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THE GROWTH OF ASP *ASPIUS ASPIUS L.*) IN LAKE BALATON AND THE SELECTIVE EFFECTS OF COMMERCIAL FISHERIES ON POPULATION STRUCTURE

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Asp is widely distributed in North and Central Europe, as well as in the catchment basins of the Black, Caspian and Aral Seas. The only predatory cyprinida is common in Lake Balaton and inhabits almost all other Hungarian waters, too.

Due to deterioration of water quality having occurred especially during the last decade the fish fauna of Lake Balaton has significantly changed. According to studies on the most numerous species, modifications in their growth rate and population structure have been observed as compared to previous years (BÍRÓ, 1970; 1972; 1973; BÍRÓ and GARÁDI, 1974).

The growth of asp in Lake Balaton has not yet been studied. Since it is an important member of the fish fauna, the aim of our work was to determine its growth at different areas of the lake. Furthermore, the population structure, rates of mortality and production as well as the regulating effects of the fisheries on the stock have been studied.

Material and methods

The material of our scale investigations was sampled from among the fish caught with 1000 m long nets randomly on the fishery stations of Siófok, Tihany, Balatonszemes, Fonyód and Keszthely during July–October, 1974 – 75. The selected sampling places represent differently eutrophicated areas of the lake along its longitudinal axis. Their standard and total length and weight were measured; 15 – 20 scales were detached from the surface above the lateral line between the posterior margin of the pectoral and the first ray of the dorsal fins. 496 specimens were studied in 1974. In 1975 further 217 specimens were measured and scales from 107 fish were collected for ageing. During the two years altogether 713 fish were studied amongst them the age and growth of 599 specimens were analyzed in details. After cleaning, about 10 well-developed wet scales were placed between slides and studied with profile projector at a 40-times magnification. Ageing of fish was done by the number of winter marks developed on the scales. The total lateral radii (R) and the annual ring distances from the focus were measured. On the basis of measured length and weight data the length–weight relationship was calculated according to HUXLEY (1924) cit. BEVERTON and HOLT, 1957). The regression between the standard

lengths and the total lateral radii of scales was determined by the least square method. The intercept of the line on the abscissa was taken into consideration as a correction factor in the back-calculation of fish lengths (FRASER, 1916). Maximum standard length attained was estimated graphically according to FORD – WALFORD's method (WALFORD, 1946). BERTALANFFY's (1938, 1957) growth-model was applied for correct comparison of the growth rates using the back-calculated standard length of fish caught at different areas of Lake Balaton. Rates of mortality and survival were estimated according to age-composition of the sample (RICKER, 1958). Biomass and its relative production were assessed according to RICKER and FOERSTER (1948) and RICKER (1958) for the most intensively exploited age groups from 3+ to 10+. The instantaneous coefficients of growth in weight necessary to the assessment of production were calculated after CHAPMAN (1968) and TESCH (1968). On the basis of age distribution of fish in the sample "resultant" selection ogives were constructed (BEVERTON and HOLT, 1957). When estimating the age selection of 1000 m long nets of 3.5 – 4 cm mesh, the same method was applied.

Results

1. Length distribution

The standard lengths of 599 asps studied in 1974 – 75 varied between o0 – 62 cm. Length distribution histograms of fish collected at different areas 3f Lake Balaton apart from smaller differences were asymmetrical. In the

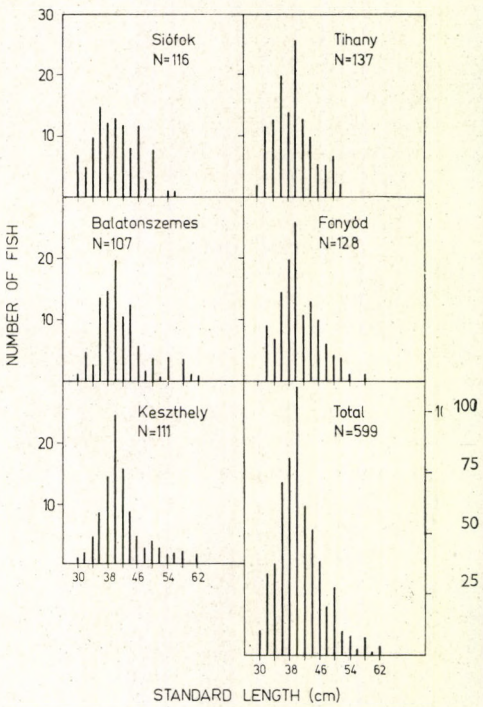

Fig. 1. Histograms of standard length distribution of asps caught at different areas of Lake Balaton

environs of Siófok the length of specimens ranged from 36 to 50 cm, while at other places of the lake fish about 40 cm predominated. According to the 599 specimens investigated, the average standard length of asps caught in Lake Balaton was 42.2 cm. Fish of greater length up to 62 cm can be caught more frequently at the south-western part (environs of Balatonszemes, Keszthely Bay) of the lake *(Fig. 1)*. Standard length of about 80–85 per cent of asps caught by fishermen in Lake Balaton ranges from 32 to 46 cm.

