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STUDIES ON SAGITTAL OTOLITH MORPHOLOGY AND MORPHOMETRIC RELATIONSHIPS OF *TRICHOGASTER FASCIATA* FROM THE UPPER BRAHMAPUTRA BASIN, ASSAM

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ABSTRACT
Morphometrics of sagittal length, width and mass of *Trichogaster fasciata* was evaluated to find out any relationship that exist with standard length (SL) and fish weight (FW). Analysis of morphometric relationships showed that otolith mass (OM) showed highest degree of dependency on fish length and weight followed by otolith length and otolith width. The study also revealed that a significant relationship exists between standard length and weight of the fish. Paired t- test between left and right otolith showed that otolith length and otolith mass had almost identical P value(0.61 and 0.62 respectively) whereas otolith width showed the least value (0.37), indicating no significance differences between left and right otoliths. Results obtained from the current study provide additional information in understanding its biology and taxonomy of the fish which can be helpful in situations where standard protocols do not provide satisfactory inferences.

KEYWORDS: morphology, otolith, relationship, sagitta

INTRODUCTION

Otoliths or earstones, found at the back of cranium of most teleost fishes serves as an organ of balancing and hearing in fishes (Platt and Popper, 1981; Gauldie, 1988). Composing mainly of calcium carbonate and 0.2 to 10% organic matter (Campana, 1999), all bony fishes consists of three pairs of otoliths: lapillus, asteriscus and sagitta. Amongst the three pairs, the sagittae are the largest in majority of bony fishes (Harvey *et al.*, 2000; Zorica *et al.*, 2010**)**, shows highest morphological variability and hence, most studied in different fish groups (Kumar *et al.*, 2012). Morphological characteristics of otoliths has been extensively used to understand fish's ontogeny (Tombari *et al*., 2005; Gonzalez Naya*et al*., 2012), biology and environment (Gauldie,1988;Torres *et al.*, 2000; Volpedo and Echeverria, 2003), phylogeny (Gaemers, 1984; Nolf, 1985), paleontological studies (Carpenter *et al.*, 2003;Jawad *et al.*, 2011), ecomorphology (Torres *et al*., 2000; Volpedo and Echeverria, 2003)and systematics (Lombarte *et al*., 1991; Smale *et al*., 1995; Volpedo and Echeverria, 2000). Sagittal otoliths measurements are applied in regression analysis to determine their relationships with fish length and weight for predicting different aspects of fish biology.

It has shown fair reliability in predicting the standard length of the fishes in general (Harvey *et al*., 2000). Accordingly, it is seen that biometric relationships between body and different otolith measurements has been successfully availed in stock identification (Smith *et al.*, 2002; De Vries *et al*., 2002; Tuset *et al*., 2003; Poulet *et al.*, 2004), gut content analysis for prey identification(Reid, 1995; Bowen, 2000) etc. in fishes. Information retrieved from such studies can be immensely helpful to extrapolate size and identity of fishes in situations where no other means available. Furthermore, otolith parameters along with their relationships have shown to be fairly reliable taxonomic tools (Lombarte *et al*., 2006).

Trichogaster fasciata is a popular aquarium fish, widely distributed in the South Asian countries. Various aspects of *T. fasciata* such as length-weight relationship (Paswan *et al*., 2012), feeding and reproductive biology (Gupta, 2015; Deori *et al*., 2017), captive breeding (Islam *et al*., 2017) etc. have been carried out successfully. However, detailed study regarding their otolith morphology and morphometric relationship is still lacking. Therefore, a thorough investigation was carried out to generate some basic information on sagittal morphology of *T. fasciata*, and its relationships with body size. The data obtained from the current study will support future studies in understanding the biology and environment of the fish in greater detail.

MATERIALS AND METHODS

A total of 100 samples were collected and preserved in 10% formalin from different landing centres of Dibrugarh district of upper Assam, India between August, 2017 and January, 2018. The formalin preserved specimens were

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brought to the Fish & Fisheries Laboratory, Department of Life Sciences, Dibrugarh University for further analysis. Analyses were conducted within the first week after sampling.

Morphometric measurements and analysis

Digital caliper was used to measure the standard length (SL) of the sample specimens to the nearest mm. Standard length was measured from tip of the snout to the end of the caudal peduncle. Similarly, a standard analytical balance was used to weigh the fishes to the nearest 0.001 gm. The sagittae were extracted out from sacculus of the specimens and were first washed in 70% alcohol and then stored in dry glass vials for further studies. The left and right sagittae were kept separately. Otolith length (OL) and otolith width (OW) were accurately measured using digital calipers. The otolith mass (OM) was also accordingly measured to the nearest 0.001gm. The morphological descriptions of the sagittae were done following Tuset *et al*. (2008).

