J. mar. biol. Ass. India, 1999, 41 (1 & 2) : 56 – 61

METRIC AND MERISTIC CHARACTERISTICS OF SCALES OF EURYHALINE FISH, *ETROPLUS SURATENSIS*

JOHNSON PIUS AND V. R. PRAKASAM
Department of Zoology, F.M.N. College, Kollam-691 001, Kerala

ABSTRACT

The morphology of the scales of euryhaline fish, *Etroplus suratensis* (Perciformes; Cichlidae) was studied to evaluate the relationship between scale characteristics like length, width, number of circuli, primary and secondary radii, cteni, and size of fish. Statistical analysis of the data indicated a positive correlation between fish size and scale characteristics. A differential growth was also noticed in the scales from different body positions. Of the various scales examined from body regions like head, operculum, dorsolateral, midlateral, ventrolateral and caudal peduncle, the midlateral scales appeared to be the first formed ones showing many typical scale characteristics. A comparison of the scales of the fish occupying fresh and brackishwater habitats demonstrated that salinity might bring about changes in scale characteristics.

INTRODUCTION

TELEOSTEAN scales, based on their characteristics like circuli, radii, ctenii, granulations and tubulations, are widely used in ichthyological research, as they can generate a lot of information relating to taxonomy and systematics (Sire, 1986; Seshappa, 1985; and Coburn and Gaglione, 1992). The importance of specific scale structures in relation to age and growth of fishes has also been demonstrated (Senk and Kaludjevic, 1963; Glenn and Mathias, 1985; Bigler, 1988; Prakasam and Johnson, 1988; Kaeriyama, 1989; and Lippitsch, 1990). A perusal of the literature showed that there was no uniformity in the definition of scale characteristics. As for example, the scale size had been measured based on the scale length, scale width and scale radius. Another was that the primary (complete) or secondary (incomplete) radii had been considered together. Further, the habitat parameters of the fish seemed to be ignored for scale characterization. In addition the metrics and the meristics of fish scales in relation to size of fish had not been taken into account. Therefore, an extensive study was undertaken using a locally abundant Cichlid euryhaline species, *Etroplus suratensis* from two distinct habitats of fresh and brackish waters.

MATERIAL AND METHODS

Specimens of *Etroplus suratensis* (pearl spot) of freshwater and brackishwater origin from Sasthamcotta freshwater lake and Ashtamudi brackishwater lake (Kollam district, Kerala) respectively, were studied using size groups SI-3.0 to 6.0 cm, SII-6.1 to 9.0 cm, SIII-9.1 to 12.0 cm, SIV-12.1 to 15.0 cm, SV-15.1 to 18.0 cm and SVI-18.1 to 21.0 cm. Six fishes belonging to each size group were used in the study. Scales were removed from different body regions like head, operculum, dorsolateral, midlateral, ventrolateral and caudal peduncle. From each body region 5 scales were observed. The description of terms of scale surface features and the procedure adopted for scale observation were those of Prakasham and

Johnson (1988). Among the metric parameters, scale length was measured in the anterior-posterior axis of scale while the width at right angles to the length, to a nearest of 0.5 mm. The meristic parameters taken for study included number of circuli, radii and ctenii. Circulus number was counted along the middle region of embedded portion of scales where it was at its maximum. The number of primary and secondary radii was counted separately. The data obtained were analysed statistically applying coefficient of correlation 'r' and linear regression equation $\hat{Y} = \overline{Y} + b(X - \overline{X})$ where X = length of scales and Y = number of circuli. The number of ctenii including ciliated spines was counted in the exposed portion of scales. The differences in the metric and meristic characteristics between the corresponding size groups of freshwater fishes versus brackishwater fishes of *E. surtensis* were analysed using student's 't' test.

RESULTS

Table 1 and 2 show the metric and meristic characteristics of scales from different body positions for the smallest and largest size groups (SI and SVI) of fishes. The data of the other size groups (SII, SIII, SIV, SV) are excluded from the tables since they exhibited a linear increasing trend corresponding to the increase in size of the fish.

Scale length and width

It may be noted that scales from different body positions were of various length and width. The minimum length and width of scales was observed in the operculum whereas the maximum length and width in the midlateral scales. Further, the length and width of scales increased corresponding to increase in size of fish but the rate of increase was not identical in different body positions. This indicated a differential growth rate in the length and width of scales. A comparison of scale length and width between corresponding size groups of freshwater and brackishwater forms showed that the ratio of increase was higher in freshwater *E. suratensis*. Student's 't' test showed that the difference was significant ($P < 0.10$) in many size groups as shown in Table 1.

