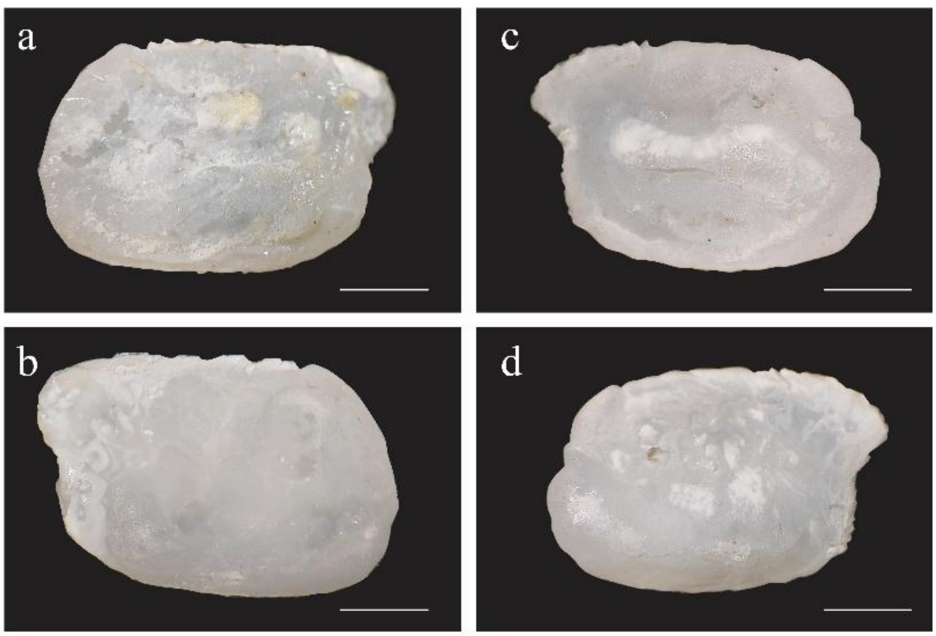

Figure. 2 Otolith shapes of *Glossogobius giuris* (a: inward face of left otolith; b: outward face of left otolith; c: inward face of right otolith; d: outward face of right otolith; scale: 1 mm)

The mass of left otolith *(LOW)* showed differences between gender, size and season. Specifically, *LOW* of males (7.18±0.14 SE mg) was heavier than females (7.08±0.15 SE mg, t-test, t=-0.49, P<0.05; Table 1), but this value in the dry (6.46±0.11SE mg) was lighter than in wet sseason (7.92±0.22 SE mg, t=-6.13; P<0.05; Table 1) seasons. The *LOW* of immature (4.36±0.06 SE mg) was lighter than the mature (8.38±0.12 SE mg, t=-21.44; P<0.05; Table 1). A similar trend was found in the right otolith mass *(ROW)*, which varied with season (t=-6.35; P<0.05) and fish size (t=14.96; P<0.05; Table 1), but not with gender (t=-0.77; P>0.05; Table 1).

Table 1. Otolith mass of *Glossogbius giuris* between sex, season and fish size parameters

Comparison	Groups	No. of fish	Mean (mg)	SE	*P*
Left otolith mass	Female	659	7.08	0.15	0.05
	Male	632	7.18	0.14	
Right otolith mass	Female	659	7.17	0.16	0.36
	Male	632	7.38	0.21	
Left otolith mass	Dry season	590	6.46	0.11	0.00
	Wet season	701	7.69	0.16	
Right otolith mass	Dry season	590	6.50	0.11	0.00
	Wet season	701	7.92	0.22	
Left otolith mass	Immature	405	4.36	0.06	0.00
	Mature	885	8.39	0.12	
Right otolith mass	Immature	405	4.54	0.14	0.00
	Mature	885	8.52	0.17	

The otolith mass varied according to the sampling sites, reaching the highest values in CRCT (7.99±0.21 *LOW* and 8.63±0.42 *ROW*) and lowest values in LPST (6.53±0.23 *LOW* and 6.54±0.22 *ROW*) and DDCM (6.55±0.16 *LOW* and 6.59±0.16 *ROW*) (one-way ANOVA, F_{LOW}=13.21; F_{ROW}=13.63; P<0.05 for both cases) (Fig. 2).

