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STUDIES ON THE RELATIONSHIPS BETWEEN STANDARD LENGTH AND WHOLE RETINA OF THREE FRESHWATER FISHES

RAVIKANT KUMAR SAURABH* AND KRISHAN NANDAN PD. SINGH[1]
Department of Zoology, Magadh University, Bodh Gaya - 824 234
[1]Department of Zoology, R. K. D. College, Patna - 800 020
E-mail: r.k.saurabh@ymail.com

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***Corresponding author**

ABSTRACT
A comparative evaluation between different standard length (SL) and whole retina (WR) in three fresh water air breathing fishes namely *A. cuchia*, *C. fasciatus* and *C. batrachus* was done. A negative allometric relationship between two parameters was established in *A. cuchia* and *C. fasciatus* but in *C. batrachus* a positive correlation was observed. However, after attains a critical point of growth, the growth of retina in C. *batrachus* was of retina stopped and thereafter differential growth in SL and WR of the fish were observed.

INTRODUCTION

The fishes are one of the largest and diversified groups of vertebrates. It shows tremendous diversity in its morphology, habitat and physiology. In fishes general sensitivity of vision is poorly developed though the teleosts are provided with an eye having well developed retina. Fishes have almost a flattened eye with six occulomotor muscles and exhibit the typical vertebrate plan with some variation in relation to its habitat. In fishes a very clear relationship exists between habitat, retinal structure, vascularisation of eye and behavior with retinomotor responses (Walls, 1963). The retina of fishes goes on growing throughout the life exhibiting some degree of correlation with its body length (John and Easter, 1974).

Many investigators have explored the features of structural details of retina in fishes. Maximova, (2005); Maximova *et al.*, (2005); Stocum, (2006) have explored the structure and physiology of vision of fishes. However, such studies in relation to Indian fishes in relation to their habitat are very scanty.

The present work has been undertaken to compare and correlate the size of the fish with its retina to assess the acuity of vision in fishes inhabiting different habitat.

MATERIALS AND METHODS

For the comparative study three fresh water air breathing fishes were selected as experimental animals. (Table 1)

Live specimen of these fishes were collected from their ponds around Patna (Bihar). The fishes were kept separately for 15 days in aquarium in the laboratory for acclimation.

After taking standard length of the three groups of fishes eyes were taken out and were fixed in Bouin's Smith fixative in a way that orientation of eye ball can be easily identified. The fixed eye balls were processed for block preparation and 5-8 μ paraffin section was cut. The serial sections were double stained by haemotoxylin and eosin as per the method suggested by Pantin (1962).

Name	Sys. Position	Habitat
Amphipnous cuchia (Ham-Buch)	Amphinoidae. Synbranchiformes	Mud, borrow
Colisa fasciatus (Bloch)	Perciformes Anabantoidei Belontidae	Muddy water
Clarias batrachus (Linn)	Siluriformes Claridae	Muddy water

The standard length and width of the whole retina of the three fishes were measured and the relationship between the two was statistically analyzed by the following methods

1. Karl Pearson's Coefficient of Correlation and its test of significance.

To study the distribution behaviour of various characteristics the following formula was used.

Pearson's $\chi^2 = \sum_{i=1}^{k} (Oi - Ei)^2 / I = 1, 2......................k$

Where,

O = observed frequency
E = expected frequency

The degree of freedom is (k-1) where, k being the number of classes in the distribution Table.

2. To study the correlation between different parameter of each variety of fishes, the following formula of Karl Pearson's was used.

$$r_{xy} = \frac{\text{Cov (x,y)}}{\text{SD of X x SD of Y}}$$

$$= \frac{(1/N)\Sigma XY - \quad \Sigma\overline{X}\overline{Y}}{\sqrt{\{(1/N\Sigma X^2 - \overline{X}^2\}} \quad X \quad \sqrt{\{1/N\Sigma X^2 - \overline{Y}^2\}}}$$

Where,

$\overline{X}$ = Mean of the variable representing the characteristic X.

$\overline{Y}$ = Mean of the variable representing the characteristic Y.

3. Test of linearity of regression.

The relation between two character of the fishes were subjected to Linearity test of Regression.

The following formula was used.

$$F = \frac{n^2 - r^2}{1 - n^2} X \frac{N-h}{h-2}$$

Where,

n = is the value of correlation determined by Bivariate table.

F = Distribution with degrees of freedom (h-z) and (N-h)

N = No. of fishes studies for the two variable.

Here, h is the number of array in bivariate Table of Y – axis and r = Pearson's 'r'

RESULTS

The standard length and thickness of whole retina of three fishes were taken and measured for correlation and have been presented in Table 2.

