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Biometric comparison of samples of the clupeid fish, *Escualosa thoracata* (Val. 1847) from two localities

S. DUTT AND B. V. SESHAGIRI RAO

Department of Marine Sciences, Andhra University, Visakhapatnam

Abstract

Random samples of white sardine *Escualosa thoracata* from Bombay on the west coast and Gollapalem on the east coast are compared using 't' test and Chi-square test for meristic characters and multivariate analysis for body measurements. Eleven meristic characters and six body measurements were used in the present study.

INTRODUCTION

Exploitation of marine fishes demands studies directed towards the understanding of the distribution of the exploited stockes in space and time. In the north-east Atlantic, and particularly in the North Sea, a number of studies have been carried out towards identification of the different exploited stocks and the spatial distribution of the different phases in the life-history of each stock. From such studies has developed the concept of the 'unit stock' (Cushing,1968). The stocks of the major exploited fishes of the north-east Atlantic like the herring, cod etc., (Cushing, 1968; Harden Jones, 1968) occupy defined areas, have recognisable migration routes and relatively confined spawning grounds. Moreover, each area may support two races (as in the case of the herring) which are distinguished on the basis of differences in biometric characters and in spawning seasons. Thus, such races are distinguished on the basis of their spawning seasons as spring, summer, autumn or winter spawners.

There have been relatively few studies in the seas surrounding India, and in fact in tropical waters, directed towards the identification of the exploited stocks of fishes. As has been pointed out by Dutt (1972, 1977), the concept of unit stocks cannot be easily applied to tropical fishes like the clupeoids. Available data show that many of the marine pelagic species represented along the Indian coast form a population continuum as defined by Mayr (1969); compared to the stocks of the higher latitudes, they do not have well-defined spawning grounds and they have relatively more extended spawning seasons. While detailed studies on migration have not been carried out, available data suggest that feeding and spawning grounds are not clearly demarcated from one another and, as a corollary, distinctive migrations are not apparent. Another feature to which Dutt (1977) has drawn attention is the fact that at least related species of tropical clupeids [*e.g., Sardinella fimbriata* (Val.) and *S. gibbosa* (Bleeker)] show less variation between themselves than, for example, two races of a coldwater clupeid (*e.g., Clupea harengus* Linn.) from the North Sea or Western Baltic. Many tropical genera include much

larger numbers of species than do those of higher latitudes. A consequence of this is that it is sometimes difficult, even for the expert, to readily distinguish related species. Considering their biology and behaviour, it can be appreciated that the identification of different stocks of a given species presents some problems. Fishing is largely confined to coastal waters and samples are not available from different localities in the area over which a stock may be distributed. The few tagging experiments that have been carried out have not been successful because there are few returns of recaptured fish due to a variety of causes like the illiteracy and ignorance of the fishermen, the remote location of the coastal fishing villages and inadequacy of communication systems.

A few studies have been carried out in India to distinguish different stocks of some clupeoids on the basis of differences in biometric characters. In this connection, the terms population or stocks and races have been indiscriminately used, although, as pointed out by Dutt (1962), the terms refer to distinct kinds of biologic units. Among the first such preliminary studies is that of Devanesen and Chidambaram (1943), who made a brief reference to differences observed in length of head and tail in samples of oil sardine (*Sardinella longiceps* Val.) from different localities in the eastern part of the Arabian Sea, and suggested the occurrence of more than one 'race'. Devanesen (1943) observed differences in head length of the oil sardine from Malabar and the' Bombay-Karachi region'. Prabhu and Dhulkhed (1972) observed three 'varieties' of oil sardine in the catches off Mangalore, distinguishable on the basis of differences in head length and height [=depth] of body. They do not mention the lengths of the specimens in the samples of the three 'varieties' which they also refer to as types A, B and C. They did not rule out the possibility of type A with its relatively shorter head and deeper body representing a hybrid between *S. fimbriata* (Val.) and *S. longiceps* Val. They further suggested the possibility of the intermingling of different 'varieties' in the Mangalore zone. All the above studies are of a preliminary nature.

Pillay (1952, 1954) carried out biometric and serological studies on the stocks of *Hilsa ilisha* (Ham. Buch.) in the Hooghly; he showed that the stocks of this species from river Hooghly and lake Chilka differ in some meristic characters and in body measurements (Pillay, 1957). Rao (1967a) distinguished the stocks of *Anchoviella* [=*Stolephorus*] *commersonii* from Waltair and the Godavari estuary on the basis of differences in some meristic characters and body measurements, employing 't' test and multiple regression analysis, respectively. Rao (1967b) observed two 'groups' of *Stolephorus insularis* Hardenberg at Waltair which he, following Hardenberg (1934), tentatively identified as two subspecies—*S. insularis insularis* Hardenberg and *S. insularis baweanensis* Hardenberg, "more for convenience than to stress the taxonomic [*sic*] level of the two groups" (p. 13). He observed that the former 'group' was represented in all samples from October to February and in some samples from February to June and that the latter 'group' was represented in samples from February to June.

