SCALE CHARACTERISTICS IN RELATION TO SIZE IN CICHLID FISH, *OREOCHROMIS MOSSAMBICUS*

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ABSTRACT

Teleostean scale characteristics like length, width, number of circuli, primary radii, secondary radii and ctenii were studied to delineate its relationship with total length in a euryhaline fish, *Oreochromis mossambicus* (Perciformes: Cichlidae). Statistical analysis proved a positive correlation between the scale characteristics and fish size. The characteristics of midlateral scales indicated that these scales appeared first during squamation chronology. Further observations also indicated that differences in salinity could modify the morphometrics of scales.

Keywords : Fish scale morphometrics, *Oreochromis mossambicus,* circuli, radii, ctenii

INTRODUCTION

The scales of modern teleosts have characteristic structures like circuli, radii and ctenii which are useful in the study of systematics. Further, scales are also used in age determination by counts of annual growth rings eventhough such counts may underestimate the age of fishes (Summerfelt and Hall, 1987; and Lippitsch, 1990). However, age and growth changes in fishes are reflected in the morphometrics and other scale characteristics. (Glenn and Mathias, 1985; Bigler, 1988; Prakasam and Pius, 1988 and Kaeriyama, 1989). Pius and Prakasam (2001) reported about the influence of the heavy metal content of the environment on fish scales. Namanpreet and Dua (2004) had studied the structural aspects like circulus of scales for species discrimination among various species like *Labeo calbasu, L. rohita, L. gonius and L. bata*. A literature survey, however, revealed that there is a paucity of detailed information on the scale characteristics like circuli, radii, and ctenii of common fishes found in varied aquatic habitats. Hence, the present study was undertaken on a locally abundant fish, *Oreochromis mossambicus* (Cichlidae) belonging to two distinct habitats of fresh and brackishwaters.

MATERIAL AND METHODS

Specimens of *Oreochromis mossambicus* of freshwater and brackishwater origin were studied by selecting half a dozen fishes belonging to each of the seven size groups *viz.* SI – 3.0 to 6.0 cm, S II – 6.1 to 9.0 cm, S III – 9.1 to 12.0 cm, S IV – 12.1 to 15.0 cm, SV – 15.1 to 18.0 cm, SVI – 18.1 to 21.0 cm and S VII –21.1 to 24.0 cm. Scales were collected from various body positions like head, operculum, dorsolateral, midlateral, ventrolateral and caudal peduncle. Five scales were observed from each body position. The description of terms on scale characteristics and methods adopted for scale observation were same as those of Prakasam and Pius (1988). Accordingly, scale length was measured in the anterior – posterior axis of scale while the width at right angles to the length, to the nearest 0.5 mm. Circuli number was counted along the middle region of the embedded portion of scales where it was at its maximum. The number of ctenii including weak ctenii was counted in the exposed portion of scales. The number of primary and secondary radii was counted separately. The data obtained was analysed statistically for calculating the correlation coefficient 'r' and linear regression equation Y = Y + b(x – x) where x = length of scales and Y = number of circuli. The differences in scale characteristics between freshwater and brackishwater *O. mossambicus* were analysed using student's 't' test.

RESULTS AND DISCUSSION

Data on the characteristics of scales from different body positions of the smallest and largest size groups (SI and SVII) of *O. mossambicus* is shown in Table 1 and 2.

The length and width of scales showed variations in different body positions (Table 1). The minimum length and width was noted in operculum whereas the maximum was in the midlateral scales. Earlier reports of Sire (1986), Bilton (1988) and Lippitsch (1990) have shown such variations in different body positions. Further, there was also an increase in scale length and width corresponding to increase in size of fish as also reported by Adelman (1987); and Kamonrat and Doyle (1989). However, the rate of increase was not the same in different body positions indicating a differential growth rate of scales.

A comparison of scale length and width between corresponding size groups of freshwater and brackishwater forms using 't' test showed that the rate of increase was higher in brackishwater *O. mossambicus* .

The circuli number was least in the opercular scales whereas it was highest in the midlateral scales (Table 2). There was also an increase in the number of circuli corresponding to increase in fish size in all body positions and hence it is a close reflection of increase in fish

Table 1 : Data showing the length of scales (mm), width of scales (mm) and the number of circuli in scales from various body regions of two size groups (S I and S VII of *Oreochromis mossambicus* from fresh and brackishwaters. Mean ± standard deviations are given. Comparison using student's 't' test. P<0.01 : * significant.

