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VARIATIONS OF FISHES OF GENUS MERLUCCIUS IN ATLANTIC OCEAN AND MEDITERRANEAN SEA

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In this study, the association between morphometric, meristic and osteological characters was used comparatively. Therefore, as a result of this work, five subspecies were determined along the coasts of NE-Atlantic, Mauritania, SW- and S-Africa, and Mediterranean Sea; and one species off shores of the United States; namely: *Merluccius merluccius atlanticus, M. m. senegalensis, M. m. capensis, M. m paradoxus* and *M. m mediterraneus* and *M. bilinearis.*

INTRODUCTION

Hake fishes of the genus *Merluccius* (Rafinesque, 1810) wandering in different Oceans and Seas. Nowadays, its fishery is attracting many countries due to its economical importance to their fishery industries. Since past time till recent days, it is subjected to many researches owing to its curious systematic and distribution.

Among the previous work, those of **Belloc** (1929,1933,1935 and 1937) were occupied the important position as a comprehensive studies on hakes. **Belloc** (1929) described five species of genus *Merluccius:* (European: *Merluccius merluccius* Linnaeus, 1758; American: *M. bilinearis* Mitchill, 1814; South-African: *M. capensis* Castelnau, 1861; North Pacific: *M. productus* Ayres, 1855; and South Pacific: *M. gayi* Guichenot, 1845).

Belloc (1933,1935 and 1937) noted the presence of *M. merluccius* along the coast of Mauritania and announced the presence of a new form of hake off the shore of Senegal being distinguished from the European one by the mean vertebral counts. After the revision of **Norman** (1937) two species were added to this genus namely: *M. hubbsi* Marini, 1932 in South Atlantic, along the coasts of South America, and *M. australis* Hutton, 1872 in New Zealand.

Many synonyms were given for each species of genus *Merluccius* Rafinesque, 1810:

I. *Merluccius merluccius* (Linnaeus, 1758)

Synonyms: Gadus merluccius L.; Gadus ruber Lacépède, 1803; Merluccius smiridus Rafinesque, 1810; Gadus merlus Risso, 1810; Gadus maraldi Risso, 1810; Onus riali Rafinesque, 1810; Merluccius vulgaris Cloquet, 1824; Gadus merluccius argentatus Faber, 1829; Merluccius ambigus Lowe, 1840; Merluccius sinuatus Swainson, 1840; Merlucius lanatus Gronovius in Grey, 1854; Epicopus gayi Günther, 1860; Merluccius argentatus Günther, 1862; Merluccius linnaei Malm, 1877; Trachinoides moroccanus Borodin, 1934.

II. *Merluccius bilinearis* (Mitchill, 1814)

Synonyms: Stomodon bilinearis Mitchill, 1814; Gadus albidus Mitchill, 1817; Merluccius albidus De Kay, 1842.

III. *Merluccius capensis* Castelnau, 1861

Synonym: Gadus merluccius L. sensu Pappe, 1854.

IV. *Merluccius productus* (Ayres, 1855)

Synonyms: Merlangus productus Ayres, 1855; Homalopomus trowbridgii Girard, 1856; Gadus productus Günther, 1862.

V. *Merluccius gayi* (Guichenot, 1848)

Synonyms: Merlus gayi Guichenot, 1848; Merluccius angustimanus German, 1899.

VI. *Merluccius hubbsi* Marini, 1932

Synonyms: Merluccius gayi Cunningham, 1871; Merluccius bilinearis Mitchill, 1814 sensu Ribeiro, 1915.

VII. *Merluccius australis* (Hutton, 1872)

Synonyms: Gadus australis Hutton, 1872; Merluccius gayi Guichenot, 1848 sensu Günther, 1880.

Since the revision of **Norman** (1937) till present time, many studies in relation to the systematics of fishes of genus *Merluccius* from different localities were published by various authors. Among them were those by **Svetovidov** (1948), **Le Gall** (1952 a and b), **Letaconnoux** (1952), **Maurin** (1952 and 1954), **Cadenat** (1952), **Heldt** (1952), **Matta** (1953, 1954 and 1956), **Beaulieu** and **Corbeil** (1964), **Smith** (1965), **Leim** and **Scott** (1966), **Schmidt** (1968), **Komarov** (1969), **Sauskan** (1969), **van Eck** (1969), **Mombeck** (1970 a, b and 1971), and **Haigh** (1972). The discrimination between the different populations given by the previous authors was mostly based on the morphometric and meristic characters and scarcely on osteology.

More recently, biochemical and serological identification of fish stocks are attracting the sight of many researchers. Few works were done on hakes, like those of **Vasilev** and

Šerstnev (1969), **Mackie** and **Jones** (1971), and **Pichot** (1971). It is obvious from the previous researches that discrepancies are existing in the nominations given to different populations of genus *Merluccius* from various localities.

Thus, the aim of this study is the revision of variations in morphometric, meristic and osteological characters of hakes from different regions in the Atlantic Ocean and the Mediterranean Sea.

MATERIALS AND METHODS

Fishes from the Atlantic Ocean were supplied for this study by the Polish fishing vessels. In regard to the Mediterranean Sea, fishes were collected from fish markets in Alexandria. Locations and number of samples are given in Fig. 1.

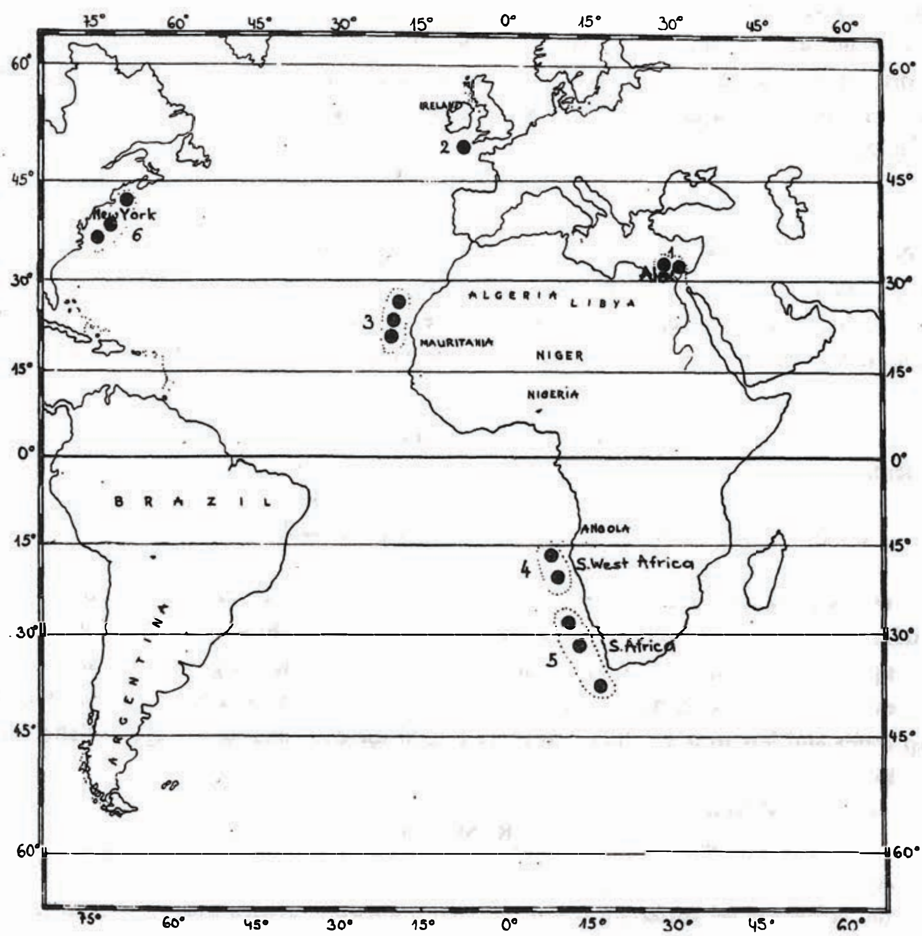

Fig. 1. Locations and number of samples of:

1. Merluccius merluccius mediterraneus;
2. M.m. atlanticus; 3. M.m. senegalensis;
4. M.m. capensis; 5. M.m. paradoxus; 6. M. bilinearis

In the present study, 925 fishes were esamined, that is 323 individuals of M. *bilinearis* (September, 1970; April and September, 1971); 20 individuals of *M. m. atlanticus* (March, 1971); 190 individuals of *M. m. senegalensis* (August and November, 1971); 174 individuals of *M. m. capensis* (March, 1972), 85 individuals of *M. m. mediterraneus* (November and December, 1972); and 133 individuals of *M. m. paradoxus* (March, 1972 and January, 1973). As fishes brought in frozen conditions, all the length measurements and other characters were taken after defrosting.

For morphometric studies, 20 measurements were obtained from each fish (**Le Gall**, 1952 and **Laevastu**, 1965) to the nearest millimeter using varnier calliper. Ratios of different body measurements were calculated for each individual fish according to the formula R = l/s (where R = ratio, l = larger value and s = smaller value), and thereafter, the means were obtained.

For meristic characters, counts of two dorsals, pectoral, ventral, anal rays, vertebrae (urostyl not included) and gill rakers (on the first gill arch of the left side) were done. The variances and their square roots (standard deviation) were calculated according to the formula:

$$S^2 = \frac{\Sigma f\,(X-\bar{x})^2}{n-1}$$

(where, S^2 = variance, X = observed count, $\bar{x}$ = mean of count, f = frequency of each count, and n = total number of fishes).

The difference between the means of different meristic counts for alternative populations of NE-, SE-Atlantic and Mediterranean Sea were studied by applying the t-test:

$$t_o = \frac{\bar{x}_1 - \bar{x}_2}{\text{standard deviation of difference}}$$

where,

$$\text{stand. deviat. of diff.} = \sqrt{\frac{\Sigma(X_1-\bar{x}_1)^2 + \Sigma(X_2-\bar{x}_2)^2}{n_1+n_2-2}} \;X \sqrt{\frac{n_1+n_2}{n_1 X n_2}}$$

For osteological studies, 108 skulls from all the fishes of different localities were studied. Each skull was semiboiled to remove the flesh and to obtain the bones without damage and then left to dry at room temperature. For the purpose of bleaching, the bones were immersed in hydrogen peroxide 40% for two hours, after that washed under tap water and left to dry. The otoliths were used for determining the age of fishes after sectioning and burning.

RESULTS

Biometric studies

The influence of different items of environmental factors notably: temperature, salinity, oxygen, carbon dioxide and light, that can induce certain variations in morphometric and meristic characters of fishes had been previously studied by many researchers. **Gunter** (1950) stated that certain constant differences in fishes which correlated with geographical distribution might be no more than differences produced derectly by the variable environmental factors. Therefore, they must not be taken as indicators of genetic of hereditary separation at all. **Mc Hugh** (1954 a and b) found that duration of light on *Leuresthes tenuis,* during its early development, decreased the number of vertebrae and anal fin rays; also other than temperature and salinity effects on Pacific herring, pressure and light penetration were affecting. **Garside** (1966) during his study on developmental rate and vertebral number of salmonids, noted that the number of vertebrae decreased with increased temperature until an intermediate state was reached and then start ed to increase. For summing up the previous researchers on this subject, the included tables indicating the authors and the affected characters with different environmental factors. **Bidgood** and **Berst** (1967) found that rearing temperature and diets for rainbow trout could account for the variations in proportions of body parts. **Martin** and **Sandercock** (1967) presented a correlation between both counts of pyloric caeca, and number of gill rakers and their development, and the amount of plankton eaten by lake trout. **Lee** and **Williams** (1970) attributed the highly significant variations in number of second dorsal and anal rays in species of *Taeniomembras* to salinity differences. **Ehrlich** and **Farris** (1970) found that the myomer numbers in *Leuresthes tenuis,* seem to be susceptible to changes in temperature.

