THE MORPHOLOGICAL CHARACTERISTICS OF OTOLITHS OF SOME ESTUARINE FISHES IN THE MOUTH OF THANLWIN RIVER AND ITS ADJACENT COASTAL AREAS*

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Abstract

Based on the external morphologies of fish, a total of 20 species of estuarine fishes selected from the mouth of Thanlwin River were identified and the sagittae otoliths were taken out from fish. The result of this study showed that otoliths of pelagic fishes compared with otoliths of demersal fishes are smaller and thinner. Furthermore otoliths of different species can have similarities in appearance but they have enough differences to be distinguished from each other. In this study, different shapes of otoliths are recorded in the fishes caught from the river mouth area of Thanlwin. These included elliptic, square, discoid, rectangle, lanceolate, triangle, pistalform and spindle shapes.

Keywords: Morphology, Thanlwin River, Otolith.

Introduction

Otoliths are structures located in the inner ear cavity of all teleost fish. Each side includes sagittae, lapilli and esterisci that are different in shape, size and location. Otoliths grow throughout a fish's life, and are formed by layers of calcium carbonate that are laid down at different rates, depending on metabolic rates during the winter form denser layers (the opaque zone), while high metabolic rates in spring and summer form less dense layers (the translucent zone). This make the otoliths look like an onion, with the opaque bands corresponding to slower growth appearing as dark rings. Because each opaque band represents a year of growth, scientists can use otoliths to estimate a fish's age. Otolith size and shape differ among species, among populations and within each species. These variations are influenced during development by both genetic and environmental factors. Due to their intra and interspecific

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variation in shape, otoliths are useful in many studies: taxonomy, phylogeny, archeology, paleontology, species' geographical variation, stock identification, food webs and others. (Rossi-wongtschowki *et al*. 2016 and Popper *et al.* 2005)

Therefore, the identification and quantification of fish species in the diet of top predators (marine mammals, fish and seabirds, among others) usually require the analysis and identification of diagnostic hard remains found in food samples. Teleost fishes consumed by predators may be rapidly digested making them unrecognizable from external morphological features. However hard parts such as bones and otoliths are much more resilient to digestion and have regularly been used to aid in the identification of partially digested remains. Although the use of otolith increments for ageing larval and juvenile fish has become increasingly popular, characterization of the development of otolith morphology in different species is still poorly resolved. (Akkiran 1885)

In the present study, the morphological characteristics of otoliths were described for each species and then the research history on otolith morphology and the terminology used was reviewed. The present study can be used to identify fishes from otolith remains found in the digestive tracts or faeces of predators, sediment samples and fossils.

Materials and Methods

From June 2016 to January 2017, the samples of fishes and their otoliths were randomly collected along the mouth of Thanlwin River including Mawlamyine, Ahlet, Sebalar, Kadonebaw, Kyaikkhami and Setse. The samples were put in the bags and containers. The samples were brought back to the laboratory, rinsed and identified using the illustration handbooks produced by the F.A.O species identification sheets for fishery purposes Vol. I-IV. Fishbase on the website of the Academic Sinica, Taiwan was used as a supplemental guide for identification purposes. Furthermore De Bruin *et al*. 1995, Fischer 1974, Mya Than Tun 2001 and Rainboth 1996 were also used to identify the samples collected from the landing sites. Then the samples were continued removing sagittae otolith for the studies of otolith morphology. The terminology and diagonastic characters of otolith were reviewed and used in this study based on Rossi-Wongtschowiski *et al.* 2016.

