Comparative Study on the Gill Morphology of *Hilsa Ilisha, Labeo Rohita* and *Clarias Batrachus* from Taungthaman Lake

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Abstract

Some morphometric and gills structure of three species of freshwater fishes, *Hilsa ilisha*, *labeo rohia* and *Clarias batrachus* from Taungthaman Lake were investigated. Gills of *Hilsa ilisha* and *Clarias batachus* are heterogeneous in nature, the length and number of filaments decreasing gradually from first to fourth gill arch. But in the *Labeo rohtia* the gills are homogenous and have almost the same number of filaments of same length on each gill arch. *Labeo rohita* had the largest number and size of gill filaments while the largest number of gill raker was recorded in *Hilsa ilisha*. *Hilsa ilisha* shows one of the characteristics of the plankton feeder, *Labeo rohita* include herbivorous fish. When compared with those of the plankton feeders and herbivores, gill filaments of *Clarias batrachus* are mores shorter and more stout therefore its possess the carnivorous fish character. In growth type, *Hilsa ilisha* was positive allometric and *Labeo rohita* and *Clarias batrachus* were negative allometric. The relationship between the fish dimension and gill dimension are show lowest to highest correlation coefficient and their values range from 0.05 to 0.97. The total filaments length of *Labeo rohita* and *Clarias batrachus* were significantly affected by it body weight. The morphometric and features of the gills of the 3 species were found to be dependent on the level of activity of the fish. *Hilsa ilisha* and *Labeo rohita* are more active swimmer and *Clarias batrachus* is more sluggish forms, occupying, benthic zones. Therefore, it is concluded that in this study, a clear relationship exist between the gill dimensions and presumed activity of the fish and also their habitat.

Keywords: heterogeneous, homogeneous, allometric,morphometric, benthic zones.

Introduction

Gills were the main sites of gas exchange in almost all fishes (Moyle and Cech, 1996). In addition to their respiratory function, the gills play an important role in the excretion of certain waste products and in the maintenance of the fish salt balance (Norman, 1963).

The gill dimensions and organization of gill arches and rakers reflect the feeding habits of the fish (Cited by Joseph Kayode Saliu and Olonire GT, 2997). A number of morphometric studies have been made of different components of gill sieve especially of Indian airbreathing fishes (Dubale 1951). Fish gill morphology correlates with metabolic demand and habitat (Gray, 1954). Despite the extreme diversity of fishes, noticeable similarities in respiratory structure occur in even distantly related species that inhabit similar environments or have comparable metabolic requirements. Reports on gills of fresh water fishes include Perry & wood (1985), Avella *et al* (1987), Perry & Laurent (1989), Brown (1992) and Goss *et al* (1992a, b, 1994).

Hilsa ilisha, *Labeo rohita* and *Clarias batrachus* are economic fresh water fishes. *Hilsa ilisha* is an anadromous migratory fish and feeds on plankton, mainly by filtering, but apparently also by grubbing on muddy bottoms. *Labeo rohita* is an important culture species in Taunghthaman Lake. It is a bottom feeder and prefers to feed on plant matter including decaying vegetation. *Clarias batrachus* (walking catfish) thrive in stagnant, frequently hypoxic waters and are often found in muddy ponds, canals, ditches and similar habitats. The species spends most of its time on, or right above, the bottom, with occasional trips to the surface to gulp air.

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The shape and structure of gill filaments and gill rakers reflect the respiration and feeding habit of a fish. These features may, to some extent, be of values in ichthyology.

The aim of the present study are;

- to compare the gill anatomy of 3 tropical freshwater fishes, *Hilsa ilisha*, *Labeo rohita* and *Clarias batrachus*.
- to conduct an investigation on the relationship between the fish dimension and gill dimension.

Materials and Methods

Study Area

The study site was Taungthaman Lake, located near Mandalay on the eastern bank of the Ayeyarwady River, Central Myanmar at 21º54´ N, 96º 03´E approximately. (Plate.1)

Plate.1. Map of Taungthaman Lake, Amarapura Township, Mandalay Division (Source from Google)

Study Period

The research work started from December 2015 to March 2016.