Despite of faet that these morphometric and meristic characters variations are affected by different environmental factors, they are still used as a tool for identification of fishes.

Morphometric characters

The morphometric ratios of different body measurements were calculated from fishes ranged in length and age respectively in the following way:

19.4–49.5 cm and II–VII years (*M. m. mediterraneus*); 40.0–71.0 cm and II–XI years (*M. m. atlanticus*); 27.5–64.5 cm and I–XI years (*M. m. senegalensis*); 23.1–66,1 cm and (I) III–XI years (*M. m. capensis*); 33.2–61.8 cm and IV–IX years (*M. m. paradoxus*); and 28.3–49.0 cm and I–VIII years (*M. bilinearis*).

The relation of mean ratios within the examined length range and age of different populations of fishes separately was studied. It was found that ratios of head length, first dorsal height, length of the pectoral, length of the ventral, caudal peduncle depth, preorbital distance and diameter of the eye beared an increasing or a decrease relationship to length or age.

Ratios of head length in all populatios exhibited slight increase with length or age except *M. bilinearis* in which they were variable. Ratios of first dorsal height, length of the pectoral and length of the ventral in all populations represented an increase with length or age. An increase in ratios of caudal peduncle depth is seen also in all populations, except *M. m. mediterraneus* in which the ratias are changeable. Ratios of preorbital distance in all populations always showed a decrease with length or age, except *M. bilinearis* in which they showed a slight increase, and were variable in *M. m. capensis.* Ratios increase, with length or age, in diameter of the eye was observed in all populations, except *M. m. paradoxus* in which the ratios were variable. The studied ratios for all the fish populations show individual variations. Means of different ratios and number of

Table 1

Mean morphometric ratios of fishes of genus *Merluccius* from different localities

Name of fishes	M. m. mediterraneus			M. m. atlanticus			M. m. senegalensis			M. m. capensis			M. m. paradoxus			M. bilinearis		
Sex	male	female	combined sexes	male	female	combined sexes	male	female	combined sexes	male	female	combined sexes	male	female	combined sexes	male	female	combined sexes
Morphometric characters / Number of fishes	19	66	85	9	11	20	77	113	190	83	90	174	33	100	133	52	271	323
Total length / standard length	1.116	1.114	1.114	1.108	1.102	1.104	1.113	1.110	1.111	1.118	1.117	1.117	1.128	1.124	1.125	1.108	1.109	1.109
Standard length / body length	1.394	1.392	1.392	1.355	1.360	1.358	1.359	1.359	1.359	1.411	1.406	1.409	1.370	1.374	1.373	1.342	1.348	1.347
Standard length / head length	3.539	3.555	3.552	3.817	3.784	3.799	3.792	3.787	3.789	3.440	3.469	3.454	3.703	3.679	3.685	3.930	3.871	3.881
Standard length / pre-first dorsal distance	3.291	3.292	3.292	3.390	3.439	3.417	3.415	3.440	3.430	3.231	3.240	3.235	3.375	3.354	3.359	3.497	3.420	3.432
Standard length / pre-second dorsal distance*	2.348	2.333	2.336	2.391	2.449	2.423	2.402	2.408	2.406	2.269	2.265	2.267	2.329	2.327	2.328	2.278	2.273	2.274
Standard length / length of the first dorsal	9.941	9.673	9.733	9.167	9.512	9.357	9.448	9.427	9.435	9.100	9.098	9.092	8.695	9.101	9.001	7.799	7.792	7.793
Standard length / length of the second dorsal	2.096	2.093	2.093	2.075	2.056	2.065	2.048	2.047	2.048	2.166	2.176	2.171	2.093	2.144	2.131	2.096	2.124	2.119
Standard length / first dorsal height	7.156	7.211	7.199	7.493	7.631	7.569	6.988	6.953	6.967	6.463	6.592	6.526	6.429	6.681	6.618	6.267	6.377	6.359
Standard length / pre-anal distance	2.197	2.185	2.187	2.200	2.225	2.213	2.182	2.182	2.182	2.167	2.159	2.163	2.251	2.214	2.223	2.136	2.120	2.122
Standard length / length of the anal	2.190	2.198	2.196	2.154	2.137	2.145	2.160	2.161	2.160	2.182	2.182	2.182	2.126	2.171	2.160	2.116	2.144	2.139
Standard length / pre-pectoral distance*	3.654	3.658	3.657	3.802	3.856	3.832	3.795	3.841	3.822	3.485	3.505	3.495	3.680	3.611	3.628	3.924	3.908	3.911
Standard length / length of the pectoral	5.735	5.825	5.805	5.830	5.887	5.861	5.165	5.153	5.158	4.491	4.583	4.537	4.645	4.762	4.733	4.644	4.760	4.741
Standard length / pre-ventral distance*	4.414	4.436	4.431	4.403	4.469	4.439	4.419	4.465	4.446	4.144	4.206	4.176	4.439	4.306	4.339	4.390	4.393	4.393
Standard length / length of the ventral	5.313	5.504	5.461	6.112	6.317	6.224	5.959	5.904	5.926	5.632	5.776	5.705	5.635	5.969	5.886	5.388	5.507	5.488
Standard length / caudal peduncle depth	23.782	23.257	23.375	22.469	22.857	22.682	20.272	19.450	19.783	20.531	20.832	20.676	20.584	21.049	20.933	22.165	22.324	22.298
Head length / pre-orbital distance	3.189	3.118	3.134	2.885	2.880	2.882	3.093	2.969	3.019	3.064	3.045	3.056	3.183	3.062	3.092	3.051	3.004	3.012
Head length / diameter of the eye	5.091	5.458	5.376	6.279	6.428	6.361	5.485	6.437	6.052	5.624	5.761	5.687	4.940	5.152	5.100	5.349	5.694	5.638
Head length / length of the maxillary	2.180	2.213	2.205	2.151	2.138	2.144	2.429	2.388	2.405	2.432	2.397	2.414	2.436	2.388	2.400	2.256	2.267	2.265
Head length / interorbital distance*	4.453	4.198	4.255	3.750	3.793	3.773	3.749	3.558	3.635	4.019	3.984	4.001	4.178	4.177	4.177	3.899	3.838	3.848

1. For M. bilinearis, ratios indicated by the sign (*), the number of fishes examined were 47 males and 246 females.
2. For M. m. capensis, the number of fishes under combined sexes included one immature fish.

Table 2

Ratio range morphometric characters of fishes of genus *Merluccius* from different localities

Morphometric characters / Name of fishes	M. m. mediterraneus	M. m. atlanticus	M. m. senegalensis	M. m. capensis	M. m. paradoxus	M. bilinearis
Total length /standard length	1.105 – 1.119	1.086 – 1.117	1.098 – 1.121	1.103 – 1.121	1.115 – 1.136	1.105 – 1.115
Standard length / body length	1.361 – 1.400	1.344 – 1.378	1.333 – 1.384	1.362 – 1.451	1.361 – 1.381	1.320 – 1.364
Standard length / head length	3.506 – 3.771	3.645 – 3.909	3.612 – 4.000	3.219 – 3.766	3.630 – 3.784	3.746 – 4.126
Standard length / pre-first dorsal distance	3.235 – 3.371	3.271 – 3.529	3.277 – 3.672	3.075 – 3.428	3.312 – 3.482	3.344 – 3.549
Standard length / pre-second dorsal distance	2.298 – 2.392	2.281 – 2.486	2.319 – 2.523	2.226 – 2.367	2.300 – 2.382	2.243 – 2.327
Standard length / length of the first dorsal	9.352 – 10.776	8.344 – 10.130	9.135 – 10.380	8.937 – 9.690	8.682 – 9.464	7.483 – 8.124
Standard length / length of the second dorsal	2.054 – 2.131	1.963 – 2.178	1.999 – 2.177	2.123 – 2.218	2.074 – 2.198	2.076 – 2.198
Standard length / first dorsal heigth	7.061 – 8.030	7.244 – 8.165	6.569 – 8.238	5.886 – 7.675	6.352 – 7.063	6.074 – 6.764
Standard length / pre-anal distance	2.102 – 2.247	2.080 – 2.334	2.051 – 2.319	2.097 – 2.236	2.147 – 2.324	2.046 – 2.188
Standard length / length of the anal	2.164 – 2.271	2.076 – 2.236	2.135 – 2.230	2.143 – 2.289	2.071 – 2.203	2.098 – 2.266
Standard length / pre-pectoral distance	3.593 – 3.771	3.636 – 4.055	3.533 – 4.066	3.377 – 3.864	3.510 – 3.767	3.746 – 4.129
Standard length / length of the pectoral	5.652 – 6.268	5.634 – 6.188	4.981 – 5.857	4.292 – 5.085	4.327 – 4.923	4.585 – 4.983
Standard length / pre-ventral distance	4.375 – 4.508	4.031 – 5.040	4.134 – 4.638	4.109 – 4.851	4.157 – 4.481	4.250 – 4.571
Standard length / length of the ventral	5.125 – 6.014	5.813 – 7.167	5.690 – 6.654	5.421 – 6.761	5.197 – 6.417	5.368 – 5.933
Standard length / caudal peduncle depth	22.605 – 24.951	20.688 – 24.340	18.554 – 21.625	18.727 – 22.885	20.098 – 22.754	21.573 – 24.556
Head length / pre-orbital distance	2.950 – 3.243	2.793 – 2.988	2.777 – 3.139	2.832 – 3.368	3.000 – 3.318	2.855 – 3.150
Head length / diameter of the eye	4.798 – 6.335	5.858 – 7.500	5.112 – 7.472	4.267 – 7.329	4.506 – 5.318	4.500 – 6.428
Head length / length of the maxillary	2.097 – 2.272	2.097 – 2.257	2.320 – 2.549	2.311 – 2.462	2.286 – 2.495	2.070 – 2.321
Head length / interorbital distance	3.933 – 4.490	3.647 – 3.921	3.441 – 3.962	3.731 – 4.133	4.034 – 4.341	3.688 – 3.961

Table 3

First dorsal ray counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range						Mean	Variance	Standard deviation
		9	10	11	12	13	14			
M. m. mediterraneus	85	22	61	2				9.765	0.2297	0.4787
M. m. atlanticus	20		19	1				10.050	0.0500	0.2232
M. m. senegalensis	190	3	72	107	8			10.632	0.3503	0.5919
M. m. capensis	174		38	117	18	1		10.897	0.3360	0.5797
M. m paradoxus	133		25	86	22			10.977	0.3555	0.5962
M. bilinearis	293			11	213	66	3	12.208	0.2613	0.5112

Table 4

Second dorsal ray counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range								Mean	Variance	Standard deviation
		36	37	38	39	40	41	42	43			
M. m. mediterraneus	85	8	18	57	2					37.623	0.4756	0.6896
M. m. atlanticus	20			4	13	3				38.950	0.3658	0.6048
M. m. senegalensis	190				21	113	49	6	1	40.226	0.4935	0.7025
M. m. capensis	174		1	11	56	74	28	4		39.741	0.8172	0.9040
M. m. paradoxus	133			6	5	42	63	17		40.602	0.8476	0.9207
M. bilinearis	293			30	106	108	42	7		39.624	0.8723	0.9340

Table 5

Anal ray counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range									Mean	Variance	Standard deviation
		35	36	37	38	39	40	41	42	43			
M. m. mediterraneus	85	1	11	41	29	3					37.258	0.5989	0.7739
M. m. atlanticus	20			5	6	9					38.200	0.6947	0.8335
M. m. senegalensis	190			8	61	100	19	2			38.716	0.5538	0.7442
M. m. capensis	174			3	5	46	76	42	2		39.891	0.8146	0.9026
M. m. paradoxus	133				2	9	46	51	25		40.662	0.8316	0.9114
M. bilinearis	293			3	34	88	84	54	23	7	39.849	1.5527	1.2461

Table 6

Pectoral ray counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range						Mean	Variance	Standard deviation
		12	13	14	15	16	17			
M. m. mediterraneus	85	1	51	33				13.376	0.2614	0.5113
M. m. atlanticus	20		13	7				13.350	0.2395	0.4894
M. m. senegalensis	190		4	96	89	1		14.458	0.3025	0.5500
M. m. capensis	174			11	97	64	2	15.328	0.3718	0.6098
M. m. paradoxus	133			36	89	8		14.789	0.2887	0.5373
M. bilinearis	293		27	188	73	5		14.191	0.3743	0.6118

fishes are given in Table 1 for separate and combined sexes. It appears from these results that there are no apparent differences between sexes for different fish populations. Ratio ranges for different morphometric characters are given in Table 2.