2. Length–weight relationship

The regression coefficient of the relationship was found to be b = 2.5985 according to the length and weight data collected at 5 different areas of Lake Balaton *(Fig. 2)*. Altough the length distribution of the fished stock is relatively uniform, territorial and seasonal differences of length–weight relationship

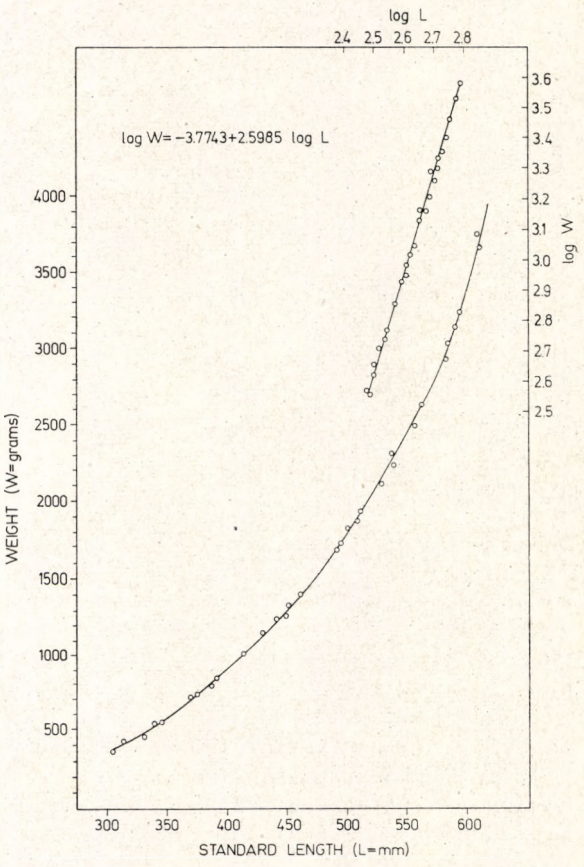

Fig. 2. Length–weight relationship in asp of Lake Balaton

should have been in relation to food consumed and condition. From the shape of the curve it seems that a greater specific weight belongs to the unit of growth in length especially above 40 – 45 cm standard length of asp.

3. Growth of scales in relation to the standard length and age

The majority of about 6000 scales examined taken from 599 asps was symmetrically developed. The annual marks developed on normal scales could be distinguished without difficulties in contrast to findings on the scales of other Balaton fish. Only in older fish about 30 – 40 per cent of the scales examined showed deformations, irregularly developed marks as well as damages and regenerated spots. The relationship between the standard lengths and the total lateral radii of scales is well represented by the calculated linear regression. Its intercept on the abscissa is 7.89 mm *(Fig. 3)*.

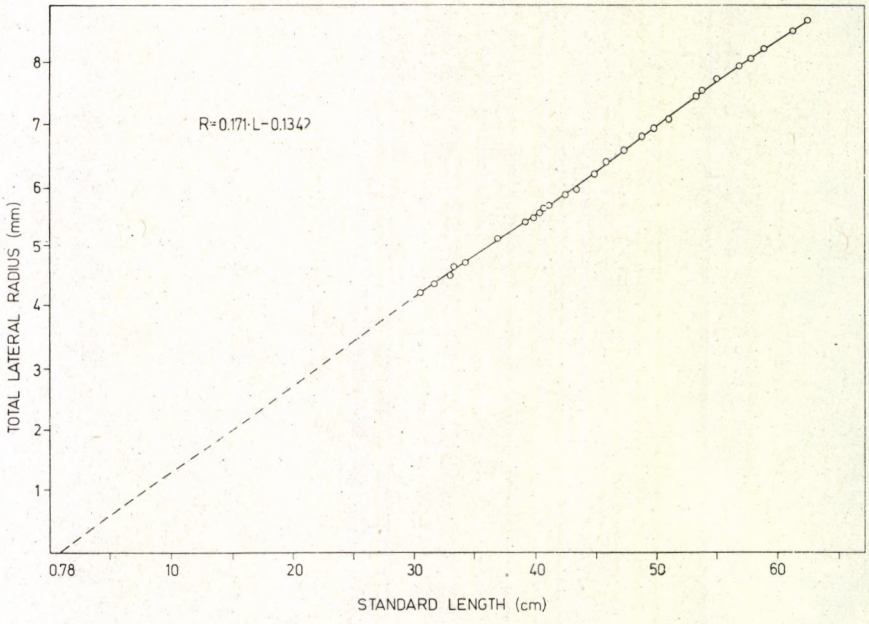

Fig. 3. Linear regression of average lateral radii of scales (R) in the function of standard lengths (L) established for selected specimens of asp

A stepped, gently S-shaped relationship seems to exist between the standard lengths and the average annuli distances established for specimens in age groups 3+ to 11+ collected at different areas of Lake Balaton. Their mean growth, however, is more balanced *(Fig. 4)*. Between age groups 3+ to 11+ the following averages were measured in mm: 4.69, 5.29, 5.69, 6.16, 6.76, 7.04, 8.40 and 8.66. Total lateral radii of scales of older fish (from age group 6+ upward) grow annually in a relatively smaller extent.

