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A CONTRIBUTION TO THE STUDY OF HETEROGENEITY OF THE ADRIATIC SARDINE (*SARDINA PILCHARDUS* WALB.) POPULATION

DOPRINOS IZUČAVANJU HETEROGENOSTI POPULACIJE SRDELE (*SARDINA PILCHARDUS* WALB.) JADRANSKOG MORA

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A study of the heterogeneity of sardine population inhabiting the eastern Adriatic Sea was made on the basis of variations of the head length and number of gillrakers in relation to the body length. Statistical methods were used to determine the extent of difference and overlap of these characters. Results indicate that tested groups of sardine from the northern and middle Adriatic are heterogeneous with respect to the number of gillrakers.

INTRODUCTION

Variations of head length and the number of gillrakers in relation to body length are numerical characteristics often used for the characterization of a fish population or subpopulation of the same species occurring in different areas. These characteristics refer to the shape of the fish and may be indicative of a process of adaptation to environmental variations in time. This paper presents a study of the heterogeneity of sardine population living in the eastern Adriatic Sea based on the above mentioned characteristics.

Heterogeneity of the northern and middle Adriatic sardine population was studied by some earlier authors who were mainly concerned with the variations in the number of vertebrae. Mužinić (1954) found that sardine population from the middle Adriatic was characterized by a modal number of 52 vertebrae. Krajnović-Ozretić and Žikić (1978) reported the same modal number for the northern Adriatic sardine what was in agreement with the results of Mužinić (1958). Some earlier records, however, were quite different (Fage, 1920; Zavodnik, 1962; Mozzi et Duó, 1968).

Studies of the weight-length relationship and condition factor of sardine proved a physiological difference between the northern Adriatic sardine and

the middle Adriatic sardine during spawning season and indicated the possibility of mixing of these two populations (Alegría-Hernández, 1983).

Investigations of the migrations of this species (Mužinić, 1954, 1958 and 1973; Zavodnik, 1968; Škrivanić and Zavodnik, 1973) supported the assumption that at least two sardine subpopulations co-exist in the eastern Adriatic, which differ with respect to the direction, time and extent of their migrations.

MATERIALS AND METHODS

Samples were taken from commercial catches realized at the northern and middle Adriatic fishing grounds, between October 1980 and April 1981 (Fig. 1).

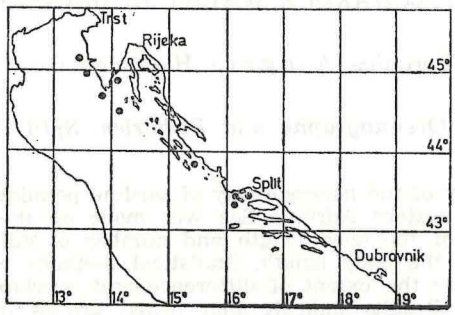

Fig. 1. Position of sampled areas in the eastern Adriatic Sea

Total body length of fish studied is expressed in milimeters. Total length of frozen specimens was corrected by the following transformation equation:

$$L = \frac{L' - 0.516}{1.014}$$

where L' is the total length of specimens after melting and L the total length of fresh fish.

Data were grouped by length classes to the nearest 5 mm. Head length was measured to the nearest 0.1 mm from the anterior end of lower maxilla to the posterior edge of subopercul um. The gillrakers were counted on the first left branchial arch and lower edge or segment which comprises hypobranchial and ceratobranchial bones of the same arch (Fig. 2). Gills were prepared for gillraker counting by the method of Andreu (1969).

The obtained data were statistically treated. Allometric relationship between fish body length and head length, on the one side, and the number of gillrakers, on the other, were calculated by the exponential function: $Y = aL^b$ where L is the total length, Y head length and gillraker number respectively, b head growth coefficient and increase rate of gillraker number

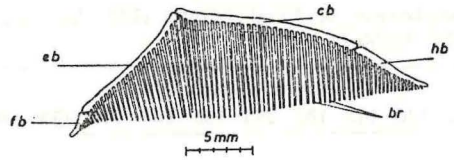

Fig. 2. Morphological structure of the first left gill arch of sardine with gill filaments removed: hb — hipobranchial, cb — ceratobranchial, eb — epibranchial, fb — faringobranchial, br — gill-rakers

respectively and *a* constant. Results for the same length groups (125—195 mm) from either of the locations were statistically compared to avoid the effect of fish length variation on calculations.

