

BIOMETRIC STUDIES ON *SARDINELLA MADERENSIS* LOWE
AND *SARDINELLA AURITA* CUV. & VAL. FROM THE
MEDITERRANEAN SEA AT ALEXANDRIA (U.A.R.)

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Pre-orbital distance (Pr.O.), from the tip of the snout to the anterior margin of the eye.

Body depth (B.D.), the vertical distance between the dorsal and ventral profiles of the body, measured at the broadest part of the body.

All the preceding measurements were taken for 474 fish of *S. maderensis* ranging in length between 65 and 284 mm., and 463 fish of *S. aurita* ranging in length between 45 and 224 mm. The ratio of each of the previous measurements to the standard length were made for every single fish and then the average for each centimeter length group is calculated. The average for all length groups was also obtained.

2.—Meristic characters :

For the study of the meristic characters of these two species, data were obtained on the following :

- (a) number of gill rakers ;
- (b) number of vertebrae ;
- (c) number of rays in the different fins.

The number of fin rays in the dorsal, anal, pectoral and ventral fins were counted with the naked eye. For *S. maderensis*, the number of rays were counted in the dorsal and anal fins of 180 fish ; while in the pectorals and ventrals, 104 and 52 fish were respectively considered. For *S. aurita*, the fin rays in the dorsal and anal fins of 223 fish were counted, while rays of the pectorals and ventrals of only 49 fish were recorded.

The fish after that was dissected to know its sex, state of gonad maturity and to count the number of gill-rakers. The number of gill-rakers on the lower part of the first gill arch from the left side in 132 fish *S. maderensis* ranging in length between 50 and 270 mm were recorded. The same was done on 189 fish of *S. aurita* ranging in length between 60 and 310 mm. These counts were then considered for each centimeter length groups within the length range studied.

After that, the fish was then immersed in boiling water for few minutes to remove the flesh in order to reveal the vertebral column for vertebral count. As far as vertebral count is concerned, data were obtained from 594 fish, *S. maderensis*, ranging in length between 70 and 270 mm, and 508 fish, *S. aurita*, ranging in length between 40 and 230 mm.

RESULTS

Systematic position, synonyms and diagnostic features of *S. maderensis* and *S. aurita* :

It is essential to give notes on the systematic position, synonyms and diagnostic features of the two species considered as introduction to the biometric studies done on them.

*Classification and Synonyms:*Superclass *Pisces*Class *Osteichthyes*Subclass *Actinopterygii*Superorder *Teleostei*Order *Clupeiformes*Suborder *Clupeoidei*Family *Clupeidae*Genus *Sardinella*Species *maderensis* (a)*aurida* (b)(a) **Valid scientific name:**

S. maderensis is considered to be the correct specific name, being the oldest among the synonyms.

Synonyms:*Clupea maderensis* Lowe, 1839 (Madeira)*Sardinella grunigera* Valenciennes, 1847 (Egypt)*Aluosa eba* Valenciennes, 1847 (Senegal)*Sardinella eba* Cuv. & Val.*Sardinella camerounensis* Regan, 1917 (Cameron).**Diagnosis:**

D. 17 - 21; A. 17 - 22; P. 14 - 17; V. 8; L.l.r 40 - 50; L.t.r. 9 - 13.

Depth of body 2.9 - 4.1, length of head 3.4 - 4.5; predorsal distance 2.1 - 2.5; preventral distance 1.8 - 2.2; preanal distance 1.1 - 1.5; from origin of pectoral to origin of anal 3.3 - 4.3; all in standard length.

Length of snout 3.2 - 4.2; eye-diameter 3.1 - 4.5; inter-orbital width 3.9 - 5.8; length of upper jaw 2.1 - 3.0; length of base of dorsal fin 1.3 - 2.2; height of dorsal fin 1.3 - 2.2; length of anal base 1.2 - 1.6; length of pectoral fin 1.2 - 1.8; length of ventral fin 2.1 - 2.9; depth of caudal peduncle 2.5-3.0; all in length of head.

Ventral scutes moderately pointed; their number 18-20 + 13-15 (total number 31-34). Number of gill rakers 70-166 on the lower arch of specimens larger than 60 mm in standard length. Their number increases with the size of the fish.

A deep body, deepest at dorsal origin, laterally strongly compressed. Length of head considerably less than greatest depth. Diameter of eye as long as or slightly longer than snout. Scales cycloid, perforated on their posterior edge. Each ventral fin contains eight rays.

(b) **Valid scientific name :**

The most commonly used scientific name is *Sardinella aurita* Valenciennes. A few ichthyologists (Fowler 1941) use the apparently oldest name *Sardinella allecia* Rafinesque.

Synonyms :

Clupea allecia Rafinesque, 1810 (Sicily).

Engraulis desmaresti Risso, 1826 (Nice).

Clupea auro-cittata Swainson, 1839 (Palermo).

Sardinella aurita :

Valenciennes, 1847 (Gulf of Motee).

Pellegrin, 1914 (West Africa).

Regan, 1917 (examined specimens from Brazil, U.S.A., West Africa, the Mediterranean, the Indo-Australian Archipelago, China and Japan).

Sardinella anchovia Valenciennes, 1847 (Rio de Janeiro).

Sardinella lemuru Bleeker, 1853 (Batavia).

Sardinia pseudohispanica Poey, 1861 (Cuba).

Clupea aurita Gunter, 1868 (Mediterranean).

Clupea brasiliensis Steindachner, 1880 (Rio de Janeiro).

Sardinella excisa Antipa, 1906 (Constanza).

Clupea venulosa Steinitz, 1927 (Haifa).

Diagnosis :

D. 16-20; A. 15-19; P. 16-18; V. 9; L.l.r. 43-51; L.tr r11-12.

Depth of body 3.9-5.0; length of head 3.9-4.6; distance from tip of snout to dorsal origin 2.1-2.6; from tip of snout to ventral origin 1.9-2.3; from tip of snout to anal origin 1.3-1.6; from origin of pectoral to origin of ventral 3.5-4.5; from origin of pectoral to origin of anal 3.6-4.6; all in standard length.

Length of snout 2.7-4.2; eye diameter 2.3-4.4; inter-orbital width 3.7-4.8; length of upper jaw 2.2-2.9; length of base of dorsal fin 1.5-2.0; height of dorsal fin 1.5-1.9; length of anal base 1.4-1.9; length of pectoral fin 1.4-1.9; length of ventral fin 2.3-3.1; all in length of head.

Ventral scutes sharply pointed; in number 18-21 + 13-17 (total number 32-35). Gill rakers long and slender, densely packed, 100-170 on the lower arch of specimens larger than 90 mm in standard length. The number varies with the size of the fish, and in specimens of 350 mm may reach 280 (Rossignol, 1955).

Delimitation of area of distribution :

The continental shelves of the tropical and subtropical waters are inhabited by *S. maderensis* and *S. aurita*. The latitudes constituting its distribution is known to be within 30° or 40° to the North and South.