Since the white sardine *Escualosa*

thoracata forms a good fishery at Bombay on the west coast and Gollapalem on the east coast of India, and statistically adequate samples from the two localities in comparable length groups could be obtained, it was felt that, as a first step, a biometric comparison of samples of stocks of the species from the two coasts would be worthwhile.

Material and Methods

Random samples of *Escualosa thoracata* were collected from two localities: Bombay (14–1–1975) and Gollapalem (2–2–1975). Meristic data and body measurements of 100 specimens of *E. thoracata* (60–73 mm SL) from Bombay and of 100 specimens (59–75 mm SL) from Gollapalem were recorded. The counts and measurements were made following Whitehead *et al.*, (1966).

Following Bailey (1959), Student's 't' test and Chi-square test have been used to test the significance of the differences in each of the meristic characters of the samples from the two localities. Body measurements of samples from the two localities were subjected to D^2 analysis (Rao, 1952) using a Honeywell 400 computer.

The following body measurements were selected for the present study: 1. standard length, 2. body depth, 3. head length, 4. predorsal distance, 5. prepelvic distance and 6. pre-anal distance.

The variance-covariance matrix, correlation matrix D^2 and F were computed. The programmes were run for the two sexes from each locality separately to test the significance of any differences between the sexes.

The covariance between any two characters X and Y is obtained by the equation:

$$\text{Cov}(X, Y) = \frac{(Xi-\bar{X})(Yi-\bar{Y})}{N-1}, \text{ where}$$

X_i = the value of X for the specimen
Y_i = the value of Y for the specimen
$\bar{X}$ = mean of X
$\bar{Y}$ = mean of Y
N = number of specimens.

The correlation matrix is computed using the equation:

$$\text{Cor}(X, Y) = \frac{\text{Cov}(X, Y)}{\sqrt{\text{Var}(X) \times \text{Var}\ Y}}$$

The D^2 between two groups is computed following Rao (1952): where,

$$D^2 = (\bar{X}_k - \bar{Y}_k)\ W^{(kr)}\ (\bar{X}_r - \bar{Y}_r)$$

$\bar{X}_k$ = mean of the kth character in the dfirst group
$\bar{Y}_x$ = mean of the kth character in the second group
W^{kr} = (k, r) th element in the inverse of the pooled variance covariance matrix
P = number of characters.

To test the significance of the differences between two groups, 'F' is calculated using the equation:

$$F = \frac{N_1 N_2 (N_1 + N_2 - P - 1)}{(N_1 + N_2)\ P\ (N_1 + N_2 - 2)} X\ D^2$$

where,

P = number of characters used
N_1 and N_2 = the number of specimens in the two groups.

Meristic Characters: The frequency distribution (Figs. 1–11), mean values ($\bar{X}$), standard deviation (S.D.) and standard error (S.E.) of the 11 characters studied are given in Table 1 a–k. The values of 't' and Chi-square are given in Tables 2 and 3.

The 't' test reveals significant differences between the samples from the two localities in the following 10 of the 11 characters for which the samples were compared: (*i*) dorsal fin rays, (*ii*) pectoral fin rays, (*iii*) pre-pelvic scutes, (*iv*) post-pelvic scutes, (*v*) total number of scutes, (*vi*) gill rakers on upper arm, (*vii*) gill rakers on lower arm, (*viii*) pre-haemal vertebrae, (*ix*) haemal vertebrae, (*x*) total number of vertebrae.

The only meristic character in which the samples from the two localities do not differ significantly is the number of anal fin rays.

The Chi-square test gave the same result as the 't' test, except that the difference between the two samples in the number of prehaemal vertebrae also was not significant, apart from the number of anal fin rays. It is recognised that of the two, the Chi-square test is a more sophisticated one. When the means of the 11 meristic characters of the two samples are compared, we do not observe any particular trend towards an increase or decrease in the values of the means of the samples from one of the two coasts. The sample from Gollapalem shows relatively higher means for the number of pectoral and anal fin rays and the numbers of gillrakers both on the upper and lower arms. The sample from Bombay has relatively higher means for the numbers of dorsal fin rays, scutes and vertebrae.