Meristic characters

The same number of fishes as in morphometric studies were used to determine the meristic characters, except those of *M. bilinearis* which is represented by 294 fishes for vertebral counts and 293 fishes for the rest of meristic characters. Consequently, the same length range is similar, even that of *M. bilinearis.*

Seven meristic characters were used in this study. The relation between mean counts of meristic characters and length or age of fishes revealed no clear differences. Comparing mean counts of each studied character for separate and combined sexes in different samples of the same population of fishes, no apparent differences was observed. For the sake of comparison between different populations of fishes, mean count for each character of combined sexes were used.

1. Fin ray counts

In Tables 3, 4, 5 and 6, range of counts for single and paired fins, number of fishes under each count, mean, variance and standard deviation for each population are given.4,5,6, Figures 2, 3, 4 and 5 represent the variation of frequency percentage with

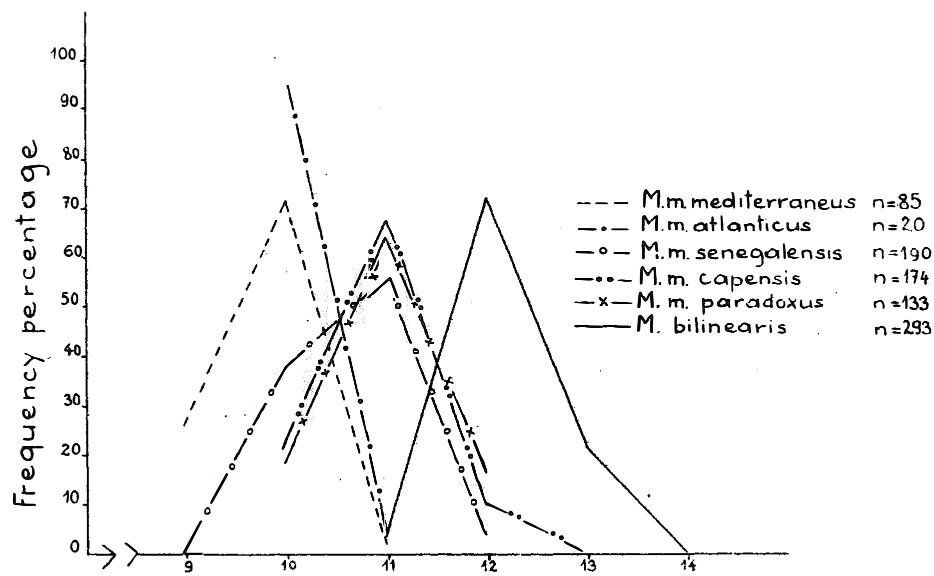

Fig. 2. Frequency percentage distribution of First dorsal ray counts of genus Merluccius from different localities

range of counts for each character in different populations. It was noted that the ventrals were represented by seven rays, which were always constant in all studied populations.

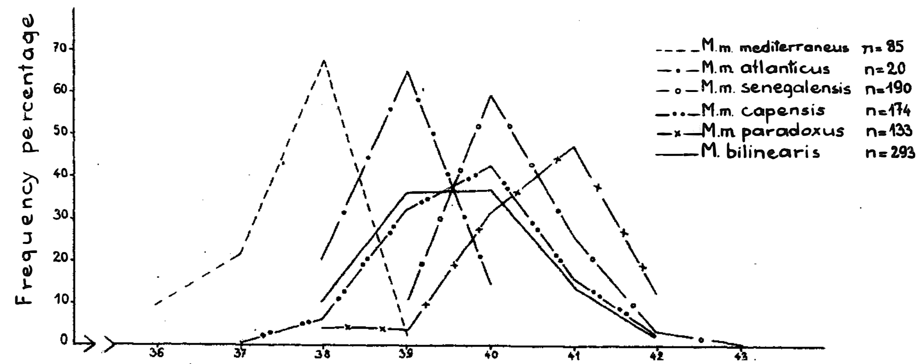

Fig. 3. Frequency percentage distribution of second dorsal ray counts of genus Merluccius from different localities

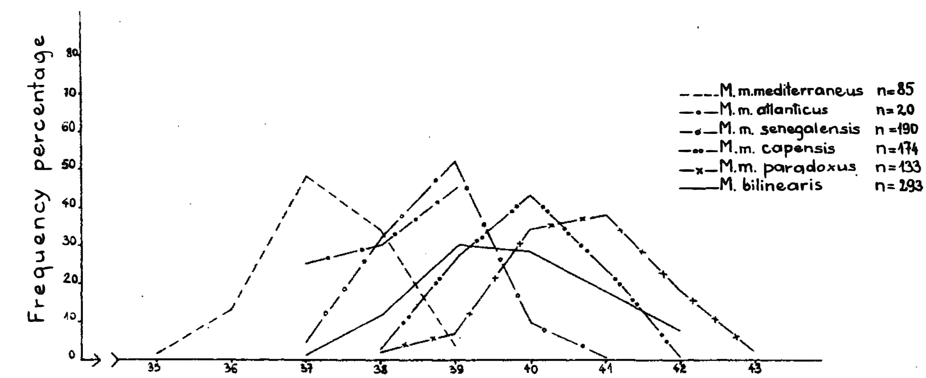

Fig. 4. Frequency percentage distribution of anal ray counts of genus Merluccius from different localities

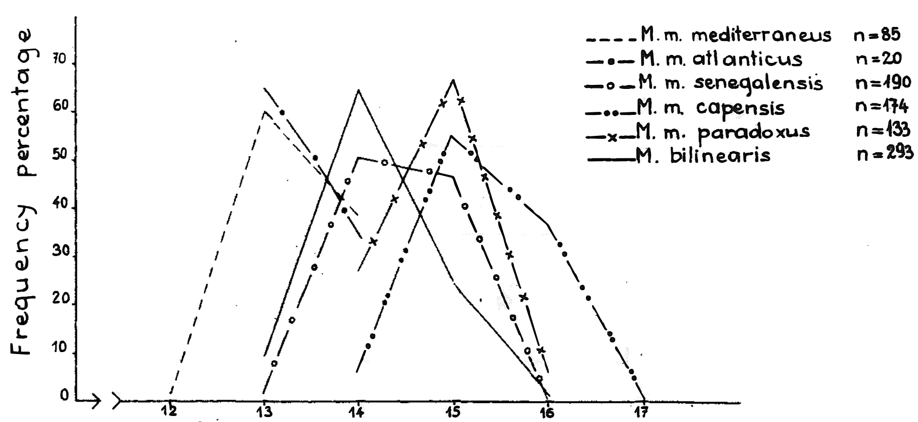

Fig. 5. Frequency percentage distribution of pectoral ray counts of genus Merluccius from different localities

Table 7

Total vertebral counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range										Mean	Variance	Standard deviation
		48	49	50	51	52	53	54	55	56	57			
M. m. mediterraneus	85		3	32	43	7						50.635	0.4725	0.6874
M. m. atlanticus	20		7	8	5							49.900	0.6211	0.7881
M. m. senegalensis	190				1	31	121	37				53.021	0.3805	0.6169
M. m. capensis	174	1	42	107	24							49.885	0.3913	0.6255
M. m. paradoxus	133							13	66	46	8	55.368	0.5526	0.7434
M. bilinearis	294					1	65	159	64	5		54.023	0.5216	0.7222

2. Vertebral counts

Range of vertebral counts, number of fishes under each count, mean, variance and standard deviation for different populations are given in Table 7. Variation of frequency percentage of each count within the recorded range are shown in Fig. 6. The study of the partitioned vertebral column revealed that it consisted of six cervical vertebrae which were always constant in all populations. Frequency percentage for both abdominal and caudal vertebral counts are demonstrated in Figures 7 and 8.

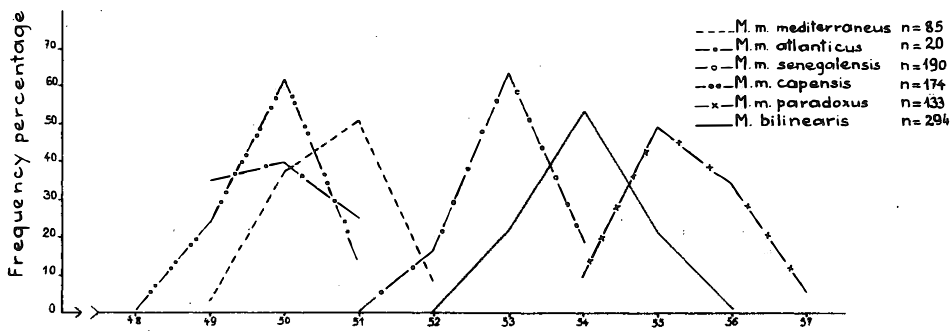

Fig. 6. Frequency percentage distribution of total vertebral counts of genus Merluccius from different localities

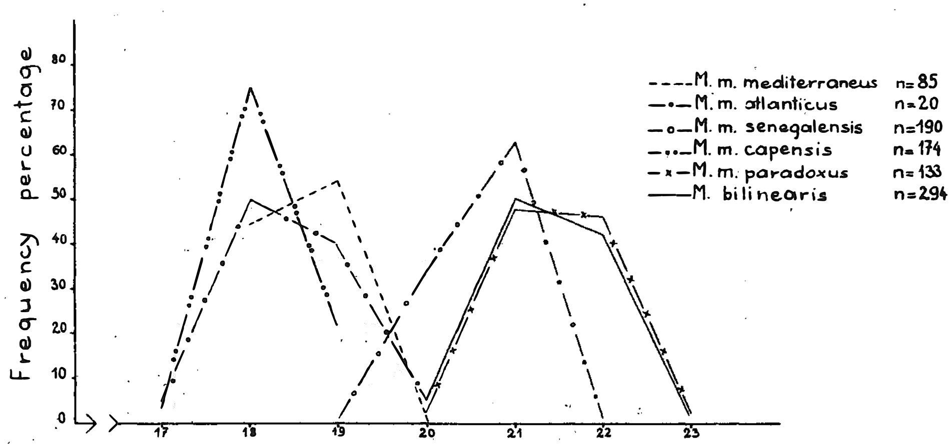

Fig. 7. Frequency percentage distribution of abdaminal vertebral counts of genus Merluccius from different localities

3. Gill raker counts

Table 8 represents the range of variation in total gill raker counts on the whole gill arch for different populations. The number of fishes, mean, variance and standard deviation also are given. Figure 9 demonstrates the variation of frequency percentage of