The temperature of the sea water is probably the restricting factor governing their distribution. The yearly isotherm of the sea 18° C marks the limits of the distribution of *S. aurita* (Furnestine, 1952).

S. maderensis is however more localised in its distribution. The yearly surface isotherm which governs its distribution is probably not lower than 20°C.

Many laboratory experiments have been carried out on the effect of the change in environmental factors (particularly temperature and salinity) upon the morphological structures of fish. The characters most affected in a fish are the so-called "meristic characters" which include the numbers of vertebrae, of fin rays and spines and the like. All these structures show variations independent of the others as stated by Schmidt (1917), Dannevig (1932) and Taaning (1944). It has been found that the water temperature in which a fertilized fish egg passes its embryonic development greatly influences the resulting vertebral numbers of the hatched larva. The effect of environmental variation on fin rays count take place at a later stages after hatching and during the development of the larval fish than in vertebrae. Quantitative differences between these characters in a species of fish from different areas might either be due to :

- (1) The result of genetical differences (i.e. different varieties).
- (2) Different environmental differences operating on the progeny, genetically the same, during the early developmental stages.

Grégory (1928 a and b) attempted to determine species and races by means of the external features or what are called "Profile types". This conception is criticised by Conrad (1938); Thompson (1943) and Kesteven (1950) on the basis that these profiles could change considerably with sex and age.

The identification of races or species by means of the numerical ratio between the dimensions of two parts of the body (i.e. indices) was followed by many workers, Hofer (1898); Kostamarov (1922); Feldt (1927); Hofman (1927); Dixoh (1931) and Dottrens (1950) have worked the indices based on these ratios in the Carp, Tunny and Sea-trout. Kesteven (1950), objected to this method; he prefers to express the different body dimensions by covariance and regression equation. He mentioned that the method of indices by ratio was more successful for species like Sea-trout and Carp than for marine species as Herring and Mullet,

The identity of *S. maderensis* and *S. aurita* inhabiting the Mediterranean waters of Egypt based on both ratio indices and regression calculation is not studied. It is attempted in this study to fill this gap and to compare the results with those found on the same species in other areas.

A.—Morphometric Characters

1.—Morphometric measurements of *S. maderensis*:

(a) Ratio indices:

For the study of morphometric characters of *S. maderensis* twelve measurements on the fish were obtained to the nearest millimeter as already stated in the methods. The morphometric index of each measurement was calculated for every fish as a numerical ratio between this measurement and the standard length. Then the mean value of the ratio for every centimeter group and for all length groups were obtained. All these ratio values for the different morphometric measurements are shown in Table (1). The values from this table could be summarised as follows:

Morphometric index	The index range	The index mean
T.L / S.L	1.18 - 1.25	1.23
S.L / Pt.D	1.73 - 1.82	1.76
S.L / Pr.D	2.31 - 2.44	2.35
S.L / Pt.A	1.13 - 1.20	1.14
S.L / Pr.A	1.33 - 1.42	1.35
S.L / Pr.V	2.07 - 2.24	2.12
S.L / B.D	2.91 - 3.32	3.66
S.L / H.L	3.97 - 4.86	4.26
H.L/E.D	3.45 - 4.14	3.70
H.L / Pr.O	3.14 - 4.14	3.29
H.L / I.O	3.45 - 4.25	3.71

(b) Morphometric regressions:

The observed values of six morphometric characters viz; standard length, pre-anal length, pre-ventral length, pre-dorsal length, head length and eye-diameter against total length were plotted as scatter diagrams in figure (3).

The points in all cases aggregate in distinctly straight lines; consequently the linear regression formula:

$$Y = a + b X$$

was used to obtain the regression formula for each morphometric characters.

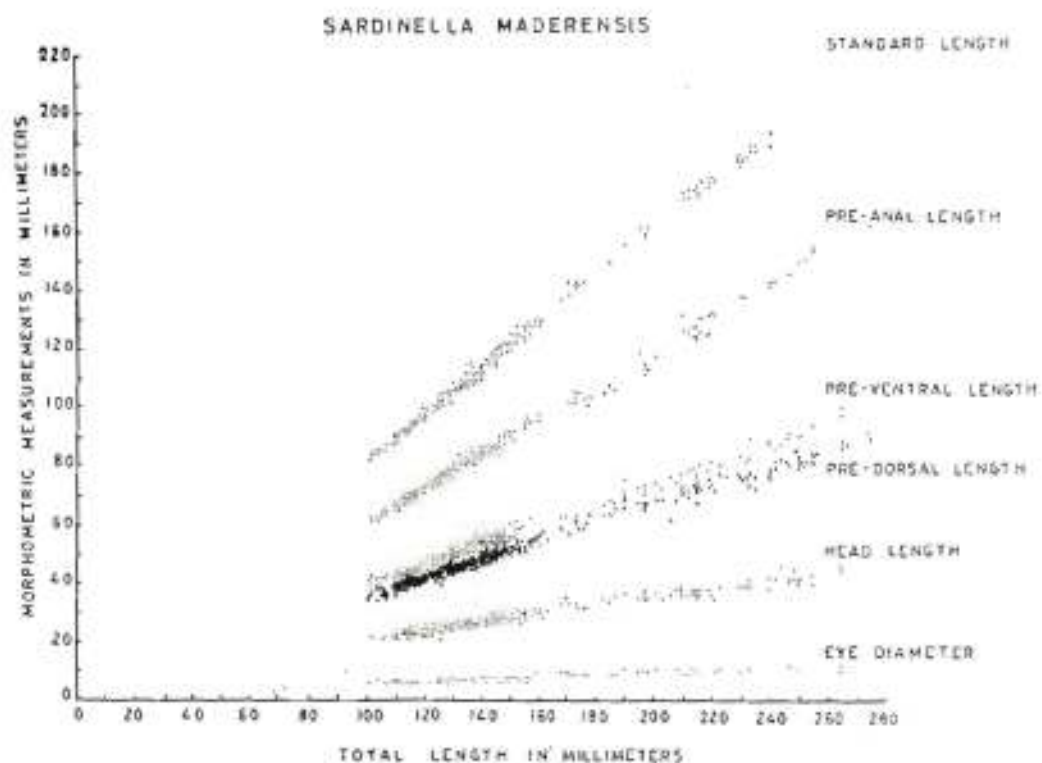


FIG. 3.—A scatter diagram to show the relation, between the total length and the different morphometric measurements for *S. maderensis*.

TABLE I.—MORPHOMETRIC INDICES FOR DIFFERENT MORPHOMETRIC MEASUREMENTS IN *S. sardensis*.