Body Measurements: The means ($\bar{X}$) of the 6 body measurements and standard deviation, for male and females separately, as well as for the pooled values of both sexes from Bombay and Gollapalem are given in Table 4. The D^2 and 'F' values computed to test the significance of the differences between the two sexes from each locality are given.

The differences between the two sexes from each locality are not significant while the differences between the samples from the two localities are significant (Tables 5 and 6) in regard to all the six body measurements.

Summary

A biometric comparison of samples of the white sardine *Escualosa thoracata* from Bombay on the west coast and Gollapalem (in Andhra Pradesh) on the east coast of India has revealed that:

1. in regard to meristic characters, the stocks from the two localities differ from each other significantly in 9 of the 11 characters on the basis of the Chi-square test. The 't' test revealed a significant difference between the two stocks in one more character, that of the two tests, the Chi-square test is recognised at the more sophisticated one.
2. in regard to body measurements, the stocks from the two localities differ from each other in all the 6 salient measurements.

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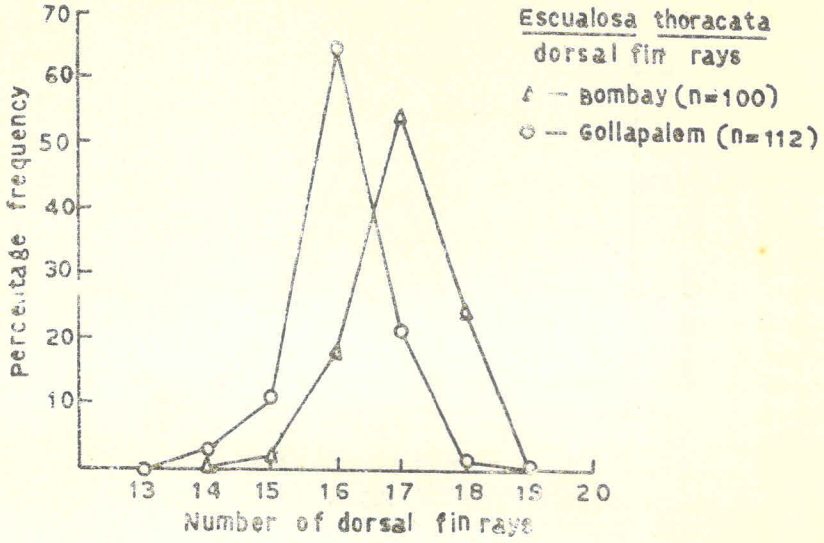
Escualosa thoracata
dorsal fin rays
Δ — Bombay (n=100)
○ — Gollapalem (n=112)
Percentage frequency
70
60
50
40
30
20
10
13 14 15 16 17 18 19 20
Number of dorsal fin rays

FIG 1.

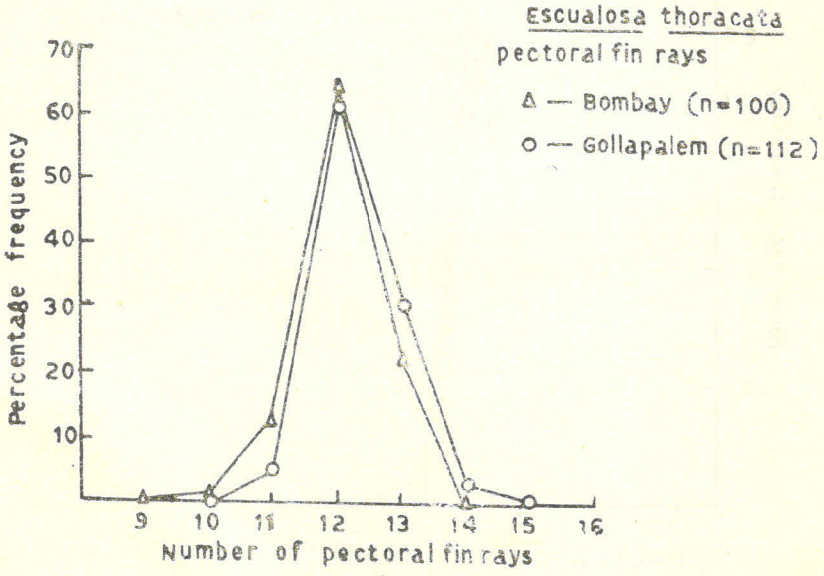
Escualosa thoracata
pectoral fin rays
Δ — Bombay (n=100)
○ — Gollapalem (n=112)
Percentage frequency
70
60
50
40
30
20
10
9 10 11 12 13 14 15 16
Number of pectoral fin rays

