

BILATERAL ASYMMETRY IN PAIRED MERISTIC AND
MORPHOMETRIC CHARACTERS OF *LABEO DERO*
(HAMILTON) : CYPRINIDAE, CYPRINIFORMES

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(With 2 Tables)

I—INTRODUCTION

All vertebrates are known to be bilaterally symmetrical, although many cases of anomalous asymmetries are known among them. The extent of the occurrence of asymmetry increases as one descends down the vertebrate series from mammals to fishes. Fishes are, although, bilaterally symmetrical as far as their general body shape and major parts are concerned, yet an irregular form of asymmetry is well established in many of their important taxonomic characters. In the order Pleuronectiformes a normal dextral or sinistral asymmetry is established (Hubbs & Hubbs, 1944). Asymmetry in the gill raker count in Chars has been reported by Vladykov (1954) and a higher number of branchiostegal rays on the left side of Pacific Salmon has been observed by Jordan and Evermann (1896). Landrum (1966) analysed the differences between the number of the elements on the left and the right side structures of four paired meristic elements of three species of Salmon with a view to ascertain the extent of the asymmetry in them and to know whether data of one side of the fish could be used for the other without bias. In support of the study of the asymmetry in fishes, Landrum (1966) stated :

“As a consequence of these known asymmetries in fish, morphological characters from both sides of all species, ideally, should be examined for taxonomic and racial studies, or examination should be limited to one chosen side. If the latter alternative has been adopted, problems arise if the chosen side is mutilated or otherwise unobtainable. In racial studies on Pacific Salmon (Fukuhara *et al.*, 1962), data on various meristic characters were arbitrarily collected from the left side of all specimens. The racial study involved multivariate analysis of data from several meristic characters; therefore occasional failures to obtain information from any one lost or damaged character prevented the specimen's use and reduced the usable sample size. As the reliability of the analysis was in part determined by the sizes of samples, unusable specimens were both a statistical and an economic loss.”

To the best of knowledge of the present authors, such a study has not so far been made for Indian fishes and hence the need for the present study which attempts to make an analysis of differences between the number of elements and measurements of different body parts in left and right side structures of five paired meristic and seven

morphometric characters of a freshwater cyprinid fish, *Labeo dero* (Hamilton). The object of the present analysis is to ascertain the extent and direction of asymmetry in these characters and to determine the usefulness of the information in taxonomic studies of the species.

II—MATERIAL AND TECHNIQUE

The data regarding the paired meristic and morphometric characters were obtained from 104 specimens, preserved as National Collection in the Zoological Survey of India, Calcutta. The material pertains to India, Nepal, and Burma. The characters examined are :

Meristic :—

1. Number of scales along the lateral line. 2. Number of scales in the lateral transverse series. 3. Number of branchiostegal rays. 4. Number of pectoral fin rays. 5. Number of pelvic fin rays.

Morphometric :—

1. Length of head. 2. Diameter of eye. 3. Length of snout. 4. Height of opercular flap. 5. Width of operculum. 6. Length of pectoral fin. 7. Length of pelvic fin.

The record of a particular character, which was either damaged on one or both sides, was not made.

III—EXPLANATION OF TERMS AND MEASUREMENTS

The different meristic and morphometric characters used in this study are briefly described below. The paired bony structures have been counted or measured both from the left and the right sides without dissecting them.

1. *Scales along the lateral line.*—All scales, which were penetrated by a lateral line tube, were counted. The count included the first scale starting from the angle of operculum to the last scale at the base of caudal fin. In some cases supernumerary scales were interpolated between two scales of the lateral line. Since such scales were unpenetrated, they were not counted.

2. *Scales in the lateral transverse series.*—All the scales from the origin of dorsal fin to the lateral line are included in this character. No count of scales has been taken below the lateral line.

3. *Number of branchiostegal rays.*—All bony branchiostegal rays, arising from the ceratohyal and the epihyal, were counted. Care was taken to avoid extra counts caused by abnormal lengthwise fission of a single ray.