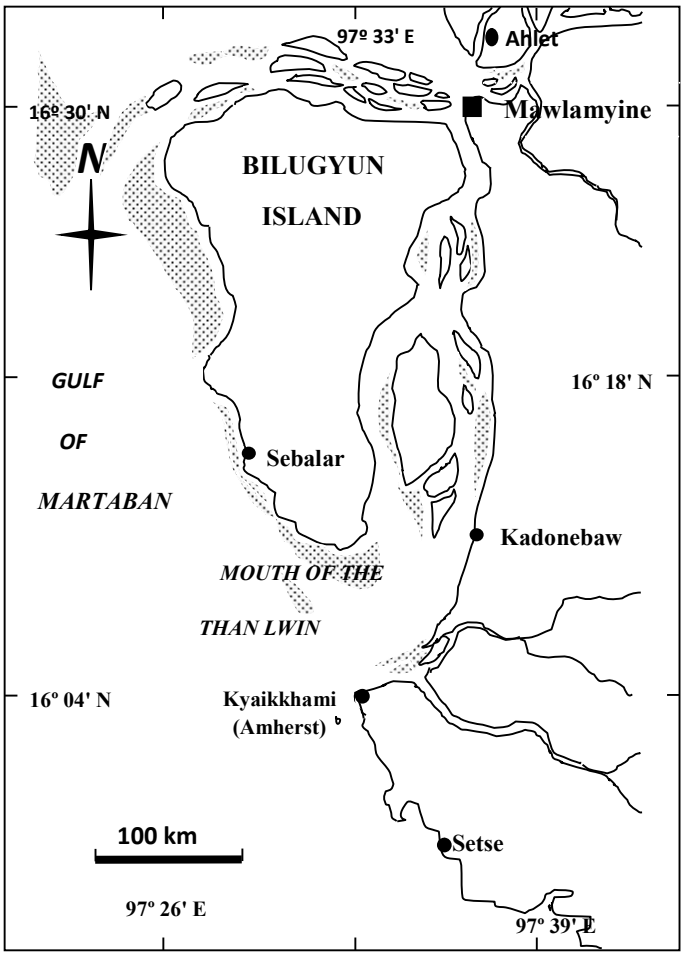

Figure 1. Map showing the specimens collection sites of fishes at the mouth of Thanlwin River.

Removing Otolith

According to the methods of Secor (1991), sagittal otoliths of fish were generally removed with a sharp fish knife and a pair of forceps or tweezers. In this way, a knife with a 15-20 cm blade and a pair of forceps or tweezers about 10 cm long were used. Firstly the head of the fish were griped by putting thumb and forefinger in its eye sockets and laid the body of the fish

on a counter with the tail pointing away. Then put the knife blade on the top of the fish's head about 1 eye diameter behind the eyes and slanted the blade away, at about a 30 angle, slice back and down about one head length and cut vertically through the top of the skull over the preopercle. After that, pushed the rear of the brain to one side, or cut it out all together. The pair of otoliths should be visible underneath the rear of the brain, still inside the skull. They may or may not be resting inside hallows in the base of the skull. Forceps were used to pull out both otoliths. They will not be attached to anything other than soft tissue. Finally the otoliths were cleaned out with water or younger fingers and soft dry in a paper envelope.

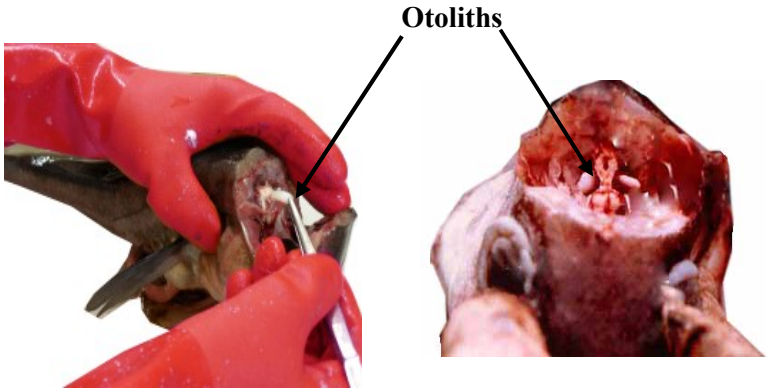

Figure 2. Removing sagittae otolith from a fish

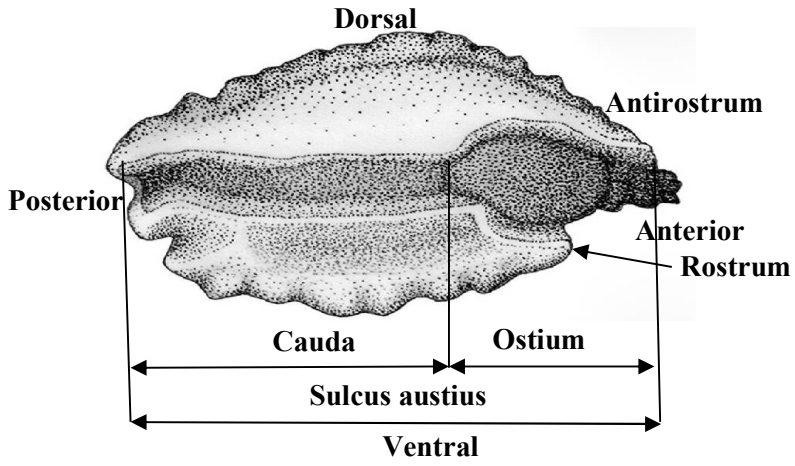

Figure 3. Illustrated glossary for sagittae otolith of fishes in the present study

Results

***Collia dussumieri* Valenciennes, 1848 (Local name- Nga-Kyan-Yat) figs. 4A, 5A, 6A**

Shape: pisiform. **Anterior region:** peaked. **Posterior region:** round. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum:** not developed. **Antirostrum:** developed. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** ostial; **morphology:** homosulcoid; **colliculum:** monomorphic; **ostium**: rectangular; **cauda:** rectangular.