FIG.2

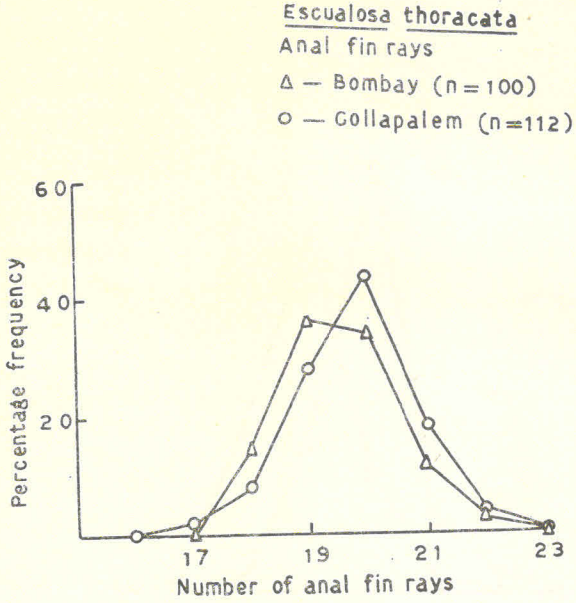
Escualosa thoracata
Anal fin rays
Δ — Bombay (n=100)
o — Gollapalem (n=112)
60
40
20
Percentage frequency
17
19
21
23
Number of anal fin rays

FIG.3.

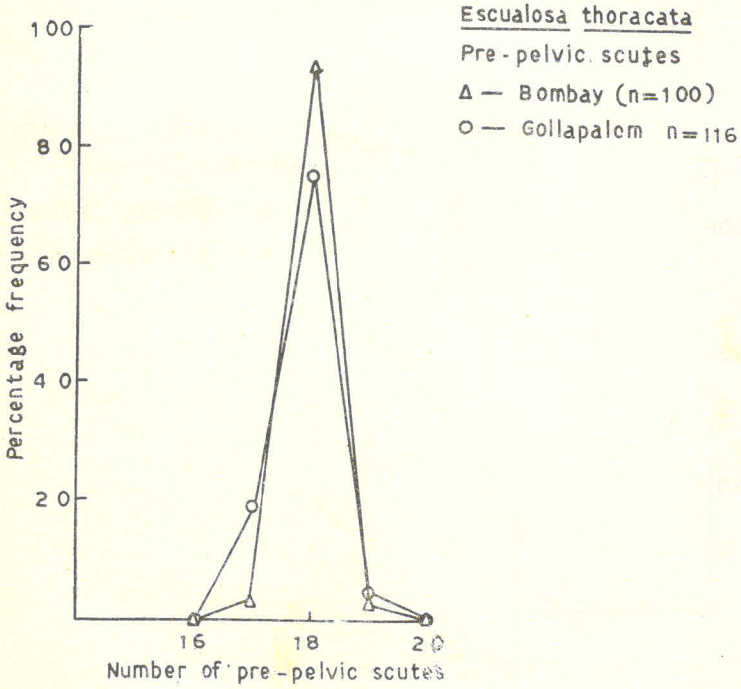
Escualosa thoracata
Pre-pelvic scutes
Δ — Bombay (n=100)
o — Gollapalem n=116
100
80
60
40
20
Percentage frequency
16
18
20
Number of pre-pelvic scutes

FIG.4.

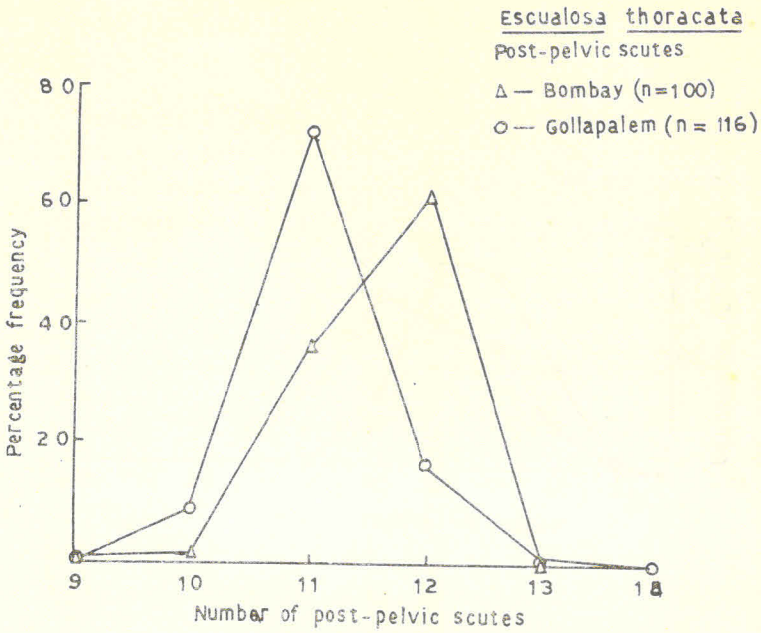
Escualosa thoracata
Post-pelvic scutes
Δ — Bombay (n=100)
o — Gollapalem (n = 116)
80
60
40
20
Percentage frequency
9
10
11
12
13
18
Number of post-pelvic scutes

FIG . 5.