4. *Pectoral and pelvic fin rays.*—All branched and unbranched rays, which extended upto the girdle, were counted.

5. *Length of head.*—The head length is measured from the tip of snout to the posterior edge of the bony operculum.

6. *Diameter of eye.*—The eye diameter is measured as the distance between the anterior and the posterior edges of the bony orbit,

7. *Length of snout.*—The length of snout is measured from the tip of the snout to the anterior edge of the bony orbit.

8. *Height of the opercular flap.*—The maximum height of the bony opercular flap was measured as the distance between the dorsal end of the operculum and the ventral edge of the opercular flap. The dorsal end of the bony operculum was determined by an incision made in the crease, that resulted from upward flexion of the opercular flap.

9. *Maximum width of operculum.*—The maximum width of the bony operculum was measured as the distance between the posterior end of bony operculum to its anterior margin. The anterior margin was determined by an incision made in the crease that resulted from anteriorward flexion of the operculum.

10. *Length of pectoral and pelvic fins.*—The maximum length of the pectoral and the pelvic fins has been taken as the length of the longest ray which was measured from its base (above the skin) to its tip.

All the measurements are shown in centimeter scale.

IV—STATISTICAL PROCEDURE

The observations of the left and the right sides of both male and female specimens have been tabulated for each of the characters studied. Under each observation, the value of left side has been subtracted from that of the right side ; the differences are positive when right side values are more than those of the left and negative in the reverse case.

The significance of mean difference of values between the left and right sides of the meristic and morphometric characters observed in each sample has been determined by using the formula for Students' 't' test, so as to ascertain whether there is any asymmetry in these characters and that the mean x value is significantly different from zero.

$$t = \frac{\bar{x} \sqrt{N}}{\sqrt{\frac{\sum x^2}{N} - \frac{(\sum x)^2}{N^2}}} \quad \text{OR} \quad t = \frac{\bar{x} - \mu}{s/\sqrt{N}}$$

($\mu = \text{Zero}$)

- where t = Students' 't' test
 \bar{x} = mean calculated by the formula $\sum x/N$
 $\sum x$ = the summation of the difference of right minus left counts or measurements.
x = the value of right minus left counts or measurements in one specimen.
N = number of observations (It is different from 'n' which is N-1)
 $\sum x^2$ = the sum of square of individual values of x ($x_1^2 + x_2^2 + x_3^2 \dots \dots \dots x_n^2$).

N-1 = degrees of freedom
 s = standard deviation and determined by

$$\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{N}}{N-1}$$

In order to ascertain the significance, the probability of happening either greater or lesser than zero (mean value) has been taken into account. Probability level was considered at 0.025 level (5 percent level of one-tailed table).

The probability value of 't' has been seen from the table given by Fisher and Yates (1953). The hypothesis tested was that the difference between the left and right side counts and measurements was zero.

V—RESULTS

An analysis of the differences in both meristic and morphometric characters between the right and left sides of the male and female specimens has been made and the results are presented below.

Bilateral variation in meristic characters (Table 1) :

Number of lateral line scales.—In this character the female exhibited a greater percentage of asymmetrical development with larger mean difference than the male. The percentage of specimens exhibiting asymmetry in lateral line scales and the direction of asymmetry varied among samples of each sex and among combined samples of both the sexes. As shown by right hand column (headed 'p'), the probability values for the observed mean differences are not significant. For males, the differences in left and right side counts averaged 36 percent and in females averaged 43 percent. Asymmetry between right and left side scale counts occurred in approximately 39 percent of the total of 89 specimens. The direction of asymmetry in male indicates that the right side develops approximately 0.07 scales more than the left side, and in female it indicates that the right side develops approximately 0.15 scales less than left side. In the total number of male and female examples the right side develops approximately 0.04 scales less than the left side. The difference in the variation of the counts in lateral lines of the right and left sides could be attributed to chance factors and hence cannot be attached any significance. This is proved by the value of 'p' which is greater than 0.05 in all the cases (Table 1). The overall mean difference between right and left side counts (0.044) is also insignificant.