RESULTS

Head length

Head length frequencies by length classes with respective mean values and the variance of analyzed sardine samples from the northern and middle Adriatic are given in Tables 1 and 2.

Functional allometric relationships were also calculated (Table 3). Theoretical curves given in Fig. 3 were obtained from these calculations.

Table 1. Frequency distribution of head length (LC) by length classes of sardine from the northern Adriatic

	Length classes (mm)															
LC (mm)	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
24	5	2														7
25	3	8	1													12
26	15	12	4	3	2											36
27	1	8	20	28	7											64
28			10	72	53	5	2									142
29			1	42	110	68	8									229
30				3	48	75	25	9								160
31					5	20	30	26	5							86
32							3	12	10	3	1					28
33								2	8	7	4					20
34									13	30	16	4				62
35									2	12	13	13	10			49
36										1	4	12	6	4		27
37											7	8	17	6	6	44
38													4	9	9	22
39													1	1	3	5
Total	25	30	36	148	225	168	68	49	38	53	45	37	38	20	18	994
Mean	25.5	25.9	27.2	28.1	28.9	29.7	30.4	31.1	32.8	34.0	34.8	35.6	36.5	37.3	37.8	30.4
Variance	0.73	0.81	0.58	0.62	0.74	0.53	0.62	0.57	1.30	0.71	1.45	0.88	1.14	0.73	0.56	9.16

Table 2. Frequency distribution of head length (LC) by length classes of sardine from the middle Adriatic.

	Length classes (mm)															
LC (mm)	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
24	1															1
25	6	2														8
26	3	4	5													12
27	1	4	11	8	12	1										37
28			2	15	16	7	1									41
29				3	41	37	9	1								91
30					18	80	78	19								195
31					2	34	102	81	14	3						236
32						1	26	54	53	18	1					153
33							3	15	50	47	27	1				143
34								2	21	64	40	17	3			147
35									1	25	48	49	17	1		141
36										5	14	34	35	6	1	95
37										1	1	12	33	16	3	66
38												4	6	11	12	33
39													1	3	6	10
40														2	3	5
Total	11	10	18	26	89	160	219	172	139	163	131	117	95	39	25	1414
Mean	25.3	26.3	26.8	27.8	28.8	29.9	30.7	31.4	32.6	33.7	34.4	35.4	36.2	37.4	38.3	32.3
Variance	0.59	0.56	0.36	0.39	0.97	0.69	0.64	0.74	0.79	1.12	0.95	1.00	0.96	1.16	0.92	7.36

Table 3. Parameters of regression betwen total length and head length in sardine from the northern and middle Adriatic.

	Areas	
Parameters	Northern Adriatic	Middle Adriatic
Coef. corr.	0.994	0.996
a	—0.5564	—0.5636
b	0.9337	0.9366
$_{Y.X}$		
Conf. lim. 95%	$\pm$0.0246	$\pm$0.0145
s_b	20.02×10^{-3}	6.7×10^{-3}
$s^2_{Y.X}$	2.13×10^{-5}	0.24×10^{-5}
$d^2_{Y.X}$	27.64×10^{-5}	3.10×10^{-5}

Values of head length increase coefficient are indicative of a very small and not significant difference ($F_s = 1.437$, $P > 0.05$) between these two sardine groups.

Gillraker numbers

Results of gillraker counts on the lower edge of the first branchial arch are given in Tables 4 and 5. It was found that the northern Adriatic sardine of 125—195 mm in length had 50—68 cerato-hypobranchial gillrakers and mean value 59.61 $\pm$ 2.37.