Table 8

Total gill raker counts of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Range															Mean	Varian-ce	Standard deviation
		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
M. m. mediterraneus	85	49	29	7													9.506	0.4196	0.6478
M. m. atlanticus	20	1	17	2													10.050	0.1553	0.3941
M. m. senegalensis	190					11	79	65	31	4							14.674	0.7924	0.8902
M. m. capensis	174								1	17	53	79	21	3			18.638	0.8103	0.9002
M. m. paradoxus	133									3	11	26	37	35	19	2	20.165	1.6845	1.2979
M. bilinearis	293							4	23	151	84	23	6	2			17.427	0.8482	0.9210

Table 9

Range of gill raker counts on upper and lower gill arch of genus *Merluccius* from different localities

Name of fishes	Number of fishes	Upper gill arch			Lower gill arch		
		Range	Mean	Standard deviation	Range	Mean	Standard deviation
M. m. mediterraneus	85	1–2	1.400	0.4929	8–9	8.106	0.3095
M. m. atlanticus	20	2	2.000	–	7–9	8.050	0.3941
M. m. senegalensis	190	3–4	3.326	0.4701	10–13	11.347	0.6788
M. m. capensis	174	4–6	4.828	0.4487	12–16	13.810	0.7322
M. m. paradoxus	133	4–7	5.534	0.6461	12–17	14.632	0.9651
M. bilinearis	293	3–5	4.140	0.4024	12–16	13.287	0.7166

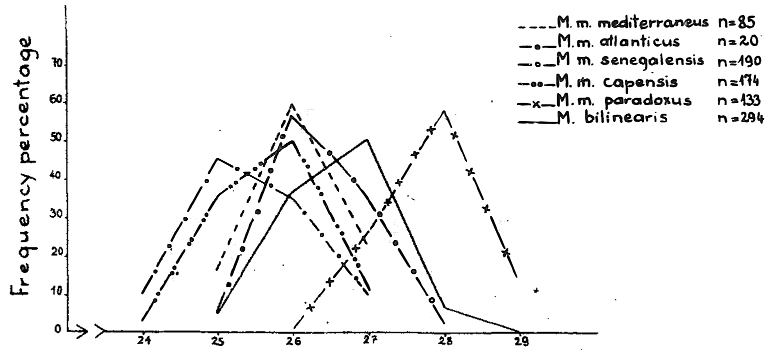

Fig. 8. Frequency percentage distribution of caudal vertebral counts of genus Merluccius from different localities

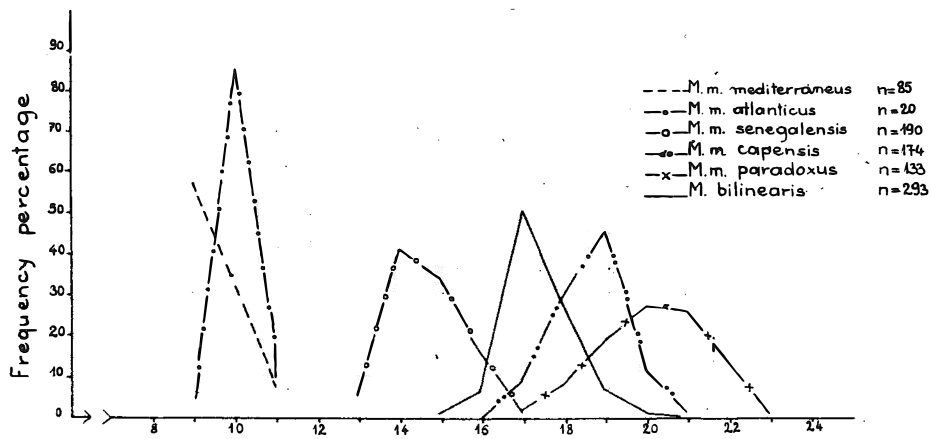

Fig. 9. Frequency percentage distribution of total gill raker counts of genus Merluccius from different localities

each count within the recorded range for different populations. Range of gill raker counts on upper and lower gill arch, means and standard deviations in each populations are shown in Table 9.

OSTEOLOGICAL STUDIES

So far, little is known about the osteology of hake, except data, given for *M. bilinearis, M. productus* and *M. merluccius (***Svetovidov**, 1948); and for *M. bilinearis* and *M. productus (***abdul Mujib**, 1967). The former gave drawings of the skull in different views and of some separate bones. The latter, during his study on the cranial osteology of the gadoid fishes, described detailly the bones of the cranium and its related bones, illustrating them with drawings.

Therefore, in this study, the general features of 108 skulls and some selected bones, namely' hyomandibular, operculum, urohyal, post-temporal and os pelvis, from fishes

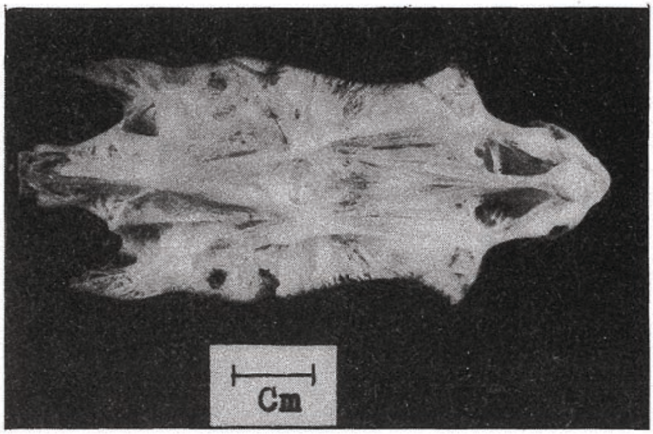

Fig. 10. Skull (dorsal view) of M. m. mediterraneus (Lt: 37.2 cm)

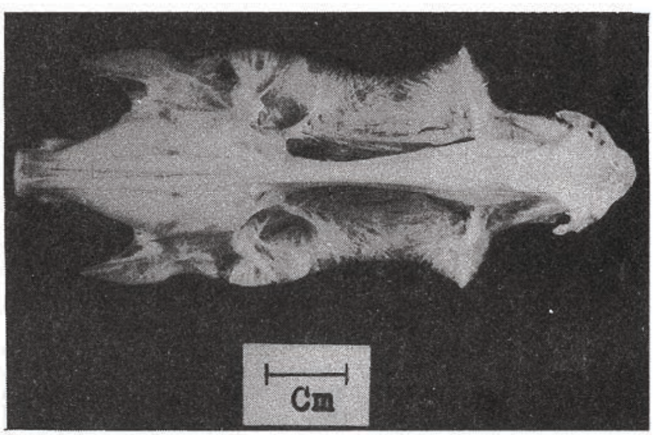

Fig. 11. Skull (ventral view) of M. m. mediterraneus (Lt: 37.2 cm)

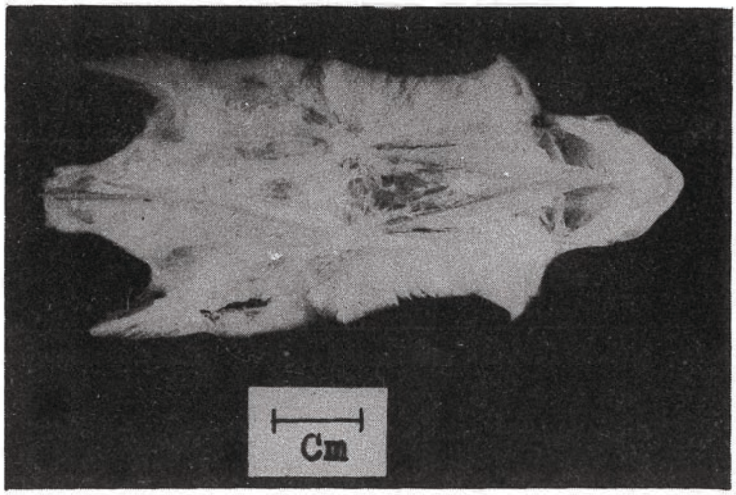

Fig. 12. Skull (dorsal view) of M. m. atlanticus (Lt: 40.0 cm)

Fig. 13. Skull (ventral view) of M. m. atlanticus (Lt: 40.0 cm)

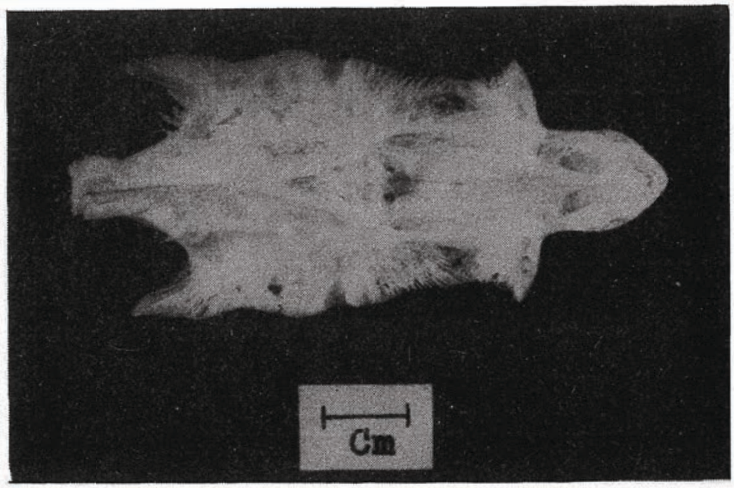

Fig. 14. Skull (dorsal view) of M. m. senegalensis (Lt: 38.0 cm)

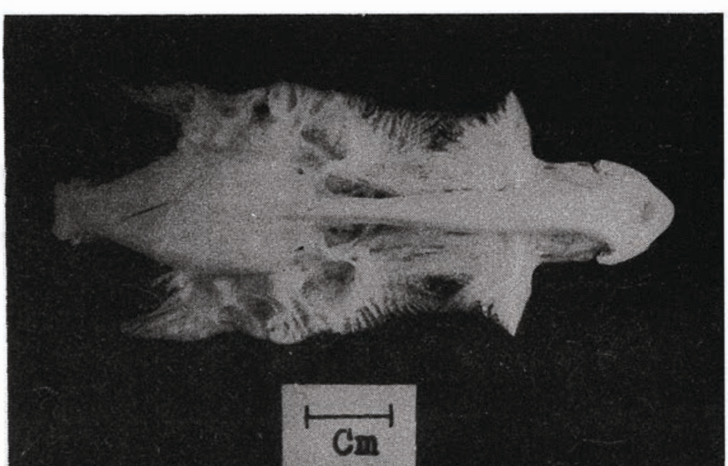

Fig. 15. Skull (ventral view) of M. m. senegalensis (Lt: 38.0 cm)

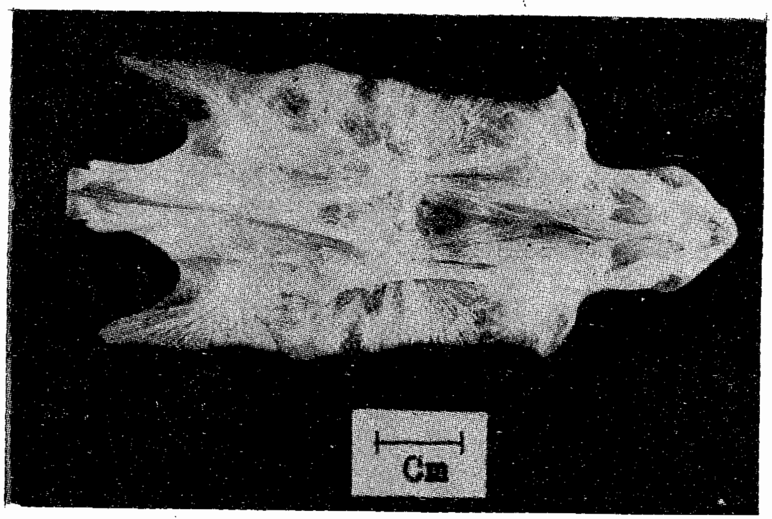

Fig. 16. Skull (dorsal view) of M. m. capensis (Lt: 40.0 cm)