***Cynoglossus Bengalensis* Hamilton, 1822 (Local name- Khway- Shar) figs. 4B, 5B, 6B**

Shape: triangular. **Anterior region:** flattened or irregular. **Posterior region:** flattended. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum and Antirostrum:** absent. **Sulcus acusticus: position:** Inframedian; **orientation:** descending; **opening:** mesial; **morphology:** homosulcoid; **colliculum:** homomorphic; **ostium**: tubular; **cauda:** tubular.

***Datnioides polota* Hamilton, 1822 (Local name- Nga- kyar- Ma) figs. 4C, 5C, 6C**

Shape: lanceolated or oval. **Anterior region:** irregular. **Posterior region:** peaked or blunt. **Dorsal edge:** crenated. **Ventral edge:** irregular. **Rostrum:**

developed. **Antirostrum:** absent. **Sulcus acusticus: position:** inframedian; **orientation:** ascending; **opening:** ostial; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: bent; **cauda:** tubular slightly curved.

***Glossogobius giuris* Hamilton, 1822 (Local name- Kat- Tha- Poe) figs. 4D, 5D, 6D**

Shape: rectangular or irregular. **Anterior region:** oblique or flattened, sinuated. **Posterior region:** rounded or sinuated. **Dorsal edge:** entire. **Ventral edge:** dentated. **Rostrum and Antirostrum:** absent. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** mesial; **morphology:** homosulcoid; **colliculum:** homomorphic; **ostium**: oval; **cauda:** oval.

***Gobioides bunchanani* Day, 1878 (Local name- Nga-Yet-Ni) figs. 4E, 5E, 6E**

Shape: squared or irregular. **Anterior region:** flattened or irregular. **Posterior region:** flattended. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum and Antirostrum:** absent. **Sulcus acusticus: position:** Inframedian; **orientation:** descending; **opening:** pseudo-ostiocaudal; **morphology:** heterosulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** tubular.

***Hilsa ilisha* Cuvier, 1836 (Local name- Nga-Tha-Lout) figs. 4F, 5F, 6F**

Shape: lanceolated. **Anterior region:** lanceolated and peaked. **Posterior region:** oblique-round. **Dorsal edge:** dentate. **Ventral edge:** entire. **Rostrum:** developed. **Antirostrum:** developed. **Sulcus acusticus: position:** median; **orientation:** horizontal, **opening:** ostial; **morphology:** pseudo-archaesulcoid, **colliculum:** heteromorphic; **ostium**: funnel-like; **cauda:** elliptic, oval.

***Harpadon neherus* Hamilton- Buchanan, 1822 (Local name- Nga-Hnet) figs. 4G, 5G, 6G**

Shape: pisiform. **Anterior region:** peaked. **Posterior region:** round. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum:** not developed. **Antirostrum:** developed. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** ostial; **morphology:** pseudo-archaesulcoid; **colliculum:** heteromorphic; **ostium**: tubular; **cauda:** funnel- like.

***Lepturacanthus savala* cuvier, 1829 (Local name- Nga-Ta-Khon) figs. 4H, 5H, 6H**

Shape: oval. **Anterior region:** flattened. **Posterior region:** lobe. **Dorsal edge:** entire. **Ventral edge:** irregular or entire. **Rostrum and Antirostrum:** absent. **Sulcus acusticus: position:** supramedian; **orientation:** horizontal; **opening:** pseudo- ostiocaudal; **morphology:** archaesulcoid; **colliculum:** monomorphic; **ostium**: funnel- like; **cauda:** tubular.

***Mugil cephalus* Linnaeus, 1758 (Local name- Kat- Bulu) figs. 4I, 5I, 6I**

Shape: lanceolated or rectangular. **Anterior region:** peaked. **Posterior region:** two peaks. **Dorsal edge:** dentate or crenate. **Ventral edge:** dentate or irregular. **Rostrum:** not developed. **Antirostrum:** developed. **Sulcus acusticus: position:** inframedian; **orientation:** ascending; **opening:** ostial; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: bent; **cauda:** straight tubular.