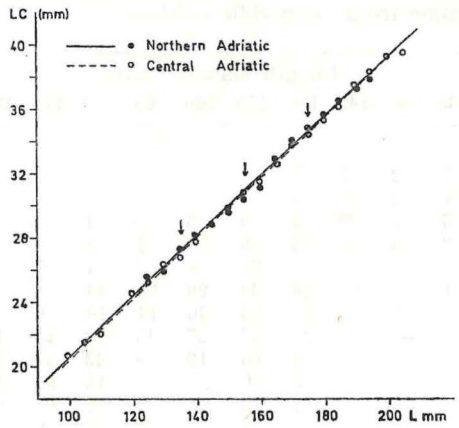

Fig. 3. Relationship between head length (LC) and total length (L) in sardine from the northern and middle Adriatic

Table 4. Frequency distribution of cerato-hypobranchial gillrakers (Bri) by length classes of sardina from the northern Adriatic.

	Length classes (mm)															
Bri	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
50	1	1														2
51	1	2		1												4
52	4	4	2	1												11
53	—	6	1	—	1											8
54	1	6	—	5	2											14
55	2	3	5	7	5	1										23
56		1	3	12	8	3		1								28
57		—	1	8	12	8	1	2			1					33
58		1	1	8	40	16	1	2	1	1	—					71
59			—	7	22	14	4	4	1	—	—					52
60			1	7	20	10	14	5	1	2	—	2				62
61				4	12	16	10	5	5	6	1	2		1		62
62				1	3	6	4	3	6	3	3	—	1	—	1	31
63					1	4	2	4	4	8	6	3	2	1	—	35
64						2	—	1	1	2	2	3	—	—	2	13
65							1	1	1	2	3	7	4	2	—	21
66									1	1	4	2	5	2	4	19
67											1	1	—	2	2	6
68													1	1	1	3
Total	9	25	14	60	126	80	37	28	21	25	21	20	13	9	10	498
Mean	52.5	53.3	55.3	57.3	58.5	59.5	60.5	60.4	61.9	62.3	63.7	63.9	65.1	65.3	65.7	59.65
Variance	2.69	3.00	4.37	4.88	3.19	3.90	2.03	4.75	3.61	3.10	4.81	3.83	2.38	4.22	2.84	9.20

Table 5. Frequency distribution of cerato-hypobranchial gillrakers (Bri) by length classes of sardine from the middle Adriatic

	Length classes (mm)															
Bri	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
54	2	1		1	1											5
55	—	—	1	2	1	2										6
56	2	1	1	2	4	1	2	1	1							15
57	2	3	3	2	9	8	5	3	5	1						41
58	1	1	2	6	12	15	10	10	8	3	4					72
59	2	1	1	3	15	19	23	8	8	7	7	1				95
60		1	1	3	13	28	39	29	20	14	8	3	1			160
61				1	9	22	45	30	17	14	9	7	3			157
62				—	1	25	37	27	25	28	15	12	7	3		180
63				1	1	8	18	18	24	23	17	16	8	1	2	137
64						8	10	22	8	15	30	18	9	2	—	122
65						1	9	4	8	12	12	13	7	5	2	73
66							1	5	3	9	9	9	9	7	4	56
67								2	2	3	7	10	12	4	6	46
68								1	1	2	3	7	7	4	2	27
69										1	1	1	6	3	2	14
70											1	4	4	1	—	10
71												1	1	2	1	5
72												1	—	2	—	3
73													1		—	1
74															2	2
Total	9	8	9	21	66	137	199	160	130	132	123	103	75	34	21	1227
Mean	56.7	57.3	57.4	58.0	58.8	60.3	61.0	61.6	62.1	62.6	63.3	64.5	65.6	66.8	67.4	62.17
Variance	3.11	3.35	2.02	4.43	2.98	4.00	3.67	4.83	5.38	5.22	6.16	6.83	7.48	7.04	7.85	4.60

