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Linear Regression Relationships Between Different Scale Parameters and Body Size of *Labeorohita* (Family Cyprinidae) Collected from Baran Dam of Bannudistrict, Khyber Pakhtunkhuwa Province, Pakistan

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Abstract: The present study was based on the study of linear regression relationship between scale length and body size of *Labeorohita*inorder to observe the correlation between increases in whole body sizeand growth of scales in fish. The results of the presentinvestigation revealed that there were weak correlation ($r \leq 0.50$) occurbetween Body size (TL) and scale length(S L) and scale width (SW), however, moderate correlation (when $r > 0.50 < 0.70$) between scale length (SL) and Width (SW). Thus, the overall results of this study revealed that though correlation between whole body and scale growth was found to be positive but weak. While on the other hand, moderate type of correlation was found between increase in scale size and width.

Key words: *Labeorohita* · Scales · BaranDam

INTRODUCTION

Fish scales are dermally derived, specifically in the mesoderm. This fact distinguishes them from reptiles' scales pale ontologically. Generally, the same genes involved in tooth and hair development in mammals are also involved in the scales development [1]. True cosmoid scales can only be found on the extinct*crossopterygians*. The inner layer of the scale is made up of lamellar bone. On top of this lies a layer of spongy or vascular bone and then a layer of dentine-like material called cosmine. The upper surface is keratin. The *coelacanth* has modified cosmoid scales that lack cosmine and are thinner than true cosmoid scales.Ganoids scale can be found on gars (Family *Lepisosteidae*) and bichirs and reed fishes (Family *Polypteridae).* Ganoids scales are similar to cosmoid scales, but a layer of ganoid lies over the cosmine layer and under the enamel. Ganoid scales are diamond shaped, shiny and hard. Within the ganoine are guanine compounds, iridescent derivatives of guanine found in a DNA molecule. The iridescent properties of these chemicals provide the ganoine its shine [2]. Placoid scales are found on cartilaginous fish including sharks. These scales, also called denticles, are similar in structure to teeth and have one median spine and two lateral spines. Leptoidscales are found on higher orders of bony fish. They can be divided into two types such as, cycloid and ctenoid scales. Cycloid scales have a smooth adage and are most common on fish with soft fin rays, such as salmon and carps. Ctenoid scales have a tooth outer edge and are usually found on fish with spring fine rays, such as bass and crappie [3].

In *Labeorohita,* cycloid scales are present. Each scale has a focus which is a part of the scale that developed first during ontogenesis. The focus which lies in the anterior part of the scale, divides the scale into anterior or (cephalic to focus), posterior (caudal to focus) and lateral fields on the lateral sides of the scales few mucus pores are found in the focus region. From the focus lines of growth (the ridge) start opening called circuli. The space between circuli is called circuli space. In the anterior and lateral parts, the circuli are partitioned by deep and narrow groove that run radially towards the focus called radii. Radii categorized into three types primary, secondary and tertiary. The higher numbers of radii correlated to the better nutrition condition of fish. Radii represent the line of scale flexibility [4].

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Agassiz [5] was the first investigator who studied the scales in scientific manner. Here he makes use of the scale as basis for his classification of fishes into the placoid, ganoids, ctenoids the later including the clupeoids [5]. A main specific feature of scales in representative of the large taxa of bony fishes has been described in the paper of [6]. In his study, he described the various characters, such as scale length, breadth, different types and shapes of ctenii, different position of focus and types and shapes of radii in different families of fishes. He also studies the gray snapper (*Neomaelisgriseus*) mutton snapper (*Neomaenis*) of family *Lutjanidae*. He gives the arrangement of ctenii, radii and circuli on the scale of this two species (on page 160). Jenkins and Lachner studied the scale characters in American fish belong to genera *Nocomis*and*Hybosis*. They studied the relationship of the number of radii with increase in body length in the specimens of these two genera [7].