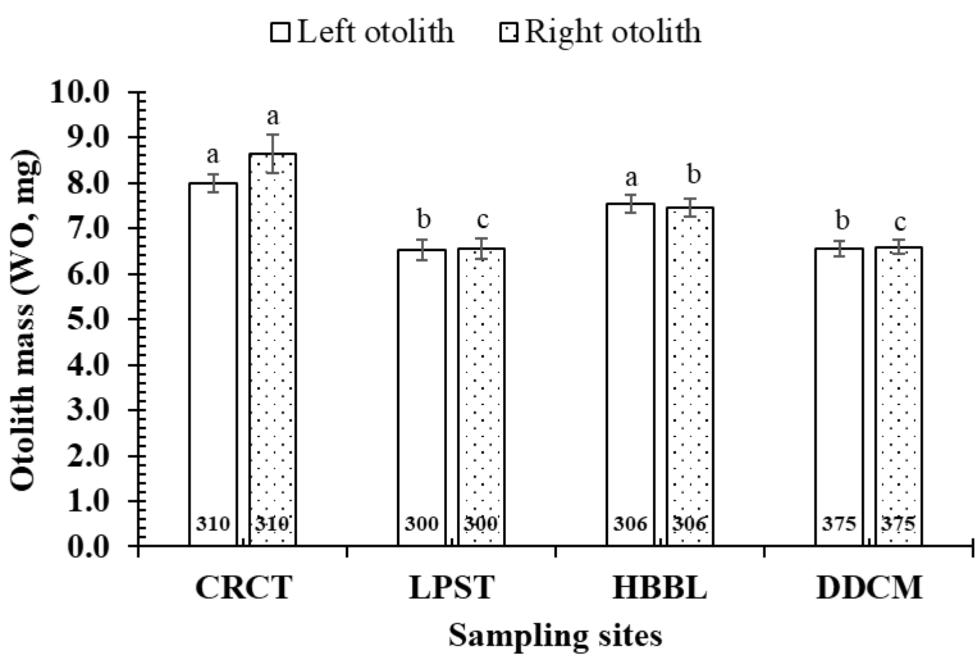

Figure 2. Otolith mass of *Glossogbius giuris* between four sites
(CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau; number in columns: number of fish; standing bar: standard error of mean; a, b, c: show a significant difference at the 5% level of significance.)

The relationship between otolith mass and fish size. As a similar value in both sides of otoliths, the left of otolith was used to verify the relationship between otolith mas and fish dimension measurements. The results showed that otolith mass was a positive relationship with fish weight (*W*, Fig. 3), total length (*TL*, Fig. 4), eye diameter (*ED*, Fig.

5), body height (*BD*, Fig. 6) and head length (*HL*, Fig. 7) due to positive determination value. It showed that otolith mass increased as fish grew.

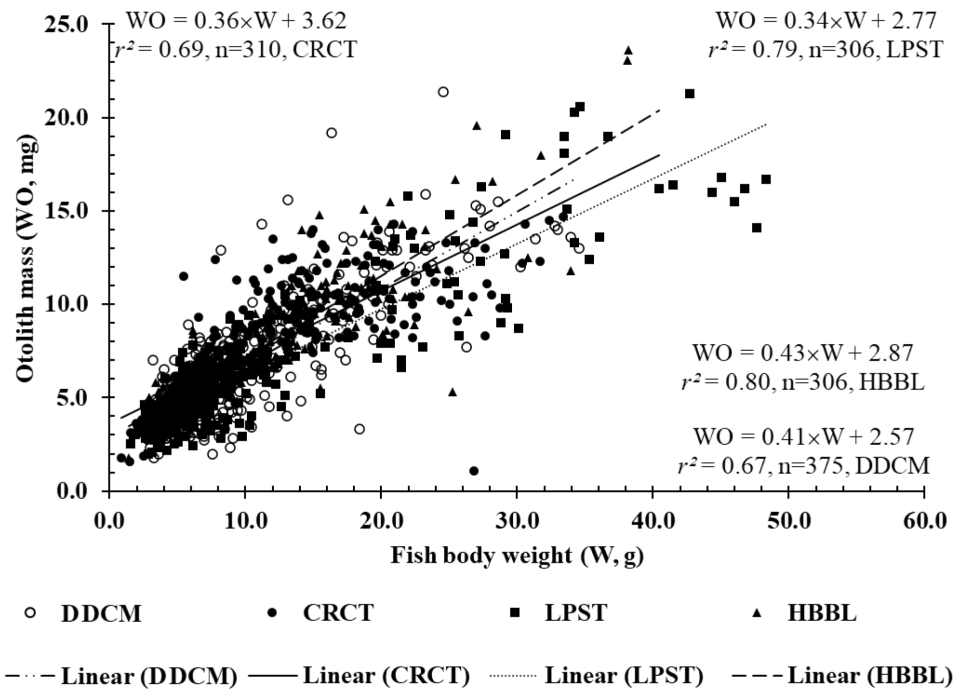

Figure 3. Relationship between otolith mass and body weight in the four locations (CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau)