Table 6. Parameters of regression between total length and the number of cerato--hypobranchial gillrakers (Bri) and total number of gillrakers (Brt) of the first branchial arch in the northern and middle Adriatic sardine

Parameters	Areas			
	Northern Adriatic		Middle Adriatic	
	Bri	Brt	Bri	Brt
Coef. corr.	0.968	0.956	0.980	0.978
a	0.6735	1.0043	0.9135	1.1570
$b_{Y.X}$	0.5028	0.4296	0.3978	0.3666
Conf. film. 95%	±0.0589	±0.0461	±0.0237	±0.0294
s_b	24.95×10^{-3}	21.36×10^{-3}	10.95×10^{-3}	13.63×10^{-3}
$s^2_{Y.X}$	3.30×10^{-5}	2.42×10^{-5}	0.64×10^{-5}	0.98×10^{-5}
$d^2_{Y.X}$	42.93×10^{-5}	31.47×10^{-5}	8.28×10^{-5}	12.80×10^{-5}

High range of gillraker number was recorded for every length class with variations of 7 to 11 gillrakers. Higher values were obtained for the middle Adriatic sardine: the number of cerato-hypobranchial gillrakers varied from 54—74 with mean value 62.17 $\pm$ 1.93. All length classes show a variation of 9—14 units.

Calculated values of the allometric constant and other statistical values of the regression between the total length and gillraker number on the lower edge of the first branchial arch are given in Table 6.

The relationship between the cerato-hypobranchial gillraker number and total length are plotted in Fig. 4.

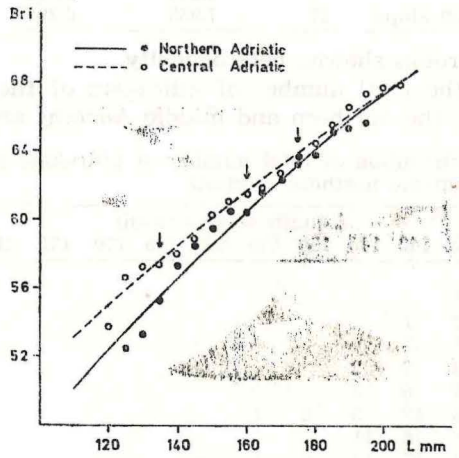

Fig. 4. Relationship between the number of cerato-hypobrachial gillrakers (Bri) and total length (L) in sardine from the northern and middle Adriatic

T-method for significance of difference was applied to test the difference between calculated rate of increase in the number of cerato-hypobranchial gillrakers (*b*). Minimum significant difference was obtained to be 0.072. The difference between coefficients *b* was 0.105. It exceeded the critical difference. The comparison intervals of coefficient *b* showed no overlap:

Areas	Upper limit	Coefficient *b*	Lower limit
Northern Adriatic	0.5391	0.5028	0.4665
Middle Adriatic	0.4137	0.3978	0.3819

Calculated increase rate of the number of cerato-hypobranchial gillrakers in sardine from the compared areas differ considerably ($F_s = 14.275$, $P < 0.05$).

The covariance analysis was used to test the homogeneity of the intercept a of the regression between sardine length and the number of cerato-hypobranchial gillrakers. The results are as follows:

Source of variation	df	SS × 10^{-4}	MS × 10^{-4}	F_s	P
Between groups	1	6.120	6.120	0.774	n.s.
Within group	28	222.51	7.947		
Common slope of groups	1	214.542	214.542	727.894	.05
Deviation from common slope	27	7.958	0.295		
Difference between slopes	1	2.812	2.812	14.275	.001
Deviations in each group	26	5.121	0.197		
Between intercepts	1	6.144	6,144	20.827	.001
Deviation from common slope	27	7.958	0.295		

Tested sardine groups showed heterogeneity.