***Nibea soldado* Lacepedw, 1802 (Local name- Nga-Byat) figs. 4J, 5J, 6J**

Shape: rectangular. **Anterior region:** flattened. **Posterior region:** flattenrd. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum and Antirostrum are absent. Sulcus acusticus: position:** inframedian; **orientation:** descending; **opening:** pseudo- ostial; **morphology:** heterosulcoid; **colliculum:** heteromorphic; **ostium**: lateral; **cauda:** tubular markedly curved.

***Ompok bimaculatus* Bloch, 1794 (Local name- Nga-Nu-Than) figs. 4K, 5K, 6K**

Shape: Discoidal or seed- like. **Anterior region:** oblique. **Posterior region:** peaked. **Dorsal edge:** entire or serrated. **Ventral edge:** serrated. **Rostrum:** not developed. **Antirostrum:** not developed. **Sulcus acusticus: position:** Inframedian; **orientation:** descending; **opening:** ostial; **morphology:** pseudo-archaesulcoid; **colliculum:** heteromorphic; **ostium**: tubular; **cauda:** tubular.

***Osteobrama belangeri* Valenciennes, 1844 (Local name- Nga-Pyin-Ma) figs. 4L, 5L, 6L**

Shape: Discoidal or seed- like. **Anterior region:** irregular. **Posterior region:** round, serrated. **Dorsal edge:** serrated. **Ventral edge:** serrated. **Rostrum:** not developed. **Antirostrum:** not developed. **Sulcus acusticus: position:**

median; **orientation:** horizontal; **opening:** ostial; **morphology:** pseudo-archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** rectangular.

***Parambasis ranga* Hamilton, 1822 (Local name- Nga-zin-Set) figs. 4M, 5M, 6M**

Shape: rectangular. **Anterior region:** flattened. **Posterior region:** two peaks. **Dorsal edge:** entire. **Ventral edge:** crenated or entire. **Rostrum:** developed. **Antirostrum:** not developed. **Sulcus acusticus: position:** supramedian; **orientation:** descending; **opening:** ostial; **morphology:** pseudo-archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** tubular.

***Platycephalus indicus* Linnaeus, 1758 (Local name- Nga-Sin-Nin) figs. 4N, 5N, 6N**

Shape: oval or elongated. **Anterior region:** peaked. **Posterior region:** two peaks. **Dorsal edge:** entire. **Ventral edge:** dentated or entire. **Rostrum:** developed. **Antirostrum:** not developed. **Pseudo-rostrum and pseudo-antirostrum** present or not developed. **Sulcus acusticus: position:** supramedian; **orientation:** descending; **opening:** ostio- caudal; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** tubular.

***Puntius conchonius* Hamilton, 1822 (Local name- Nga- Khone-Ma) figs. 4O, 5O, 6O**

Shape: Discoidal or seed- like. **Anterior region:** peaked or blunt. **Posterior region:** peaked or rounded. **Dorsal edge:** serrated. **Ventral edge:** serrated. **Rostrum;** developed. **Antirostrum:** not developed. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** ostial; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** discoidal.

***Polynemus paradiseus* Linneus, 1758 (Local name- Nga-Pone-Nar) figs. 4P, 5P, 6P**

Shape: spindle- shape. **Anterior region:** lobed. **Posterior region:** lobed or sinuated. **Dorsal edge:** irregular. **Ventral edge:** entire. **Rostrum;** developed. **Antirostrum:** not developed. **Sulcus acusticus: position:** median;

orientation: descending; **opening:** ostial; **morphology:** pseudo-archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic or funnel- like; **cauda:** tubular.

***Salmophasia bacalia* Hamilton, 1822 (Local name- Nga- Dar- shay) figs. 4Q, 5Q, 6Q**

Shape: Elliptic. **Anterior region:** peaked. **Posterior region:** round. **Dorsal edge:** irregular. **Ventral edge:** serrated. **Rostrum:** developed. **Antirostrum:** absent or not developed. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** ostial; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: bent; **cauda:** tubular slightly curved.

***Setipinna taty* Valenciennes, 1848 (Local name- Nga-Byar) figs. 4R, 5R, 6R**

Shape: Pisiform. **Anterior region:** peaked or blunt. **Posterior region:** rounded. **Dorsal edge:** irregular. **Ventral edge:** serrated. **Rostrum;** developed. **Antirostrum:** absent or not developed. **Sulcus acusticus: position:** Inframedian; **orientation:** descending; **opening:** ostial; **morphology:** pseudo- archaesulcoid; **colliculum:** heteromorphic; **ostium**: elliptic; **cauda:** tubular.