Body region	Habitat	Scale length (mm) in two size groups		Scale width (mm) in two size groups		Circuli number in two size groups	
		SI	S VII	SI	S VII	SI	S VII
1. Head	FW	1.0 ± 0.1	6.6 ±0.3	1.0 ± 0.1	7.5 ± 0.4	30.0 ±5.9	120.4 ±5.6
	BW	1.0. ± 0.0	6.7±0.2	1.0±0.1	7.3± 0.5	28.1±3.6*	121.6±3.8*
2. Operculum	FW	0.7 ± 0.3	6.6 ± 0.5	0.6 ± 0.2	6.6 ± 0.4	23.0 ± 4.9	113.0 ± 5.8
	BW	0.5 ± 0.1	6.9 ± 0.5	0.7 ± 0.2	6.8 ± 0.4*	18.8 ± 9.8*	104.4 ± 6.4*
3. Dorsolateral	FW	0.9 ± 0.2	6.7 ± 0.3	1.0 ± 0.2	8.5 ± 0.5	29.2 ± 6.5	139.1 ± 5.6
	BW	1.0 ± 0.3	6.9 ± 0.4*	0.9 ±0.3 *	8.4 ± 0.5*	26.3±6.1	139.8 ± 8.6*
4. Midlateral	FW	1.1 ± 0.2	7.3 ± 0.4	1.1 ± 0.2	9.4 ±0.6	38.6 ± 6.4	154.1 ±7.8
	BW	1.1 ± 0.2	7.6 ± 0.4*	1.1 ± 0.3	9.0 ± 0.6*	36.8 ± 6.6*	151.9 ± 8.2*
5. Ventrolateral	FW	0.9 ±0.1	6.3 0.6	0.9 ± 0.1	6.5 ± 0.9	27.5 ± 5.2	129.2 ±12.8
	BW	1.0 ± 0.3	6.3 ± 0.6	1.0 ± 0.0	6.6 ±0.8	27.8 ± 4.3*	126.5 ±13.7*
6. Caudal	FW	0.7 ± 0.2	6.0 ± 0.7	0.7 ± 0.2	6.7 ±0.6	32.1 ± 5.3	137.0 ± 3.6
	BW	0.7 ±0.2	6.5±0.3	0.7±0.2	6.9 ±0.5*	31.0 ± 4.5*	132.5 ± 3.7

FW = freshwater; BW = brackishwater.

Table 2 : Correlation coefficient and linear regression equation calculated between length of scales Vs. Circuli number and width of scales *vs.* circuli number in the various body regions of freshwater and brackishwater *Oreochromis mossambicus.*

	CORRELATION COEFFICIENT (R)				REGRESSION EQUATION			
	Scale Length *vs* Circuli No.		Scale Width *vs* Circuli No.		Scale length *vs* Circuli No.		Scale width *vs* Circuli No.	
Body Region	**FW**	**BW**	**FW**	**BW**	**FW**	**BW**	**FW**	**BW**
1. Head	0.9	0.9	0.9	0.9	Y = 21.9+13.9X	Y=24.3 + 15.9X	Y = 26.7 + 12.4X	Y=4.5 + 16.0X
2. Operculum	0.9	0.9	0.9	0.9	Y = 20.7+13.0X	Y=13.6 + 13.6X	Y = 20.3 + 13.0X	Y=11.6+ 13.6X
3. Dorsolateral	0.9	0.9	0.9	0.9	Y = 15.5+16.9X	Y=4.7 + 17.6X	Y = 21.3 + 13.7X	Y= 10.4 + 15.1X
4. Midlateral	0.9	0.9	0.9	0.9	Y = 26.2+17.0X	Y= 9.4 + 18.3X	Y =35.5 + 12.9 X	Y= 17.2 + 14.2X
5. Ventrolateral	0.9	0.9	0.9	0.9	Y = 20.3+15.7X	Y=10.9 + 16.6X	Y = 25.8+ 13.5X	Y=12.3+ 16.0X
6. Caudal	0.9	0.9	0.9	0.9	Y = 30.8+15.5X	Y= 13.5 + 16.8 X	Y = 26.8 + 14.8X	Y= 13.8 + 16.0X

X = length or width of scales Y = number of circuli; FW = freshwater, BW = brackishwater.

growth. Similar observations have been reported by Glenn and Mathias (1985), Kaeriyama (1989), and Pius and Prakasam (1999). Calculation of correlation coefficient 'r' between scale length and circuli number showed that these were positively correlated in both freshwater and brackishwater fish. Thus, based on this relationship, the total length of fish could be backcalculated, especially with the help of the derived regression equation. In tropical fishery management, this method would then prove advantageous over the conventional annulus counting method of age and growth determination.

Comparison of the data between freshwater and brackishwater forms of *O. mossambicus* showed that the rate of increase number of circuli between successive size groups was different. It is also noted that the circuli number was comparatively higher in freshwater fishes. Application of 't' test showed that the differences in circuli number between corresponding size groups of fresh and brackishwater forms was significant at $P < 0.10$ in many body positions.