Frequencies of the total number of gillrakers of the first left branchial arch of sardine from the northern and middle Adriatic are shown in Tables 7

Table 7. Frequency distribution of total number of gillrakers (Brt) by length classes of sardine from the northern Adriatic

	Length classes (mm)															
Brt.	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
76	3	1														4
77	—	1	1													2
78	7	1	2	1												11
79	4	3	1	—												8
80	4	6	2	3	2											17
81	1	3	4	6	3											17
82	—	2	8	13	5	2	1									31
83	1	2	6	16	11	4	—									40
84		2	3	17	14	6	1	1								44
85		1	4	19	18	8	2	—								52
86			2	19	34	14	6	2	1							78
87			1	18	40	22	6	2	2	3	1					95
88				12	41	25	8	4	2	2	1	1	1			97
89				6	19	24	9	9	3	4	2	3	—			79
90				2	16	23	9	6	4	3	3	2	1		1	70
91				2	8	10	11	10	7	7	5	4	1	1	—	66
92				2	5	11	4	5	3	9	6	5	2	2	1	55
93					3	5	2	2	5	8	8	7	2	2	3	47
94					1	3	2	1	2	4	6	6	3	1	4	33
95						1	3	—	—	2	4	3	6	2	1	22
96							—	1	1	2	1	1	8	1	2	17
97							1	—		—	1	2	4	3	1	12
98								—		—	—	—	2	2	1	5
99								1		—	—	—	—	—	—	1
100										1	1	1	1	1	—	5
101											—	1	1	—	—	2
102											2	1	—	2	1	6
103												—	1	—		1
104												1		1		2
Total	20	22	34	136	221	158	65	44	30	45	41	38	33	18	15	920
Mean	78.7	80.6	82.4	85.1	87.0	88.4	89.5	90.1	90.8	91.8	93.0	93.6	95.2	96.4	94.7	88.3
Variance	2.81	7.05	6.53	7.29	6.44	6.68	8.38	6.60	6.39	7.07	10.36	12.45	8.80	13.36	3.24	13.46

and 8. Mean gillraker number of the northern Adriatic sardine was 88.29 ± 2.90 with the gillraker range 76—104. Gillraker number varied from 9 to 17 gillrakers in sardine specimens of the same length. The middle Adriatic sardine showed the range of 80—111 gillrakers and mean value 92.85 ± 2.56. This number varied between 12 and 19 gillrakers within individual length classes.

Calculated parameters of the allometric relationship between the total length and total gillraker number are given in Table 6. Theoretical curves obtained from these data are given in Fig. 5.

Table 8. Frequency distribution of total number of gillrakers (Brt) by length classes of sardine from the middle Adriatic

	Length classes (mm)															
Brt.	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	Total
80	1			1												2
81	—	1	1	—												2
82	2	—	1	1	1											5
83	—	1	2	1	1	1										6
84	—	1	—	—	3	1										5
85	2	4	2	1	1	3	2		1							16
86	2	5	2	4	5	6	2	2	4	1						33
87	1	1	4	3	14	11	5	8	7	1	4					59
88	1	1	2	6	19	12	14	8	9	5	2					79
89	—	1	—	1	7	21	14	13	8	8	7	2	1			83
90	1	—	1	2	13	21	24	23	10	14	5	8	1	1		124
91		—	2	—	7	18	30	20	11	14	7	4	5	—		118
92		1		3	9	29	35	19	17	19	13	11	3	3	1	163
93					1	14	34	17	20	24	12	13	4	1	—	140
94						9	30	24	17	20	14	16	7	1	1	139
95						6	11	10	15	18	13	10	10	1	—	94
96						2	8	15	8	12	15	14	7	4	1	86
97						1	3	5	4	9	12	8	7	4	2	55
98							3	2	3	6	11	9	11	5	5	55
99								2	2	3	7	8	10	2	2	36
100								3	2	3	2	2	4	1	1	18
101								1	1	2	3	7	7	1	2	24
102										2	2	3	5	4	2	18
103											2	2	4	4	2	14
104												2	5	2	1	10
105												1	—	1	1	3
106												2	2	1	2	7
107														1	1	2
108														1	1	2
Total	10	16	17	23	81	155	215	172	139	161	131	122	93	38	25	1386
Mean	85.1	85.9	86.3	87.3	88.6	90.5	91.8	92.3	92.4	93.4	94.5	95.7	97.5	99.0	100.5	92.8
Variance	9.86	5.73	8.09	5.06	5.16	6.87	6.18	9.45	10.66	9.60	12.61	14.69	15.12	20.19	16.17	8.48