Number of circuli

An increase in the number of circuli corresponding to increase in fish size was evident in scales from all the body positions. It was also seen that the opercular scales had the minimum number of circuli whereas the maximum was recorded in the midlateral scales. Calculations of correlation coefficient 'r' between scale length and circuli number showed that these were positively correlated (Table 2) in both freshwater and brackishwater fish.

A comparison of data between freshwater and brackishwater forms, showed that there were differences in the rate of increase of circuli number between successive size groups. It was also found that the number of circuli was less in scales of brackishwater than freshwater forms. Computation of 't' test showed that the difference in circuli number between corresponding size groups of freshwater and brackishwater was significant at $P < 0.10$ in different body positions.

Number of radii

The operculum and head had comparatively less number of primary radii whereas the maximum was on the midlateral scales. The number of secondary radii was minimum on the caudal scales and maximum on the midlateral scales.

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 (SI & SVI) of* Etroplus suratensis *from fresh and brackishwaters. Mean ± standard deviations are given; comparision using student's 't' test p < 0.10 : * significant. Fw=Freshwater; Bw=Brackishwater.*

Body regions	Habitat	Scale Length (mm) in two size groups		Scale width (mm) in two size groups		Circuli number in two size groups	
		SI	SVI	SI	SVI	SI	SVI
1. Head	FW	2.0 ± 0.5	7.1 ± 0.6	1.9 ± 0.1	7.6 ± 0.4	54.0 ± 1.4	181.4 ± 15.0
	BW	1.3 ± 0.2*	6.3 ± 0.3*	1.5 ± 0.4*	6.7 ± 0.4*	38.3 ± 6.9	170.2 ± 3.9*
2. Operculum	FW	1.7 ± 0.2	5.1 ± 0.6	1.6 ± 0.2	5.2 ± 0.7	58.8 ± 2.1	139.4 ± 13.7
	BW	1.1 ± 0.2*	5.0 ± 0.9	1.1 ± 0.2*	4.7 ± 0.3	31.2 ± 5.4*	114.4 ± 8.5*
3. Dorsolateral	FW	2.1 ± 0.3	6.5 ± 0.4	1.8 ± 0.2	7.6 ± 0.3	57.4 ± 1.7	212.6 ± 19.6
	BW	1.4 ± 0.3*	6.6 ± 0.2	1.4 ± 0.3	7.2 ± 0.4	47.5 ± 2.8	196.3 ± 17.1
4. Midlateral	FW	2.2 ± 0.5	7.1 ± 0.2	1.9 ± 0.1	7.4 ± 0.3	62.3 ± 3.7	249.1 ± 20.8
	BW	1.6 ± 0.2	7.3 ± 0.4	1.6 ± 0.4	7.7 ± 0.4	60.1 ± 14.7	225.8 ± 14.6
5. Ventrolateral	FW	1.9 ± 0.5	6.9 ± 0.1	1.7 ± 0.2	6.6 ± 0.4	55.0 ± 3.7	216.9 ± 22.4
	BW	1.5 ± 0.5	6.9 ± 0.1	1.5 ± 0.5	6.7 ± 0.2	47.6 ± 7.2	186.7 ± 31.6
6. Caudal	FW	1.6 ± 0.3	5.7 ± 0.9	1.5 ± 0.0	6.0 ± 0.6	50.6 ± 2.6	215.8 ± 33.1
	BW	1.2 ± 0.2*	5.8 ± 0.2	1.2 ± 0.2*	6.3 ± 0.4	50.8 ± 11.7*	195.6 ± 3.1*

TABLE 2. *Correlation coefficient and linear regression equation calculated between length of scales vs. circuli number; and width of scales and circuli number in the various body regions of freshwater and brackishwater* Etroplus suratensis. *X = length or width of scales Y = number of circul; Fw = Freshwater; Bw = Brackishwater*