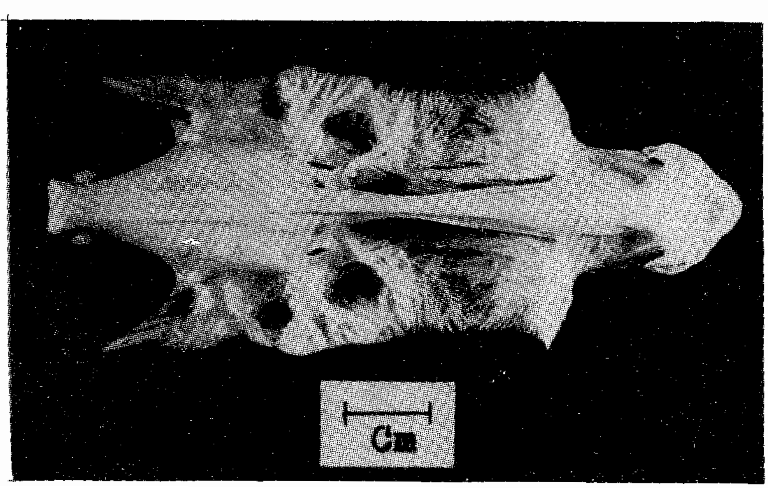

Fig. 17. Skull (ventral view) of M. m. capensis (Lt: 40.0 cm)

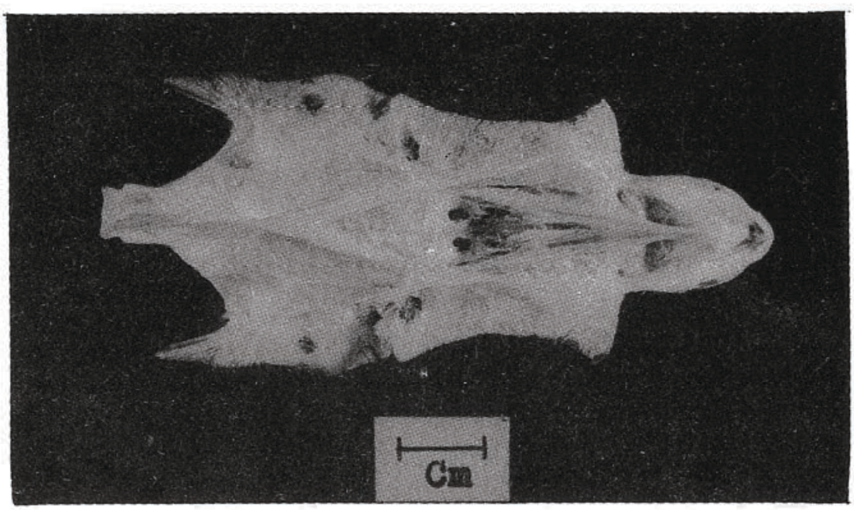

Fig. 18. Skull (dorsal view) of M. m. paradoxus (Lt: 41.0 cm)

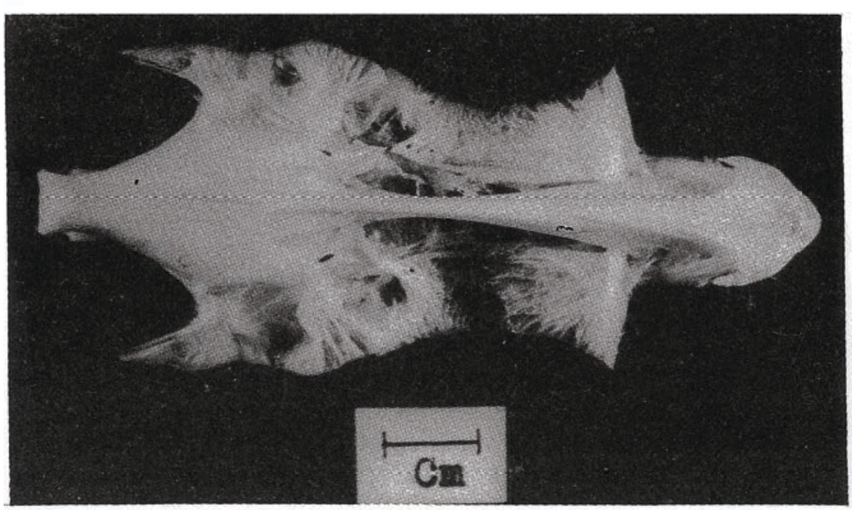

Fig. 19. Skull (ventral view) of M. m. paradoxus (Lt: 41.0 cm)

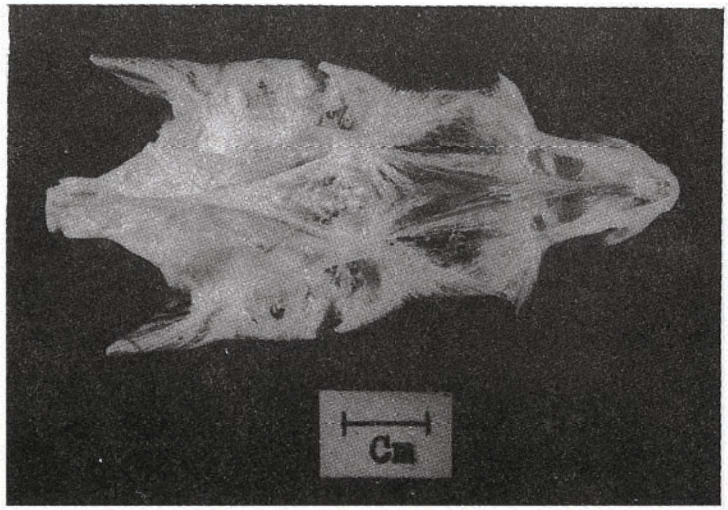

Fig. 20. Skull (dorsal view) of M. bilinearis (Lt: 40.0 cm)

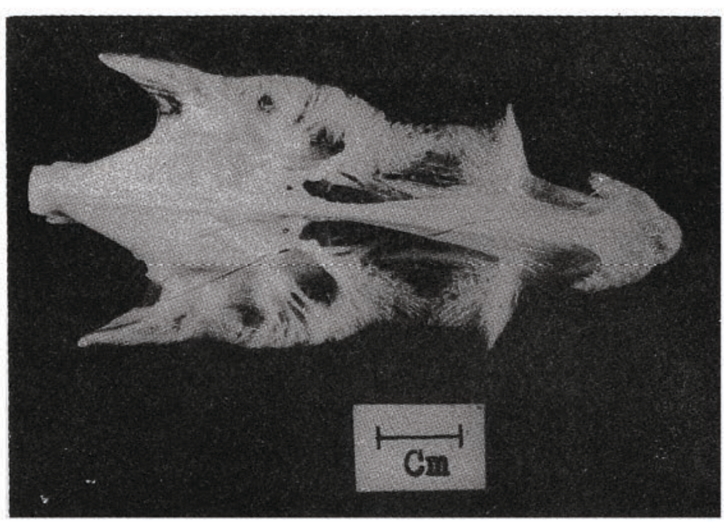

Fig. 21. Skull (ventral view) of M. bilinearis (Lt: 40.0 cm)

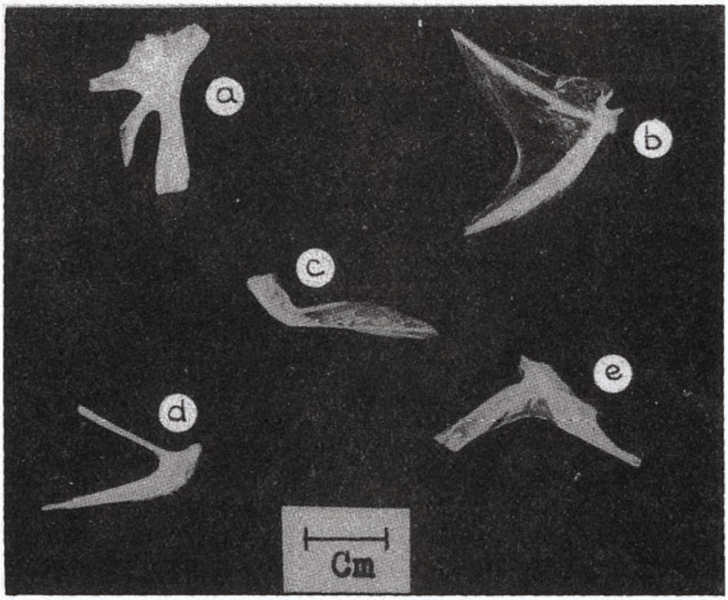

Fig. 22. a. Hyomandibular, b. Operculum, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 37.2 cm) of M.`m. mediterraneus

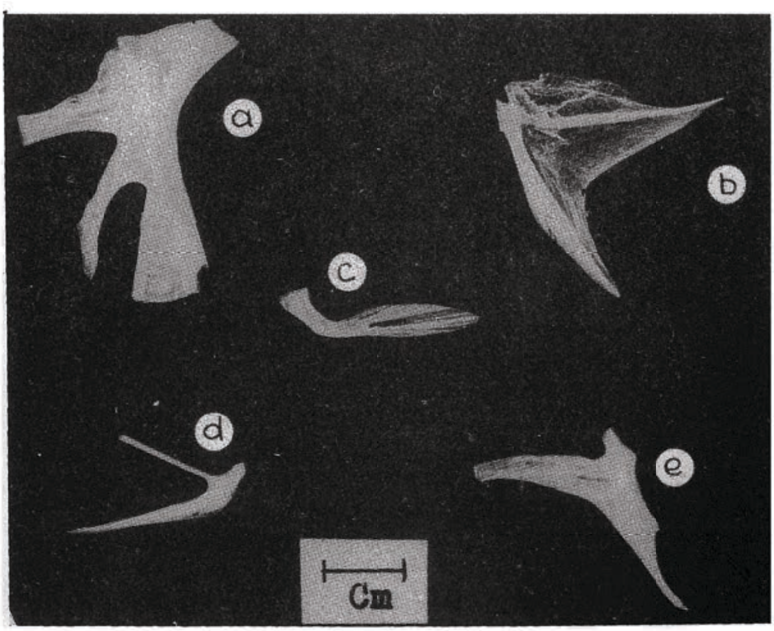

Fig. 23. a. Hyomandibular, b. Opercuium, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 71.0; 46.6; 40.0; 40.0 and 46.6 cm) of M. m. atlanticus