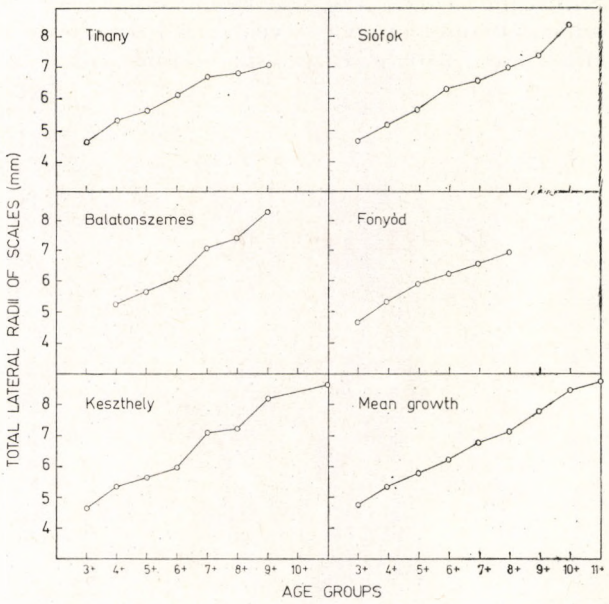

Fig. 4. Average lateral radii of scales measured by age-groups

4. Growth in standard length and weight

According to the measured standard lengths of specimens in different age groups their average growth seems to be uniform, nevertheless, definite areal deviations in rate of growth were observed especially in Keszthely Bay. Deviation from the mean in an age group resulted in about $\pm 1-7$ cm difference *(Fig. 5)*. Trends of changes in weight are just the same as in length.

TABLE I

Mean standard lengths back-calculated from scales of asps caught in the environs of Siófok

Age groups	Year class	N	Standard lengths (mm)									
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}
3+	1971/72	17	95	203	299	–	–	–	–	–	–	–
4+	1970/71	34	95	195	281	346	–	–	–	–	–	–
5+	1969/70	26	95	203	281	338	383	–	–	–	–	–
6+	1968/69	20	96	203	289	346	395	437	–	–	–	–
7+	1967/68	15	101	212	271	345	388	427	465	–	–	–
9+	1965/66	3	88	171	269	356	402	433	460	487	510	–
10+	1964/65	1	103	197	301	356	396	430	464	496	527	554
Average:			96	197	284	347	392	431	463	491	518	554
Total:		116										

In environs of Siófok and Tihany the growth in weight from the fifth year of age is faster when compared to previous years, and the weight of oldest specimens is between 2200 and 2800 g. In the surroundings of Balatonszemes, the

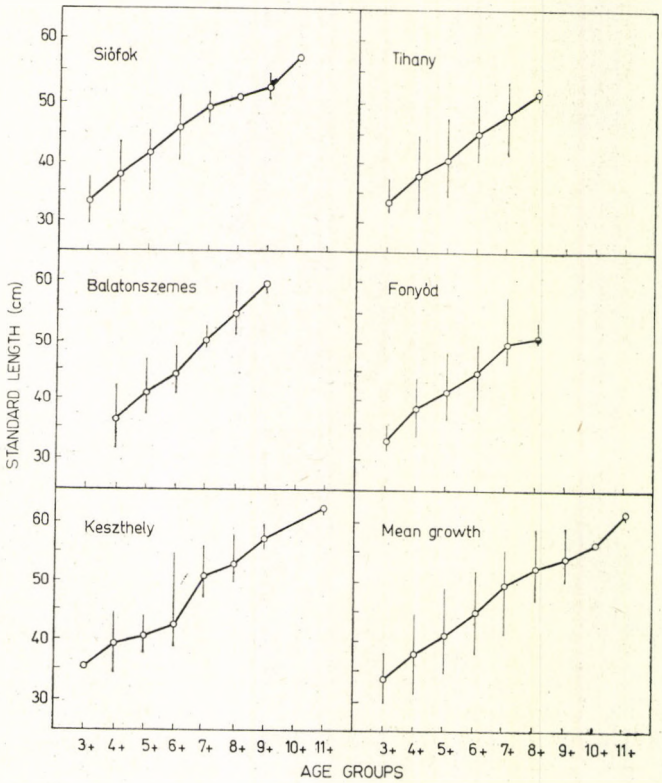

Fig. 5. Measured standard lengths in various age groups of asps caught at five different areas of Lake Balaton