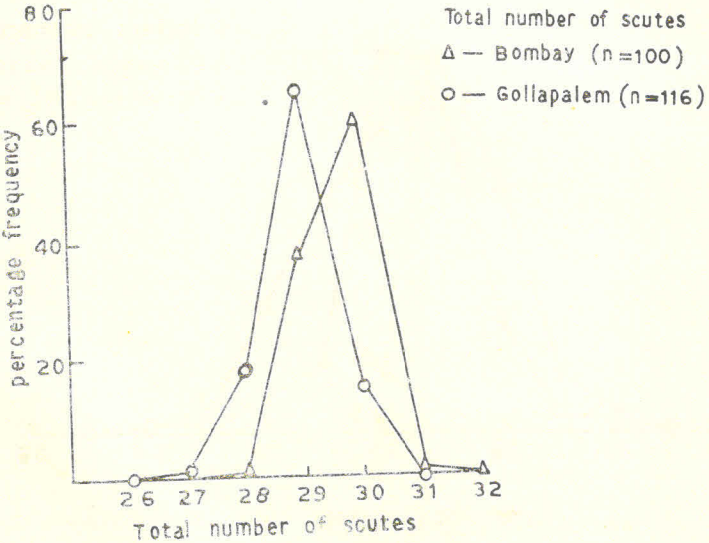
Total number of scutes
Δ — Bombay (n=100)
o — Gollapalem (n=116)
80
60
40
20
percentage frequency
26
27
28
29
30
31
32
Total number of scutes

FIG . 6.

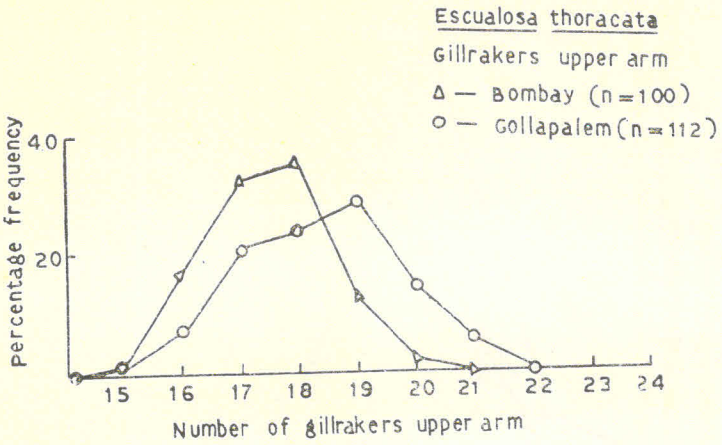
Escualosa thoracata
Gillrakers upper arm
Δ — Bombay (n=100)
○ — Gollapalem (n=112)
Percentage frequency
40
20
15 16 17 18 19 20 21 22 23 24
Number of gillrakers upper arm

FIG. 7.

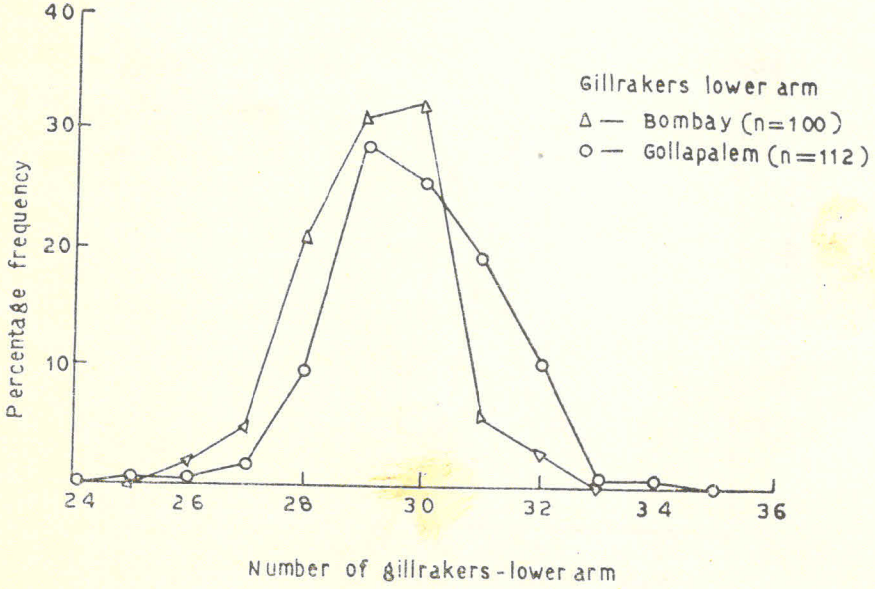
Gillrakers lower arm
Δ — Bombay (n=100)
○ — Gollapalem (n=112)
Percentage frequency
40
30
20
10
24 26 28 30 32 34 36
Number of gillrakers-lower arm

FIG. 8.