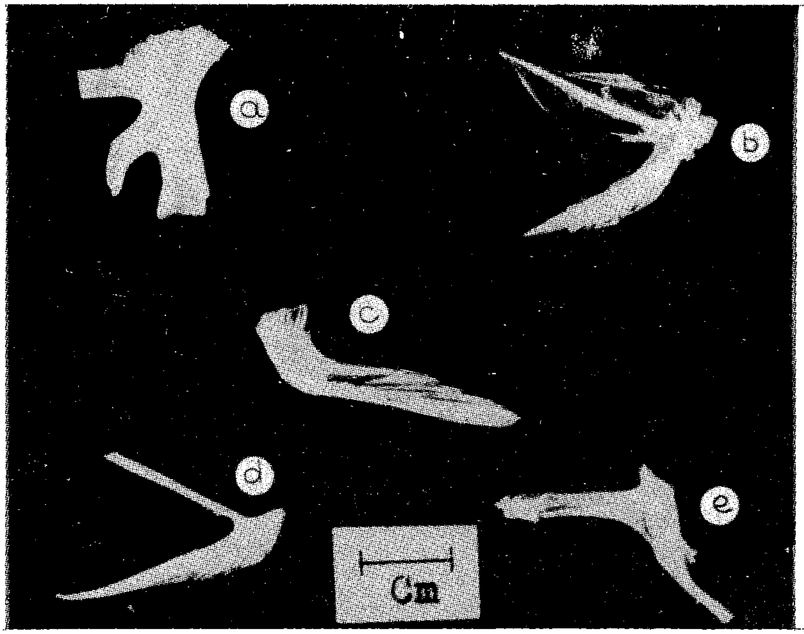

Fig. 24. a. Hyomandibular, b. Operculum, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 47.0; 39.0; 47.0; 47.0 and 39.0 cm) of M. m. senegalensis

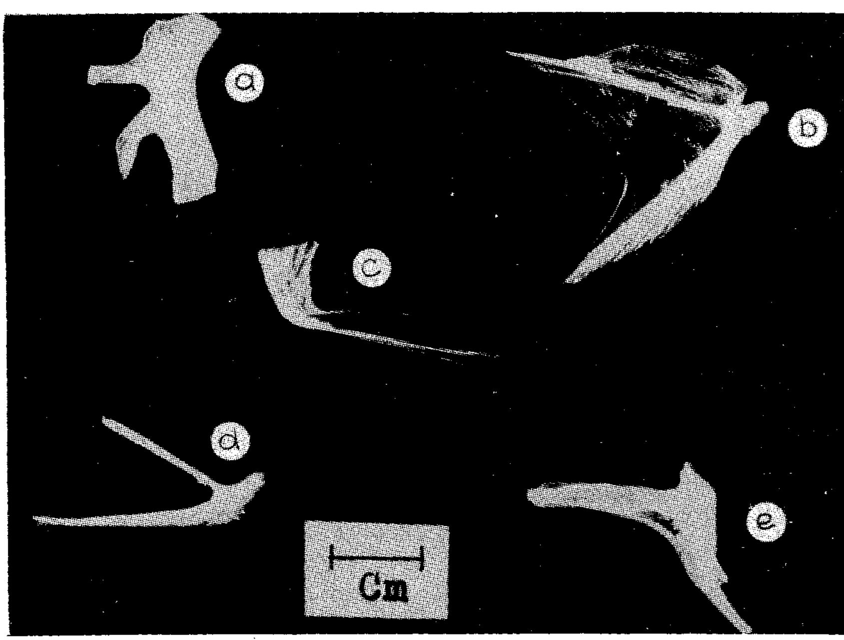

Fig. 25. a. Hyomandibular, b. Operculum, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 40.0; 40.0; 40.0 and 50.0 cm) of M. m. capensis

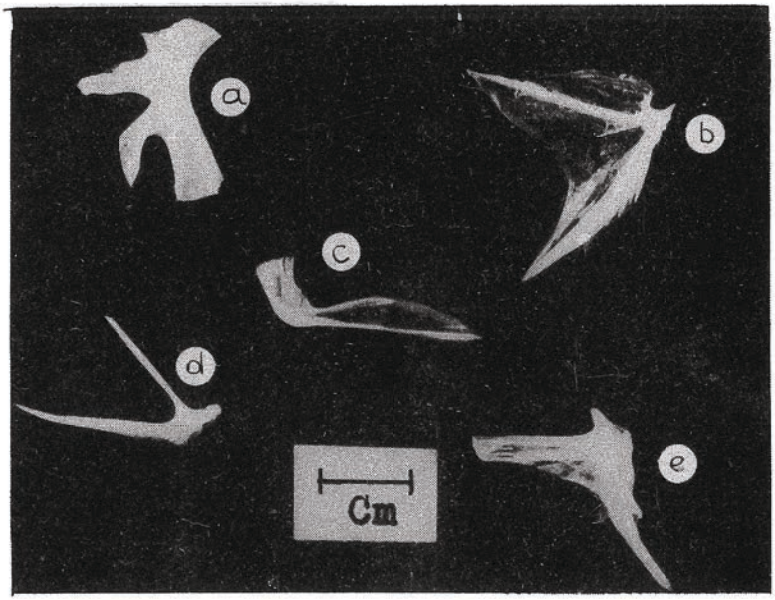

Fig. 26. a. Hyomandibular, b. Operculum, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 41.0; 41.0; 41.0; 41.0 and 45.0 cm) of M. m. paradoxus

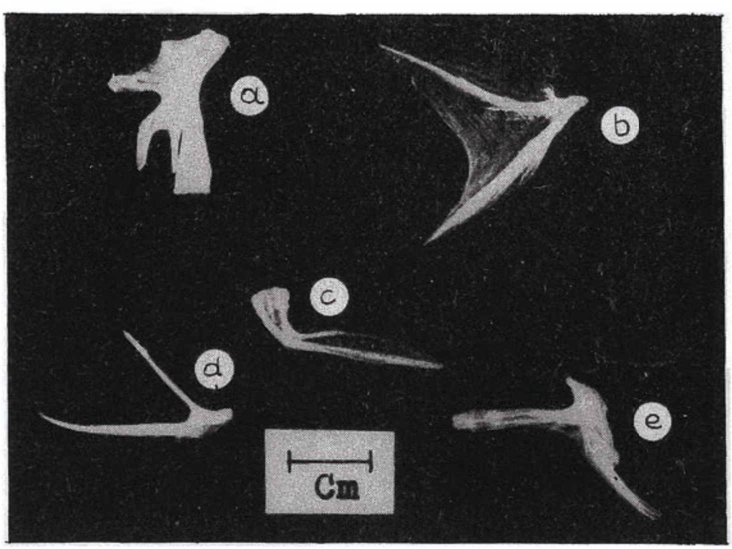

Fig. 27. a. Hyomandibular, b. Operculum, c. Urohyal, d. Post-temporal and e. Os pelvis (Lt: 40.0; 44.0; 40.0; 40.0 and 40.0 cm) of M. bilinearis

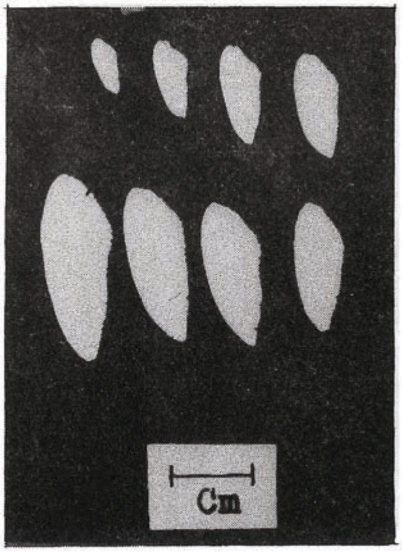

Fig. 28. Otoliths of M. m. mediterraneus (Lt: 14.0; 19.7; 24.1; 28.2; 33.5; 37.2; 40.8 and 48.0 cm)

Fig. 29. Otoliths of M. m. atlanticus (Lt: 40.0; 46.0; 51.0; 56.5 and 71.0 cm)

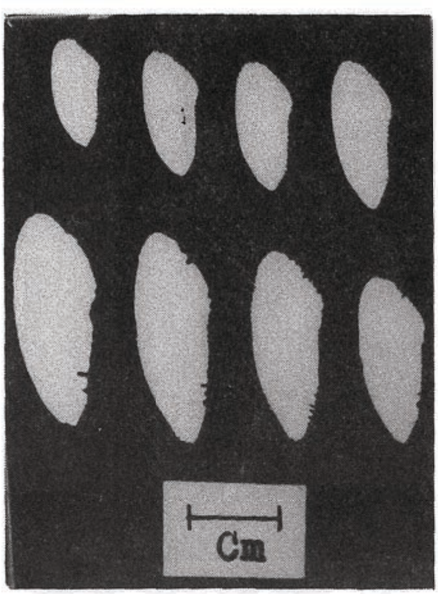

Fig. 30. Otoliths of M. m. senegalensis (Lt: 27.8; 30.1; 35.8; 40.0; 45.0; 50.6; 57.5 and 62.0 cm)

Fig. 31. Otoliths of M. m. capensis (Lt: 23.1; 27.7; 32.4; 35.2; 40.5; 46.2; 50.6 and 61.2 cm)

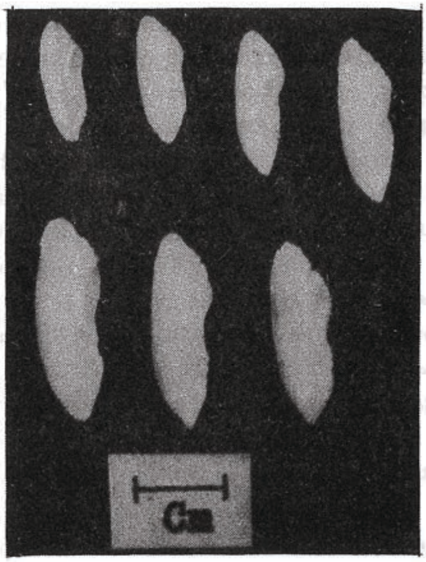

Fig. 32. Otoliths of M. m. paradoxus (Lt: 33.2; 37.9; 42.0; 47.5; 50.5; 55.7 and 61.7 cm)

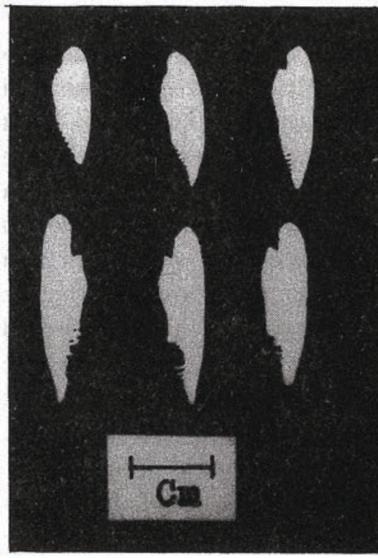

Fig. 33. Otoliths of M. bilinearis (Lt: 28.8; 32.3; 35.7; 36.2; 44.3 and 49.0 cm)

of different populations were dealt with. The cranium and bones (nearly of similar fish size as much as possible) from fishes of different populations were demonstrated. Besides, otoliths were also taken into consideration. The otoliths are represented for fishes of 5 cm length groups within the studied length range in each population.

The examination of the general features of skulls and bones for each population separately revealed no clear differences between length or sex. It was observed for otoliths of *M. bilinearis* that it had a notch in the broader part where it becomes more clear with increase in length. It was seen that the otoliths of hakes bore visible marginal serrations. Their deformation with the increase of fish size was observed in all populations, but it was clearly shown in *M. bilinearis, M. m. atlanticus,* and *M. m. senegalensis.* The photographes of skulls, bones and otoliths for each population are given in Figures 10–33.

DISCUSSION

Due to the various methods used by different researchers to determine the morphometric ratios, e.g., the smaller value percentage of the larger one, and ratio in total or stanandard length, it is difficult to refer the present results to those in the previous studies.