Number of scales in lateral transverse series.—The comparison is made from the left and right side counts of 83 specimens. In this character the female exhibits a greater percentage of asymmetrical development with larger mean difference than male. In the male specimens asymmetrical development occurs in approximately 29 percent, in females approximately 38 percent and approximately 34 percent in the combined sample of both male and female specimens. The left side counts exceed those of right side in males approximately 16%, in females approximately 29% and in combined samples of males

and females approximately 23%. The direction of asymmetry in males indicates that the right side develops approximately 0.08 scales less than the left side, in female it indicates that the right side develops approximately 0.2 scales less than left side and in combined sample of males and females the right side develops approximately 0.14 scales less than left side. The variation in the number of scales of the two sides, in the males and combined samples of males and females, is insignificant but in the female specimens it is statistically significant at 5% level.

Number of branchiostegal rays.—The branchiostegal rays counts were collected from 103 specimens of this species. In this character the males exhibited a greater percentage of asymmetrical development with larger mean difference than the females. In the male specimens, asymmetrical development occurs in approximately 22%, in females approximately 13% and in the combined sample of male and female specimens approximately 18%. The left side count exceeds right side count in approximately 18% in males, approximately 11% in females and in the combined sample of males and females asymmetry occurs in approximately 15%. The direction of asymmetry in males indicates that the right side develops approximately 0.18 rays less than the left side, and in females it indicates that the right side develops approximately 0.09 rays less than the left side. In the combined sample of males and females the right side develops approximately 0.14 rays less than the left side. The mean difference is statistically insignificant at 5% level for females but in males it is significant.

Number of pectoral fin rays.—The comparisons were made from the right and the left side counts of 103 specimens. In this character the female exhibited a greater percentage of asymmetrical development with larger mean difference than the male. In the male specimens, asymmetrical development occurs in approximately 40%, in females approximately 49% and in the combined sample of male and female specimens approximately 45%. The left side counts exceed those of right side in approximately 16% in males, 34% in females and 25% in combined sample of males and females. The direction of asymmetry in males indicates that the right side develops approximately 0.04 rays more than the left side and in females it indicates that the right side develops approximately 0.18 rays less than the left side. In the combined sample of male and female specimens the right side develops approximately 0.08 rays less than the left side. The mean difference observed is insignificant for this sample.

Number of pelvic fin rays.—A comparison has been made for right and left side counts of 103 specimens. In this character the females exhibited a greater percentage of asymmetrical development with larger mean difference than the males. In the male specimens asymmetrical development occurs in approximately 2%, in females approximately 6% and in the combined sample of males and females approximately 4%. The left side counts exceed those of the right side in none of the male specimens, approximately 6% in females and approximately 3% in the total lot. The direction of asymmetry in male indicates that the right side develops approximately 0.02 rays more than the left side and in female it indicates that the right side develops approximately 0.06 rays less than the left side. In the

TABLE 1.—Bilateral variation in number of lateral line scales, scales in lateral transverse series, branchiostegal rays, pectoral fin rays and pelvic fin rays *Labeo dero* (Hamilton)