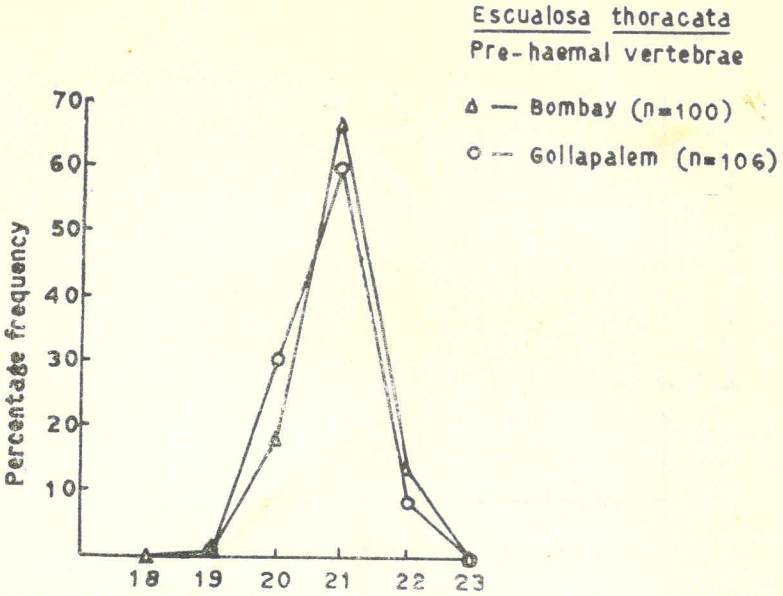
Escualosa thoracata
Pre-haemal vertebrae
Δ — Bombay (n=100)
o — Gollapalem (n=106)
Percentage frequency
70
60
50
40
30
20
10
18 19 20 21 22 23
Number of pre haemal vertebrae

FIG. 9.

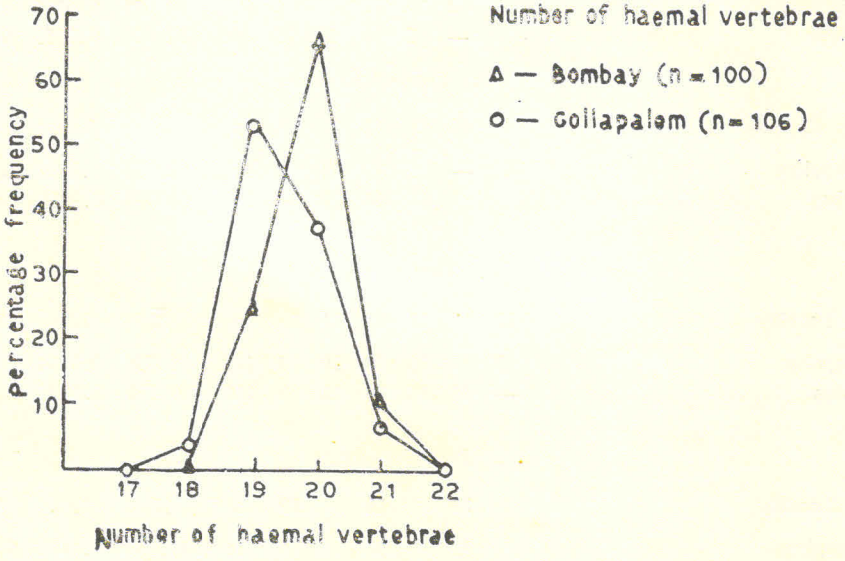
Number of haemal vertebrae
Δ — Bombay (n = 100)
o — Gollapalem (n = 106)
Percentage frequency
70
60
50
40
30
20
10
17 18 19 20 21 22
Number of haemal vertebrae

FIG. 10.