***Taenioides gracilis* Valenciennes, 1837(Local name- Kar- att) figs. 4S, 5S, 6S**

Shape: squared or irregular. **Anterior region:** flattened. **Posterior region:** flattened. **Dorsal edge:** entire. **Ventral edge:** entire. **Rostrum and Antirostrum:** absent. **Sulcus acusticus: position:** median; **orientation:** horizontal; **opening:** mesial; **morphology:** homosulcoid; **colliculum:** homomorphic; **ostium**: oval; **cauda:** oval.

***Oreochromis aureus* (Local name- Tilapia) figs. 4T, 5T, 6T**

Shape: elliptic. **Anterior region:** peaked or blunt. **Posterior region:** rounded. **Dorsal edge:** irregular. **Ventral edge:** crenated. **Rostrum;** developed. **Antirostrum:** developed. **Sulcus acusticus: position:** supramedian; **orientation:** ascending; **opening:** ostial; **morphology:** heterosulcoid; **colliculum:** pseudo- archaesulcoid; **ostium**: rectangular; **cauda:** tubular slightly curved.

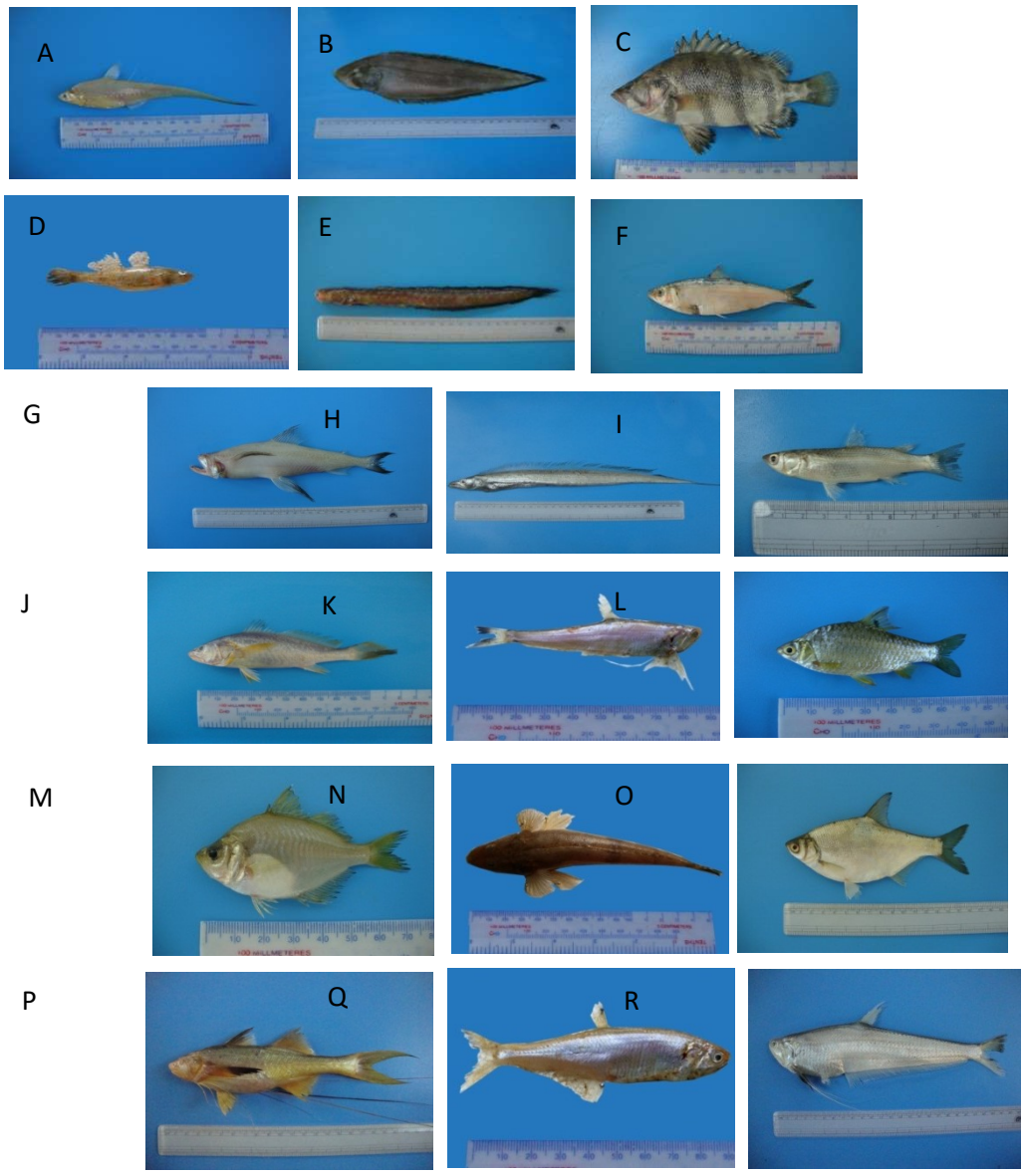