Total length group in mm.	TL/S.L		SL/Pr. D		SL/Pr. A		SL/Pr. A		SL/Pr. V		SL/H. L		SL/B. D		HL/E. D		HL/Pr. O		HL/I. O			
	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio	No.	ratio		
65 — 74	3	1.18	3	1.78	3	2.34	3	1.20	3	1.40	3	2.07	3	2.91	3	4.14	3	4.14	3	4.14		
95 — 104	9	1.22	9	1.73	9	2.32	9	1.14	9	1.35	9	2.03	9	3.97	7	3.78	9	3.48	9	3.14		
105 — 114	55	1.23	53	1.74	55	2.33	55	1.13	55	1.35	55	2.10	55	4.02	51	3.71	55	3.59	55	3.21		
115 — 124	67	1.23	65	1.75	65	2.34	65	1.14	65	1.35	65	2.10	67	4.10	64	3.72	67	3.73	65	3.28		
125 — 134	84	1.23	75	1.75	75	2.34	75	1.13	75	1.34	75	2.10	84	4.17	72	3.66	84	3.66	75	3.23		
135 — 144	100	1.23	91	1.75	91	2.32	91	1.13	91	1.34	91	2.11	100	4.23	82	3.64	100	3.75	91	3.29		
145 — 154	54	1.23	54	1.77	54	2.34	54	1.14	54	1.34	54	2.12	54	4.20	53	3.68	54	3.68	54	3.32		
155 — 164	13	1.24	13	1.70	13	2.30	13	1.13	13	1.33	13	2.12	13	4.19	13	3.69	13	3.74	13	3.33		
165 — 174	8	1.22	8	1.77	8	2.34	8	1.13	8	1.37	8	2.14	8	4.26	8	3.81	8	3.45	8	3.54		
175 — 184	4	1.22	4	1.81	4	2.30	4	1.16	4	1.42	4	2.24	4	4.43	4	3.87	4	3.67	4	3.57		
185 — 194	5	1.22	5	1.78	5	2.31	5	1.14	5	1.35	5	2.19	5	4.27	3	3.75	5	3.71	5	3.46		
195 — 204	8	1.23	8	1.79	8	2.33	8	1.16	8	1.40	8	2.22	8	4.49	7	3.71	8	3.61	8	3.44		
205 — 214	9	1.22	9	1.80	9	2.41	9	1.14	9	1.35	9	2.16	9	4.67	7	3.61	9	3.68	9	3.34		
215 — 224	12	1.24	12	1.82	12	2.39	12	1.14	12	1.38	12	2.22	12	4.73	12	3.58	12	3.59	12	3.22		
225 — 234	10	1.24	10	1.80	10	2.41	10	1.15	10	1.37	10	2.20	10	4.71	9	3.54	10	3.82	10	3.36		
235 — 244	9	1.24	9	1.82	9	2.43	9	1.14	9	1.35	9	2.19	9	4.73	8	3.47	9	3.88	9	3.39		
245 — 254	15	1.25	15	1.80	15	2.43	15	1.15	15	1.35	15	2.18	15	4.83	14	3.42	15	3.65	15	3.27		
255 — 264	4	1.25	4	1.78	4	2.43	4	1.14	4	1.32	4	2.16	4	4.86	3	3.55	4	4.01	4	3.20		
265 — 274	4	1.25	4	1.79	4	2.42	4	1.15	4	1.35	4	2.16	4	4.84	3	3.32	4	3.98	4	3.25		
275 — 284	1	1.25	1	1.79	1	2.44	1	1.15	1	1.35	1	2.14	1	4.68	1	3.44	1	3.92	1	3.62		
Total number	474		454		454		454		454		474		424		474		454		388			
Av. index . . .		1.23		1.76		2.35		1.14		1.35		2.12		4.26		3.65		3.70		3.29		3.71

In this equation :

Y = the morphometric measurement in millimeters.

X = the total length in millimeter.

a and b are constants which can be determined using the statistical method of least square in which.

$$b = \frac{N \sum xy - (\sum x) (\sum y)}{N \sum x^2 - (\sum x)^2}$$

$$a = \frac{\sum y - b \sum x}{N}$$

where : N = the number of items in the sample.

In Table (2) showing the mean observed morphometric measurements at 5 mm. length intervals are given. The respective equations are calculated from the preceding equations and are presented in Table (3). These regression equations were used to obtain the calculated measurements of the fore-mentioned characters. The average observed values and the calculated values for these measurements are compared in Table (4). In Figure (4) the straight lines represent the calculated values and the dots the average ones. The close fitness of the mean observed values on the straight lines show that the regression equations expressing straight lines are correct and they best fit the morphometric characters in question.

TABLE 3.—REGRESSION EQUATIONS OF THE DIFFERENT MORPHOMETRIC CHARACTERS RELATIVE TO TOTAL LENGTH IN *S. maderensis*

Morphological Characters	Regression Equation
Standard length	S.L = 3.1387 + 0.7943 T.L
Preanal length	Pre.A = 3.0897 + 0.5809 T.L
Pre-ventral length	Pre.V = 4.5816 + 0.3505 T.L
Pre-dorsal length	Pre.D = 4.2573 + 0.3186 T.L
Head length	H.L = 6.7889 + 0.1441 T.L
Eye-Diameter	E.D = 2.3515 + 0.0362 T.L

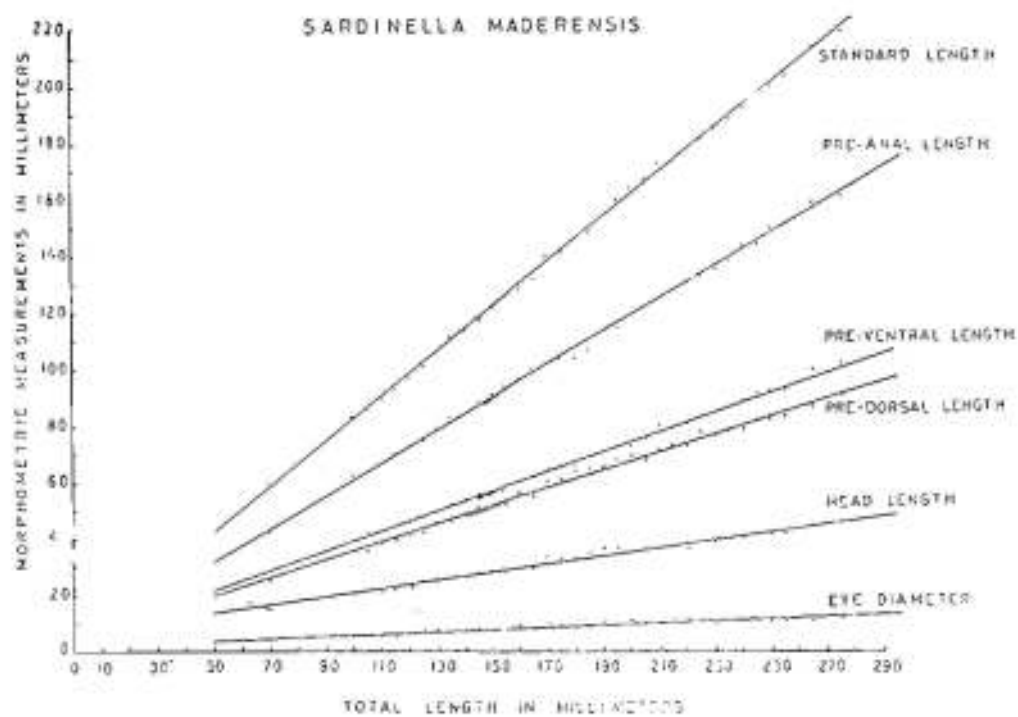


FIG. 4.—The relation between the total length and the different morphometric measurements for *S. maderensis*.