Body Regions	Scale length vs. Circuli no.		Scale width vs. circuli no.					
	FW	BW	FW	BW	FW	BW	FW	FW
1. Head	0.85	0.95	0.87	0.97	$\hat{Y} = 11.74 + 23.7X$	$\hat{Y} = 5.2 + 26.7x$	$\hat{Y} = 14.3 + 21.3X$	$\hat{Y} = 5.2 + 23.7X$
2. Operculum	0.85	0.81	0.81	0.83	$\hat{Y} = 14.3 + 24.7X$	$\hat{Y} = 8.5 + 21.2X$	$\hat{Y} = 35.4 + 17.1X$	$\hat{Y} = 3.0 + 23.3X$
3. Dorsolateral	0.95	0.75	0.96	0.74	$\hat{Y} = -3.3 + 33.11X$	$\hat{Y} = 2.2 + 31.1X$	$\hat{Y} = 11.9 + 26.2X$	$\hat{Y} = 10.0 + 26.0X$
4. Midlateral	0.91	0.95	0.91	0.92	$\hat{Y} = -3.6 + 35.9X$	$\hat{Y} = 3.7 + 30.2X$	$\hat{Y} = 3.6 + 32.3X$	$\hat{Y} = 13.8 + 27.4X$
5. Ventrolateral	0.92	0.92	0.94	0.90	$\hat{Y} = 8.3 + 31.8X$	$\hat{Y} = 21.2 + 25.6X$	$\hat{Y} = -0.3 + 33.9X$	$\hat{Y} = 30.3 + 23.4X$
6. Caudal	0.92	0.90	0.93	0.91	$\hat{Y} = 5.0 + 37.4X$	$\hat{Y} = 2.8 + 35.2X$	$\hat{Y} = 2.4 + 34.8X$	$\hat{Y} = 14.7 + 29.4X$

The study of relationship between length of fish and number of radii showed that primary radii number was positively correlated to fish length except in operculum (Table 4) in freshwater *E. suratensis* whereas in brackishwater species there was positive correlation in all body regions. The number of secondary radii in freshwater form was positively correlated with fish length in the operculum alone and negatively correlated in other body regions. In brackishwater species there was negative correlation in all body regions.

The significance of the differences in the number of primary radii between corresponding size groups of freshwater versus brackiswater forms was tested using student's 't' test. A significance at $p < 0.10$ level in various body positions was clear. Similarly, the difference in the number of secondary radii between corresponding size groups of freshwater versus brackishwater forms was also significant at $p < 0.10$ level in many body positions and size groups (Table 3).

Ctenii in scales

Ctenii were absent in the head and opercular regions (Table 3). Maximum number of ctenii were found in scales of midlateral region. Thus in this fish both cycloid and ctenoid scales were present. Ctenoid scales were distributed on the lateral sides of the body. Many ctenii on the margin of scales were very weak or ciliated especially in fishes of small size groups. The number of ctenii showed no increase in number corresponding to size increase in both freshwater and brackishwater *E. suratensis*. Calculation of Student's 't' test between number of ctenii of corresponding size groups of fresh and brackishwater species showed a significant difference at $p < 0.10$, the number of ctenii being higher in freshwater form.

DISCUSSION

In accordance with the reports that scales of different body regions show variations in size (Sire, 1986; Bilton, 1988; and Lippitsch, 1990), the present study showed that length and width of scales varied in different body positions, indicating a differential growth of scales. (Yang, 1971; Bilton, 1988; Lippitsch, 1990 and Johnson and Prakasam, 1993). The increase in length and width of scales was also closely associated with increase in size of fish similar to the observations made in various fishes by Witkowski *et al.,* (1984); Adelman (1987); and Kamonrat and Doyle (1989).

The increase in circuli number corresponding to increase in size of scales indicated that addition of circuli number was a close reflection of the gradual increase in fish growth. Similar observations were reported by Yang (1971), Glenn and Mathias (1985), Seshappa (1985), Bigler (1988), and Kaeriyama (1989). Interstingly, based on the number of circuli, the total length of fish could be predicted using the regression equation. This might also be useful in fishery management since age determination based on annulus counting is difficult in tropical fishes.

The finding that there existed a positive correlation between fish total length and number of primary radii enabled back calculation of the fish length as proposed by Prakasam and Johnson (1988).

Senk and Kaludjevic (1963) suggested that the creation of secondary radii was connected with sexual maturity of fish in *Barbus merioidionallis.* Kostic and Maletin (1989), however, stated that most intensive creation of secondary radii was in the initial or young stages of life. It is likely that fresh radii originated as incomplete or secondary radii and as fish size increased they tend to get transformed into complete or primary radii.