Fish scales are light weight flexible dermal armor. They characteristically overlap; besides protection, these imbrications can also provide flexibility so that the fish can flex their bodies in different ways (including bending and twisting) for predation, defense and mobility. Three parameters describe the geometrical characteristics of scales, aspect ratio[8]. Rohu (*Labeorohita*) is a species of fish of carp family, found in rivers in South Asia [9]. *Labeorohita* is popular in Thailand, Bangladesh, northern India and Pakistan. It is a non-oily white fish. It reaches a maximum length 2.0 mm and a weight of about 110kg [10]. The most important freshwater culturable fishes of Pakistan are the major Indian*carps* like Rohu (*Labeorohita*), Thaila (*Catlacatla*) and Mori (*Cirrhinusmrigala*). Someexotic species such as Gulform (*Cyprinuscarpio*), Grass carp (*Ctenopharyngodonidella*) and Silver carp (*Hypophthalmichthysmolitix)* are also introduced in Pakistan. In ourcountry, suitable or common combinations of fish for composite fish culture system are *Labeorohita*, *Catlacatla*and *Cirrhinusmrigala* whereas thespecific interactions among fish species are important in the sustenance of anypolyculture system and much research work has been done on the culture of these threefish species under different treatments [11, 12].

In Asia, on average, almost 30%of the total animal protein intake is derived from fish. Among the Southeast Asian countries, fish protein provides 45%of the total protein consumed [13]. Fish is a highly nutritious food, containing high amounts of protein with high biochemical value for humans. Fish is a principal source of animal protein for over half of the global population. The major *carps* like *Catlacatla, Labeorohita* and *Cirrhinusmrigala* are the most preferred farmed fish species in the Punjab (Pakistan), because of their fast growth and higher acceptability to the consumers [14]. *L. rohita* (Rohu) was selected for investigation in the present study due to its rapid growth, attainment of large size, quality of flesh and consumer preference. So due to the importance of the fish *Labeorohita*, the present study is designed to analyze the relationship between scale growth and increase in body size of *Labeorohita*in Baran Dam of district Bannu. Furthermore, present study will also be useful in observing some characters that later could be helpful in fish taxonomy, fisheries management and conservation.

MATERIALS AND METHODS

Sampling Collection: Cyprinid fish *Labeorohita* for study were collected during the period of November 2013 to January 2014 fromBaran Dam ofBannu. Total length (TL) in millimeter was measured from the tip snout (closed to mouth) to the caudal fin. The scales samples were taken from the following regions of the lateral line of specimen.Each specimen was identified up to the species level and at least 6 scales were collected and rest of the methods was followed byZubia and Rehana[15]. The following parameters were used for studying parameters such as

SL= Total length of scales,
SW= width of scales,
TL=Total length of body.

By using all these parameters, we can find out the different relationships between total length of fish and different scale parameters. The relationship between the all above mention parameters were calculated by linear regression equation as given byKhan and Siddiqui [16].

$$Y=a+bX$$

where Y =dependent variable (scale length/width/number of radii number of ctenii in horizontal or vertical rows). X = fish length (independent variable), a = constant/intercept b = regression slope.

Statistical Analysis: All data was measured and arranged in Table 1. Statistical analysis was performed by using Microsoft office excel Software. Scatter plot diagrams were plotted between different parameters, in order to shows the strength of correlation between two variablesas shown in Figures 1-3, respectively.

Table 1: Linear regression relationship between the body size and various parameters of scales in *Labeorohita* collected from Baran dam, District Bannu.

		Total length (TL) in mm			Scale parameters inmm			Regression Y=a+bX			
X	Y	Average	Min.	Max.	Average	Min.	Max.	a	b	r	CT
TL	SL	21.16	18.5	28.5	1.66	0.3	2.9	0.804	0.021	0.402	**
TL	SW	21.16	18.5	28.5	1.39	0.3	2	0.555	0.021	0.385	**
SL	SW	1.66	0.3	2.9	1.39	0.3	2	0.339	0.814	0.667	***

Footnotes: CT= correlation type, ** Represents weak correlation (r<0.50), *** Represents moderate correlation (r = 0.60-0.69). Where a=intercept; b= regression slope; r= correlation coefficient.