TABLE II

Mean standard lengths back-calculated from scales of asps caught in the environs of Tihany

Age groups	Year class	N	Standard lengths (mm)								
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
3+	1971/72	12	94	204	300	—	—	—	—	—	—
4+	1970/71	57	93	216	301	350	—	—	—	—	—
5+	1969/70	32	96	199	272	332	379	—	—	—	—
6+	1968/69	24	93	192	265	325	371	411	—	—	—
7+	1967/68	9	104	207	292	343	390	432	470	—	—
8+	1966/67	2	100	219	292	348	395	431	464	496	—
9+	1965/66	1	102	243	300	342	382	408	431	452	484
Average:			97	211	288	340	383	420	455	474	484
Total:		137									

rate of growth in weight is more rapid compared to other parts of the lake and asps in their fifth year of age usually have more than 1000 g body weight. From this time on their growth in weight is intensive and the greatest specimens attain about 3300 g. In the environs of Fonyód and Keszthely Bay the mean weight of fish grows at a more steady rate. In the vicinity of Fonyód the biggest asp had a weight of 2200 g and that in the Keszthely Bay about 3800 g. Here specimens of greater body weight often occur. By age groups

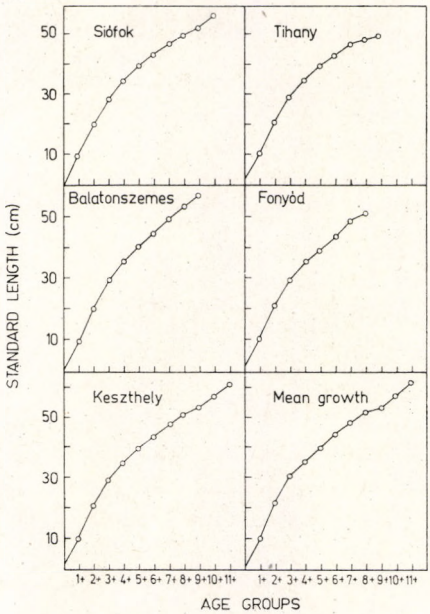

Fig. 6. Mean growth in standard length back-calculated from the annual marks developed on the scales of asps at different areas of the lake

TABLE III

Mean standard lengths back-calculated from scales of asps caught in the environs of Balatonszemes

Age groups	Year class	N	Standard lengths (mm)								
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
3+	1971/72	5	–	–	–	–	–	–	–	–	–
4+	1970/71	31	93	206	275	349	–	–	–	–	–
5+	1969/70	31	95	205	285	344	388	–	–	–	–
6+	1968/69	25	97	211	290	345	388	426	–	–	–
7+	1967/68	6	98	218	296	348	398	440	480	–	–
8+	1966/67	4	108	226	314	374	420	261	496	528	–
9+	1965/66	4	91	217	309	373	422	465	503	535	566
Average:			97	213	294	355	403	448	493	531	566
Total:		106									

(from 3+ to 11+) the following annual mean growth in weight were registered in grams: 562, 809, 1008, 1337, 1866, 2261, 2788, 2840 and 3712.

On the basis of standard lengths back-calculated from the scales, the growth in length of asp at different areas of Lake Balaton is more smoothed than the measured averages *(Fig. 6, Tables I—VI)*. It is conspicuous that changes in body measurements of 8—11 year-old specimens are also intensive especially in the environs of Siófok, Balatonszemes and Keszthely Bay. Differences between measured and back-calculated average standard lengths are relatively small.

Analyzing the growth in length of different age groups by year class strengths, different rates of growth were observed in age-groups up to 6+ and then from 7+ upward. This deviation appeared chiefly in the Keszthely Bay in contrast to the environs of Siófok and Balatonszemes *(Fig. 7)*. The back-calculated standard lengths in different areas were graphically represented according to WALFORD's (1946) method and theoretically attainable maximum lengths (L_∞) were derived. For Lake Balaton on an average it was 68.2 cm.