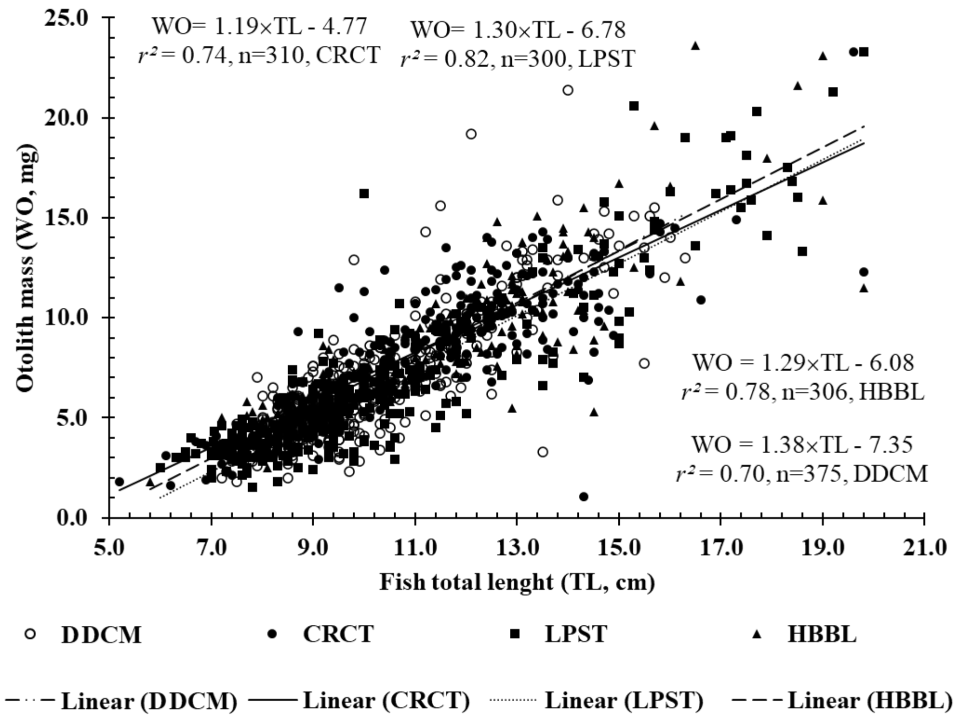

Figure 4. Relationship between otolith mass and total length in the four locations (CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau)