TABLE 4.—CALCULATED MORPHOMETRIC MEASUREMENTS FOR *Sardinella maderensis* AFTER RESPECTIVE REGRESSION EQUATIONS

Length groups in mm.	S.L.		Pre-Anal		Pre-Ventral		Pre-Dorsal		Head Length		Eye Diameter	
	obs.	calculated	obs.	calculated	obs.	calculated	obs.	calculated	obs.	calculated	obs.	calculated
70	60	58.7397	43	43.7527	29	29.1166	26	26.5593	15	16.8759	4	4.8855
100	83	82.5687	62	61.1797	42	39.6316	36	36.1173	21	21.1989	6	5.9715
105	86	86.5402	64	64.0842	42	41.3841	36	37.7103	22	21.9194	6	6.1525
110	90	90.5117	67	66.9887	43	43.1366	39	39.3033	22	22.6399	6	6.3335
115	93	94.4832	70	69.8932	45	44.8891	40	40.8963	23	23.3604	6	6.5145
120	97	98.4547	73	72.7977	46	46.6416	42	42.4893	23	24.0809	6	6.6955
125	101	102.4262	75	75.7022	48	48.3941	43	44.0823	25	24.8014	7	6.8765
130	106	106.3977	79	78.6067	50	50.1466	46	45.6753	25	25.5219	7	7.0575
135	111	110.3692	83	81.5112	52	51.8991	47	47.2683	26	26.2424	7	7.2385
140	114	114.3407	85	84.4157	54	53.6516	49	48.8613	27	26.9629	7	7.4195
145	118	118.3122	88	87.3202	56	55.4041	51	50.4543	28	27.6834	8	7.6005
150	122	122.2837	91	90.2247	57	57.1566	52	52.0473	29	28.4039	8	7.7815
155	126	126.2552	94	93.1292	59	58.9091	53	53.6403	29	29.1244	8	7.9625
160	129	130.2267	97	96.0337	60	60.6616	56	55.2333	30	29.8449	9	8.1435
165	132	134.1982	100	98.9382	62	62.4141	55	56.8263	31	30.5654	8	8.3245
170	140	138.1697	101	101.8427	64	64.1666	60	58.4193	34	31.2859	10	8.5055
175	142	142.1412	104	104.7472	65	65.9191	61	60.0123	33	32.0064	9	8.6865
180	148	146.1127	104	107.6517	66	67.6716	64	61.6663	33	32.7269	9	8.8675
185	149	150.0842	106	110.5562	68	69.4241	65	63.1983	35	33.4474	9	9.0485
190	158	154.0557	118	113.4607	75	71.1766	68	64.7913	37	34.1679	10	9.2295
195	160	158.0272	115	116.3652	73	72.9291	68	66.3843	36	34.8884	10	9.4105
200	164	161.9987	116	119.2697	73	74.6816	69	67.9773	36	35.6089	11	9.5915
205	167	165.9702	122	122.1742	75	76.4341	68	69.5703	36	36.3294	10	9.7725
210	173	169.9417	129	125.0787	80	78.1866	71	71.1633	37	37.0499	10	9.9535

215	174	173.9132	127	127.9832	79	79.9391	73	72.7563	37	37.7704	10	10.1345
220	178	177.8847	130	130.8877	81	81.6916	74	74.3493	37	38.4909	11	10.3155
225	182	181.8562	132	133.7922	83	83.4441	78	75.9423	40	39.3114	11	10.4965
230	185	185.8277	136	136.6967	84	85.1966	77	77.5353	39	39.9319	10	10.6775
235	189	189.7992	139	139.6012	87	86.9491	79	79.1283	39	40.6524	10	10.8585
240	193	193.7707	144	142.5057	89	88.7016	79	80.7213	41	41.3729	11	11.0395
245	197	197.7422	145	145.4102	91	90.4541	82	82.3143	43	42.0934	11	11.2205
250	201	201.7137	150	148.3147	92	92.2066	83	83.9073	42	42.8139	11	11.4015
255	204	205.6852	152	151.2192	93	93.9591	84	85.5003	42	43.5344	11	11.5825
265	214	213.6282	159	157.0282	100	97.4641	88	88.6863	45	44.9754	11	11.9445
275	220	221.5712	162	162.8372	102	100.9691	91	91.8723	46	46.4164	12	12.3065

2.—Morphometric measurements of *S. aurata* :(a) *Ratio indices* :

For the study of the morphometric characters of *S. aurata*, the previously mentioned eleven measurements on the fish were obtained to the nearest millimeter as already stated in Chapter II. Likewise, the ratio indices, the mean values of the ratio for each centimeter group and for all length groups were obtained. All these values for the different morphometric measurements are shown in Table (5). The values from this table could be summarised as follows :

Morphometric index	The index range	The index mean
T.L / S.L	1.19 — 1.21	1.20
S.L / Pt.D	1.72 — 1.88	1.84
S.L / Pr.D	2.15 — 2.47	2.37
S.L / Pt.A	1.11 — 1.15	1.14
S.L / Pr.A	1.32 — 1.37	1.34
S.L / Pr.V	1.87 — 2.17	2.06
S.L / B.D	4.23 — 4.86	4.42
S.L / H.L	3.31 — 4.84	4.22
H.L / E.D	3.86 — 4.56	3.98
H.L / Pr.O	2.98 — 4.33	3.27
H.L / I.O	3.86 — 4.56	3.99

(b) *Morphometric regressions* :

The observed values of six morphometric characters viz : standard length, pre-anal length, pre-ventral length, pre-dorsal length, head length and eye-diameter against total length were plotted as scatter diagrams (Fig. 5). The points in all cases aggregate in distinct straight lines; consequently likewise, the linear regression formula : $Y = a + b \cdot x$, was used to obtain the regression formula for each morphometric character.

From Table (6) showing the mean observed morphometric measurements, the respective equations are calculated and presented in Table (7). These regression equations were used to obtain the calculated measurements of the fore-mentioned characters. These are compared with averaged observed ones in Table (8). In Fig. (6) the straight lines represent the calculated values and the dots the average ones. The close fitness of the mean observed values on the straight lines show that the regression equations expressing straight lines are correct and they best fit the morphometric characters in question.