In case of *A. cuchia,* it was observed that as the standard length (SL) of fishes increases, the thickness of whole retina (WR) decreases. The values of SL and WR presented in Table 2, clearly indicates that a fish having a SL of 524.114mm have a thickness of WR of 0.183mm and fish having a SL of 644.08mm shows a thickness of WR of 1.698mm. Similarly, the percentage of SL/WR ratio also confirms that with the increase in SL, thickness of WR decreases proportionally. The value of 'r' calculated between these two parameters was -0.9228, which was significant at 1% thereby suggesting a significant correlation ship between these two parameters (Fig. 1)

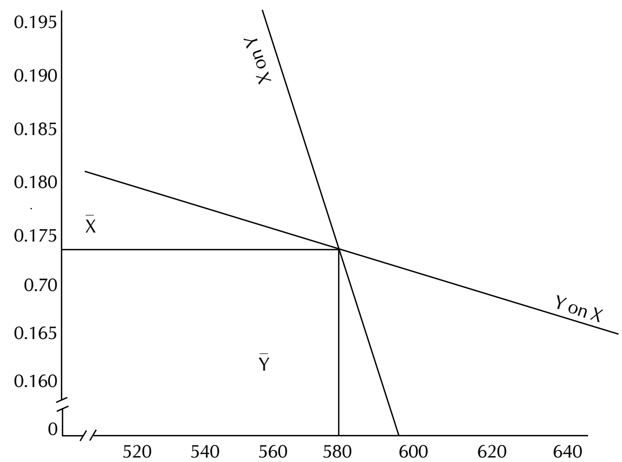

Figure 1: Regression line of X and Y valuees of *A. cuchia*

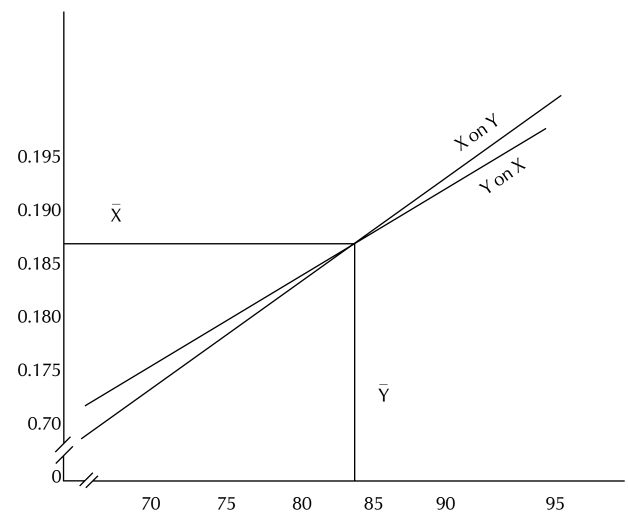

Figure 2: Regression line of X and Y valuees of *C. fasciatus*

Table 2: The standard length and thickness of whole retina of three fishes namely *A. cuchia, C. batrachus, C. fasciatus*

A. cuchia			*C. fasciatus*			*C. batrachus*		
SL in mm	WR in mm	SL/WR ratio in %	SL in mm	WR in mm	SL/WR ratio in %	SL in mm	WR in mm	SL/WR ratio in %
5243.142 ± 9.590	0.183 ± 0.004	0.0349	71.00 ±1.9849	0.1732 ±0.0042	0.244	112.74 ±3.129	0.118 ±0.002	0.105
553.5 ±7.483	0.1750 ±0.0068	0.0316	74.97 ±1.6091	0.1827 ±0.0011	0.244	122.39 ±3.109	0.125 ±0.003	0.111
584.6 ±9.208	0.1775 ±0.003	0.030	82.98 ±1.0545	0.1913 ±0.0039	0.231	132.77 ±3.607	0.135 ±0.003	0.102
617.8 ±9.569	0.1700 ±0.0028	0.028	85.87 ±1.4792	0.1899 ±0.005	0.221	145.03 ±3.060	0.146 ±0.002	0.101
6.44.08 ±7.466	0.1698 ±0.0083	0.026	92.15 ±1.4871	0.1888 ±0.0058	0.205	153.78 ±3.140	0.154 ±0.003	0.100

Table 3: Calculation of coefficient correlation between SL and WR of three fishes

Sl.No.	Name of fish	Name of characteristic	No. of fish examined	Value of 'Pearson' 'r'	Value of 't'	Inference
1	*A. cuchia*	SL vs WR	71	0.9228	19.8956	Highly significant
2	*C. fasciatus*	—do—	82	0.8553	11.0472	—do—
3	*C. batrachus*	—do—	100	0.91553	22.4960	—do—

Critical value of 't' at 1% p level -1.671 at 5% -2.00 at df 60 and above.

Table 4: Calculation of test of linearity of regression

Sl.No.	Name of fish	Name of characteristic	Value of 'r' Bivarate table	Value of 'r' 'Pearson' s formula	Value of 'F'	Inference
1	*A. cuchia*	SL vs WR	-0.93	-0.9228	1.2601	F not significant at 5% p level
2	*C. fasciatus*	—do—	0.79	0.77772	0.8005	do
3	*C. batrachus*	—do—	0.90	0.9153	2.7189	do

Critical value of 'F' at 5% p – leavel – 4.40 at df (h-2) (N-h)