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 SVI) of* Etroplus suratensis *from fresh and brackish waters. Mean ± standard deviations are given; comparison using student's 't' test P < 0.10 : *significant, FW = Freshwater; BW = Brackishwater*

Body Regions	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	SVI	SI	SVI	SI	SVI
1. Head	FW	0.0 ± 0.0	7.2 ± 0.7	7.0 ± 0.6	1.9 ± 0.9	0.0 ± 0.0	0.0 ± 0.0
	BW	0.0 ± 0.0	0.5 ± 0.6	4.3 ± 1.9*	4.1 ± 2.6	0.0 ± 0.0	0.0 ± 0.0
2. Operculum	FW	7.1 ± 0.3	4.8 ± 0.6	2.3 ± 0.6	3.4 ± 0.7	0.0 ± 0.0	0.0 ± 0.0
	BW	1.7 ± 2.6*	2.8 ± 1.3	2.1 ± 1.0	1.2 ± 1.5*	0.0 ± 0.0	0.0 ± 0.0
3. Dorsolateral	FW	7.1 ± 0.0	10.2 ± 0.3	2.9 ± 0.1	0.8 ± 0.4	20.0 ± 7.0	31.9 ± 10.1
	BW	7.2 ± 1.9	10.0 ± 0.7	2.1 ± 1.1	1.3 ± 0.4	4.1 ± 9.3	35.0 ± 12.2
4. Midlateral	FW	6.1 ± 0.3	10.8 ± 0.7	3.7 ± 0.6	1.0 ± 0.5	0.0 ± 0.0	93.0 ± 53.6
	BW	7.3 ± 2.4	10.3 ± 1.7	2.1 ± 1.0*	1.3 ± 0.5	39.1 ± 21.4*	91.6 ± 60.6
5. Ventrolateral	FW	7.5 ± 0.2	10.0 ± 1.4	2.9 ± 1.2	0.9 ± 0.7	0.0 ± 0.0	62.5 ± 70.3
	BW	7.6 ± 1.8	10.3 ± 1.1	1.9 ± 0.7	1.3 ± 0.3	4.1 ± 9.3	62.5 ± 37.5
6. Caudal	FW	7.8 ± 0.5	11.0 ± 0.6	1.3 ± 0.1	0.7 ± 0.6	0.0 ± 0.0	51.3 ± 23.7
	BW	7.8 ±1.0*	9.4 ± 1.3*	2.4 ± 0.6	1.2 ± 0.7	0.0 ± 0.0	35.5 ± 12.5

TABLE 4. *Correlation coefficient and linear regression equation calculated between total fish length and number of primary radii and total fish length vs. no. of secondary radii in the scales of various body regions in freshwater and brackishwater* E. suratensis *(X = fish Length; y = no. of primary radii; or secondary radii; FW = Freshwater; BW = Brackishwater)*

Body Regions	CORRELATION COEFFICIENT (R) Fish length vs. number of primary radii		CORRELATION COEFFICIENT (R) Fish length vs. number of secondary radii		REGRESSION EQUATION Fish length vs. number of primary radii		REGRESSION EQUATION Fish length vs. number of secondary radii	
	FW	BW	FW	BW	FW	BW	FW	BW
1. Head	0.34	0.17	-0.74	-0.07	$\hat{Y}$ = 6.4 + 1.1X	$\hat{Y}$ = 0.71 + 0.07X	$\hat{Y}$ = 9.5 + -0.45	$\hat{Y}$ = 4.2 + -0.03X
2. Operculum	-0.33	0.04	0.12	-0.02	$\hat{Y}$ = 7.0 + -0.01X	$\hat{Y}$ = 1.6 + 0.01X	$\hat{Y}$ = 1.6 + 0.03X	$\hat{Y}$ = 2.5 - 0.007X
3. Dorsolateral	0.64	0.59	-0.63	-0.44	$\hat{Y}$ = 7.3 + 0.2X	$\hat{Y}$ = 7.4 + 0.2X	$\hat{Y}$ = 2.8 - 0.1X	$\hat{Y}$ = 2.5 - 0.08 X
4. Midlateral	0.69	0.52	-0.53	-0.36	$\hat{Y}$ = 6.7 + 0.27X	$\hat{Y}$ = 7.2 + 0.2X	$\hat{Y}$ = 3.0 - 0.14X	$\hat{Y}$ = 2.7 - 0.08X
5. Ventrolateral	0.44	0.37	-0.47	-0.45	$\hat{Y}$ = 3.3 + 0.1X	$\hat{Y}$ = 7.2 + 0.18X	$\hat{Y}$ = 2.5 - 0.1X	$\hat{Y}$ = 2.2 - 0.07X
6. Caudal	0.76	0.36	-0.53	-0.39	$\hat{Y}$ = 7.2 + 0.2X	$\hat{Y}$ = 6.3 + 0.17 X	$\hat{Y}$ = 1.6 - 0.05 X	$\hat{Y}$ = 2.1 - 0.07X

It was interesting to note that in brackishwater *E. suratensis* there was marginal decrease in scale size, number of circuli, number of radii and number of ctenii when compared to its freshwater counterpart. This implied that environmental parameter like salinity can alter the meristic characteristics of scales.