TABLE 5.—MORPHOMETRIC INDICES FOR DIFFERENT MORPHOMETRIC MEASUREMENTS IN *S. aurita*

Total length group in mm.	TL/S.L		SL/Pl.D		SL/Pr.D		SL/Pl.A		SL/Pr.A		SL/Pr.V		SL/H.L		SL/B.D		HL/E.D		HL/Br.O		HL/I.O	
	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r
45 — 54	1	1.21	1	1.72	1	2.15	1	1.13	1	1.34	1	1.87	1	3.31	1	4.77	1	4.33	1	4.33	1	4.33
55 — 64	7	1.20	7	1.76	7	2.24	7	1.11	7	1.34	7	1.97	7	3.57	7	4.48	7	3.86	7	4.02	7	3.80
65 — 74	13	1.19	13	1.77	13	2.24	13	1.13	13	1.35	13	2.00	13	3.64	13	4.34	13	3.94	13	3.63	13	3.94
75 — 84	26	1.19	26	1.77	26	2.28	26	1.13	26	1.34	26	2.01	26	3.82	26	4.36	26	4.35	26	3.52	26	4.35
85 — 94	8	1.19	8	1.76	8	2.29	8	1.14	8	1.35	8	2.04	8	3.79	8	4.33	8	4.56	8	3.60	8	4.56
95 — 104	19	1.20	19	1.79	19	2.32	19	1.14	19	1.35	19	2.03	19	3.84	19	4.23	19	3.90	19	3.38	19	3.96
105 — 114	21	1.19	21	1.82	21	2.35	21	1.14	21	1.36	21	2.05	21	4.00	21	4.25	21	3.86	21	3.31	21	3.86
115 — 124	10	1.21	10	1.83	10	2.33	10	1.14	10	1.35	10	2.07	10	3.95	10	4.26	10	4.12	10	3.53	10	4.12
125 — 134	1	1.21	1	1.81	1	2.29	1	1.13	1	1.37	1	1.98	1	3.81	1	4.86	1	4.50	1	3.86	1	4.50
135 — 144	9	1.20	7	1.81	7	2.37	7	1.14	7	1.32	7	2.05	9	4.06	7	4.46	9	3.96	7	2.98	7	3.99
145 — 154	51	1.20	49	1.82	49	1.36	49	1.15	49	1.34	49	2.07	51	4.12	47	4.55	51	4.01	49	3.19	49	4.01
155 — 164	32	1.21	30	1.85	30	2.39	30	1.14	30	1.33	30	2.09	32	4.21	26	4.44	32	3.87	30	3.27	30	3.87
165 — 174	52	1.21	41	1.85	41	2.37	41	1.14	41	1.34	41	2.10	52	4.22	35	4.46	52	3.95	41	3.26	40	4.01
175 — 184	62	1.21	58	1.85	58	2.38	58	1.14	58	1.34	58	2.10	62	4.31	46	4.41	62	4.02	58	3.17	56	4.06
185 — 194	67	1.20	67	1.86	67	2.41	67	1.14	67	1.34	67	2.13	67	4.45	44	4.43	67	3.91	67	3.16	60	3.88
195 — 204	55	1.20	55	1.86	55	2.41	55	1.14	55	1.34	55	2.13	55	4.53	29	4.46	55	3.88	55	3.20	46	3.87
205 — 214	25	1.21	25	1.87	25	2.42	25	1.15	25	1.34	25	2.14	25	4.55	13	4.50	25	3.96	25	3.13	17	3.87
215 — 224	4	1.20	4	1.88	4	2.47	4	1.15	4	1.34	4	2.17	4	4.84	1	4.58	4	4.19	4	3.18	1	4.00
Total number	463		442		442		442		442		442		463		354		463		442		412	
Av. Index		1.20		1.84		2.37		1.14		1.34		2.06		4.22		4.42		3.98		3.27		3.99

TABLE 3.—MORPHOMETRIC INDICES FOR DIFFERENT MORPHOMETRIC MEASUREMENTS IN *S. aurita*

Total length group in mm.	TL/S.L		SL/Pt.D		SL/Pr.D		SL/Pt.A		SL/Pr.A		SL/Pr.V		SL/H.L		SL/B.D		HL/E.D		HL/Br.O		HL/I.O	
	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r	n	r
45 — 54 . . .	1	1.21	1	1.72	1	2.15	1	1.13	1	1.34	1	1.87	1	3.31	1	4.77	1	4.33	1	4.33	1	4.33
55 — 64 . . .	7	1.20	7	1.76	7	2.24	7	1.11	7	1.34	7	1.97	7	3.57	7	4.48	7	3.86	7	4.02	7	3.86
65 — 74 . . .	13	1.19	13	1.77	13	2.24	13	1.13	13	1.35	13	2.00	13	3.64	13	4.34	13	3.94	13	3.63	13	3.94
75 — 84 . . .	26	1.19	26	1.77	26	2.28	26	1.13	26	1.34	26	2.01	26	3.82	26	4.36	26	4.35	26	3.52	26	4.35
85 — 94 . . .	8	1.19	8	1.76	8	2.29	8	1.14	8	1.35	8	2.04	8	3.79	8	4.33	8	4.06	8	3.60	8	4.56
95 — 104 . . .	19	1.20	19	1.79	19	2.32	19	1.14	19	1.35	19	2.03	19	3.84	19	4.23	19	3.96	19	3.38	19	3.96
105 — 114 . . .	21	1.19	21	1.82	21	2.35	21	1.14	21	1.36	21	2.05	21	4.00	21	4.25	21	3.86	21	3.31	21	3.86
115 — 124 . . .	10	1.21	10	1.83	10	2.33	10	1.14	10	1.35	10	2.07	10	3.95	10	4.26	10	4.12	10	3.53	10	4.12
125 — 134 . . .	1	1.21	1	1.81	1	2.29	1	1.13	1	1.37	1	1.98	1	3.81	1	4.96	1	4.50	1	3.86	1	4.50
135 — 144 . . .	9	1.20	7	1.81	7	2.37	7	1.14	7	1.32	7	2.06	9	4.06	7	4.46	9	3.96	7	2.98	7	3.99
145 — 154 . . .	51	1.20	49	1.82	49	1.36	49	1.15	49	1.34	49	2.07	51	4.12	47	4.55	51	4.01	49	3.19	49	4.01
155 — 164 . . .	32	1.21	30	1.85	30	2.39	30	1.14	30	1.33	30	2.09	32	4.21	26	4.44	33	3.87	30	3.27	30	3.87
165 — 174 . . .	52	1.21	41	1.85	41	2.37	41	1.14	41	1.34	41	2.10	52	4.22	35	4.46	52	3.95	41	3.26	40	4.01
175 — 184 . . .	62	1.21	58	1.85	58	2.38	58	1.14	58	1.34	58	2.10	62	4.31	46	4.41	62	4.02	58	3.17	56	4.06
185 — 194 . . .	67	1.20	67	1.86	67	2.41	67	1.14	67	1.34	67	2.13	67	4.45	44	4.43	67	3.91	67	3.16	60	3.88
195 — 204 . . .	55	1.20	55	1.86	55	2.41	55	1.14	55	1.34	55	2.13	55	4.53	29	4.46	55	3.88	55	3.20	46	3.87
205 — 214 . . .	25	1.21	25	1.87	25	2.42	25	1.15	25	1.34	25	2.14	25	4.55	13	4.50	25	3.96	25	3.13	17	3.87
215 — 224 . . .	4	1.20	4	1.88	4	2.47	4	1.15	4	1.34	4	2.17	4	4.84	1	4.58	4	4.19	4	3.18	1	4.00
Total number . . .	463		442		442		442		442		442		463		354		463		442		412	
Av. Index		1.20		1.84		2.37		1.14		1.34		2.06		4.22		4.42		3.98		3.27		3.99