TABLE IV

Mean standard lengths back-calculated from scales of asps caught in the environs of Fonyód

Age groups	Year class	N	Standard lengths (mm)							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
3+	1971/72	13	97	205	306	—	—	—	—	—
4+	1970/71	43	94	204	289	356	—	—	—	—
5+	1969/70	36	97	203	282	342	394	—	—	—
6+	1968/69	23	97	207	292	345	389	428	—	—
7+	1967/68	10	104	222	303	357	401	443	484	—
8+	1966/67	3	97	212	281	355	386	432	468	507
Average:			97	208	292	351	392	434	476	507
Total:		128								

TABLE V

Mean standard lengths back-calculated from scales of asps caught in the Keszthely Bay

Age groups	Year class	N	Standard lengths (mm)									
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
3+	1971/72	7	83	205	337	—	—	—	—	—	—	—	—
4+	1970/71	23	93	213	298	367	—	—	—	—	—	—	—
5+	1969/70	34	93	204	280	336	381	—	—	—	—	—	—
6+	1968/69	29	93	195	268	321	362	403	—	—	—	—	—
7+	1967/68	9	108	210	283	337	391	444	487	—	—	—	—
8+	1966/67	4	108	217	298	358	395	435	474	512	—	—	—
9+	1965/66	3	96	199	286	361	414	458	496	528	556	—	—
11+	1963/64	2	108	205	302	368	414	453	487	517	545	576	602
Average:			97	206	294	349	392	438	486	519	550	576	602
Total:		111											

TABLE VI

Mean standard lengths back-calculated from scales of asps caught at five different areas of Lake Balaton

Age groups	Year-class	N	Standard lengths (mm)										
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
3+	1971/72	54	92	204	310	–	–	–	–	–	–	–	–
4+	1970/71	188	93	206	288	353	–	–	–	–	–	–	–
5+	1969/70	159	95	202	280	338	385	–	–	–	–	–	–
6+	1968/69	121	103	201	280	336	381	421	–	–	–	–	–
7+	1967/68	49	103	213	289	346	393	437	477	–	–	–	–
8+	1966/67	13	103	218	296	358	399	439	475	510	–	–	–
9+	1965/66	11	94	207	291	358	405	441	472	500	529	–	–
10+	1964/65	2	103	197	301	356	396	430	464	496	527	554	–
11+	1963/64	2	108	204	302	368	414	453	487	517	545	576	602
	Average:		96	206	290	348	392	434	474	504	529	565	602
	Total:	599											

Parameters involved in BERTALANFFY's (1938, 1957) growth model were $t_0 = -0.63$ year and $K = 0.1518$. The last one in the asymptotic model *(Fig. 8)* indicates the rate of growth. Insignificant territorial differences in the K-values ($0.10 < P < 0.05$) have been observed. Higher K-constants combined with smaller L_∞-values represent a more intensive growth rate of younger age groups (up to 7+) in the environs of Tihany and Fonyód compared to other parts of the lake. Though, the annual growth in age groups 1+ to 11+

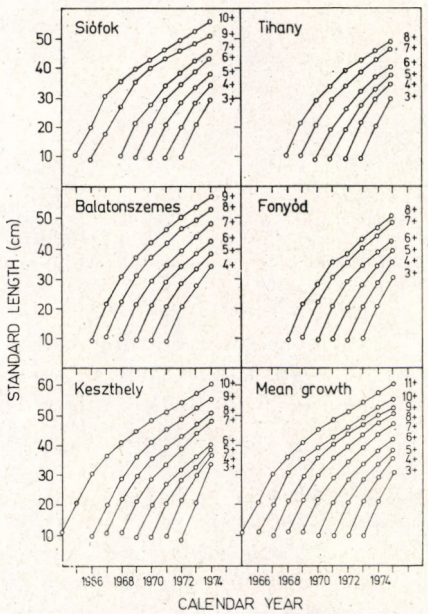

Fig. 7. Growth by year-class strength of various age groups in Lake Balaton

in the surroundings of Siófok, Balatonszemes and Keszthely is slower and more uniform, the attainable maximum lengths here surpass by some 10 – 17 cm those that could be registered in the vicinity of Tihany and Fonyód. Their deviation from the mean, however, have been insignificant. Comparing the

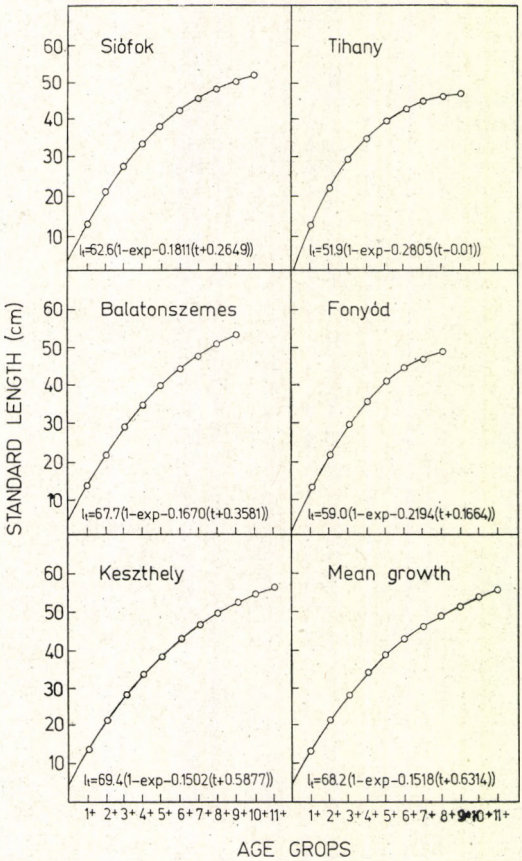

Fig. 8. Asymptotic growth in length of asp in Lake Balaton represented by BERTALANFFY's (1938, 1957) growth model; l_t = standard length in every t-period of time in cm, if t = 1 year