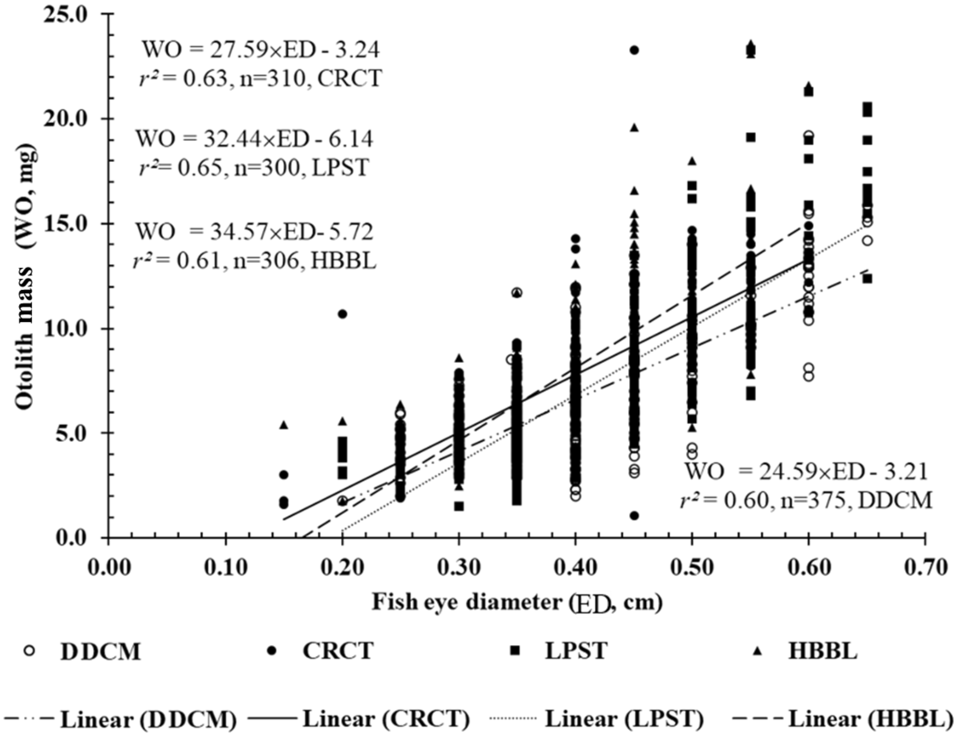

Figure 5. Relationship between otolith mass and eye diameter in the four locations (CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau)

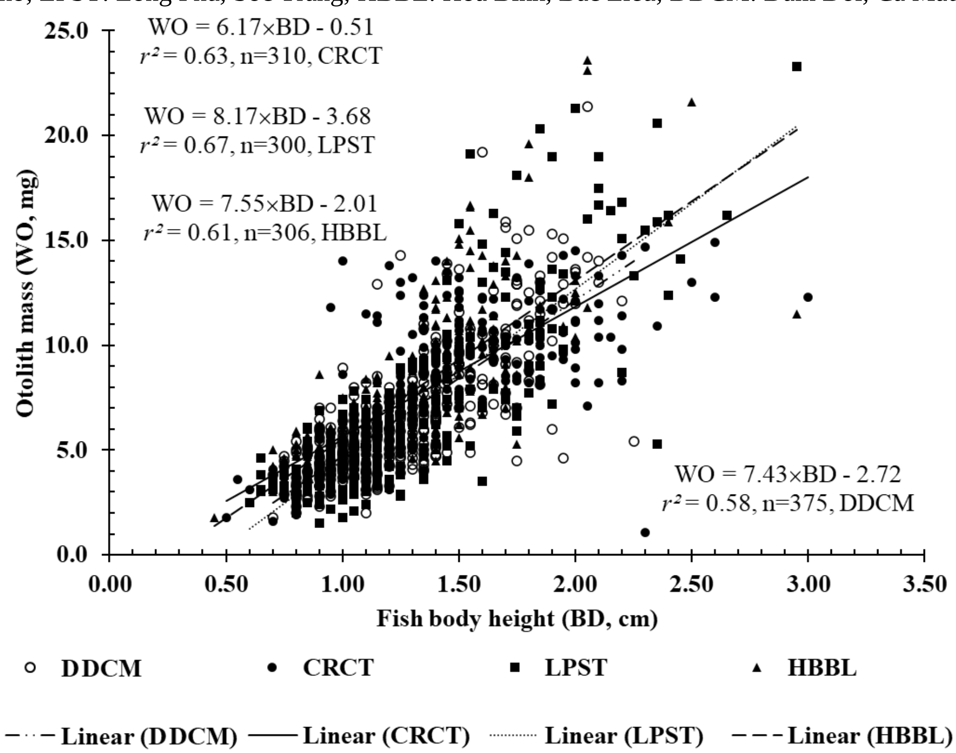

Figure 6. Relationship between otolith mass and body height in the four locations (CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau)