Figure 4. Habit photo of A) *Collia dussumieri,* B) *Cynoglossus Bengalensis,* C) *Datnioides polota,* D) *Glossogobius giuris,* E) *Gobioides bunchanani,* F) *Hilsa ilisha,* G) *Harpadon neherus,* H) *Lepturacanthus savala,* I) *Mugil cephalus,* J) *Nibea soldado,* K) *Ompok bimaculatus,* L) *Osteobrama belangeri*, M) *Parambasis ranga,* N) *Platycephalus indicus,* O) *Puntius conchonius,* P) *Polynemus paradiseus,* Q) *Salmophasia bacalia,*

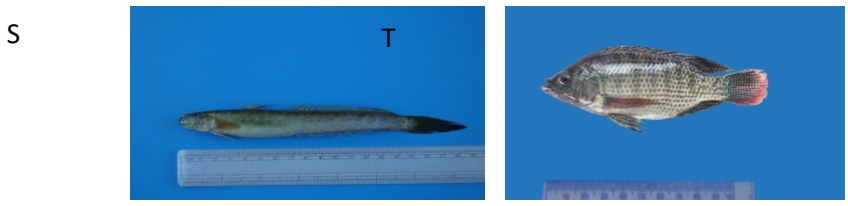

Figure 4. Habit photo of S) *Taenioides gracilis* and T) *Oreochromis aureu.*

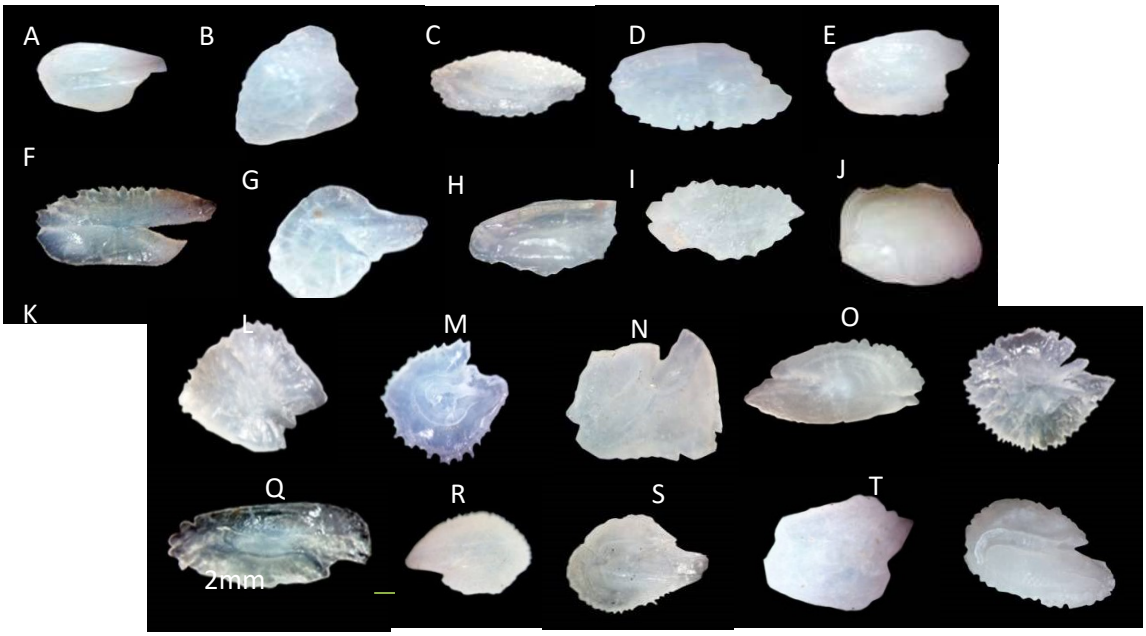

Figure 5. Otolith photo of A) *Collia dussumieri,* B) *Cynoglossus Bengalensis,* C) *Datnioides polota,* D) *Glossogobius giuris,* E) *Gobioides bunchanani,* F) *Hilsa ilisha,* G) *Harpadon neherus,* H) *Lepturacanthus savala,* I) *Mugil cephalus,* J) *Nibea soldado,* K) *Ompok bimaculatus,* L) *Osteobrama belangeri*, M) *Parambasis ranga,* N) *Platycephalus indicus,* O) *Puntius conchonius,* P) *Polynemus paradiseus,* Q) *Salmophasia bacalia,* R) *Setipinna taty,* S) *Taenioides gracilis* and T) *Oreochromis aureus* .