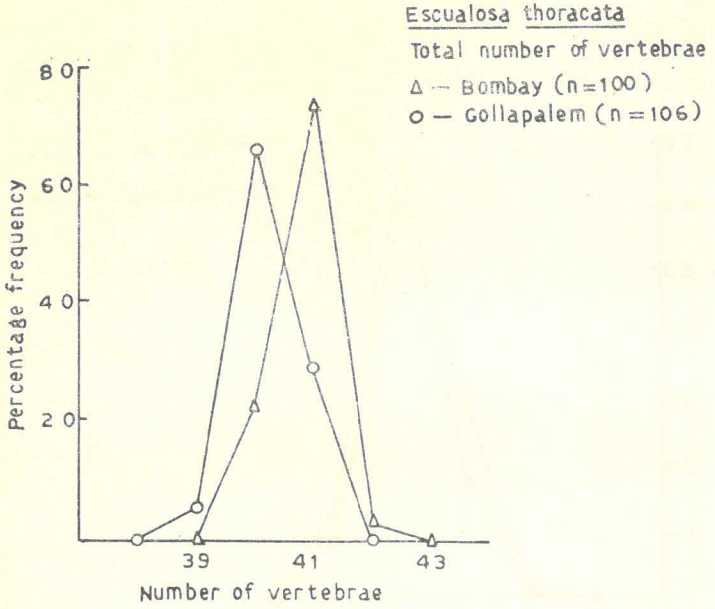

FIG 11

TABLE 1. FREQUENCY DISTRIBUTION OF MERISTIC CHARACTERS OF *E. thoracata* FROM GOLLAPALEM AND BOMBAY

a. *Dorsal fin rays*

Locality	14	15	16	17	18	n	$\bar{X}$	S.D.	S.E.
Gollapalem	3	12	72	24	1	112	16.071	0.6776	0.0640
Bombay	—	2	18	55	25	100	17.030	0.7135	0.07135

b. *Pectoral fin rays*

Locality	10	11	12	13	14	n	$\bar{X}$	S.D.	S.E.
Gollapalem	—	5	70	34	3	112	12.312	0.3577	0.0338
Bombay	1	13	64	22	—	100	12.070	0.3851	0.0385

c. *Anal fin rays*

Locality	17	18	19	20	21	22	n	$\bar{X}$	S.D.	S.E.
Gollapalem	2	9	30	48	20	3	112	19.750	0.9814	0.0927
Bombay	—	15	36	34	12	3	100	19.520	0.9846	0.0984

d. *Pre-pelvic suctes*

Locality	17	18	19	n	$\bar{X}$	S.D.	S.E.
Gollapalem	22	90	4	116	17.844	0.4473	0.0416
Bombay	3	94	3	100	18.000	0.0600	0.0060

e. *Post-pelvic scutes*

Locality	10	11	12	13	n	$\bar{X}$	S.D.	S.E.
Gollapalem	11	85	19	1	116	11.086	0.2856	0.0265
Bombay	1	37	62	—	100	11.610	0.2579	0.0257

f. *Tota number of scutes*

Locality	27	28	29	30	31	n	$\bar{X}$	S.D.	S.E.
Gollapalem	2	21	75	18	—	116	28.939	0.6336	0.0588
Bombay	—	1	38	60	1	100	29.300	0.6115	0.06115

g. *Gillrakers Upper arm*

Locality	15	16	17	18	19	20	21	n	$\bar{X}$	S.D.	S.E.
Gollapalem	1	8	23	26	32	16	6	112	18.357	1.3353	0.1261
Bombay	1	17	32	35	13	2	—	100	17.480	1.0146	0.1014

h. *Gillrakers Lower arm*

Locality	25	26	27	28	29	30	31	32	33	34	n	$\bar{X}$	S.D.	S.E.
Gollapalem	1	1	2	10	32	30	22	12	1	1	112	29.875	1.4150	0.1337
Bombay	—	2	5	21	31	32	6	3	—	—	100	29.160	1.8084	0.118

i. *Pre-haemal vertebrae*

Locality	19	20	21	22	n	$\bar{X}$	S.D.	S.E.
Gollapalem	1	32	64	9	106	20.764	0.6073	0.5899
Bombay	1	18	67	14	100	20.940	0.5969	0.0596

j. *Haemal vertebrae*

Locality	18	19	20	21	n	$\bar{X}$	S.D.	S.E.
Gollapalem	4	56	39	7	106	19.462	0.6753	0.0655
Bombay	—	24	66	10	100	19.860	0.5660	0.0566

k. *Total number of vertebrae*

Locality	39	40	41	42	n	$\bar{X}$	S.D.	S.E.
Gollapalem	5	70	31	—	106	40.245	0.5286	0.0513
Bombay	—	23	74	3	100	40.800	0.4690	0.0469