Identification of specimens

The identification used in the present work was according to Talwar and Jhingran (1991).

Gill Collections and Preparation

A total of 14 specimens were used in this study, They all were collected from Taungthaman Lake from December 2015 to March 2016. The fishes were collected 4 to 5 samples per species. The collection was conducted as random various sizes were to avoid the data bias.

For all specimens, standard length was measured and weights were estimated for conducting length–weight relationship. After taking the fresh weight of the fish, the opercula were removed and continuous flow of distilled water was passed over the gills in order to clear the mud. The gill arches of right side were dissected out carefully, separated and placed in dishes of freshwater; one arch to each disc. The number of filaments on each side of each arch was counted under a dissecting microscope. The average length of the filaments was determined by measuring every tenth filament. From this measurement the average length of the filaments was established. All the measurements were made under dissecting binocular microscope and an improved variety of camera sony.

Statistical Analysis

The relationship between the length (L) and weight (w) of fish was expressed by Pauly (1983):

$$W = aL^b$$ (Pauly, 1983)

Where

W = Weight of fish in (g)
L = Total Length (TL) of fish in (cm)
a = Constant (intercept)
b = The Length exponent (slope)

Regression analysis was conducted to correlate the length-weight relationship between the body of fish and gill parameters of the respective species using the formular as given by Bailey (1968):

$$Y = a + bX \qquad \text{(Bailey, 1968)}$$
$$a = \bar{Y} - b\bar{X}$$
$$r = \frac{\Sigma(X-\bar{X})\Sigma(Y-\bar{Y})}{\sqrt{\Sigma(X-\bar{X})^2\ \Sigma(Y-\bar{Y})^2}}$$

The calculation in is implemented with Excel and SPSS Statistics 19 versions.

Results

Comparative Morphology of Gill structure

Structure of gill in *Hilsa ilisha*

Five pairs of gills are present. In *Hilsa ilisha,* four pairs are normal gill type and a pair is pseudobranch (Plate.2). The pseudobranch is the reduced first gill arch of a fish. It is a small, gill-like structure and found on the inner side of the base of the gill cover. The gill filaments were present along on the convex border of each gill arch. The gill arch is 'Z' shaped and oriented in such a fashion that the gill lamellae of dorsal side moved away towards the auditory region and freely attached to the base of cranium by means of a membrane.The gill septum was moderately long and extended up to half the length of a primary lamella. The gill rakers were long and slender. The filaments on arch showed variation in their length at different regions of the gill arch.

Structure of gill in *Labeo rohita*

Four pairs of gills are present (Plate.3). Gills in *Labeo rohita* are homogenous structure with greater number of filaments than those of *Hilsa ilisha*. Each gill arch possesses two rows of gill rakers which are situated on the inner concave border. The outer convex border of each gill arch bears a double row of gill filaments. The gill arch is "crescent" shape. All gill arches are similar in their shape. The gill septum extended half way down the length of the filaments. Gill rakers are short and flat situated on both sides of the gill arch. Length of filaments on the side ends were shorter than middle parts and shape of filaments are flat.

Structure of gill in *Clarias batrachus*

Structure of gill in *Clarias batrachus* had four pairs of gill differ in their size and shape (plate.4). The gill filaments were present along on the convex border of each gill arch. The gill arch is '7' shaped. The gill size decreased gradually from first to fourth gill arch. All the arches bear gill rakers which lie on the inner concave border and gill filaments are present on the outer convex border. The gill septum was moderately long and extended up to half the length of a primary lamella. *C.batrachus* has two rows of gill rakers on each gill arch. The outer rows are developed, whereas the inner rows are reduced. The gill rakers are stuff and are well developed in the first gill arches of those species and become much reduced in the rest of the gill arches. The gill rakers are long and arranged on about one third of the length of arch. The number of filaments decreased from anterior to posterior and filament shape are long and thin.

Statistical Analysis

The total sample size was 14 fishes and comprised at the rate of 4 to 5 samples per species. Obvious differences existed in the morphometric and parameters of the gills amongst the three species (Table.1). *L.rohita* had the largest number of filaments amongst the three species while the largest number of gill rakers was recorded in *H. ilisha*.