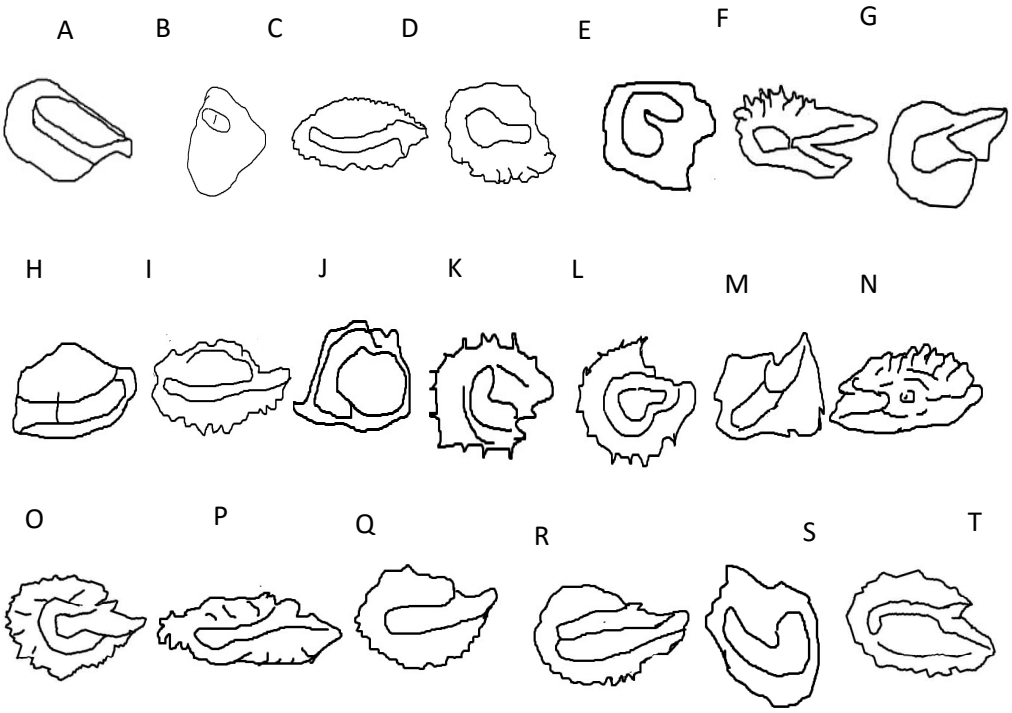

Figure 6. Otolith sketch of A) *Collia dussumieri,* B) *Cynoglossus Bengalensis,* C) *Datnioides polota,* D) *Glossogobius giuris,* E) *Gobioides bunchanani,* F) *Hilsa ilisha,* G) *Harpadon neherus,* H) *Lepturacanthus savala,* I) *Mugil cephalus,* J) *Nibea soldado,* K) *Ompok bimaculatus,* L) *Osteobrama belangeri*, M) *Parambasis ranga,* N) *Platycephalus indicus,* O) *Puntius conchonius,* P) *Polynemus paradiseus,* Q) *Salmophasia bacalia,* R) *Setipinna taty,* S) *Taenioides gracilis* and T) *Oreochromis aureus* .

Table 1. Showing the comparison of the otolith's characters among the different species