In both studied groups of sardine the number of gillrakers and its variations increase with the increase of the body length. Small specimens of the middle Adriatic sardine have on the average more gillrakers and smaller increase rate than those from the northern Adriatic.

It was observed that the number of gillrakers was greater in females (Fig. 6) but differences found between males and females from both areas were not significant.

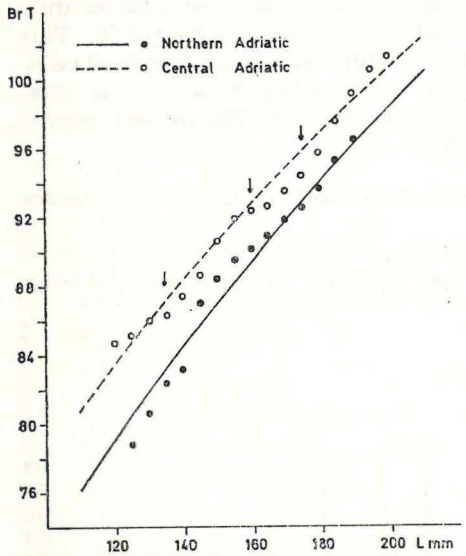

Fig. 5. Relationship between the total number of gillrakers (Brt) and total length (L) in sardine from the northern and middle Adriatic

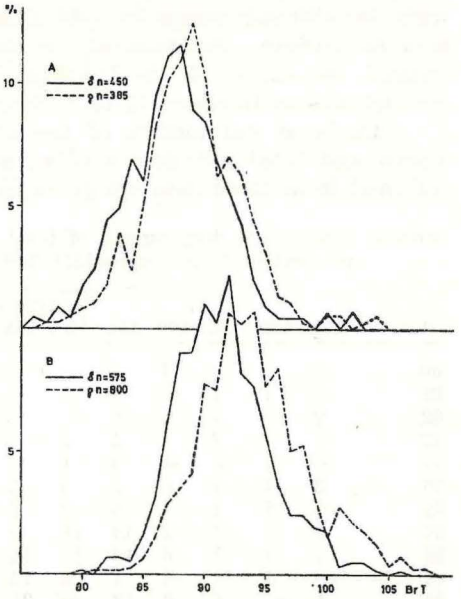

Fig. 6. Variation of the total gillraker number in male and female sardine from the northern (A) and middle (B) Adriatic

The comparison of increase rates of the total gillraker number by T--method showed their difference to be 0.063. This values exceeded the critical difference of 0.061. The comparison intervals for the coefficients *b* were computem from these values:

Areas	Upper limit	Coefficient b	Lower limit
Northern Adriatic	0.4607	0.4296	0.3985
Middle Adriatic	0.3864	0.3666	0.3468

Accordingly, there is no overlap of their ranges. This indicates that the increase rates of total gillraker numbers differ significantly ($F_s = 4.545$, $P < 0.05$).

Similar results were obtained by the covariance analysis:

Source of variation	df	SS × 10⁻⁴	MS × 10⁻⁴	F_S	P
Between groups	1	14.967	14.967	2.431	n.s.
Within groups	28	172.420	6.158		
Common slope of groups	1	168.513	168.513	772.995	0.05
Deviation from common slope	27	5.886	0.218		
Difference between slopes	1	1.053	1.053	6.194	0.05
Deviations in each group	26	4.428	0.170		
Between intercepts	1	5.396	5.396	24.748	0.001
Deviation from common slope	27	5.886	0.218		

The proportion of the northern Adriatic sardine which had the same characteristics as those of the middle Adriatic sardine was estimated by the Royce's method (1957). Mean values of regression equation were used for each group as well as respective common standard deviation from the regression. The percentage of the head length overlap is very high (93.58%). It was estimated that the total gillraker number of the northern Adriatic sardine overlapped that of the midle Adriatic sardine by 43.80%. The percentage of the overlap of cerato-hypobranchial gillraker numbers was lower (38.78%).