values back-calculated from the scales according to FRASER (1916) and those represented after WALFORD's (1946) and by BERTALANFFY's (1938, 1957) model, there is a maximum deviation of 4 cm in the different age groups.

5. *Age distribution*

From the asps studied in 1974 – 75, altogether 599 specimens were aged on the basis of the number of completely developed annuli and counted to age groups 3+ to 11+. The overwhelming majority of fish caught in Lake Balaton belonged to age groups 4+ to 6+. The age distribution of asps likewise that of the length was asymmetrical *(Fig. 9)*.

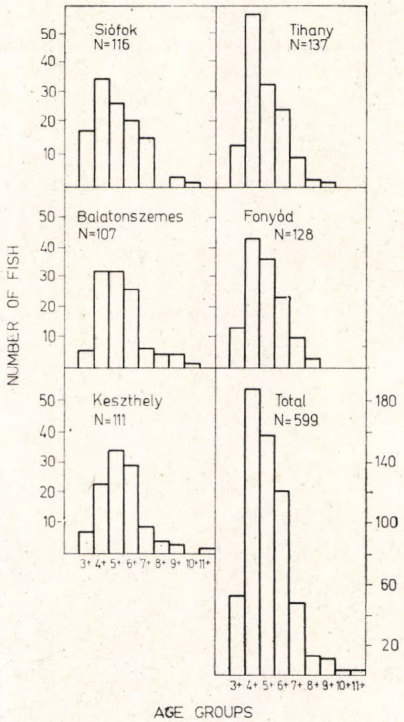

Fig. 9. Age distribution of asps originated from five different areas of the lake

According to samples originated from different areas of Lake Balaton the following percentual values are characteristic for the commercially exploited part of the population:

3+	9.0 %	6+	20.2 %	9+	1.8 %
4+	31.3 %	7+	8.1 %	10+	0.3 %
5+	26.5 %	8+	2.1 %	11+	0.3 %

6. Mortality

Individual numbers in various age groups was taken as representative ratio for the catchable part of the population of Lake Balaton. Instantaneous total mortality coefficient was calculated by the diminishing number of specimens by using their logarithms of natural base *(Fig. 10)*. This calculation refers to the most abundant age groups from 4+ to 9+. On the average, the instantaneous total mortality coefficient for the entire Lake Balaton proved to be $Z = 0.6460$. At the different areas of the lake this value varied between 0.5928 and 0.7969. Their differences were significant ($0.05 < P < 0.02$). Average survival rate was assessed to be $S = 52$ per cent, hence the average annual mortality rounded about $A = 48$ per cent. Both values fluctuated

TABLE VII

Rates of mortality and survival in asps caught at five different areas of Lake Balaton

Place of sampling	Age groups	Z	S	A
Siófok	4+ – 9+	– 0.6343	0.5326	0.4674
Tihany	4+ – 8+	– 0.7969	0.4493	0.5507
Balatonszemes	5+ – 9+	– 0,5928	0.5543	0.4457
Fonyód	4+ – 8+	– 0.6606	0.5169	0.4831
Keszthely	5+ – 9+	– 0.6837	0.5066	0.4934
Average:	4+ – 9+	– 0.6460	0.5220	0.4780

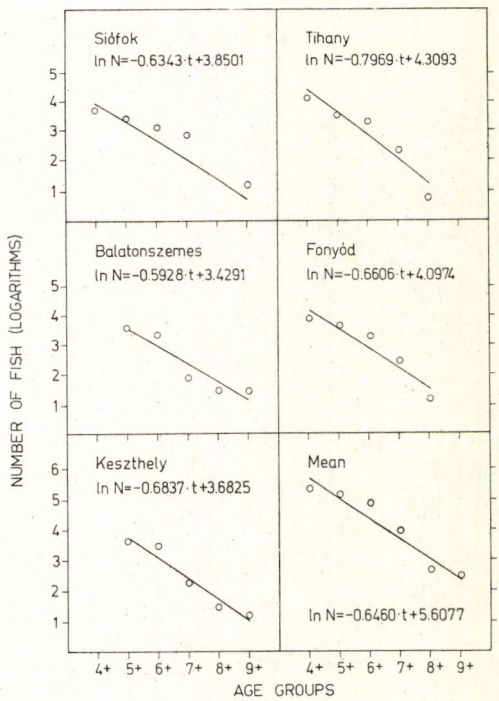

Fig. 10. Mortality of asp in age groups 4+ to 9+ at different areas of the lake. N = number of fish, t = time interval = 1 year

between 45 and 55 per cent by area *(Table VII)*. These estimated rates chiefly concern age groups intensively exploited by commercial fisheries. Because of the small number of young fish (age groups 0+ to 3+) in the catches, the rates of mortality and survival for the whole asp population of the lake cannot be assessed definitely.