Comparison of the range of mean morphometric ratios from different populations of hake revealed a close semilarity in some ratios or overlap of the others. In spite of these overlaps in the ranges, the ratio means indicated to certain distinction between different populations. As a result, there are some characters which demonstrated differentiation between them, namely: length of the first dorsal, first dorsal height, length of the pectoral, lengthof the ventral, caudal peduncle depth, diameter of the eye and interorbital distance. Mean ratios of morphometric characters of hake populations from NE and SE Atlantic including those from Mediterranean Sea will be compared separately. Fish populations from these regions in comparison with those from NW Atlantic coast will be discussed. It is clearly seen from the obtained results, that a close similarity is occurred between the morphometric ratios of *M. m. capensis* and *M. m. paradoxus.* The only observed difference was a slight decrease in the preorbital ratio of *M. m. paradoxus* in relation to length or age, which did not appear in *M. m. capensis.*

Separation of *M. m. atlanticus* and *M. m. senegalensis* can be determined by the use of ratio means of standard lenght to first dorsal height, lenght of the pectoral, lenght of the ventral, caudal peduncle depth and head lenght to diameter of the eye. These characters are larger in *M. m. senegalensis* than in *M. m. atlanticus.*

M. m. mediterraneus differs from those of European, West and South African regions in possessing smaller length of first dorsal, this is due to the lower number of rays. Lower height of first dorsal, smaller length of the pectoral end lower depth of caudal peduncle are similar in *M. m. atlanticus* and differ in other populations. Length of the ventral is similar in *M. m. capensis,* and larger than in *M. m. atlanticus, M. m. senegalensis* and *M. m. paradoxus.* Diameter of the eye is similar to those of *M. m. capensis* and *M. m. paradoxus,* on the other hand, it is slightly smaller than in *M. m. atlanticus* and *M. m. senegalensis.* Interorbital distance is alike in *M. m. capensis* and *M. m. paradoxus,* while it is smaller than in *M. m. atlanticus* and *M. m. senegalensis.*

Geographical relationship was also observed in ratios of length of first dorsal, first dorsal height, length of the pectoral and diameter of the eye, where they increased from the North to the South (see Table 1).

Concerning the comparison of *M. bilinearis* with hakes from eastern part of the Atlantic, it was found that it had the same distinctive and similar characters as in other populations. It can be separated from other populations by larger length of first dorsal than in others, this is also attributed to the large number of rays. Means ratio of standard lenght to first dorsal height is close to *M. m. capensis,* white length of the pectoral is closer to *M. m. paradoxus* than to the others. Length of the ventral approaches to that of *M. m. mediterraneus,* while caudal peduncle depth reaches to those of *M. m. mediterraneus* and *M. m. atlanticus.* Diameter of the eye is closer to *M. m. capensis* and differs from the others, while the interorbital distances approaches those of *M. m. atlanticus.*

Examination of first dorsal ray counts of hakes from different populations revealed the discrimination between three groups of fishes from the peaks occupied by the dominant number of fishes (see Fig. 2). The first group comprised *M. m. mediterraneus* and *M. m. atlanticus* where they had the same peak at 10. The second group occupied the peak at 11 and was represented by *M. m. senegalensis, M. m. capensis* and *M. m. paradoxus.* It was found also that when excluding fishes with nine rays in *M. m. senegalensis* and those with thirteen rays like in *M. m. capensis,* as were are represented by small number, this group would have the same range. The differentiation between European hake and *M. senegalensis* using first dorsal ray counts in also given by **Maurin** (1954). The mean counts of first dorsal ray for these populations serves to indicate to a geographical pattern among them. This pattern is represented by increase of mean count from the North to the South (see Table 3), which is confirmed also by the decrease in the ratio, standard length (length of first dorsal, for these populations. The third group is characterised by domination of fishes with 12 rays where it occupies a separate peak and is represented by *M. bilinearis* (see Fig. 2).

Second dorsal ray counts show another type of differentiation among these populations. *M. m. mediterraneus, M. m. atlanticus* and *M. m. paradoxus* were found to have separate peaks at 38, 39 and 41, respectively, while *M. m. senegalensis* and *M. m. capensis* were associated in one peak at 40. The second dorsal ray counts were used also by **Maurin** (1954) for the separation between *M. merluccius* and *M. senegalensis.* The second dorsal ray counts for *M. bilinearis* are demonstrated by a blunt peak at 39–40 which is overlapped with *M. m. atlanticus* and *M. m. senegalensis* (see Fig. 3).

Anal ray counts shoved that in *M. m. mediterraneus* fishes with 37 rays predominated in *M. m. capensis* with 40 rays and in *M. m. paradoxus* with 41 rays. *M. m. atlanticus* and *M. m. senegalensis* both are represented by dominant fishes with 39 rays, while *M. bilinearis* has the dominating fishes with 39–40 rays. A clear overlap within the ranges of these different populations was observed, despite of their occupating separate peaks (see Fig. 4).

The similarity between *M. m. mediterraneus* and *M. m. atlanticus* is observed from the pectoral ray counts where they occupy the same peak at 13 rays. *M. m. capensis* and *M. m. paradoxus* occupied one peak at 15 rays, while the range of *M. m. capensis* increased by one ray. The dominating count in *M. m. senegalensis* lies between 14–15 rays, while for *M. bilinearis* it is represented by 14 rays. An overlap of the ranges in different populations is clearly seen from the pectoral ray counts (see Fig. 5).

On the basis of total vertebral counts another form of differentiation within these populations is appeared. *M. m. mediterraneus* (51), *M. m. senegalensis* (53) and *M. m. paradoxus* (55) were characterized by separate peaks, while *M. m. atlanticus* and *M. m. capensis* occupied one peak (50), where their ranges overlapped with that of *M. m. mediterraneus.* The separation between hakes using vertebral counts is confirmed by the findings of **Maurin** (1954) for *M. merluccius* and *M. senegalensis,* **Sauskan** (1969) for different species of hakes in the Atlantic Ocean, and **van Eck (1969)** for *M. m. capensis* and *M. m. paradoxus. M. bilinearis* is represented by the range overlapping those of *M. m. senegalensis* and *M. m. paradoxus,* where the fishes at (54) dominate (see Fig. 6). The study of the partitioned vertebral column revealed that the abdominal counts for *M. m. atlanticus* and *M. m. capensis* had the same peak at (18), while *M. m. mediterraneus* (19). *M. m. senegalensis* and *M. m. paradoxus* were associated in one peak (21). The abdominal count of M. bilinearis appeared to be identical with that of *M. m. paradoxus* in the peak (21) or the range (see Fig. 7). Although an overlap is seen from the caudal vertebral counts, we can separate between certain populations i.e., *M. m. atlanticus* (25), *M. m. mediterraneus, M. m. senegalensis* and *M. m. capensis* (26), *M. m. paradoxus* (28) and *M. bilinearis* (see Fig. 8).

The study of the total gill raker counts served to clear a discrimination between different populations of hakes (see Fig. 9). This result is confirmed by the findings of **Maurin** (1954) and **Sauskan** (1969). This separation is also shown from the mean gill raker counts on upper, lower or whole gill arch (see Tables 8 and 9). The mean counts of gill raker demonstrated a geographical variation pattern within populations of NE-and SE-Atlantic. This variation is represented by an increase in the mean counts from the North to the South.

Results of meristic characters measurements from different hake populations are compared with the findings of other authors (Table 10). General outlook on ranges of meristic characters of hakes from NE- and SE-Atlantic including Mediterranean Sea, indicated to a visible discrepancies existing between these findings. It was shown that the range of first dorsal ray counts of the all populations lies between 9–13. The difference between the various populations is represented by an increase of one ray over the minimum or a decrease of one or two rays below the maximum. An overlap in the ranges given for other characters is shown also. Even in the recent data given by **van Eck** (1969), the range of gill rakers noted for *M. m. capensis* is nearly the same as for *M. m. senegalensis* in the present study. While that of *M. m. paradoxus* is similar to that of *M. m. capensis* and increases by one ray in *M. m. paradoxus* in the present study. The range of vertebrae seems to be identical but he counted the urostyl. Therefore, from this comparison it is apparent that these characters may be affected by variable environmental factors which can produce the existing discrepancies.

As it is shown from the previous discussion, there are overlaps in most of the count ranges of meristic characters. By applying the t-test between the mean of counts for each meristic characters of alternative populations revealed the existed significance of the means to identify the populations. It was found that the difference between the means is highly significant at $t_{0.05}$ and $t_{0.01}$ between most of populations for all meristic characters, except first dorsal count is nonsignificant *M. m. capensis* and *M. m. paradoxus* at both levels, while significant at $t_{0.05}$ and nearly significant at $t_{0.01}$ *M. m. mediterraneus* and *M. m. atlanticus* Also the difference is non-significant for pectoral counts *(M. m. mediterraneus* and *M. m. atlanticus* and vertebral counts *(M. m. atlanticus* and *M. m. capensis)*, (see Table 11).

Comparative study of skulls from different populations gave an indication of the shape of lateral ethmoid, frontal and sphenotic regions as an evidence for differentiation. The curvature resulting from the union of lateral ethmoid and frontal bone appears to be distinct in *M. m. mediterraneus, M. m. atlanticus, M. m. senegalensis* and *M. m. paradoxus.* This area appears in *M. m. capensis* and *M. bilinearis* as a straight line. *M. bilinearis* differs from other populations by a sharp straight anterior frontal which broadens posteriorly forming, with the sphenotic bone, the broad distal part of the skull (see Figs. 10–21). It is shown from Figures 22–27 that a slight differences occurred between the similar bonesin different populations. Examination of the otoliths shape indicated to

Table 10

Meristic characters of fishes of genus *Merluccius* according to different Authors

Name of Authors		Norman (1937)							Svetovidov (1948)		Maurin							Cadenat (1952)				
Localities		In respect to different species distribution									(1952)					(1954)		Cape Town	Congo	Cap Vert	Mediterranean	Region of Mamelles
											Casablanca	Agadir	Oued Draa	Cap Juby	Mauritania	Casablanca to Mauritania						
Meristic characters / Names of fishes		M. hubbsi	M. gayi	M. australis	M. productus	M. bilinearis	M. capensis	M. merluccius	M. merluccius	M. bilinearis	Different populations					M. senegalensis	M.merluccius	M. capensis	M. polli	M. senegalensis	M.m.mediterraneus	M. senegalensis
Number of fishes		–	4	3	5	8	17	15	8	2	887	14	20	40	39	77	77	1	2	61	2	24
First dorsal eay counts		(11)12–13	11	11	11–12	12–13	10–11	(9)10–11	9–10	12	9–11	9–11	9–11	9–11	10–12	9–12	9–11	10	10	11	9–10	–
Second dorsal ray counts		36–39	36–40	36–43	39–42	36–41	35–40	37–40	37–40	39	35–41	39–41	38–41	36–41	38–42	38–43	36–43	40	38–39	38–40	38–39	–
Anal ray counts		37–41	37–39	36–42	41–43	37–40	37–40	36–39	36–40	39–40	–	–	–	–	–	–	–	39	36–37	36–39	36–37	–
Pectoral ray counts		12–14	15–16	13	16	13–14	about 14	(12)13–14	13–14	14–15	–	–	–	–	–	–	–	–	–	–	–	–
Vertebral counts		–	–	–	–	–	–	–	–	–	49–55	51–55	50–55	50–55	50–55	51–55	49–52	51	53	53–56	52	53–56
Gill raker counts	upper	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	2	2–4	2	3–4
	lower	10–13	15–18	10	15–17	10–14(15)	13–14	7–8	8–12	13	–	–	–	–	–	–	–	13	8	7–12	8	14–17
	total	–	–	–	–	–	–	–	–	17–18	–	–	–	–	–	13–16	9–11	–	–	–	–	–