RESULTS AND DISCUSSIONS

In presentstudy, we have collected about 100 samples of *Labeorohita* from Baran Dam of Bannu during the period from March 2013 to February 2014 with size ranged from 18.5 to 67.5mm in total length (TL). We worked on selected parameters i.e.,total length (TL), scale length (SL) and (scale width) SW in order to find out the strength ofrelationships between the above mention parameters calculated by linear regression equation as given by Khan and Siddiqui [16].

Y=a+bX

where Y is dependent variable (scale length/width); X is independent variable (body size), a=constant/ intercept=regression slope.

Fig. 1: Lateral line cycloid scales of *Labeorohita*

Then we noted the correlation values r-values for all parameters as shown in Table 1, respectively. Figure 1 shows that there was weak correlation between total length vs scale length (TL vs SL). Figure 2 shows that there was weak correlation between total length vs scale width (TL vs SW). Figure 3 shows that there was moderate correlation between scale length vs scale width (SL vs SW).

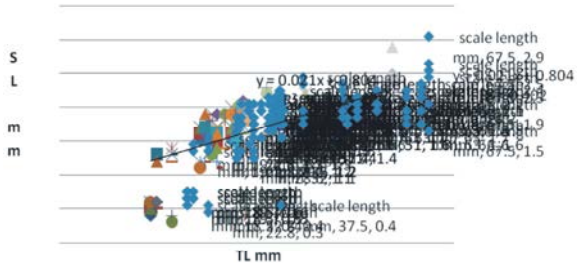

Fig. 1: Linear relationship between scale length (SL) and total length (TL).

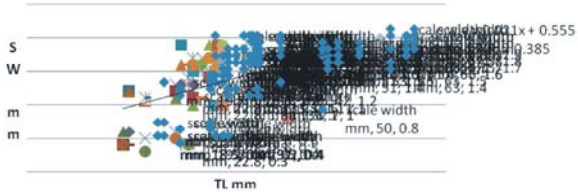

Fig. 2: Linear relationship between scale Width (SW) and total length (TL).

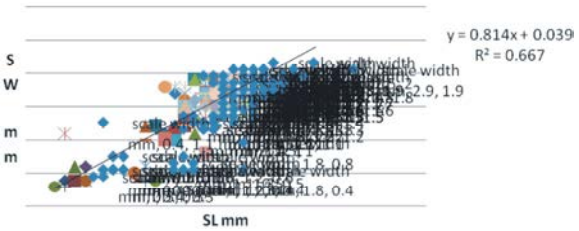

Fig. 3: Linear relationship between scale length (SL) and scale width (SW).

Ifr<0.50 then it exhibita weak correlation exist between two parameters. Whereas ifr = 0.60-0.69 then it is called moderate correlation, however, whenr>0.70 then it is called strong correlation. So from the overall results, it had been concluded that there was weak correlation (r<0.50) between TL vs. SL and TL vs. SW, while moderate type correlation (when r values ranged from 0.60 to 0.69) was observedbetween SL vs. SW, as shown in Table 1, respectively. Figures 1-3 revealed thatthe regression slope was increases which mean that correlationswerepositivebut found to be weak (r<0.50)

between body length vs. scale length and body lengthvs. scale width except the scale lengthsvs. scale width that show a moderate type of correlation ($r > 0.60<0.70$), which might be due to environmental changes including proper maintenance of food for growth, sufficient temperature and better salinity etc. While in contrast,weak correlation between total length vs. scale length (TL vs. SL) and total length vs. scale width (TL vs. SW) were found to be due to scarcity of food, insufficient temperature and unbalance salinity condition and some other negative changes in environment. Hence,in the present study, it was observed thatif scale size increases than scale width will also be increasing accordingly, therefore, it was concluded that the correlation between these two scale parameters was found to be much better as compare to the remaining other the correlations that exist between total length vs scale length and total length vs scale width, respectively.