Characters	Sex	Number examined	% asymmetrical	% asymmetrical towards left	Σx	Σx^2	Mean of (R-L) \bar{x}	s	t	p
Lateral line scales	Male	42	35.7	16.7	3	21	0.071	± 0.712	0.648	>0.05
	Female	47	42.6	27.7	-7	29	-0.148	± 0.779	1.296	>0.05
	Total	89	39.3	22.5	-4	50	-0.044	± 0.752	0.551	>0.05
Scales in lateral transverse series	Male	38	28.9	15.8	-3	11	-0.078	± 0.538	0.776	>0.05
	Female	45	37.8	28.9	-9	19	-0.2	± 0.624	2.149	<0.05
	Total	83	33.7	22.9	-12	30	-0.144	± 0.586	1.311	>0.05
Branchiostegal rays	Male	50	22.0	18.0	-9	11	-0.180	± 0.437	2.905	<0.001
	Female	53	13.2	11.3	-5	6	-0.094	± 0.325	1.827	<0.10
	Total	103	17.5	14.5	-14	17	-0.135	± 0.384	3.565	<0.001
Pectoral fin rays	Male	50	40.0	16.0	2	26	0.04	± 0.726	0.388	>0.05
	Female	53	49.0	34.0	-10	76	-0.188	± 1.193	1.146	>0.05
	Total	103	44.7	25.2	-8	102	-0.077	± 0.996	0.784	>0.05
Pelvic fin rays	Male	50	2.0	0.0	1	1	0.02	± 0.141	0.996	>0.05
	Female	53	5.7	5.7	-3	3	-0.056	± 0.232	1.754	<0.10
	Total	103	3.9	2.9	-2	4	-0.019	± 0.194	0.989	>0.05

TABLE 2.—Bilateral variation in measurements of Length of head, diameter of eye, length of snout, height of opercular flap, width of operculum, pectoral fin length, and pelvic fin length of *Labeo dero* (Ham.)

Characters	Sex	Number Examined	% asymmetrical	% asymmetrical towards left	Σx	Σx^2	Mean of $\frac{(R - L)}{x}$	s	t	p
Length of Head	Male	50	60.0	42.0	-10.5	19.25	-0.21	±0.588	2.523	<0.02
	Female	54	53.7	22.2	0.5	11.25	0.009	±0.46	0.143	>0.05
	Total	104	56.7	31.7	-10.0	30.5	-0.096	±0.534	1.833	<0.10
Diameter of eye	Male	50	40.0	24.0	- 2.0	5.0	-0.04	±0.316	0.904	>0.05
	Female	54	37.0	14.8	2.5	5.75	0.046	±0.325	1.655	<0.10
	Total	104	38.5	19.2	0.5	10.75	0.103	±0.322	3.229	<0.002
Length of snout	Male	50	52.0	28.0	1.5	19.0	0.03	±0.621	0.339	>0.05
	Female	54	59.3	20.4	5.0	25.5	0.092	±0.687	0.984	>0.05
	Total	104	55.8	24.0	6.5	44.5	0.062	±0.654	0.966	>0.05
Height of opercular flap	Male	50	60.0	46.0	-10.5	12.75	-0.21	±0.463	3.118	<0.002
	Female	54	46.3	37.0	- 5.0	12.5	-0.092	±0.476	1.42	>0.05
	Total	104	52.9	41.3	-15.5	25.25	-0.149	±0.475	3.197	<0.002

TABLE—2 (Contd.)

Characters	Sex	Number Examined	% asymmetrical	% asymmetrical towards left	Σx	Σx^2	Mean of $(R - L)_{\bar{x}}$	s	t	p
Width of Operculum	Male	50	52.0	32.0	- 4.0	11.0	-0.08	± 0.465	1.216	>0.05
	Female	54	35.2	12.5	3.0	5.5	0.055	± 1.0	0.404	>0.05
	Total	104	43.3	22.1	- 1.0	16.5	-0.009	± 0.4	0.227	>0.05
Length of pectoral fin	Male	46	45.7	11.1	8.5	13.75	0.184	± 0.519	2.4	<0.02
	Female	51	54.9	29.4	- 2.5	10.75	-0.04	± 0.458	0.622	>0.05
	Total	97	50.5	20.6	6.0	24.5	0.061	± 0.509	1.178	<0.10
Length of pelvic fin	Male	48	56.3	29.2	- 3.0	21.0	-0.062	± 0.664	0.643	>0.05
	Female	52	55.8	17.3	9.5	18.75	0.182	± 0.577	2.273	<0.05
	Total	100	56.0	23.0	6.5	39.75	0.06	± 0.63	0.952	>0.05

combined lot of male and female specimens the right side develops approximately 0.02 rays less than the left side. For this character asymmetry occurs approximately in 2—6% of the specimens—much less frequently than for the other four meristic characters examined. Variation in the number of rays from the opposite side resulted in very small mean difference. Although the left side count generally exceeds that of the right, the test for differences is not statistically significant.