TABLE 2. *E. thoracata*. SIGNIFICANCE OF THE DIFFERENCES IN THE MEANS OF MERISTIC CHARACTERS IN SAMPLES FROM BOMBAY AND GOLLAPALEM DETERMINED BY APPLYING 'T' TEST

Character	D.f.	T	Significance at 5% level
Dorsal fin rays	210	9.9850	Significant
Pectoral fin rays	210	2.8869	Significant
Anal fin rays	210	1.6939	Not significant
Pre-pelvic scutes	214	3.1206	Significant
Post-pelvic scutes	214	7.3286	Significant
Total number of scutes	214	4.2280	Significant
Gillrakers upper arm	210	6.3792	Significant
Gillrakers lower arm	210	3.9524	Significant
Pre-haemal vertebrae	204	2.0857	Significant
Haemal vertebrae	204	4.5480	Significant
Total number of vertebrae	204	7.9142	Significant

TABLE 3. *E. thoracata*. SIGNIFICANCE OF THE DIFFERENCES IN THE MERISTIC CHARACTERS OF SAMPLES FROM BOMBAY AND GOLLAPALEM BY APPLYING THE CHI-SQUARE TEST

Character	D.f.	X^2	Significant at 5% level
Dorsal fin rays	4	76.4260	Significant
Pectoral fin rays	4	33.2628	Significant
Anal fin rays	5	7.8228	Not significant
Pre-pelvic scutes	2	13.5648	Significant
Post-pelvic scutes	3	50.1336	Significant
Total number of scutes	4	55.0152	Significant
Gillrakers upper arm	6	30.4008	Significant
Gillrakers lower arm	9	22.5114	Significant
Pre-haemal vertebrae	3	4.9028	Not significant
Haemal vertebrae	3	24.1226	Significant
Total number of vertebrae	3	49.2340	Significant

TABLE 4. *E. thoracta.* MEANS ($\bar{x}$) OF 6 BODY MEASUREMENTS (1 TO 6: *vide* TEXT) IN THE TWO SEXES AND OF POOLED DATA FROM BOMBAY AND GOLLAPALEM

Locality	Sex	Length range	N	$\bar{X}^1$	S.D.	$\bar{X}^2$	S.D.	$\bar{X}^3$	S.D.	$\bar{X}^4$	S.D.	$\bar{X}^5$	S.D.	$\bar{X}^6$	S.D.
Bombay	Male	61.0-73.0	55	65.090	±2.327	21.090	±1.023	16.072	±0.978	30.618	±1.209	30.272	±1.026	46.290	±1.978
	Female	60.0-73.0	45	65.066	±3.271	20.688	±1.239	15.866	±1.120	30.222	±1.929	29.955	±1.460	45.911	±2.530
Golla-palem	Male	59.0-74.0	64	64.843	±3.630	20.312	±1.245	15.906	±0.903	29.968	±1.781	29.500	±1.613	45.484	±2.532
	Female	60.0-71.0	36	63.444	±2.802	19.750	±1.204	15.611	±0.728	29.444	±1.462	28.694	±1.470	44.361	±2.282
Bombay	Pooled	60.0-73.0	100	65.080	±2.776	20.910	±1.137	15.980	±1.044	30.440	±1.578	30.130	±1.244	46.120	±2.239
Golla-palem	Pooled	59.0-75.0	100	64.340	±3.408	20.110	±1.254	15.800	±0.852	29.780	±1.685	29.210	±1.603	45.080	±2.493

TABLE 5. SIGNIFICANCE OF THE DIFFERENCES IN THE SIX BODY MEASUREMENTS OF THE TWO SEXES FROM BOMBAY AND GOLLAPALEM

Species	Locality	No. of Males (N_1)	No. of females (N_2)	D^2	F	Degrees of freedom $V_1 = P$	Degrees of freedom $V_2 = N + N^2 - P - 1$	Value of 'F' at 5% level	Value of 'F' at 1% level	Significance
E. thoracata	Bombay	55	45	0.5186	2.0301	6	93	2.21	3.03	Not significant
	Gollapalem	64	36	0.3981	1.4510	6	93	2.21	3.03	Not significant

TABLE 6. SIGNIFICANCE OF THE DIFFERENCES IN THE SIX BODY MEASUREMENTS (POOLED DATA OF BOTH SEXES) BETWEEN THE SAMPLES FROM BOMBAY AND GOLLAPALEM

Species	Bombay (N_1)	Gollapalem (N_2)	D^2	F	Degrees of freedom $V_1 = P$	Degrees of freedom $V_2 = N + N - P - 1$	Value of 'F' at 5% level	Value of 'F' at 1% level	Significance
E. thoracata	100	100	1.306	10.613	6	193	2.12	2.84	Significant