Opercular scales had the least number of primary radii whereas the maximum number was in the midlateral scales. The number of secondary radii was lowest in the operculum and highest in the caudal or opercular scales (Table3). The study of relationship between length of fish and number of radii showed that the number of primary radii was positively correlated to fish length except in head of freshwater *O. mossambicus* and operculum of brackishwater *O. mossambicus* (Table 4). This positive correlation also enable backcalculation of fish length as previously proposed by Prakasam and Pius (1988). The number of secondary radii was positively correlated to fish length in head, operculum and dorsolateral scales whereas it was negatively correlated in midlateral, ventrolateral and caudal scales of both freshwater and brackishwater forms.

Application of Student's 't' test showed that the difference in the number of primary radii between corresponding size groups of freshwater and brackishwater forms was significant at $P < 0.10$ in various body positions. A similar significance was also observed in the case of the number of secondary radii .

In the head and opercular scales, ctenii were absent. The maximum number of ctenii was found in midlateral scales (Table 3). Thus, both cycloid and ctenoid scales were present in *O. mossambicus*. There was no increase in the number of ctenii corresponding to size increase of fish in either habitats. Computation of 't' test for number of ctenii between corresponding size groups of freshwater versus brackishwater forms showed that the difference was significant at $P < 0.10$ level in the midlateral and ventrolateral regions.

Table 3 : Data showing the number of primary radii secondary radii and ctenii in scales of various body regions in two size groups (SI and S VII of *Oreochromis mossambicus* from fresh and brackishwaters. Mean ± standard deviations are given. Comparison using student's 't' test P< 0.10: * significant.

Body region	Habitat	No. of Primary radii in two size groups		No. of Secondary Radii in two size groups		No. of Ctenii in two size groups	
		SI	S VII	SI	S VII	SI	S VII
1. Head	FW	0.0 ± 0.0	0.7 ± 1.4	0.3 ± 0.7	2.2 ± 1.7	0.0 ± 0.0	0.0 ± 0.0
	BW	0.0. ± 0.0	0.6 ± 1.4*	0.5 ± 0.7	2.7± 1.9*	0.0 ± 0.0	0.0 ± 0.0
2. Operculum	FW	0.0 ± 0.0	0.4 ± 0.6	0.0 ± 0.0	4.2 ± 2.2	0.0 ± 0.0	0.0 ± 0.0
	BW	0.0 ± 0.0	0.2 ± 0.5	0.0 ± 0.0	4.6 ± 2.3	0.0 ± 0.0	0.0 ± 0.0
3. Dorsolateral	FW	4.2 ± 1.9	10.8 ± 1.4	2.9 ± 1.6	2.7 ± 1.9	0.0 ± 0.0	1.4 ± 3.1
	BW	5.2 ± 0.6*	10.8 ± 1.6	2.9 ± 1.2*	2.9 ±1.9	0.0 ± 0.0	1.3 ± 3.1
4. Midlateral	FW	6.0 ±1.2	11.2 ± 0.8	3.0 ± 0.5	1.1 ±0.5	17.0 ± 7.6	25.3 ± 10.9
	BW	5.8 ± 0.6*	11.1 ± 1.3*	3.1 ± 0.7	1.3 ± 0.4*	16.2 ± 7.6*	7.9 ± 10.9*
5. Ventrolateral	FW	5.3 ±0.8	11.1 ± 0.9	2.8 ± 0.6	1.4 ± 0.4	2.6 ± 3.7	11.6 ±17.7
	BW	5.0 ± 0.6	10.0 ± 1.1*	2.4 ± 0.5	1.5 ± 0.5	4.3 ± 4.3	3.3 ±18.6*
6. Caudal	FW	5.3 ± 0.5	9.8 ± 0.9	3.4 ± 1.2	1.0 ± 1.1	0.0 ±0.0	10.0 ± 10.0
	BW	5.1 ± 0.5	10.0±0.8	3.7 ± 1.2	1.5 ± 1.4	0.0 ±0.0	2.7 ± 6.1

FW = freshwater; BW = brackishwater.

Table 4 : Correlation coefficient and linear regression equation calculated between total fish length *vs* number of primary radii and total fish length *vs* number of secondary radii in scales of various body regions in freshwater and brackishwater *Oreochromis mossambicus*