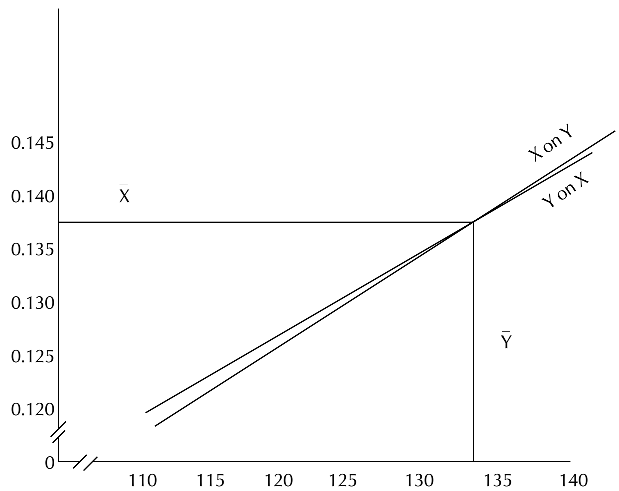

Figure 3: Regression line of X and Y values of C. *batrachus*

In case of *C. fasciatus* it was observed that when standard length of the fish increases an erratic variation in the size of whole retina was observed. The value of SL and WR presented in Table 2, clearly indicates that a fish having a SL of 71mm have a thickness of WR of 0.1732mm and a fish having a SL of 92.15mm shows a thickness of WR of 0.1888mm.In fishes having a SL of 82.98mm, the WR was of 0.1913mm. However, the SL / WR ratio clearly indicates an inverse relationship between the two parameters. The value of 'r' calculated between these two parameter was 0.7772, which was significant at 1% P – value, thereby suggesting that statistically a significant correlation ship between these two parameters do exists (Fig. 2).

However, in the case of *C. batrachus,* it was observed that with the increase in standard length of fish, the size of whole retina also proportionally increases. This shows that there is a proportional positive correlation ship between SL and WR in this fish. But on achieving a critical point of growth, the WR growth was checked, though the increase in SL of the fish continues unchecked. As such, after achieving the critical point of growth, the correlation ship between SL and WR becomes negatively proportional. The value of 'r' calculated between these two parameters was 0.9153, which was significant at 1% P – value (Fig. 3).

Statistical analysis

The statistical analysis employed to ascertain relationship between the standard length (SL) and thickness of whole retina (WR) clearly indicates that:

i. The pair of characteristics was highly correlated in the three fishes because the Coefficient of Correlation values obtained in the test of significance of all the three fishes were highly significant (Table 3)

Table 5: Calculation of regression line between the different independent characteristic of the three fishes

Name of fish	Name of characteristic	Regression
A. cuchia	SL vs WR	Y =0.2261 - 0.00009X
C. fasciatus	—do—	Y = 0.1218 + 0.0008X
C. batrachus	—do—	Y = 0.0171 + 0.0009X

Further to study the kind of relationship between the characters, test of linearty of regression was performed. The result clearly predicts that relation between the two characteristic were linear (Table 3,4 and 5). Thus. Further statistics shows that on the basis of statistical result the fishes were of different varieties.

DISCUSSION

The origin of vertebrate eye has been taken place in aquatic media and as such physical and chemical properties of media affect the structure and function of eyes. The first experimental fish of present project is *A. cuchia* which inhabits ponds with abundant growth of water hyacinth. It has also been found that these fishes often live in 'U' shaped burrows formed in soft mud of the pond (Das, 1946).

The second experimental fish was *C. fasciatus* which is amphibious in nature and lives in muddy water. Where as, the third experimental fish was *C. batrachus* also inhabits muddy water and amphibious in nature. Walls (1963) observed that eye in animal is intimately related to feeding habits and as such they place their eyes in intimate relation to the substrate.

The retina is the photo sensory part of the eyes which is directly concerned with the vision of animals. As such, photo sensory cells in fishes are responsible for acuity (sharpness) of the vision. In the present study *in A. cuchia* an irregular organization of rod and cones were observed while in *C. fasciatus* a regular square mosaic with a single cone in yhe centre of each square were found. However, in *C. batrachus* no mosaic patterns of cone distribution were found. According to wagner (1974) cone pattern may provide structural basis for fish resolution both spatially and temporarly. Whereas, Lyall (1957), was of the view that irregular mosaic occur in bottom dwelling and night active fishes. Regarding growth of retina it has been reported by John and Easter (1974), that in fishes it continued to grow throughout the life, as new retina is added in concentric rings. Lyall (1957) observed that large fishes have smaller eyes than small fishes and also found that retina of the fishes goes on growing throughout life. However, Ali and Hanyu (1963) reported that in Salmo salar, after a critical point, the retina ceases to grow in direct proportion to the increase in the length of the fish.

According to Greenwood (1966), the three fishes under consideration viz. *A. cuchia*, *C. fasciatus* and *C .batrachus* belong to the cohert enteleastia. To establish closeness among the three experimental fishes the statistical analysis done by

Mahalanobis distance test (Rao, 1952), result suggests that *C. batrachus* is closer to *A. cuchia* than *C. fasciatus*. They also suggested that *A. cuchia*. which lives in burrows, stands on the lowest level among the three fishes under consideration. The *C. batrachus*, a mud dweller, is next to *A. cuchia* while *C. fasciatus* being surface dwellers is at the top of the ladder. This conclusion is well supported with the functional anatomy of the eyes of the three fishes.

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