Bilton (1988) noted that the largest scale in the body would give the most suitable record of age and growth of fish and considered it to be the most 'preferred scale' or typical scale, as the maximum development in all the metric and meristic characteristics was found in it. Favourably considering this view, it likely that midlateral scales were the first formed ones in *E. suratensis* during squamation development. Bilton (1988) and Park and Lee (1988) had reported that during squamation development, the first scales were laid in the lateral line region which then spread to other body regions.

In a study, Lippitsch, (1990) had explained that as new scales are laid they appear as cycloid, subsequently ctenii appear and thus get transformed into ctenoid scales. In *E. suratensis* it appeared that the midlateral scales alone have been transformed into ctenoid whereas scales in other regions were retained as cycloid in the adults.

REFERENCES

ADELMAN, I. R. 1987. Uptake of radioactive amino acids as indices of current growth rate of fish. In: R.C. Summertelt and G.E. Hall (Ed.) *The age and growth of fish.* Lowa state university press. Ames IA 50010., PP 65-79.

BIGLER, B. 1988. Focal scale damage among Chum Salmon *Oncorhynchus keta* of Hokkaido, Japan. *Can. J. Fish. Aquat. Sci.,* **45** (4) : 698-704.

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

COBURN, M. AND I. J. GAGLIONE 1992. A comparative study of Percoid scales (Teleostei : Perciformes). *Copeia.,* **4** : 968-1001.

GLENN, C. L. AND J. A. MATHIAS 1985. Circuli development on body scales of young pond reared Walleye *(Stizostedion vitreum). Can. J. Zool.,* **63** : 912-915.

JOHNSON, P. AND V. R. PRAKASAM 1993. Scale characteristics of *Etroplus suratensis* in relation to body positions and size. *Proc. of the fifth Kerala Sci Cong,* Kottayam, India., PP. 398-399.

KAERIYAMA, M. 1989. Comparative, morphology and scale formation in four species of *Oncorhynchus* during early life. *Jap. J. of ichthyology.* **35** (4) : 445-52.

KAMONRAT, W. AND R. W. DOYLE 1989. Genetic variation of scale circulus spacing (CIRC) in Tilapia *(Oreochromis mossambicus/hornorum hybrid)* In: R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maciean (Ed.) *Proc. Second Int. Symp. Tilapia in Aquaculture* (ISTA II). Dept of Fish, Bangkok, Thailand, and International Centre for Living Aquatic Resources Management, Manila.

KOSTIC, D. AND S. MALETIN 1989. Arrangement and number of radial channels on the scales of Prussian carp *(Carrasius auratus gibelio* Block) from the Dead Theiss-Biserno Ostrovo. *Tiscia (Szeged).,* vol XXIII PP. 115-122.

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

PARK E. AND S. LEE 1988. Scale growth and squmation chronology for the laboratory reared hermaphrodite Fish, *Rivulus marmoratus* (cyprinodontidae) *Jap. J. Ichthylogy.,* **34** : 476-482.

PRAKASAM, V. R. AND P. JOHNSON 1988. Scale morphology of three teleosts *(Etroplus suratensis, Anabas testudineus, Sardinella longiceps)* with reference to function. *Indian J. Fish.,* **35** (3) : 221-225.

SENK, O. AND M. KALUDJEVIC 1963. A Contribution to the examination of relationships of secondary radial channels and the change of growth rate of the cycloid fish scales. *Veterinarija.,* **3** : 331-338.

SESHAPPA G. 1985. On the homogeneity of the mackerel population at Calicut during the years 1969 to 1976 as determined on the basis of C/L, C/W and TL/SL ratios. *Indian. J. Fish.,* **32** (3) : 359-374.

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

WITKOWSKI, A., B. KOKUREWICS AND M. KOWALESWSKI 1984. Early development in the Damsel Salmon *Hucho hucho* (Pisces-Salmonidae). *Acta Hydrobiol.,* **25/26** (2) : 215-223.

YANG, H. J. 1971. The phase of scales in cyprinid fishes: A study of morphological characteristics of Cyprinae fish scales. *Bull. Korean. Fish. Soc.,* **4** (2) : 66.74.