Studies on age and growth of *Labeorohita* (Ham) obtained from a moat and rivers Ganga and Yamuna were made. The scales of fish possessed certain carved out grooves like rings which were proved to be annual in nature. The rings on the margins appeared only once a year, from March to July. The body length and scale length relationship was linear. The number of fishes decreased as the age increased. The growth rate of fish was very fast and rapid growth took place during first and second years of life, there after the growth rate decreased gradually. Ninety – three percent of the total growth was achieved by the end of 7th year of life. The fish attained the lengths of 310, 500, 650, 740, 800, 850,890, 920, 940 and 960 mm at the end of 1^{st,} 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th years of life, respectively [17].

Investigation into the relation of the length of the fish to size of its scale plays an important part in population studies of fishes. Since such the relationship seem to show a straight line regression, it has generally been accepted that the scale increases in size proportionally with the increase in length of fish. In fact it has frequently been suggested that in many fishes the "scale size-body length" relationship show a curvilinear character when throughout their lives. Furthermore, one might except that the relative growth rate of scale would vary according to season even within a year. The scale size plotted against a certain length of fish usually covers so wide rang that it is fairly difficult to discuss minute changes of the relative growth rate by scale size – body length analysis [18]. Length and weight of Indian major carps in relation to growth parameters have been studied by Jhingran [18]. Wide range of size of has been observed among fishes of same age or class. Cause of it may be, as suggested by Jhingran [18] that spawning of all the individuals of the population does not take place at one time and it may cover about one month to complete the spawning of all the fishes. Some fishes hatch earlier that the others and stand to gain a good start of life. It has also been reported by Brown that the size of the fish is the most important factor which affect the growth in population.

Significance:Most fish have scales, but not all. Scales affect the fish's life through their cost of manufacture, restrictions they impose on body movement and through the protection the supply. Larger and heavier scales supply more protection, but restrict movement, smaller, lighter scales offer less protection but allow for greater freedom of movement, thus in the common Eel, Anguilla, the scales are microscopic. The cyclostomes, Hagfishes and Lampreys have no scales at all. However the fossil evidences suggests that their distant ancestors did have some. The size and distribution of scales over a fish's body often, but not always, reflect the way it lives. Thus fish that swim quickly, or that live in fast flowing waters (Trout, Tunaetc.) tend to have small scales, while fish that swim slowly in slow moving waters tend to have larger scales, i.e. Carp.

From the results it is concluded that the studies can be valuable tool in investigating systematic relationship among the species of different genera or families of fishes using the meristic characters of fish scaleswas able to separate the various groups of fishes [6]. It is for the first time that the *Labeorohita* is being studied from this point of view in Pakistan. We are only just beginning to learn about the type of countable structures present on fish scales and their relationship with increase in total body length. Present studies stimulate further scale studies (both macro and micro present in fish scales) particularly those addressing ontogeny of scale characters. We hope that present study will make a significant contribution towards obtaining a better understanding of fish evolution.

CONCLUSION

Present study was based on the study of the different parameters of scale and their relationship with the growth of fish body. In this study, it had been concluded that the correlation between scale length vs scale width (SL vs SW) was found to be moderate ($r>0.60$). This might be due to the betterenvironmental condition of their habitatsuch as, favorable temperature and salinity andappropriate amount of food which are quiet necessary for their normal

growth. On the other hand, the correlations between total length vs scale length (TL vs SL) and total length vs scale width (TL vs SW) were found to be weak (r<0.50) and this may be due to the bad conditions oftheir habitat. Thus, the present result concluded that the first correlation scale length vs scale width (SL vs SW) was found to be stronger than the correlations between total length vs scale length and total length vs scale width (TL vs SL and TL vs SW). Thus,the present study not only valuable in fish biology, it could also be helpful in fish taxonomy, fisheries management and conservation. Therefore, it should be recommended that more research work should be required on some other microstructures of a fish scale as it had been proved that scale structure could also have great importance in fish identification and fish taxonomy and also the better indicators of the impact of their certain environmental factors.

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