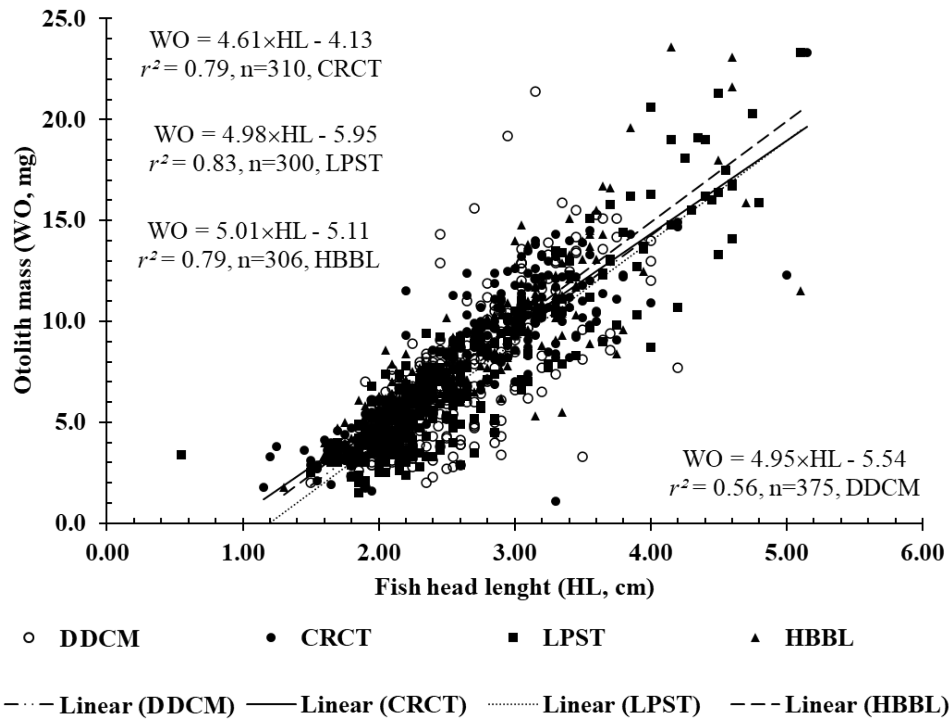

Figure 7. Relationship between otolith mass and head length in the four locations (CRCT: Cai Rang, Can Tho; LPST: Long Phu, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DDCM: Dam Doi, Ca Mau)

DISCUSSION

Although the weight of the right otolith and the left otolith was influenced by gender, season and maturity length in two different ways, the mass of the left otolith to the right was different from each other without statistical significance. This evenly showed even growth on both sides of the otolith, which was found in its congeners, *Glossogobius sparsipapillus*, living in VMD **(Nguyen and Dinh, 2020)**. Likewise, a similar in left and right sides of otoliths were also found in fish living in and out VMD, e.g., *Kurtus gulliveri* in northern, *Thunnus thynnus* in the Mediterranean Sea **(Megalofonou, 2006)**, *Pagrus auratus* and *Platycephalus* in Southeast Australia **(Hamer and Jenkins, 2007)**, *Neogobius caspius*, *Ponticola bathybius* and *Ponticola gorlap* in Iran **(Bani *et al.*, 2013)**, *Parapocryptes serperaster* in VMD **(Dinh *et al.*, 2015)**, *Trachinus draco* in the North of Tunisia **(Fatnassi *et al.*, 2017)**, *Ctenosciaena gracilicirrhus, Macrodon ancylodon, Menticirrhus americanus, Haemulon steindachneri, Pellona harroweri* and *Polydactylus virginicus* in Brazil **(Oliveira *et al.*, 2019)**, *Butis koilomatodon* in VMD **(Lam *et al.*, 2021)**, and *Periophthalmodon septemradiatus* in VMD **(Dinh *et al.*, 2021a)**

The positive relationships between otolith mass and fish size showed that otolith could be used as a fish growth indicator in the present study. A positive relationship was also found in its congener *Glossogobius sparsipapillus* living in Bac Lieu and Ca Mau **(Nguyen and Dinh, 2020)**. Some other fish species distributing in and our VMD also give similar results, such as *Neogobius caspius, Ponticola Bathybius* and *Ponticola gorlap* in Iran **(Bani *et al.*, 2013)**, *Engraulis japonicus* and *Sardinops melanostictus* distributed in the northwest Pacific Ocean **(Takasuka *et al.*, 2008)**, *Rastrelliger* *kanagurta* in Oman **(Jawad *et al.*, 2011)**, *Parapocryptes serperaster* **(Dinh *et al.*, 2015)**, *Trachurus declivis, Parequula melbournensis, Neosebastes scorpaenoides, Platycephalus aurimaculatus, Platycephalus bassensis, Platycephalus conatus, Lepidotrigla mulhalli* và *Lepidotrigla vanessa* from the waters northeast of Tasmania, Australia **(Park *et al.*, 2018)**, *Butis koilomatodon* in VMD **(Lam *et al.*, 2021)**.

Compared with *Glossogobius sparsipapillus*, the positive relationship of otolith mass with *TL, W, BD* and *HL* all gave similar results **(Nguyen and Dinh, 2020)**. Both of these studies had r^2 values ranging from 0.6 to 0.7. It showed that in this species of fish, the weight of otolith had a close relationship with the morphological indicators of the fish. However, the relationships in this study were not strong as those of *Periophthalmodon septemradiatus* **(Dinh *et al.*, 2021a)**.