The sample size, mean lengths and weight, length-weight relationships coefficient of determination (r) and growth type for three species are summarized in Table.2. In all species, the coefficient of correlation was also revealed to significant. The highly significant and good correlation r = 0.99 was found in *L.rohita*. (Figure.1)

Linear Regression

A linear regression model was used to determine the relation between the fish and gill dimensions. Results of regression analysis are given in Table.3 to 4.

Relationship conducted between the head length of fish and average gill filament length in three species revealed that, the coefficient of correlation value was established that r = 0.31 in *H.ilisha*, r =0.69 in *L.rohita* and r = 0.66 in *C.batrachus* respectively. Similarly, relationship conducted between the standard length of fish and total gill filament length in three species showed lowest significant, since the values were r = 0.37 in *H.ilisha*, r =0.64 in *L.rohita* and r = 0.38 in *C.batrachus* respectively (Table.3).

In all this studies, the relationship between the fish weight and gill dimensions (total filament length, total filament number and total gill raker number) always showed lower significant correlation. But among the recorded total filament length in *L.rohita* and *C.batrachus* were observed to bear the highest significant correlation as 0.97 and 0.93 respectively (Table.4 and Figure.2).

Discussion

The general morphology of gills in three species studied confirmed to the basic pattern of gills of bony fishes. Each gill arch is composed of two bones, the epibranchial and ceratobranchial bones. All the species studied possess these two bones. The length of these bones differs form one another in different species. The general morphology of gills in all the species are roughly similar in their structures. But there are some structural differences. In this study *H.ilisha* possess five pairs of gill arches and a pair pseudobranch, the rest of two species studied possess only four pairs of gill arches. Both *H. ilisha* and *L. rohita* have long “gill septum” and moderate in *C.batrachus*. In *H. ilisha*, the distal tipof the gill filaments are free from one another, but in *L. rohita* they unite with one another at their tips in blocks. The gill filaments of *C.batrachus* are fringe like on convex gill arch and size of gill filaments decreased from anterior to posterior. Gills of *H.ilisha* and *C.batachus* are heterogeneous in nature, the length and number of filaments decreasing gradually from first to fourth gill arch. But in the *L.rohtia* the gills are homogenous and have almost the same number of filaments of same length on each gill arch. The gill raker are long, slender and serrated in *H.ilisha* and short and flat leaf like structure in *L.rohita*, while in *C.batrachus* , the raker are long, thin and present on about one third of the gill arch. *L.rohita* has larger number and longer filament amongst the three species but the larger number and longer gill raker were recorded in *H.ilisha*. The extensive fill sieve apparatus in *H.ilisha* has developed as plankton filtration device. Plankton-feeder fishes are generally characterized with numerous and elongated rakers. These rakers carries numerous, fine spinules which are varied in shape. Rakers serve in straining water current entering pharyngeal cavity for seizing food items (Osama, 1995). In this study, *H.ilisha* fishes characterized from the rest of fishes with their gill rakers are also long, numerous and close-set. These rakers form a unique and effective sieve-like structure which serve in retaining of fine food items. It also shows one of the characteristics of the plankton feeder.

In general, gill rakers of herbivorous fishes is shorter than that of plankton-feeder fishes. They always carry numerous fine spinules. They serve as filter which prevent passing of matters attached to the marine plants and sea weeds, to the branchial chambers (Osama, 1995). In the present work, one species of *L.rohita* possess nearly same size of gills from the first gill to fourth gill. The filaments of gill are elongated and close –set and form a branchial fan but gill raker of *L.rohita* is shorter than that of *H.ilisha* and this include herbivorous fish.