DISCUSSION

Sardine, like all pelagic fishes, show a tendency towards alternant growth variations due probably to the habitat changes within annual cycle. As illustrated in Figs. 3, 4 and 5 growth variations are of cyclic character, that is head growth and the increase of gillraker numbers exhibit a defined growth rhythm which is in agreement with annual life cycle. Accordingly, the first slow growing period was recorded in length group around the 135 mm in total length, that is at the time of the first sexual maturation of sardine. The second deceleration at 155 mm and the third one at 175 mm were observed during the second and third maturation respectively. Variations which occur in sardine with respect to the analysed growth processes, that is head growth and increase of gillraker numbers may be due not only to genetic factors but also to sexual and ecological factors. Gonad development and maturation generally affect relative development, particularly that of the head and cephalic organs, slowing it down at the time of reproduction when majority of energetic processes should be directed towards species survival.

Obtained head growth coefficients showed an almost isometric head growth in relation to the sardine length. Equation by wich these relationships were calculated showed that these relationships were similar in both the middle Adriatic sardine and the northern Adriatic sardine. Values of head growth coefficients were 0.934 and 0.937 respectively. Andreu (1969) calculated head growth coefficient for sardine from the middle Adriatic to be 0.775 based on the sample of 64 specimens. However, these individuals had considerably smaller total length of 105—165 mm. The same author recorded pronounced negative allometry in the Mediterranean sardine, that is head growth coefficient was somewhere between 0.7 and 0.8.

Estimated curves which illustrate the variation of the gillraker number increase with sardine growth (Figs. 4 and 5) are almost parallel particularly when the total gillraker number of all three segments of branchial arch are taken into account. Slower increase of the number of gillrakers may be observed in larger fish particularly in sardine from the middle Adriatic.

Andreu (1969) obtained considerably lower values of increase rate of cerato-hypobranchial gillraker number for the Adriatic ($b = 0.291$) and Mediterranean sardines ($b = 0.300$). Since the total length range of the sample of sardine from the Adriatic Sea which the author used was smaller (105—165 mm) the results are not comparable. Nevertheless, it was established that neotenia was more pronounced in the northern Adriatic sardine, what is to

a certain extent in agreement with the results of Andreu for the Atlantic sardine (exponent $b > 0.4$). However, the value of gillraker number increase rate for the middle Adriatic sardine is in better agreement with that for the western Mediterranean sardine (exponent $b < 0.4$).

Regression slope equality test and critical values of b coefficient difference obtained by T-test show significant difference, at 95% level, between the gillraker number increase rate in the middle Adriatic sardine and that in the northern Adriatic sardine. In addition the covariance analysis indicates a significant difference between but not within-sardine groups from these two areas. However, the amplitudes of variations of gillraker number of the first branchial arch show differences within each individual length class. Maximum variation of 17 gillrakers in the total number of gillrakers was recorded for the northern Adriatic sardine whilst the variation amounts to 19 gillrakers for the middle Adriatic sardine. These high variation ranges of gillraker numbers in individuals of the same size and area limit in a way the possibility to apply this character for a population differentiation, even though the residual variations are considerably higher in the northern Adriatic sardine.

Lower increase rate of the gillraker number together with the smaller dispersion around the regression line and smaller variations are indicative of a tendency of this character to stabilize in the middle Adriatic sardine.

Letaconnoux (1954) and Lee (1965) found that the gillraker number in *Sardina pilchardus* increased with the water temperature increase. However, the studies of Andreu (1969) disproved their statement. This author came to the conclusion that sardine population which exhibited smaller coefficient of gillraker increase lived in the area of more stable climatic conditions.