CONCLUSION

The otolith mass was similar between left and right sides but varies with gender, fish size, season and site. The otolith mass had positive relationships with fish dimension measurements such as weight, total length, eye diameter, body height and head length due to high determinations. The findings showed that otolith mass could be used as a growth indicator for this species.

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REFERENCES

Bani, A.; Poursaeid, S. and Tuset, V. M. (2013). Comparative morphology of the sagittal otolith in three species of south Caspian gobies. Journal of Fish Biology, 82(4): 1321-1332. 10.1111/jfb.12073.

Campana, S. E. (2004). Photographic atlas of fish otoliths of the Northwest Atlantic Ocean. Canadian: NRC Research Press, 284pp.

Dehghani, M.; Kamrani, E.; Salarpouri, A. and Sharifian, S. (2016). Otolith dimensions (length, width), otolith weight and fish length of *Sardinella sindensis* (Day, 1878), as index for environmental studies, Persian Gulf, Iran. Marine Biodiversity Records, 9(1): 44. 10.1186/s41200-016-0039-0.

Diep, A. T.; Dinh, Q. M. and Tran, D. D. (2014). Species composition of gobiidae distributed in the coastal areas, Soc Trang Province. VNU Journal of Sciences: Natural Sciences and Technology, 30(3): 68-76.

Dinh, Q. M. (2008). Data of survey on the species composition of fishes in Hau Basin at An Phu district, An Giang province. Can Tho University Journal of Science, 10: 213-220.

Dinh, Q. M.; Pham, T. T. and Nguyen, K. T. L. (2009). Preliminary data on the species composition fish in Co Chien and Ham Luong river basins at Mo Cay District, Ben Tre Province. In: Le, C. X., ed. Proceedings of the 3rd National Scientific Conference on Ecology and Biological Resources. Ha Noi The Agricultural Academy Publishing House, pp.718-725.

Dinh, Q. M. (2011). The species composition and distributive characteristics of Perciformes in Hau river basin in Can Tho city, Vietnam. Journal of Science of Hanoi University of Education, 56(7): 160-168.

Dinh, Q. M. and Ly, T. V. (2014). Preliminary study result of length – weight of tank goby, *Glossogobius giuris*, distributing in Soc Trang. Can Tho University Journal of Science, 2014(2): 220-225.

Dinh, Q. M.; Qin, J. G. and Tran, D. D. (2015). Population and age structure of the goby *Parapocryptes serperaster* (Richardson, 1864; Gobiidae: Oxudercinae) in the Mekong Delta. Turkish Journal of Fisheries and Aquatic Sciences, 15(2): 345-357. 10.4194/1303-2712-v15_2_17.

Dinh, Q. M.; Phan, Y. N. and Tran, D. D. (2017). Population biology of the goby *Glossogobius giuris* (Hamilton 1822) caught in the Mekong Delta. Asian Fisheries Sciences, 30(1): 26-37. 10.33997/j.afs.2017.30.1.003.

Dinh, Q. M. (2018). Aspects of reproductive biology of the red goby *Trypauchen vagina* (Gobiidae) from the Mekong Delta. Journal of Applied Ichthyology, 34(1): 103-110. 10.1111/jai.13521.

Dinh, Q. M.; Nguyen, T. M. and Tran, L. T. (2021a). The use of otolith morphometry as an indicator for the size increase of *Periophthalmodon septemradiatus* (Teleostei: Gobiiformes) living along the Bassac River, Vietnam. Iranian Journal of Ichthyology, 8(2): 83-94. 10.22034/iji.v8i2.509.

Dinh, Q. M.; Truong, N. T.; Sy Tran, N. and Nguyen, T. H. D. (2021b). Testicular development and reproductive references of *Glossogobius giuris* in Mekong Delta, Vietnam. The Egyptian Journal of Aquatic Research, impress: 1-6. 10.1016/j.ejar.2021.09.005.

Dinh, Q. M.; Truong, N. T.; Tran, N. S. and Nguyen, T. H. D. (2021c). Ovarian and spawning reference, size at first maturity and fecundity of *Glossogobius giuris* caught along Vietnamese Mekong Delta. Saudi Journal of Biological Sciences, In press: 1-7. 10.1016/j.sjbs.2021.10.030.

Fatnassi, M.; Khedher, M.; Trojette, M.; El Houda Mahouachi, N.; Chalh, A.; Quignard, J.-P. and Trabelsi, M. (2017). Biometric data and contour shape to assess sexual dimorphism and symmetry of the otolith pairs of *Trachinus draco* from north Tunisia. Cahiers De Biologie Marine, 58(3): 261-268. 10.21411/CBM.A.8EB74E07.