It is noticed that, carnivorous fishes are characterized with their few and limited numbers of rakers which slightly varies among the same species. Rakers of the outer most row are well-developed and longer than that on the following row. All rakers are provided with fine spinules which may serve in seizing and preventing escape of smooth prey (Osama, 1995). According to the predescribed observations, it was noticed that carnivorous fishes, piscivorous, crustacean-feeder as well as fishes which feed on mixture of animal diet, are characterized by their limited number of rakers. This coincides with Suyehiro's observation (1942), during his instanding study of fishes of Japan Sea. In this study, the preceding case also coincides with the case of *C.batrachus*; carnivorous fish. When compared with those of the plankton feeders and herbivores, their gill filaments are mores shorter and the racker on this fish seem more stout.

Statistical Analysis

Length and Weight relationship of study fish

This study shows that all three study species possess positive allometric in *H.ilisha* and negative allometric in *L.rohita* and *C.batrachus*. This is because the coefficient b, differed significantly from the theoretical value of 3. The coefficient of correlation (r) of all species were strong correlation r = 0.94, 0.92 in *H.ilisha*, *C.batrachus* respectively and good correlation was found in r = 0.99 of *L.rohita*. Several authors have reported that both isometric and allometric growth for different fish species from various water bodies. King, 1991 reported allometric growth patterns for Tilapia species from Umuoseriche Lake. Length-weight relationships give information on growth patterns of fish.

In this study, the b values of three species were generally in agreement with growth type. Also, it is well known that the functional regression 'b' value represents the body form, and it is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and other factors, such as sex, age, fishing time and area and fishing vessels. (Felix *et al*, 2013).

Linear Regression of fish and gill dimensions

In statistical analysis, the total filaments length *L.rohita* and *C.batrachus* were significantly affected by it body weight. Again, the value of coefficient correlation r was intermediate correlation in *H. ilisha*. However, the study of three species were affected, though not significantly by standard length and head length. Results indicated that total filaments length was good correlated with the fish weight than other dimensions (standard length and head length).

According to Gray (1954), the more active species posses a higher respiratory metabolism, and, consequently, the size of their GRSA is greater as well. In general, it seems that more active fish have a larger number of filaments which are of a longer length, and the secondary lamellae are more closely packed (30-40 lamellae per mm filament), but are smaller in area than those of more sluggish fish (De Jager and Dekkers 1975).

The morphometric and features of the gills of the 3 species were found to be dependent on the level of activity of the fish. In this study, *H.ilisha* and *L.rohita* are more active swimmer. Due to this higher level of activity, it possesses larger number and size of filaments. *C.batrachus* is more sluggish forms, occupying, benthic zones due to this possesses small number and size of filaments. (Joseph and Olonire, 2007).

The results of this study concluded that the three study fishes, a clear relationship exist between the gill dimensions and presumed activity of the fish and also their habitat.

Table.1. Morphological parameter of fish and Gill dimensions of *Hilsa ilisha*, *Labeo rohita* and *Clarias batrachus* from Taungthaman Lake.

Species	Total body weight (g)	Standard length (mm)	Head length (mm)	Average length of filaments (mm)	Total length of filament/gill (mm)	Total number of filaments	Total number of gill rakers	Mean No. of filment/gill	Mean No. of gill rakers/gill
	Mean	Mean	Mean	Mean				Mean	Mean
Hilsa ilisha	203.5	22.025	5.8	6.86	826.78	1895	3313	118.4	207.1
Labeo rohita	410	26.2	6.64	10.82	2180.28	4801	1798	240.1	89.9
Clarias batrachus	263	35.3	7.56	4.57	291.7	1310	1359	65.5	67.95

Table .2. Descriptive statistics and estimated parameters of Length - Weight relationship of fish in the species studied.

Body of fish		Lengtn (cm)	Weight (g)	$W = a L^b$		Coefficient of correlation		Growth type
Species	N	Mean	Mean	a	b	r	b	
Hilsa ilisha	4	203.5	22.03	0.0015	3.81	0.94	b>3	Positive allometric
Labeo rohita	5	410	26.2	0.056	2.71	0.99	b<3	negative allometric
Clarias batrachus	5	263	35.3	4.6727	1.13	0.92	b<3	negative allometric

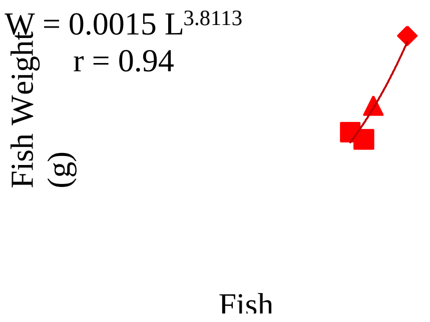
Table .3. Relationship between gill dimension and size of *Hilsa ilisha, Labeo rohita* and *Calrias batrachus* from Taungthaman Lake.