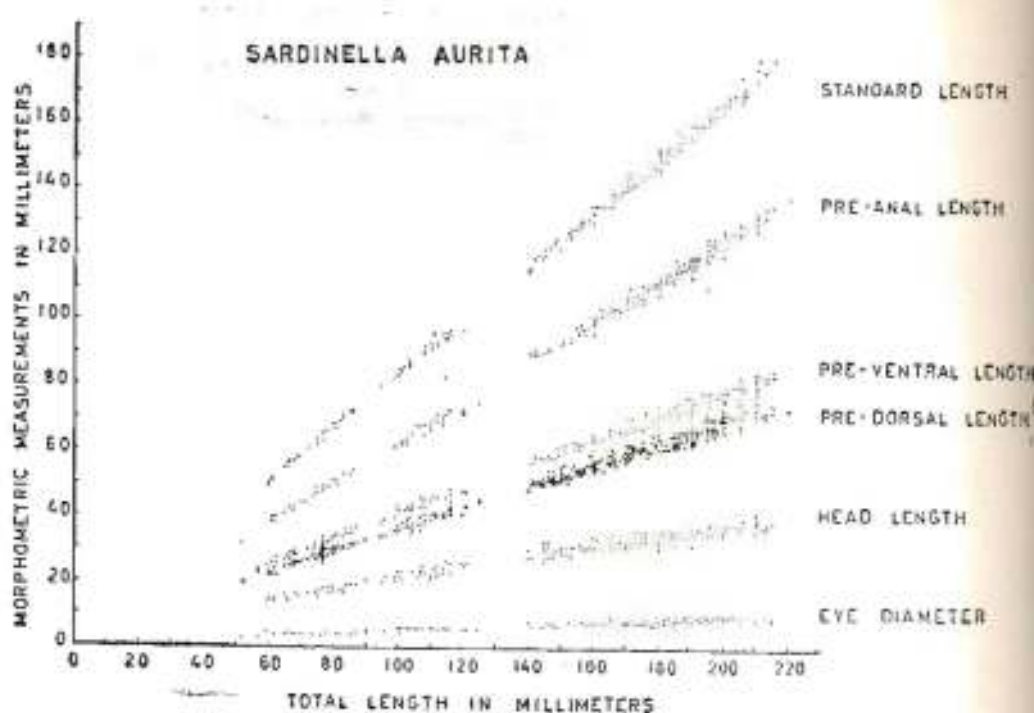


FIG 5.—A scatter diagram to show the relation between the total length and the different morphometric measurements for *S. aurita*.

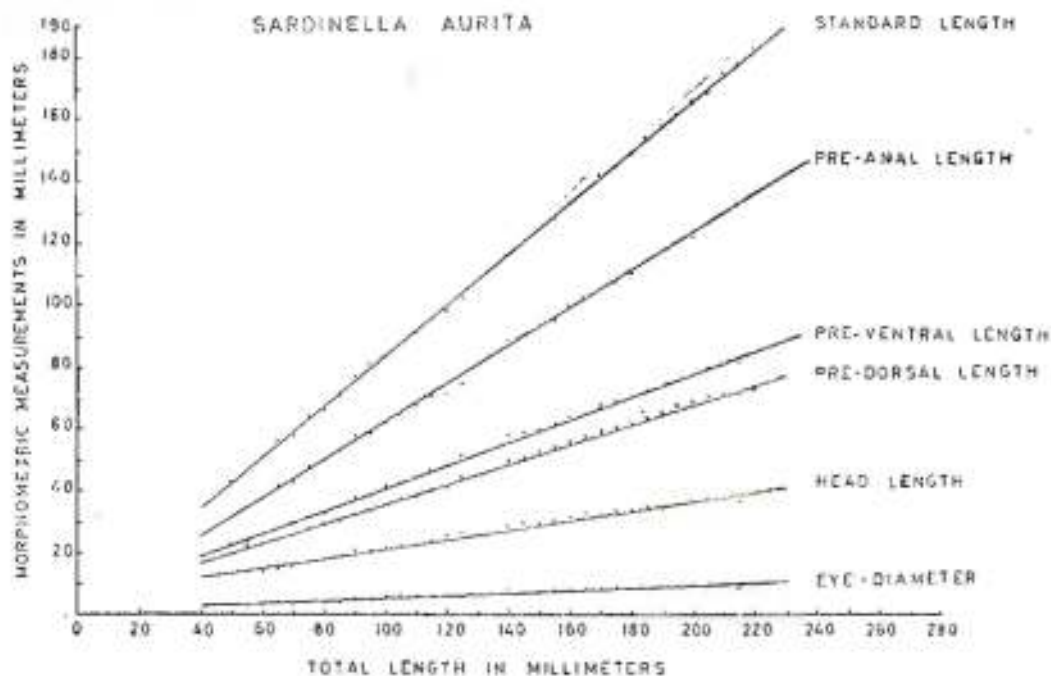


FIG. 6.—The relation between the total length and the different morphometric measurements for *S. aurita*.

TABLE 8.—CALCULATED MORPHOLOGICAL MEASUREMENT FOR *Sardinella aurita* AFTER RESPECTIVE REGRESSION EQUATION

Length group in (mm)	Standard length		Pre.-Anal		Pre-Ventral		Pre-Dorsal		Head Length		Eye diameter	
	obs	calculated	obs	calculated	obs	calculated	obs	calculated	obs	calculated	obs	calculated
50	43	42.8887	32	31.5722	23	22.7657	20	20.1249	13	13.7269	3	3.2381
55	47	46.9407	35	34.6507	24	24.6122	23	21.7439	14	14.5134	3	3.4501
60	51	51.0427	38	37.7292	26	26.4587	23	23.3629	14	15.2999	4	3.6621
65	56	55.1447	42	40.8077	28	28.3052	25	24.9819	15	16.0864	4	3.8741
70	58	59.2467	43	43.8862	29	30.1517	26	26.6009	16	16.8729	4	4.0861
75	64	63.3487	48	46.9647	32	31.9982	28	28.2199	17	17.6594	4	4.2981
80	67	67.4507	50	50.0432	33	33.8447	30	29.8389	18	18.4459	4	4.5101
85	71	71.5527	53	55.1217	35	35.6912	33	31.4579	19	19.2324	4	4.7221
90	77	75.6547	58	56.2002	38	37.5377	33	33.0769	21	20.0189	5	4.9341
95	81	79.7567	59	59.2787	39	39.3842	34	34.6969	21	20.8054	5	5.1461
100	84	83.8587	62	62.3572	42	41.2307	36	36.3149	22	21.5919	6	5.3581
105	88	87.9607	65	65.4357	43	43.0772	38	37.9339	23	22.3784	6	5.5701
110	92	92.0627	68	68.5142	45	44.9233	39	39.5529	23	23.1649	6	5.7821
115	96	96.1647	71	71.5927	47	46.7702	41	41.1719	24	23.9514	6	5.9941
120	99	100.2667	72	74.6712	48	48.6167	42	42.7909	26	24.7379	6	6.2061
125	103	104.3687	75	77.7497	52	50.4632	45	44.4099	47	25.5244	6	6.4181
140	117	116.6747	89	86.9852	58	56.0027	50	49.2669	29	27.8839	8	7.0541