Name of Authors		Heldt (1952)	Matta (1953)		Sauskan (1969)							van Eck (1969)*		Soliman (present study)					
Localities		Tunis	Archipelag Toscano	NW Sardinia	U.S., NE and SE Atlantic coasts							South Africa		Mediterranean	South Irland	Mauritania	Angola SW and S.Afrika	SW and S. Afrika	U.S. coasts
Meristic characters / Names of fishes		M. merluccius	M. merluccius		M. capensis	M. paradoxus	M. albidus	M. bilinearis	M. senegalensis	M. cadenati	M. merluccius	M.m. capensis	M. m. paradoxus	M. m. mediterraneus	M. m. atlanticus	M. m. senegalensis	M. m. capensis	M. m. paradoxus	M. bilinearis
Number of fishes		25	361	206	numerous							more than 100		85	20	190	174	133	293
First dorsal ray counts		–	9–11	9–11	–	–	–	–	–	–	–	–	–	9–11	10–11	9–12	10–13	10–12	11–14
Second dorsal ray counts		–	35–41	34–41	–	–	–	–	–	–	–	–	–	36–39	38–40	39–43	37–42	38–42	38–42
Anal ray counts		–	–	–	–	–	–	–	–	–	–	–	–	35–39	37–39	37–41	37–42	38–42	37–43
Pectoral ray counts		–	–	–	–	–	–	–	–	–	–	–	–	12–14	13–14	13–16	14–17	14–16	13–16
Vertebral counts		51–53	50–54	–	48–51	52–56	–	–	51–55	52–58	47–52	49–51	54–57	49–52	49–51	51–54	48–51	54–57	52–56
Gill raker counts	upper	–	1–2	–	–	–	–	–	–	–	–	–	–	1–2	2	3–4	4–6	4–7	3–5
	lower	–	7–9	–	–	–	–	–	–	–	–	10–14	12–16	8–9	7–9	10–13	12–16	12–17	12–16
	total	–	–	–	–	–	8–12	15–19	12–17	8–12	8–12	–	–	9–11	9–11	13–17	16–21	17–23	15–21

* Vertebral counts (urostyl included)

Table 11

t-test for the difference between the means of different meristic counts of genus *Merluccius* from different localities

Examined populations	$t_{0.05}$	$t_{0.01}$	First dorsal rays	Second dorsal rays	Anal rays	Pectoral rays	Total vertebrae	Total gill rakers
			t_o	t_o	t_o	t_o	t_o	t_o
M. m. mediterraneus – M. m. atlanticus	1.982	2.626	2.589	7.918	4.831	0.206	4.186	3.596
M. m. mediterraneus – M. m. senegalensis	1.972	2.601	11.870	28.551	14.832	15.402	28.609	48.119
M. m. mediterraneus – M. m. capensis	1.972	2.601	15.587	19.064	23.076	25.466	8.772	83.550
M. m. mediterraneus – M. m. paradoxus	1.972	2.601	15.770	25.593	28.485	19.305	47.236	70.263
M. m. atlanticus – M. m.senegalensis	1.972	2.601	4.356	7.819	2.915	8.649	20.932	22.948
M. m. atlanticus – M. m. capensis	1.973	2.603	6.466	3.812	7.995	13.989	0.099	42.139
M. m. atlanticus – M. m. paradoxus	1.976	2.609	6.862	7.763	11.372	11.286	30.428	34.498
M. m. senegalensis – M. m. capensis	1.968	2.592	4.310	5.743	13.599	14.316	48.172	42.215
M. m. senegalensis – M. m. paradoxus	1.968	2.592	5.138	4.159	21.060	5.372	30.881	45.119
M. m. capensis – M. m. paradoxus	1.968	2.592	1.183	8.208	7.392	8.081	70.115	12.167

the similarity between *M. m. mediterraneus, M. m. atlanticus, M. m. senegalensis* and *M. m. capensis.* Since that of *M. m. paradoxus* is slightly different and resembles kidney-shape, it is used to separate this species grom the *M. m. capensis* by **Mombeck** (1970 a and b) and others. *M. bilinearis* has different otolith from which is used to distinguish it from the others. It is elongated, broad at one end where there appears a notch and tappers at the other end (see Figs. 28–33). Comparison of the shape of the skulls and bones of *M. merluccius* and *M. bilinearis* given by **Svetovidov** (1948) indicated to the similarity of skulls of both to those in the present study. The other bones show slight variability.

CONCLUSIONS

From the previously mentioned interpretation of the results, we can summarise the following main points concerning the hakes of Ne-, SE-Atlantic and Mediterranean Sea:

1. The majority of the morphometric ratios are similar for all populations.
2. Most of the characters used for separation between different populations bore geographical variation patterns.
3. The meristic characters indicated to an overlap within these populations.
4. The only meristic character which alloved in the discrimination between all populations was the total gill raker counts on the whole gill arch. The vertebrae can be used for certain populations.
5. First dorsal ray and total gill raker counts represented geographical variations.
6. By applaying the t-test between the mean of counts for each meristic characters of alternative populations reveeled the existed significance of the means to identinity the populations.
7. Close similarity in the otoliths for all populations is existed.

As it is evident, the characters which are used for differentiation, are controled by enviromental factors or geographical variations. In addition, the distribution of these populations noted in the literature, indicated that *M. merluccius* coexisted with *M. senegalensis* to the shores of Senegal and also indicated thei similarity to *M. capensis.* The occurrence fo *M. m. capensis* and *M. m. paradoxus* in a wide overlapping areas is also observed. This means that there are no barriers for their isolation and they are mixed freely.

It is obvious, from these facts, that fishes inhabiting these localities can be considered as local populations of *Merluccius merluccius.* Hence, it can be useful for the fishery experts to apply subspecific nominations for these fishes, namely: *Merluccius merluccius atlanticus, M. m. senegalensis, M. m. capensis, M. m. paradoxus* and *M. m. mediterraneus.* This opinion is reckoned upon by the definition of subspecies given by **Regan** (1925 quoted by **Norman**, 1963).

However, *M. bilinearis* can be separated from other subspecies due to other features. The most important ones are skull and otoliths type. Mereover, the topography of the NW-Atlantic Ocean bottom which provides the natural isolation of *M. bilinearis* from other populations in teh Eastern Atlantic. Consequently, it can be given the specific name: *Merluccius bilinearis.*

I would like to indicate that during this sıudy, there are no observed symptoms of the coexistence of these populations within the different localities.

For future studies on this problem I would like also to recommend that it would be to find a solution through the chromosomes studies.

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ZMIENNOŚĆ RYB RODZAJU MERLUCCIUS W OCEANIE ATLANTYCKIM I MORZU SRÓDZIEMNYM

Streszczenie

Systematyka rodzaju morszczuk – *Merluccius* jest bardzo ciekawa i zarazem kontrowersyjna dla wielu autorów. Obok cech biometrycznych i osteologicznych stosuje się nawet serologię do wyjaśnienia sprzeczności i wyróżnienia poszczególnych populacji. W niniejszej pracy zastosowano jednoczesną analizę cech morfometrycznych, merystycznych i osteologicznych dla rozwiązania różnic i podobieństw pomiędzy poszczególnymi populacjami.

Z przeprowadzonych badań wynika jasno, że większość morfometrycznych danych z pomiarów różnych części ciała, jest podobna dla wszystkich badanych populacji. Obserwuje się wzrost lub spadek wraz z wielkością i wiekiem ryb pewnych stosunków morfometrycznych. Indywidualne wahania również występują. Należy zanotować, że długość pierwszej płetwy grzbietowej (D), jak jej wysokość, długość płetw piersiowych (P), długość płetw brzusznych (V), wysokość trzona ogonowego, średnicy oka jak odległość międzyocznej, wykazują pewne różnice u poszczególnych populacji. Niestety wszystkie te różnice można odnieść do różnic wynikłych na tle geograficznego oddalenia.

Stosunek między średnimi wielkościami o charakterze merystycznym a długością i wiekiem ryb u różnych populacji nie przedstawia jasnych różnic. Nie występują też wyraźne różnice wielkości średnich merystycznych w stosunku do całej populacji jak i oddzielnie dla osobników jednej płci w obrębie jednej populacji. Jedynie różnice ilościowe różniące badane populacje dotyczą ilości wyrostków skrzelowych na łuku. Liczba kręgów może być użyteczna jedynie w stosunku do pewnych populacji. Zaobserwowano że liczba wyrostków na pierwszym łuku jak i w całości wykazuje zmienność geograficzną zmieniającą się z północy na południe. Porównanie liczbowe cech merystycznych z danymi innych autorów ujawnia na ogół zgodność.

Studia porównawcze czaszki wykazują pewną odrębność u *M. bilinearis* w stosunku do pozostałych populacji, przez ostro zarysowaną kość czołową. Natomiast porównanie otolitów wykazuje podobieństwo między badanymi populacjami wschodniego Atlantyku i M. Śródziemnego w odróżnieniu od *M. bilinearis.*

W rezultacie wyodrębniono pięc podgatunków wzdłuż wybrzeży wschodnich Atlantyku: Merluccius merluccius atlanticus dla półn.-wsch. Atlantyku i *M.m. senegalensis* dla wybrzeży Mauretanii, *M.m. capensis* dla Płd.-Zach. Afryki, *M.m. paradoxus* dla Płd. Afryki i *M.m. mediterraneus* dla M. Śródziemnego oraz odrębny gatunek *M. bilinearis* dla wybrzeży Płn. Ameryki.

РАЗНООБРАЗИЕ РЫБ РОДА MERLUCCIUS В АТЛАНТИЧЕСКОМ ОКЕАНЕ И СРЕДИЗЕМНОМ МОРЕ

Р е з ю м е

Систематика рода мерлуз - Merluccius - является очень интересной и вместе с тем весьма противоречивой в работах многих авторов. Для выяснения противоречий и выделения отдельных популяций наряду с биометрическими и остеологическими признаками применяется даже серология. В настоящей работе проведен одновременный анализ морфометрических, меристических и остеологических признаков для установления различий и сходств между отдельными популяциями.

Из проведенных исследований ясно следует, что большинство морфометрических данных, полученных при измерении разных частей тела, у всех исследуемых популяций является подобным. Наблюдается рост или уменьшение вместе с размером и возрастом рыб некоторых морфометрических соотношений. Отмечаются также индивидуальные колебания. Следует подчеркнуть, что длина первого спинного плавника (D), как и его высота, длина грудных плавников (P), длина брюшных плавников (V), высота хвостового стебля, диаметр глаза, а также межглазничное пространство у отдельных популяций имеют определённые различия. К сожалению все эти различия можно отнести к различиям, вытекающим из географического места обитания.

Соотношение между средними величинами меристического характера и длиной в возрастом рыб разных популяций не имеет ярко выраженных расхождений. Не проявляются отчётливо также и различия средних меристических величин как по отношению ко всей популяции, так и отдельно для особей одного пола в границах одной популяции. Только количественные различия, отличающие исследуемые популяции, касаются числа жаберных отростков на дуге. Количество позвонков может иметь значение только применительно к определённым популяциям. Замечено, что число отростков на первой дуге, как и в целом, отражает географическую изменчивость в направлении с севера на юг. Количественное сравнение меристических признаков с данными других авторов в общем проявляет соответствие.

Сравнительное изучение черепа указывает на определённую индивидуальность у M. bilinearis, отличающую её от остальных популяций благодаря резко выраженной лобной кости. Сравнение же отолитов указывает на сходство исследуемых популяций восточной Атлантики и Средиземного моря в отличие от M. bilinearis.

В результате выделены пять подвидов вдоль восточного побережья Атлантики: Merluccius merluccius atlanticus для северо-восточной Атлантики, M.m. senegalensis для побережья Мавритании, M. m. capensis для Юго-Западной Африки, M.m. paradoxus для Южной Африки и M.m. mediterraneus для Средиземного моря, а также отдельный вид M. bilinearis для побережья Северной Африки.

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