Species	Average filament length: Head length relationship		Total filament length: Standard length relationship		Gill raker & gill filament ration
	Regression equation	r	Regression equation	r	
Hilsa ilisha	y = 7.4427x + 75.27	0.31	y = 16.819x + 103.31	0.37	1 : 1.75
Labeo rohita	y = 69.742x - 223.04	0.69	y = 51.314x - 384.23	0.64	1 : 0.47
Clarias batrachus	y = 3.6844x + 37.646	0.66	y = 0.6108x + 240.44	0.38	1 : 1.3

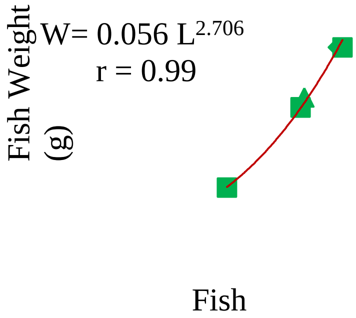
Table. 4. Results of regression analyses for measurements of gills and body weight for *Hilsa ilisha*, *Labeo rohita* and *Calris batrachus* from Taungthaman Lake.

Species		N	Regression equation	r
Hilsa ilisha	Total filament length (mm)	4	y = 2.2874x + 361.31	0.69
	Total filament number		y = 0.4383x - 4.1649	0.5
	Total gill raker number		y = 2.0056x + 420.1	0.35
Labeo rohita	Total filament length (mm)	5	y = 13.936x + 3007.3	0.97
	Total filament number		y = 1.5939x + 306.68	0.69
	Total gill raker number		y = 0.1811x + 285.37	0.72
Clarias batrachus	Total filament length (mm)	5	y = 2.2331x + 579.49	0.93
	Total filament number		y = 0.1235x + 229.51	0.62
	Total gill raker number		y = 0.058x + 256.55	0.05

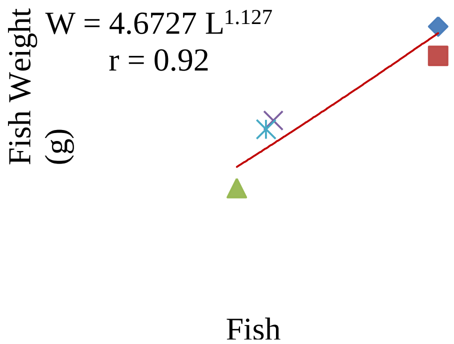
N = number of specimens r = correlation coefficients