145	131	120.7767	90	90.0637	59	57.8492	51	50.8859	30	28.6704	7	7.2661
150	125	124.8787	93	93.1422	60	59.6957	53	52.5049	30	29.4569	7	7.4781
155	128	128.9807	96	96.2207	62	61.5422	54	54.1239	31	30.2434	8	7.6901
160	133	133.0827	100	99.2992	64	63.3887	56	55.7429	32	31.0299	8	7.9021
165	137	137.1847	103	102.3777	65	65.2352	58	57.3619	33	31.8164	9	8.1141
170	142	141.2867	106	105.4562	68	67.0817	60	58.9809	33	32.6029	9	8.3261
175	145	145.3887	108	108.5347	69	68.9282	61	60.5999	34	33.3894	9	8.5381
180	149	149.4907	111	111.6132	71	70.7747	62	62.2189	34	34.1759	9	8.7501
185	154	153.5927	115	114.6917	73	72.6212	64	63.8379	35	34.9624	9	8.9621
190	158	157.6947	118	117.7702	74	74.4677	66	65.4569	35	35.7489	9	9.1741
195	162	161.7967	121	120.8487	76	76.3142	68	67.0759	36	36.5354	9	9.3861
200	166	165.8987	123	123.9272	78	78.1607	69	68.6940	37	37.3219	10	9.5981
205	169	170.0007	127	127.0057	80	80.0072	71	70.3139	38	38.1084	10	9.8101
210	175	174.1027	130	130.0842	81	81.8537	72	71.9329	38	38.8949	10	10.0221
215	178	178.2047	133	133.1627	82	83.7002	72	73.5519	37	39.6814	9	10.2341
220	183	182.3067	138	136.2412	85	85.5467	73	75.1709	40	40.4679	10	10.4461

The results of the vertebral count on the fishes considered were as follows :

TABLE 9.—GILL-RAKER COUNTS OF *S. maderensis*.

Total length (mm)	Standard length (mm)	No. of fish	No. of gill rakers	Standard deviation
50	43	1	46.00	—
80	67	1	77.00	—
100	83	11	98.36	± 3.232
110	91	15	104.46	± 5.140
120	98	15	106.33	± 5.302
130	106	15	112.80	± 8.978
140	114	15	114.87	± 5.331
150	122	15	120.80	± 5.334
160	130	10	120.80	± 4.963
170	138	3	130.33	± 11.590
200	162	1	122.00	—
210	170	4	117.25	± 0.104
220	178	3	115.33	± 1.154
230	186	5	126.00	± 11.390
240	194	4	118.25	± 12.260
250	202	11	121.55	± 10.750
260	210	2	126.50	± 2.121
		132		

Number of vertebrae	Frequency
45	69
46	467
47	58
	Total . 594

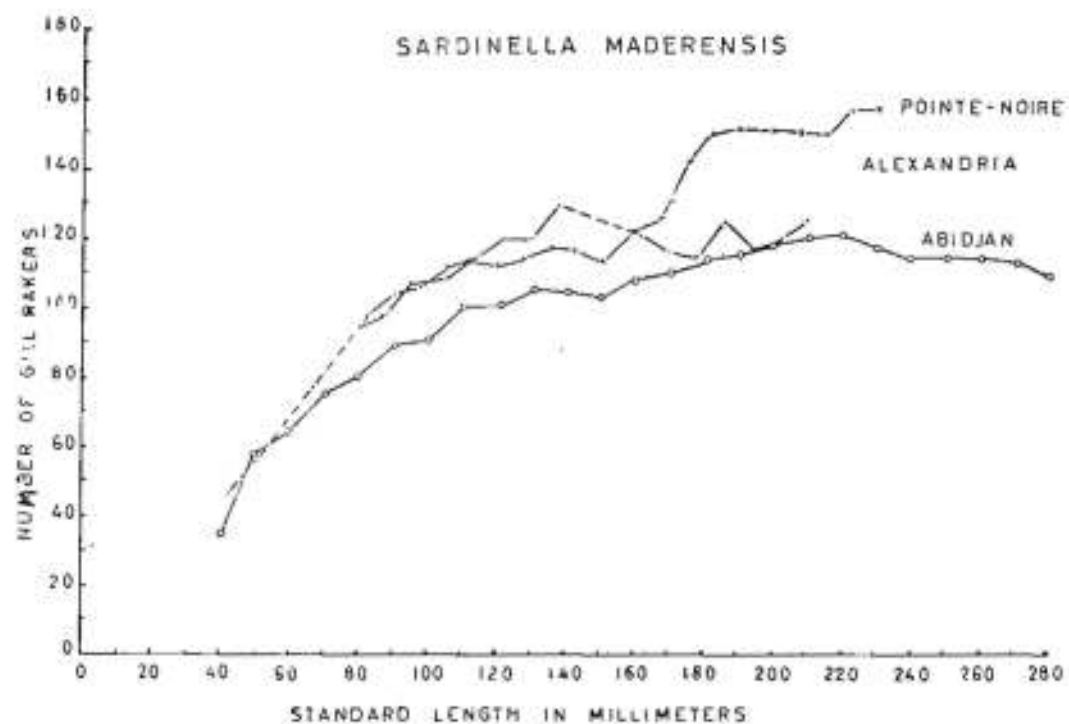


FIG. 7.—The relation between the standard length and the number of gill-rakers for *S. maderensis*.

The average vertebral count was calculated to be 45.981 and the variance equals to 0.2138 and standard deviation equals to ± 0.4624 .

These findings are compared with those on the same species as recorded by Ben-Tuvia (1960) in Palestine; by Rossignol (1955) in Pointe-Noire and by Marchal (1964) in Ivory coast. El-Maghraby (1960) gave the vertebral count of 772 fish from Alexandria. His data was reconsidered to find the average, the variance and the standard deviation to facilitate comparison.

Table (10) includes the results of those different authors. It is clear that, except for the slight variation in the range of vertebral counts, the average was found to be nearly the same.