Bilateral variation in morphometric characters (Table 2) : *Length of head*.—A comparison is made for the left and the right side measurements of altogether 104 specimens. In this character the males exhibit a greater percentage of asymmetrical development with larger mean difference than the females. In the male specimens, asymmetrical development occurs in approximately 60%, in females approximately 54% and in the combined sample of male and female specimens approximately 57%. The left side measurements exceed those of the right side in approximately 42% of males, in approximately 22% of females and in approximately 32% of the combined sample of male and female specimens. The direction of asymmetry in males indicates that the right side develops approximately 0.21 cms. less than the left side. In females the right side develops approximately 0.01 cms. more than the left side and in the total lot the right side develops approximately 0.01 cms. less than the left side. The mean difference observed is significant for male specimens and insignificant for females and for the combined lot.

Diameter of eye.—The right and left side measurements of eye diameter are taken for 104 specimens. The females exhibit a greater percentage of asymmetrical development with larger mean difference than males. In the male specimens, asymmetrical development occurs in approximately 40%, in females approximately 37% and approximately 39% in the total lot of male and female specimens. Left side measurements exceed in approximately 24% in males, approximately 15% in females and approximately 19% in the total of both. The direction of asymmetry in male specimens indicates that the right side develops approximately 0.04 cms. less than the left side, in female specimens right side develops approximately 0.05 cms. more than the left side and in combined sample the right side develops approximately 0.1 cm. more than the left side. However, the differences of the males and the females are not significant but the differences of the combined lot of males and females are significant.

Length of snout.—The left and right side measurements have been compared for 104 specimens. The male and the female groups similarly differ with no probable significant values occurring in either category. The female exhibited a greater percentage of asymmetrical development with larger mean difference than the male. In the male specimens, asymmetrical developments occur in approximately 52%, in female approximately 59% and in combined sample of both male and female specimens approximately 56%. The left side measurements of male exceed those of right side in approximately 28%, of females in approximately 20% and of combined sample in approximately 24%. The direction of asymmetrical development indicates that the right side of males develops approximately 0.03 cms. more

than the left side, of females approximately 0.09 cms. more than the left side and of both male and female examples approximately 0.06 cms. more than the left side.

Height of opercular flap.—A comparison is made from the left and the right side measurements of 104 examples. Male specimens exhibit a greater percentage of asymmetrical development with larger mean difference than the females. In the male specimens asymmetrical development occurs in approximately 60%, in female specimens approximately 46% and approximately in 53% of the combined lot of male and female specimens. Left side measurements of males exceed in approximately 46%, of females 37% and of combined lot approximately 41%. The direction of asymmetrical development indicates that the right side of the males develops approximately 0.21 cms. less than the left side, of females approximately 0.09 cms. less than the left side and of combined lot approximately 0.15 cms. less than the left side. Although the left side counts generally exceed the right in all the three, the difference is highly significant in males and in combined lot. In females the difference is not significant.

Width of operculum.—The left and right side measurements of the width of operculum has been compared for 104 specimens. Male and female groups varied similarly with no probable significant values occurring in either category. Males exhibit a greater percentage of asymmetrical development with larger mean difference than females. In the male specimens asymmetrical development occurs in approximately 52%, in females approximately 35% and in combined sample of both male and female specimens approximately 43%. The left side measurements of males exceed in approximately 32%, of females in approximately 13% and in combined sample approximately 22%. The direction of asymmetrical development indicates that right side of the males develops approximately 0.08 cms. less than the left side, in females approximately 0.06 cms. more than the left side, and in combined sample approximately 0.01 cm. less than the left side.