Statistical analysis

Standard statistical analysis was done to establish relationships among different otolith characters. Comparison of characters such as otolith length (OL), otolith width (OW), otolith mass (OM) with standard length (SL) and fish weight (FW) were carried out using linear regression model Y=a+bX. The values were first log converted and then the relationships were established. Paired t-test was carried out to detect differences between right and left sagittae. When significant differences were absent between the two, either one of right or left otolith was selected randomly to establish relationships between different parameters.

RESULTS

Morphology of Sagitta (Figure 2)**:** The sagittae is fusiform shaped with crenate margin. Sulcus acusticus is of ostial type; ostium bent-concave; cauda tubular and strongly curved. Rostrum is small and rounded. Anterior edge round; posterior edged peaked.

Statistical analysis

Comparisons of otolith length, width and mass of left and right sagitta using paired t-test showed no significant differences. The P-value for otolith mass (OM) was highest (0.62) followed by otolith length (OL=0.61) and otolith width (OW) which showed the least value of 0.37. The results of the current study revealed existence of significant relationship between standard length and weight of *Trichogaster fasciata* as evident through the R^2 value (0.91). However, the magnitude of relationships between standard length of the fish with otolith length, width and mass drops considerably. With respect to standard length, the coefficient of determination for the linear regression OM-SL attained the highest value (0.63) as compared to OL-SL (0.60) and OW-SL (0.43) while performing linear regression analysis. Similarly, with respect to fish weight, it was observed that the linear regression OM-FW showed the highest value of coefficient of determination i.e. (0.63) with OW-FW relation showing the least (0.42).

Table1: Differences between right and left sagitta otoliths of *Trichogaster fasciata* tested by paired t-test.

Standard length range (mm)	Parameter	n	t-value	df	P-value
46-62	OL	100	-0.50	99	0.61
46-62	OW	100	0.88	99	0.37
46-62	OM	100	-0.64	99	0.62

Table 2: SL, FW, OL, OW and OM of *Trichogaster fasciata*(Mean ± SE)

n	Standard length (mm)	Fish weight (g)	Otolith length (mm)	Otolith width (mm)	Otolith mass (g)
100	53.69±0.67	6.45±0.16	3.30±0.04	2.39±0.029	0.005±0.0001

*SL – Standard length, FW – Fish weight, OL-otolith length, OW-otolith width, OM-otolith mass

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Table 3: Relationship between standard length and total weight of *Trichogaster fasciata*

Standard length range (mm)	Sample size (n)	Weight range (g)	Equation (SL *vs.* FW)	R^2
46-62	100	4-11	$FW=-13.40\ SL^{0.369}$	0.91

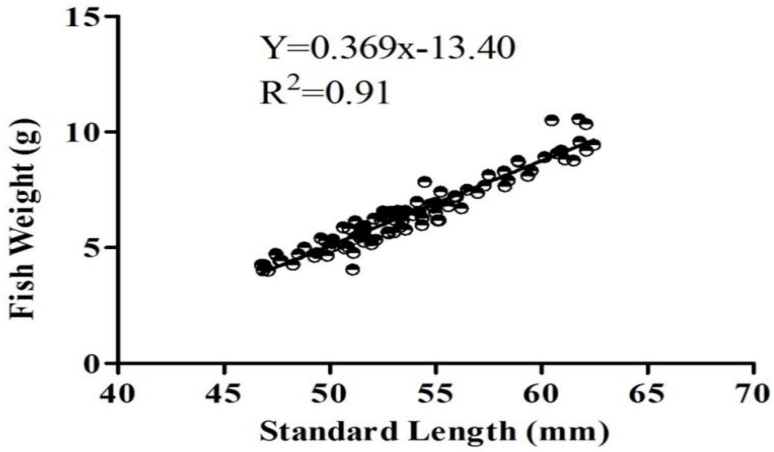

Figure 1: Relationship between standard length and total weight of *Trichogaster fasciata*

Table 4: Relationship between otolith morphometric characters and standard length (SL) and coefficient of determination (R^2)

n	OL *vs* SL	R^2	OW *vs* SL	R^2	OM *vs* SL	R^2
100	$SL=1.308\ OL^{0.812}$	0.60	$SL=1.446\ OW^{0.745}$	0.43	$SL=2.539\ OM^{0.363}$	0.63