3. Fin ray counts :

The results of fin ray counts on the fishes considered were as follows :

Dorsal Fin		Anal Fin	
Frequency	No. of rays	Frequency	No. of rays
39	17	5	16
111	18	46	17
30	19	88	18
		35	19
		6	20
Total . . . 180		180	

TABLE 10.—NUMBER OF VERTEBRAE OF *S. maderensis* ACCORDING TO DIFFERENT AUTHORS

Region	Authors	No. of Fish	Range of count	Average of count	Standard deviation
Palestine	Ben-Tuvia, 1954	631	45 — 47	45.98	± 0.49
Pointe-Noire . .	Rossignol, 1955	1267	44 — 48	45.98	± 0.44
Alexandria . . .	El-Maghraby, 1960. . . .	772	45 — 47	45.93	± 0.4234
Abidjan	Marchal, 1964	1504	44 — 47	45.979	± 0.4225
Alexandria . . .	Present work	594	45 — 47	45.981	± 0.4625

Pectoral Fin		Ventral Fin	
Frequency	No. of rays	Frequency	No. of rays
1	14	52	8
37	15		
66	16		
Total . . . 104		52	

In table (11) are given the number of fish, range of ray count in fins, its average, variance and standard deviation for each fin considered.

TABLE 11.—FIN-RAY COUNTS OF *S. maderensis*

Fins	No. of fish	Range of fin ray counts	Average	Variance	Standard deviation
Dorsal fin	180	17 — 19	17.95	0.3830	± 0.61888
Anal fin	180	16 — 20	17.95	0.6958	± 0.83415
Pectoral fin	104	14 — 16	15.63	0.2561	± 0.50606
Ventral fin	52	8	8	—	—

In Tables (12 *a*, *b*, *c* and *d*) our findings are compared with the results of El-Maghraby (1960) in front of Alexandria (after reconsidering them to get the average and standard deviation) and Ben-Tuvia (1960) from Palestine.

(b) *Sardinella aurita* :

1.—*Gill-rakers* :

The gill-raker counts of 189 fishes were obtained from fishes ranging from 60 to 210 mm total length (51 to 174 mm standard length) and grouped into 10 mm length intervals.

TABLE 12 a.—DORSAL FIN RAY COUNTS OF *S. maderensis*

Region	Authors	No. of fish	Range of Count	Average of Count	Standard deviation
Egypt	El-Maghraby, 1960 . .	154	15 — 19	17.299	± 0.75955
Palestine	Ben-Tuvia, 1960 . .	—	17 — 21	—	—
Egypt	Present work	180	17 — 19	17.950	± 0.61888

TABLE 12 b.—ANAL FIN RAY COUNTS OF *S. maderensis*

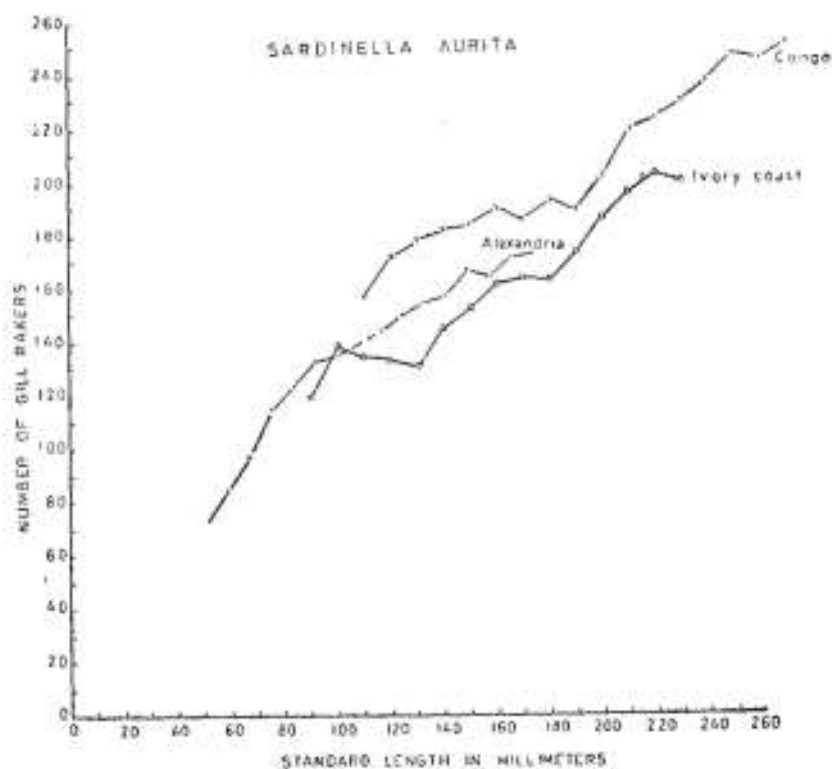
Region	Authors	No. of fish	Range of Count	Average of Count	Standard deviation
Egypt	El-Maghraby, 1960 . .	154	16 — 20	18.305	± 0.7948
Palestine	Ben-Tuvia, 1960 . .	—	17 — 22	—	—
Egypt	Present work	180	16 — 20	17.950	± 0.83415

TABLE 12 c.—PECTORAL FIN RAY COUNTS OF *S. maderensis*

Region	Authors	No. of Fish	Range of count	Average of count	Standard deviation
Egypt	El-Maghraby 1960 . .	159	13 — 17	15.075	± 0.79196
Palestine	Ben-Tuvia, 1960 . .	—	14 — 17	—	—
Egypt	Present work	104	14 — 16	15.630	± 0.50606

TABLE 12d.—VENTRAL FIN RAY COUNTS OF *S. maderensis*

Region	Authors	No. of Fish	Range of count
Egypt	El-Magbiaby 1960. . .	—	8
Palestine	Ben-Tuvia 1960 . . .	—	8
Egypt	Present work	52	8

FIG. 8.—The relation between the standard length and the number of gill-rakers for *S. aurita*

It was found that the number of gill-rakers on the lower part of the first gill arch of the left side of the fish, varies between 73-174 within the whole length range considered. The recorded gill-raker counts, its average and standard deviation for each length group are given in Table (13). In Fig. (8) the average number of gill-rakers for the successive length groups were plotted against the length.

2. Vertebral count :

Counting the vertebrae was carried out on 508 fish. The variance and the standard deviation were calculated for the range of vertebral count recorded. The results of the vertebral count on the fishes considered were as follows :

Number of vertebrae	Frequency
46	4
47	239
48	259
49	6
Total . . .	508

The average vertebral count was calculated to be 47.526 and the variance equals to 0.2893 and standard deviation equals to 0.5379.

In Table (14), the results of vertebral count ; its range, average and standard deviation are included for different authors in various localities.

TABLE 13.—GILL-RAKER COUNTS OF *S. aurita*

Total length (mm)	Standard length (mm)	No. of fish	No. of gill rakers	Standard deviation
60	51	10	73.40	± 3.866
70	59	10	85.00	± 7.228
80	67	10	98.00	± 4.321
90	76	10	115.80	± 2.780
100	84	15	124.13	± 4.307
110	92	15	133.53	± 7.362
120	100	7	135.71	± 7.251
140	117	15	144.67	± 13.56
150	125	15	150.93	± 9.917
160	133	15	155.27	± 9.014
170	141	15	158.33	± 10.300
180	149	15	167.53	± 10.920
190	158	15	165.67	± 6.219
200	166	15	172.73	± 10.080
210	174	7	173.95	± 11.600
		189		