It was suggested by Škrivanić and Zavodnik (1973) that hydrographic polarization is one of the essential properties of the Adriatic Sea. Northern part is shallow and more dynamic owing to the influence of land waters of the north Italian rivers, particularly the Po River. The Middle Adriatic waters are deeper and more stable owing to the ingressions from the Mediterranean.

The covariance analysis and other tests used are indicative of the fact that, with respect to the gillraker number, sardine from both areas show high degree of heterogeneity. However, the assessment of the significance of established morphological difference obtained by the comparison of overlap shows relatively low overlap values what is another indication that at least two different sardine populations co-exist in the eastern Adriatic. Nevertheless, the overlap is still high enough to assume that mixing of sardines from these areas is highly likely.

CONCLUSIONS

From the variations of head lenght and gillraker number in relation to body lenght of the middle and northen Adriatic sardine the following may be concluded:

— Sardine from the northern and middle Adriatic were homogeneous in head growth. Head growth is almost isometric in relation to body growth in lenght.

— Considerable degree of heterogeneity of sardine population with respect to gillraker number was established. The northern Adriatic sardine had smaller number of gillrakers. The difference between groups was higher in smaller fish whilst large size fish showed smaller differences.

— Results of the overlap comparison on the basis of the number of gillrakers indicate that the northern and middle Adriatic sardines are probably separate but related stocks.

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DOPRINOS IZUČAVANJU HETEROGENOSTI POPULACIJE SRDELE (*SARDINA PILCHARDUS* WALB.) JADRANSKOG MORA

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KRATKI SADRŽAJ

Na temelju varijacije dužine glave i broja branchispina u odnosu na dužinu tijela izučavala se heterogenost populacije srdele koja obitava u istočnom Jadranu.

Koristeći uzroke srdele totalne dužine od 125—195 mm izračunati su alometrijski odnosi funkcionalnom regresijom. Rezultati su statistički uspoređivani. Slijedeći jednadžbe izražavaju odnos između ukupne dužine (L) i dužine glave (LC) i ukupne dužine (L) i broja cerato-hipobrancijalnih branchispina (Bri) te ukupnog broja branshispina prvog škržnog luka (Brt):

Sjeverni Jadran	Srednji Jadran
$LC = 0{,}289\ L^{0{,}9337}$	$LC = 0{,}273\ L^{0{,}9366}$
$Bri = 4{,}715\ L^{0{,}5028}$	$Bri = 8{,}194\ L^{0{,}3978}$
$Brt = 10{,}099\ L^{0{,}4296}$	$Brt = 14{,}354\ L^{0{,}3666}$

Rast glave gotovo je izometrijski u odnosu na dužinski rast tijela. Dobijeni indeksi rasta glave nisu signifikantno različiti.

Analizom kovarijance i drugim testovima potvrđeno je da postoji heterogenost među grupama u odnosu na broj branchispina. Vrijednosti koeficijenta porasta broja cerato-hipobrancijalnih i ukupnih branchispina sredele iz oba područja su signifikantno različiti. Residualna varijacija ovih odnosa je veća kod primjeraka sjevernog Jadrana. Signifikantna razlika u broju branchispina potvrđuje pretpostavku da postoje dvije odvojene subpopulacije srdele u razmatranim područjima.

Procijenjen je udio populacije srdele jedne grupe koja ima iste karakteristike kao i druga grupa. Relativno niska vrijednost preklapanja u odnosu na broj branchispina (38,78%, 43,80%) subpopulacije sjevernog i srednjeg Jadrana ukazuje također na razliku ali istovremeno i na određenu izmješanost.

Zapaženo je da postoji određeni ritam rasta glave i povećanja branchispina tako da se razmaci manjih brzina rasta podudaraju s godišnjim promjenama spolnog ciklusa, kad je glavnina energetskih procesa usmjerena na razmnožavanje.