Froese, R. and Pauly, D. (2021). FishBase. Accessed: 08/07/2021. www.fishbase.org.

Granadeiro, J. P. and Silva, M. A. (2000). The use of otoliths and vertebrae in the identification and size-estimation of fish in predator-prey studies. Cybium, 24(4): 383-393.

Hamer, P. A. and Jenkins, G. P. (2007). Comparison of spatial variation in otolith chemistry of two fish species and relationships with water chemistry and otolith growth. Journal of Fish Biology, 71(4): 1035-1055. 10.1111/j.1095-8649.2007.01570.x.

Jawad, L.; Ambuali, A.; Al-Mamry, J. and Al-Busaidi, H. (2011). Relationships between fish length and otolith length, width and weight of the Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1817) collected from the Sea of Oman. Croatian Journal of Fisheries, 69(2): 51-61.

Lam, T. T. H.; Nguyen, T. H. D.; Dinh, Q. M. and Nguyen, D. K. (2021). Otolith biometrics and their relationships with fish sizes of *Butis koilomatodon* living in Mekong Delta, Vietnam. Egyptian Journal of Aquatic Biology and Fisheries, 25(3): 803-814. 10.21608/ejabf.2021.181459.

Le, K. N.; Son, N. H.; Nguyen, T. N. H.; Le, H. A.; Tran, V. D.; Nguyen, T. D.; Tran, D. D.; Ha, P. H.; To, T. M. H.; Nguyen, T. V.; Vo, T. T.; Nguyen, T. T. and Dinh, Q. M. (2018). Fish species composition in Hau River Basin at Hau Giang Province. VNU

Journal of Science: Natural Sciences and Technology, 34(1): 90-104. 10.25073/2588-1140/vnunst.4723.

Matic-Skoko, S.; Ferri, J.; Skeljo, F.; Bartulovic, V.; Glavic, K. and Glamuzina, B. (2011). Age, growth and validation of otolith morphometrics as predictors of age in the forkbeard, *Phycis phycis* (Gadidae). Fisheries Research, 112(1-2): 52-58. 10.1016/j.fishres.2011.08.010.

Matics, K. I. (2000). Gobies. Vientiane, Lao: Catch and Culture - Mekong Fisheries Network Newsletter.

Megalofonou, P. (2006). Comparison of otolith growth and morphology with somatic growth and age in young-of-the-year bluefin tuna. Journal of Fish Biology, 68(6): 1867-1878. 10.1111/j.1095-8649.2006.01078.x.

Nguyen, T. H. D. and Dinh, Q. M. (2020). Otolith dimensions and their relationship with the size of *Glossogobius sparsipapillus* fish along the coastline of Mekong Delta, Vietnam. Egyptian Journal of Aquatic Biology and Fisheries, 24(2): 525-533. 10.21608/ejabf.2020.86013.

Nguyen, T. H. D. and Dinh, Q. M. (2021). Morphometric and meristic variations in *Glossogobius giuris* distributed in different locations in the Mekong Delta. TNU Journal of Science and Technology, 226(10): 31-38. 10.34238/tnu-jst.4274.

Oliveira, R. R. d. S.; Andrade, M. C.; Machado, F. S.; Cunha, É. J. S.; Freitas, F. S. d.; Klautau, A. G. C. d. M.; Giarrizzo, T. and Saint-Paul, U. (2019). Biometric relationships between body size and otolith size in 15 demersal marine fish species from the northern Brazilian coast. Acta Amazonica, 49: 299-306.

Park, J. M.; Gaston, T. F.; Riedel, R. and Williamson, J. E. (2018). Biometric relationships between body and otolith measurements in nine demersal fishes from north-eastern Tasmanian waters, Australia. Journal of Applied Ichthyology, 34(4): 801-805. 10.1111/jai.13612.

Pham, T. M. X. and Tran, D. D. (2013). Some characteristics on reproductive biology of Tank goby (*Glossogobus giuris*) distributed in Can Tho city. Can Tho University Journal of Science, 27: 161-168.

Phan, G. H.; Le, L. T. T.; Dinh, Q. M.; Truong, N. T. and Nguyen, T. H. D. (2021). Length-weight relationship, growth pattern and condition factor of *Glossogobius giuris* caught from coastal areas in the Mekong Delta. AACL Bioflux, 14(3): 1478-1485.