* OL: otolith length, OW: otolith weight, OM: otolith mass

Table 5: Relationship between otolith morphometric characters and fish weight (FW) and coefficient of determination (R^2)

n	OL *vs* FW	R^2	OW *vs* FW	R^2	OM *vs* FW	R^2
100	$FW=-0.497\ OL^{2.502}$	0.57	$FW=0.076\ OW^{2.310}$	0.42	$FW=3.358\ OM^{1.149}$	0.63

* OL: otolith length, OW: otolith weight, OM: otolith mass

Figure 2: Sagitta otolith of *Trichogaster fasciata*

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DISCUSSION

Utility of otolith in understanding the biology of a fish is well documented. The sagitta otoliths are widely used because of their form, weight, growth, consistency and chemical composition (Zorica *et al.*, 2010) and easy accessibility (Nolf, 1985). Due to their high specific variability in shape and size, we observe variations in length, width and mass in them. As such, they are considered as powerful taxonomic feature in fish identification (Battaglia *et al.*, 2010). In recent decades, it is seen that biometric relationships of otolith with that of body parameter has gained importance in understanding the biology of fishes. However, majority of the works related to regression analysis of OL, OW and OM with that of SL or FW are centered on coastal, marine or commercially important fishes (Harvey *et al.*, 2000; Waessle *et al.*, 2003; Kumar *et al.*, 2012, Park *et al.*, 2018). Hence, scarcity of knowledge persists regarding otolith morphology and relationships of freshwater fishes, especially in case of native Indian freshwater fishes. In this context, an attempt was made to unearth the morphology and the relationships of sagittal otoliths in *Trichogaster fasciata.*

Analysis of length weight relationship showed almost identical R^2 value to the one previously done by Paswan *et al.*, (2012). Detailed studies on sagitta of the fish is reported for the first time on this particular species. The results reveal that otolith mass(OM) showed highest linearity with standard length and weight of the fish which is in correspondence to other studies carried out earlier in other fish species(Zorica *et al.*, 2010; Bani *et al.*, 2012). In *T. fasciata*, it was observed that the otolith width (OW) showed least value as compared to otolith length (OL) and mass (OM) when relationships were established using linear regression equations. From the findings, it is evident that, of different studied otolith characters, it is less related to general fish morphology. On the other hand, out of the three morphometric characters taken under consideration, the coefficient of determination for otolith mass (OM) showed maximum value (R^2=0.63 in both OM vs SL and OM vs FW regression analysis). It clearly suggests that otolith mass may be more useful in prediction of standard length and weight of the fish. This could be suggested by the fact that otolith mass is highly sensitive to variations in growth rate as well as change in fish metabolism (Boehlert, 1985; Reznik *et al*., 1989; Secor and Dean, 1989; Pawson, 1990; Fletcher, 1991).The variations observed in the otolith characters may be due to variations in $CaCO_3$ deposition during sagittae development (Volpedo and Echeverria, 1999) and different morphologies of $CaCO_3$ (Kumar *et al*., 2012). Variations may also arise due to the influence of different environmental factors such as water temperature, depth, mineral and food availability (Lombarte and Fortuno, 1992; Lombarte and Lleonart, 1993; Arellano *et al.*, 1995; Aguirre and Lombarte, 1999; Tuset *et al*., 2003). The observed variations may affect physiology of hearing and communication (Popper and Fay 1993; Paxton, 2000; Lombarte and Cruz, 2007), phylogeny (Nolf and Tyler, 2006), as well as the microstructure of sagittae (Volpedo and Fernandez Cirelli, 2006; Volpedo *et al*., 2008).

The current study revealed that otolith mass of *T. fasciata* showed highest dependence on length and weight of the fish. The otolith mass of the fish might have a relationship with microhabitat (Bani *et al.*, 2012) which may be helpful in determining the feeding behaviour of the fish. Results obtained from current study provides baseline information on their shape, general morphology as well as morphometric relationships of otolith length (OL), otolith width (OW) and otolith mass (OM) with standard length (SL) and fish weight (OW). Thorough studies on these characters might be a promising tool in stock identification (Kumar *et al*., 2012) of the species in different habitats. Also, since the morphological characteristics of otolith are considered as species level identifying characters in fish systematics (Berra and Aday, 2004) it would further play a significant role in identification of the fish in situations where standard methodologies fail to provide expected results.

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