Length of pectoral fin.—The left and right pectoral fin measurements have been compared for 97 specimens. The female specimens exhibit a greater percentage of asymmetrical development with larger mean difference than the male specimens. In the male specimens asymmetrical development occurs in approximately 46%, in females approximately 55% and in combined sample approximately 51%. The pectoral fin measurements of left side exceed those of right side in approximately 11% of males, approximately 29% of females and approximately 21% of the combined sample. The direction of asymmetry in males indicates that the right side pectoral fin develops approximately 0.18 cms. more than that of the left side, in females the pectoral fin of right side develops approximately 0.04 cms. less than that of the left side and in the combined sample the right side fin develops approximately 0.06 cms. more than that of the left side fin. The mean difference observed is significant for male specimens and for female and combined sample of male and female specimens it is insignificant.

Length of pelvic fin.—A comparison has been made for the length of the pelvic fin of the two sides of 100 specimens. The male specimens exhibit a greater percentage of asymmetrical development with

greater mean difference than the females. In the pelvic fin length asymmetrical development occurs approximately 56% separately in the males, in the females and in the combined sample of both male and female specimens. The measurements of pelvic fin of right side exceed those of the left side of males in approximately 29%, of females in approximately 17% and in combined sample in approximately 23%. The direction of asymmetry indicates that the right side pelvic fin of male develops approximately 0.06 cms. less than the left side pelvic fin, of females approximately 0.18 cms. more than that of the left side and of combined sample approximately 0.06 cms. more than the left side pelvic fin. The mean difference observed is statistically insignificant for males and combined sample but it is significant in female specimens.

VI—CONCLUSIONS

No constant trend has been observed towards sexual dimorphism or effect of sampling location in respect to asymmetry of the studied characters. The meristic characters, such as the number of scales in the lateral line, the number of scales in the lateral transverse series, the number of pectoral fin rays and the number of pelvic fin rays in the females, show greater percentage of asymmetry than those of the males. In the number of branchiostegal rays, the males show greater percentage of asymmetry than the females. In the morphometric characters, such as the snout length and the pectoral fin length, the males show lesser percentage of asymmetry than females. In the length of head, the diameter of eye, the height of opercular flap and the width of the operculum, the males show greater percentage of asymmetry than the females. In the pelvic fin length both males and females show equal degree of asymmetry.

The results of the study show that *Labeo dero* (Ham.) (Pisces : Cyprinidae), which is essentially a bilaterally symmetrical animal, exhibits some asymmetry in respect to all the five meristic and seven morphometric characters studied here. In the present study no conclusive relationship has been found between the occurrence of asymmetry and the sex, but it is observed that the percentage of asymmetry in the meristic characters is more in females than the males. Out of five characters taken, four show more percentage of asymmetry in females than the males and in only one character (branchiostegal rays) males show greater percentage of asymmetry than females. For the morphometric characters in general the percentage of asymmetry is more in males than in females. Out of seven characters studied, four (head length, diameter of eye, height of opercular flap and width of operculum) show more percentage of asymmetry in males than in females. In two characters (length of snout and length of pectoral fin) the females show greater percentage of asymmetry than the males. In the length of pelvic fin both male and female specimens exhibit equal percentage of asymmetry.

In taxonomic and racial studies of *Labeo dero* (Ham), involving meristic and morphometric characters given above, the interchanging of counts and measurements of left and right sides, should be a signi-

ficant source of variation and a large number of such substitutions should affect results.

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VIII—SUMMARY

104 specimens of *Labeo dero* (Hamilton) were examined to ascertain the extent and direction of asymmetry in five meristic and seven morphometric characters. The results obtained show that the fish which is essentially a bilaterally symmetrical animal, exhibits some asymmetry in respect to all the five meristic and seven morphometric characters. No conclusive relationship could be found between the occurrence of asymmetry and the sex, but females show more asymmetry than males, in meristic characters. For morphometric characters the percentage of asymmetry is more in males than in females. It is suggested that in taxonomic and racial studies the counts and measurements of left and right sides should be interchanged because as a result of the asymmetry of development of various parts of the body of the fish, it would affect the results.

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