Polgar, G.; Ghanbarifardi, M.; Milli, S.; Agorreta, A.; Aliabadian, M.; Esmaeili, H. R. and Khang, T. F. (2017). Ecomorphological adaptation in three mudskippers (Teleostei: Gobioidei: Gobiidae) from the Persian Gulf and the Gulf of Oman. Hydrobiologia, 795(1): 91-111. 10.1007/s10750-017-3120-8.

Popper, A.; Ramcharitar, J. and Campana, S. (2005). Why Otoliths? Insights from inner ear physiology and fisheries biology. Marine and Freshwater Research - MAR FRESHWATER RES, 56(5): 497-504. 10.1071/MF04267.

Popper, A. N. and Lu, Z. (2000). Structure–function relationships in fish otolith organs. Fisheries Research, 46(1): 15-25. 10.1016/S0165-7836(00)00129-6.

Reichenbacher, B.; Kamrani, E.; Esmaeili, H. R. and Teimori, A. (2009). The endangered cyprinodont *Aphanius ginaonis* (Holly, 1929) from southern Iran is a valid species: evidence from otolith morphology. Environmental Biology of Fishes, 86(4): 507-521. 10.1007/s10641-009-9549-5.

Riede, K. (2004). The “Global register of migratory species” - first results of global GIS analysis. In: Werner, D. (Ed.). Biological resources and migration. Berlin: Springer, 211-218.

Rodríguez, J. and Villamizar, E. (2006). Alimentación del pez tropical *Gobioides broussonnetii* (Pisces: Gobiidae) en la Laguna de Unare, Venezuela. Revista de Biología Tropical, 54(4): 1093-1098.

Stransky, C.; Baumann, H.; Fevolden, S.-E.; Harbitz, A.; Høie, H.; Nedreaas, K. H.; Salberg, A.-B. and Skarstein, T. H. (2008). Separation of Norwegian coastal cod and Northeast Arctic cod by outer otolith shape analysis. Fisheries Research, 90(1-3): 26-35.

Takasuka, A.; Oozeki, Y.; Aoki, I.; Kimura, R.; Kubota, H.; Sugisaki, H. and Akamine, T. (2008). Growth effect on the otolith and somatic size relationship in Japanese anchovy and sardine larvae. Fisheries Science, 74(2): 308-313. 10.1111/j.1444-2906.2008.01519.x.

Talwar, P. K. and Jhingran, A. G. (1991). Inland fishes of India and adjacent countries. Rotterdam, Netherlands: Balkema, 1158.

Tarkan, A. S.; Gursoy Gaygusuz, C.; Gaygusuz, O. and Acipinar, H. (2007). Use of bone and otolith measures for size-estimation of fish in predator-prey studies. Folia Zoologica, 56(3): 328-336.

Tran, D. D.; Shibukawa, K.; Nguyen, T. P.; Ha, P. H.; Tran, X. L.; Mai, V. H. and Utsugi, K. (2013). Fishes of Mekong Delta, Vietnam. Can Tho: Can Tho University Publisher, 174.

Tran, D. D.; Cao, H. V.; Dinh, Q. M. and Tran, L. X. (2020a). An assessment of fisheries resources in the coastal water of the Mekong Delta, Vietnam. AACL Bioflux, 13(6): 3683-3693.

Tran, D. D.; Nguyen, T. V.; To, T. M. H.; Nguyen, T. T. and Dinh, M. Q. (2020b). Species composition and biodiversity index of gobiid assemblage in estuarine areas of the Mekong Delta, Vietnam. Egyptian Journal of Aquatic Biology and Fisheries, 24(7): 931-941. 10.21608/ejabf.2020.131385.

Tran, D. D.; Le, B. P.; Dinh, Q. M.; Duong, N. V. and Nguyen, T. T. (2021). Fish species composition variability in Cu Lao Dung, Soc Trang, Vietnam. AACL Bioflux, 14(4): 1865-1876.

Tuset, V. M.; Rosin, P. L. and Lombarte, A. (2006). Sagittal otolith shape used in the identification of fishes of the genus *Serranus*. Fisheries Research, 81(2-3): 316-325. 10.1016/j.fishres.2006.06.020.

Waessle, J. A.; Lasta, C. A. and Favero, M. (2003). Otolith morphology and body size relationships for juvenile Sciaenidae in the Río de la Plata estuary (35-36 S). Scientia Marina, 67(2): 233-240.