Species name	Shape	Sulcus acusticus				
		position	orientation	opening	ostium	cauda
Collia dussumieri	pisiform	median	horizontal	ostial	rectangular	rectangular
Cynoglossus Bengalensis	triangular	Inframedian	descending	mesial	tubular	tubular
Datnioides polota	lanceolated	inframedian	ascending	ostial	bent	tubular
Glossogobius giuris	rectangular	median	horizontal	mesial	oval	oval
Gobioides bunchanani	squared	Inframedian	descending	pseudo-ostiocaudal	elliptic	tubular
Hilsa ilisha	lanceolated	median	horizontal	ostial	funnel-like	oval
Harpadon neherus	pisiform	median	horizontal	ostial	tubular	funnel- like
Lepturacanthus savala	oval	supramedian	horizontal	pseudo-ostiocaudal	funnel- like	tubular
Mugil cephalus	lanceolated	inframedian	ascending	ostial	bent	straight tubular
Nibea soldado	rectangular	inframedian	descending	pseudo-ostial	lateral	tubular
Ompok bimaculatus	Discoidal	Inframedian	descending	ostial	tubular	tubular
Osteobrama belangeri	Discoidal	median	horizontal	ostial	elliptic	rectangular
Parambasis ranga	rectangular	supramedian	descending	ostial	elliptic	tubular
Platycephalus indicus	oval	supramedian	descending	ostio-caudal	elliptic	tubular
Puntius conchonius	Discoidal	median	horizontal	ostial	elliptic	discoidal
Polynemus paradiseus	spindle-shape	median	descending	ostial	funnel- like	tubular
Salmophasia bacalia	Elliptic	median	horizontal	ostial	bent	tubular
Setipinna taty	Pisiform	Inframedian	descending	ostial	elliptic	tubular
Taenioides gracilis	squared	median	horizontal	mesial	oval	oval
Oreochromis aureus	elliptic	supramedian	ascending	ostial	rectangular	tubular

Discussion

The total 20 species of fishes were selected to study their otoliths, prioring to the abundant species and different genera in Mawlamyine, Ahlet, Kadone- baw, Sebalar, kyaikkhami and Setse, along the mouth of Thanlwin River. The name of the species identified with their morphological characters are *Collia dussumieri, Cynoglossus Bengalensis, Datnioides polota, Glossogobius giuris, Gobioides bunchanani, Hilsa ilisha, Harpadon neherus, Lepturacanthus savala, Mugil cephalus, Nibea soldado, Ompok bimaculatus, Osteobrama belangeri*, *Parambasis ranga, Platycephalus indicus, Puntius conchonius, Polynemus paradiseus, Salmophasia bacalia, Setipinna taty, Taenioides gracilis* and *Oreochromis aureus*.

The result of this study showed that otoliths of pelagic fishes such as *Mugil cephalus*, *Harpadon neherus*, *Platycephalus indicus etc*. are smaller and thinner compared with otoliths of demersal fishes such as *Nibea soldado, Gobioides bunchanani, Cynoglossus Bengalensis*. According to Parmentier *et al*. 2001, fish occupying the same ecological niche show resemblances in otolith shape; pelagic fish species are known as fast swimmers and the shape of their otolirh could be an element contributing to making neurocranium lighter in order to reduce energy expenditure during swimming. On the contrary, in benthic, commensal and parasitic species, the swimming constraint is obviously weaker and does not act as a restricting factor on the otolith development. This is reinforced by their thicker otoliths. Furthermore otoliths of different species from a family can have similarities in appearance but they have enough differences to be distinguished from each other.

In the present study, the overall shape of otolith can be found pisiform shape in 3 species, triangular shape in 1 species, lanceolated shape in 3 species, rectangular shape in 3 species, squared shape in 2 species, oval or elliptic shape in 4 species, discoidal shape in 3 species and 1 species in spindle- shape. Of these 20 species studied, 15 species have rostrum and antirostrum while *Cynoglossus Bengalensis*, *Glossogobius giuris, Gobioides bunchanani*, *Lepturacanthus savala, Nibea soldado, Taenioides gracilis* are absent. Although otolith have rostrum in some fishes, antirostrum is absent or not developed. On the other hand, there is antirostrum in some fishes but rostrum is absent or undeveloped. Moreover sulcus austicus are also five types

of opening shapes in the study. They are ostial found in 13 species, ostiocaudal found in 1 species and pseudo- ostiocaudal found in 2 species, pseudo- ostial found in 1 species, mesial found in 3 species. Likewise there are six types of cauda shapes which are rectangular, elliptic or oval, bent, tubular, lateral and funnel- like and three types of ostium shapes which are tubular, elliptic and discoidal.

Conclusion

The present study was carried out by describing the detailed characters of otolith with their photos and sketchs based on the 20 species of fishes. The general otolith's shape are elliptic shape, squared shape, discoidal shape, rectangular shape, lanceolated shape, triangular shape, pisiform shape, spindle- shape. Moreover 15 species have rostrum and antirostrum while *Cynoglossus Bengalensis*, *Glossogobius giuris, Gobioides bunchanani*, *Lepturacanthus savala, Nibea soldado, Taenioides gracilis* are without rostrum and antirostrum.

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