7. Recorded commercial landings of asp

According to data on catch statistics, asp is of primary economic importance of Lake Balaton amounting to 0.9—1.5 per cent of the total annual catch. Though, this amount seems insignificant compared to that of bream comprising some 70—80 per cent of the total annual catch, nevertheless, it means about 5—6 per cent of the total noble fish caught. On an average, 11.5 metric tons of asp are harvested by the commercial fisheries. Presently about 5.5 to 6 metric tons of asp caught by sport fishermen yearly. This value have doubled as compared to the 1960's *(Fig. 11)*.

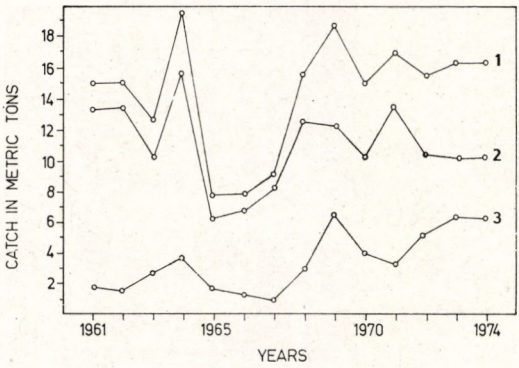

Fig. 11. Total recorded landings of asp during the period of 1961—74. 1 = Total fish landed; 2 = annual commercial landings; 3 = total fish caught by sport fishermen in metric tons

In some years during 1945—57 its total yield reached about 15—30 metric tons and from this time on a gradual decrease occurred. Due to the mass fish kill in 1965, the amount of asp landed had decreased by some 60 per cent. By 1968 the annual catch of aps approximated the average level existed prior to the fish kill. Following a fluctuation of about 3 metric tons, the yield seems to have stabilized between 1968—74.

Asp is chiefly caught in the surrounding waters of Tihany and Siófok, where its ratio to the other noble fish species varies between 8 and 10 per cent. Elsewhere, e.g. in the Keszthely Bay it has a smaller ratio around 3 to 4 per cent. In the vicinity of Tihany and Keszthely Bay of about 73 per cent of the catches consisted of individuals of more than 1 kg body weight. In the surroundings of Siófok and Balatonszemes their ratio is 68 per cent while at Fonyód it is 54 per cent.

Total recorded landings of asp at different areas of the lake during five years in the period of 1970—74 were as follows:

Keszthely	13,045 kg	23.9 %
Balatonszemes	11,177 kg	20.4 %
Fonyód	10,735 kg	19.6 %
Tihany	10,080 kg	18.4 %
Siófok	9,538 kg	17.4 %
Total:	54,576 kg	100.0 %

8. *Selective effects of commercial fisheries on the population structure*

The cod-end-mesh selection of the seine nets is one of the significant parameters in fish stock regulation. The commercial fishery directly influences the total mortality, density as well as age and length distribution of the catchable asp population.

The standard side-web-mesh of 1000 m long seine nets used in Lake Balaton is 45 mm, and their cod-end-mesh is 35 mm in summer time while 25 mm during autumn. Selectivity of the nets were estimated according to percentage length and age distribution of fish caught. The 50 per cent length

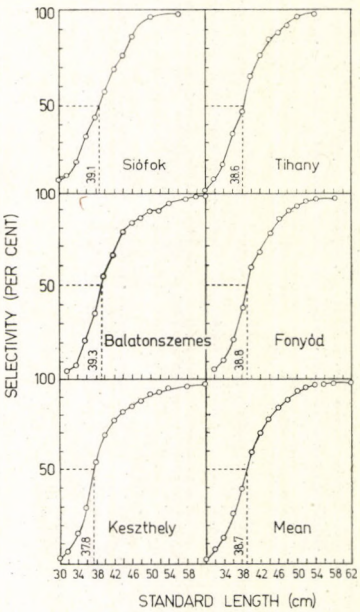

Fig. 12. Cumulative standard length selection ogives of 1000 m long seine nets used in Lake Balaton

retention of the nets was found at 38.7 cm standard length of the fish. These indexes calculated for different areas of the lake characterized by highly significant deviations from the mean of 1.3 cm as a maximum ($P \ll 0.001$) *(Fig. 12)*. Analyzing the selectivity of the nets by the age of fish, on an average 4.3 year of age retained in 50 per cent was obtained. Its territorial differences are highly significant ($P \ll 0.001$) *(Fig. 13)*. When comparing the cumulative ("resultant") selection ogives obtained for different areas of the lake their shape seems to be very similar. Only the ogive procumbent in its upper section obtained for the Keszthely Bay shows a certain divergence from the mean: a lower 50 per cent of age retention index has been accompanied by a higher mean age.