(a)*Hilsa ilisha*

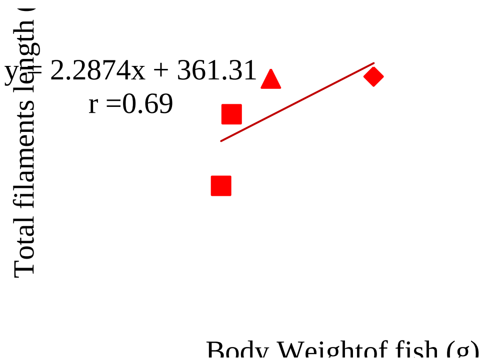


(b) *Labeo rohita*

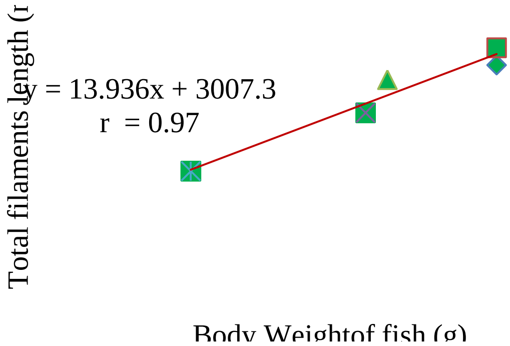


(c) *Claris batrachus*

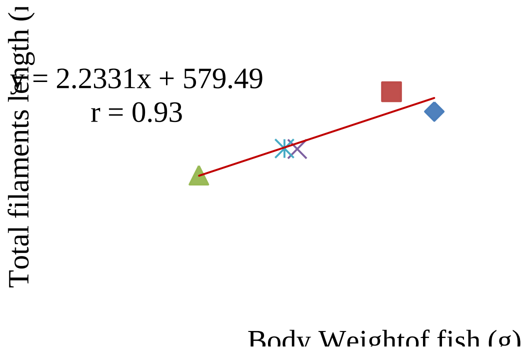
Figure .1. Compresion of fish length and weight relationship in *Hilsa ilisha*, *Labeo rohita* and *Claris batrachus* from Taungthaman Lake.



(a)*Hilsa ilisha*



(b) *Labeo rohita*



(c) *Claris batrachus*

Figure .2. Correlation between body weight of fish and total filaments length in three species.

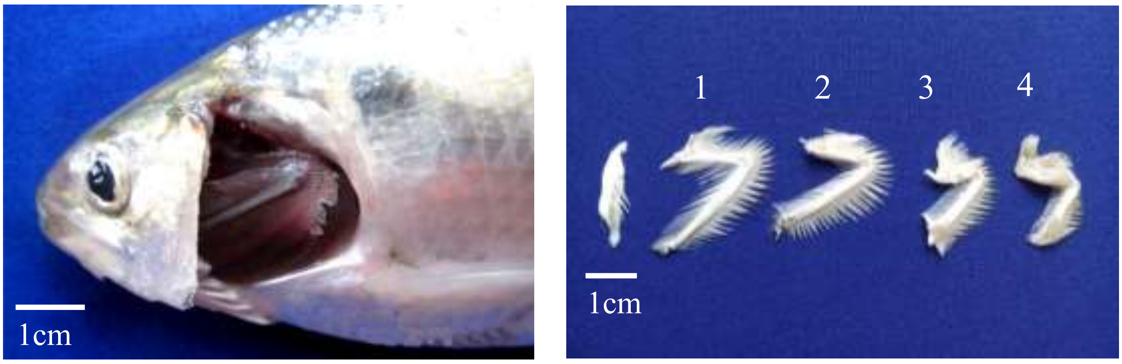


Plate.2.Position and Gill morphology of *Hilsa ilisha*

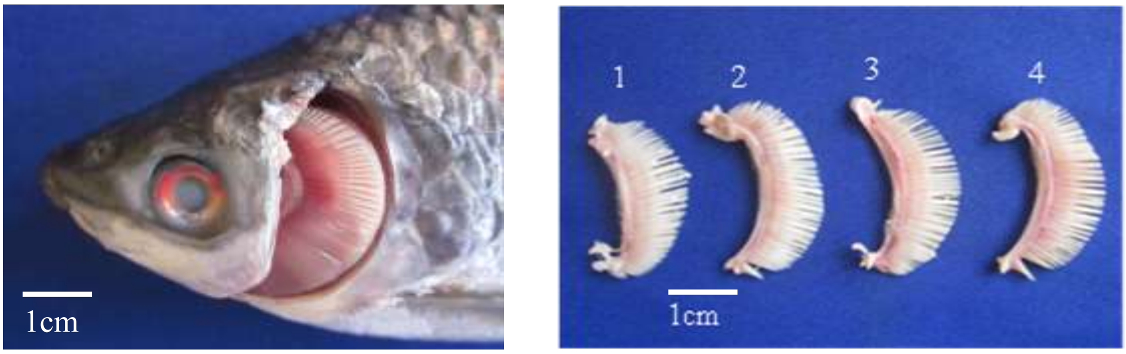


Plate.3. Position and Gill morphology of *Labeo rohita*

Plate.4. Position and Gill morphology of *Clarias batrachus*

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