	CORRELATION COEFFICIENT (R)				REGRESSION EQUATION			
	Fish Length *vs* no. of primary radii.		Fish Length *vs* no. of secondary radii.		Fish length *vs* No. of primary radii		Fish length *vs* No. of secondary radii	
Body Regious	FW	BW	FW	BW	FW	BW	FW	BW
1. Head	-0.2	0.2	0.4	0.2	Y = 1.2 –0.5 X	Y= 0.1 – 0.02 X	Y = 2.6 + 0.1X	Y= 1.0 + 0.6 X
2. Operculum	0.3	-0.1	0.6	0.5	Y = 0.1+ 0.02 X	Y=0.7 + 0.02 X	Y =1.5 + 0.2X	Y=0.4+ 0.1X
3. Dorsolateral	0.8	0.8	0.02	0.08	Y = 3.9+ 0.3X	Y=4.6 + 0.3X	Y =2.8 + 0.0X	Y= 2.5 + 0.0X
4. Midlateral	0.7	0.7	-0.7	-0.5	Y = 6.1+0.2 X	Y= 4.9 + 0.3X	Y =4.2-0.1 X	Y= 3.4 – 0.0X
5. Ventrolateral	0.7	0.8	-0.6	-0.2	Y = 4.4+0.2X	Y=3.9 + 0.3X	Y =3.4 – 0.0X	Y=2.6 – 0.0X
6. Caudal	0.6	0.8	-0.6	-0.3	Y = 5.3+0.2 X	Y=4.6 + 0.2 X	Y =4.0 – 0.1X	Y= 2.9– 0.0X

X = fish length. Y= number of primary radii or secondary radii; FW = freshwater, BW = brackishwater.

As the largest scale in the body would show the maximum development in all the metric and meristic characteristics, it was suggested by Bilton (1988) that such scales would give the most suitable record of age and growth of fish and for identification as 'typical' or 'preferred' scale. On this ground, it may be inferred that the midlateral scales are the first laid scales in *O. mossambicus* during squamation development similar to many other fishes (Bilton, 1988; and Pius and Prakasam, 1999). Also, the midlateral scales which are initially cycloid get transformed into ctenoids whereas other scales remained as cycloid during the course of development.

It was also interesting to observe that the variations in the metric and meristic features of scales from freshwater and brackishwater fishes are obvious indications of their gradual isolation and evolution into distinct stocks under the influence of salinity differences.

REFERENCES

Adelman, I.R., 1987. Uptake of radioactive amino acids as indices of current growth rate of fish. *In: The Age and Growth of Fish.* pp 65-79. R. C. Summerfelt and G. E. Hall (Ed.) Iowa State Univ. Press. Ames. IA 50010.

Bigler, B., 1988. Focal scale damage among Chum Salmon *Oncorhynchus keta* of Hokkaido, Japan. *Can. J. Fish. Aqat. Sci.*, **45 A**: 698 – 704.

Bilton, H.T., 1988. The body area and size that Chinook, Coho and Chum Salmon fry first form their scales. *Can. Tech. Rep. Fish. Aquat. Sci.*, **1632**: p 17.

Glenn, C.L. and Mathias, J.A., 1985. Circuli development on body scales of young pond reared walleye *(Stizostedion vitreum). Can. J. Zool.,* **63**: 912 – 915.

Kaeriyama, M., 1989. Comparative morphology and scale formation in four species of *Oncorhynchus* during early life. *Jap. J. of Ichthyology.,* **35** (4): 445 - 452.

Kamonrat, W. and Doyle, R.W., 1989. Genetic variation of scale circulus spacing in *Tilapia. In:* R. S. V. Pullin, T. Bhukasan, K. Tonguthai and J. L. Mc Lean (Ed.). *Proc. II Int. Symp.,* Dep. of Fish., Bangkok, Thailand.

Lippitsch, E., 1990. Scale morphology and squamation patterns in Cichlids (Teleostei; Perciformes): A comparative study. *J. Fish. Biol.*, **37**: 265 – 291.

Namanpreet, K. and Dua, A., 2004.

Species specificity as evidenced by Scanning Electron Microscopy of fish scales. *Curr. Sci.,* **875**: 692-696.

Park, E. and Lee, S., 1988. Scale growth and squamation chronology for the laboratory reared hermaphrodite Fish, *Rivulus marmoratus* (Cyprinodontidae). *Jap. J. Ichthyology*. **34**: 476 – 482.

Pius, J. and Prakasam, V.R., 1999. Metric and meristic characteristics of scales of euryhaline fish, *E. suratensis. J. Mar. Biol. Ass. India.,* **41** (1&2) : 56-61.

Pius, J. and Prakasam, V.R., 2001. Composition, squamation chronology and regeneration of the elasmoid scales of *Oreochromis mossambicus* (Perciformes). *Indian J. Anim. Sci.,* **71**(3) : 290 – 296.

Prakasam, V.R. and Pius, J., 1988. Scale morphology of three teleosts (*Etroplus suratensis, Anabas testudineus, Sardinella longiceps*) with reference to function. *Indian J. Fish.,* **35** (3): 221 – 225.

Sire, J.Y., 1986. Ontogenetic development of surface ornamentation in the scales of *Hemichromis bimaculatus* (Cichlidae). *J. Fish. Biol.,* **28:** 713-724.

Summerfelt, R.C. and Hall, G. E., 1987. *Age and Growth of Fish.* Iowa State Univ. Press Ames., IA 50010.