It appears from the indexes given that the seine nets above 38.7 cm standard length and 4.3 year of age of asp can be considered as non-selective ones.

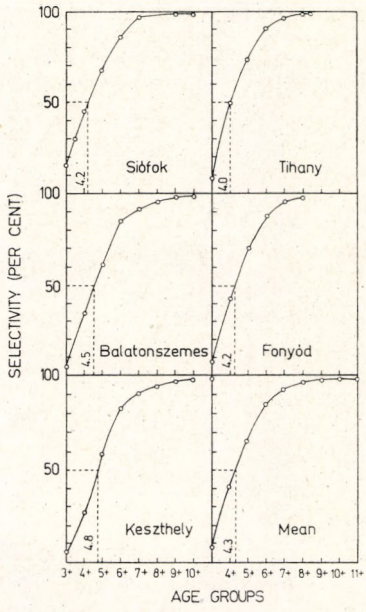

Fig. 13. Cumulative age selection ogives of the seine nets at different areas of the lake

Having calculated the regressions together the standard error of the regression coefficients between the selectivity indexes obtained for mean standard length ($\bar{L}$) and age ($\bar{t}$), and those of the instantaneous total mortality (Z) and average annual mortality (A) coefficients, the following relationships were derived:

(1) $Z = -0.0477 \cdot \bar{L} + 2.5197 \pm 0.077 \quad (P \ll 0.001)$
(2) $Z = -0.2688 \cdot \bar{t} + 1.8295 \pm 0.3652 \quad (0.02 < P < 0.01)$
(3) $A = -0.0246 \cdot \bar{L} + 1.4393 \pm 0.6708 \quad (0.2 < P < 0.1)$
(4) $A = -0.1375 \cdot \bar{t} + 1.1761 \pm 0.071 \quad (P \ll 0.001)$

Except relationship (3) all of them are significant or highly significant. Consequently, the selectivity of the seine nets strongly influences the mortality coefficients (Z and A) of the asp population modifying its size hierarchy and age composition.

9. *Biomass and production: the $P/\bar{B}$ ratio*

Initial (B_0) and average biomass ($\bar{B}$) of age groups 4+ to 10+ were assessed according to the asymptotic growth by using the number of fish in different age groups (N), their mean weight (W), the mortality (Z) and the instantaneous coefficients of growth (G) *(Table VIII)*. The average biomass in the sample was B = 526.7 kg, while its annual increase was about P = 150.6 kg. The average $P/\bar{B}$ ratio for the age groups given was 28.6 per cent. Annual net production rate was the highest in age group 4+ (36.4 per cent) and in

TABLE VIII

Mean biomass and production rate in age groups 4+ to 10+ of asp inhabiting Lake Balaton

Age groups	N (pc)	W (g)	$NW=B_0$ (kg)	Z	G	Z−G	$\overline{B}$ (kg)	$\overline{B}G = P$ (kg)	$P/\overline{B} \cdot 100 =$ = A. P. %
4+	188	809	152.1	0.6460	0.3643	0.2817	131.8	48.01	36.4
5+	159	1008	160.3	0.6460	0.2220	0.4240	129.7	28.79	22.2
6+	121	1337	161.8	0.6460	0.2827	0.3633	134.6	38.05	28.3
7+	49	1866	91.4	0.6460	0.3332	0.3128	77.9	25.96	33.3
8+	13	2261	29.4	0.6460	0.1895	0.4565	23.4	4.43	18.9
9+	11	2788	30.7	0.6460	0.2106	0.4354	25.1	5.29	21.1
10+	2	2840	5.7	0.6460	0.0178	0.6282	4.2	0.07	1.8
Total:	543		631.4				526.7	150.60	

$$\overline{B} = \frac{B_0(1 - \exp - (Z - G))}{Z - G}, \text{ if } Z > G \quad P/\overline{B} \cdot 10 \text{ C} = \text{A.P.} = 28.6\%$$

older groups (5+ to 7+) this rate varied between 22.2 and 33.3 per cent. Just the same rates were obtained for age groups 8+ to 9+, where the $P/\overline{B}$ ratio has been calculated for age groups intensively exploited by commercial fisheries, therefore the ratio of asps younger than 4+ (age groups 0+ to 3+) is excluded.

From the initial biomass (B_0 = 631.4 kg) of 4+ to 10+ aged fish 48 per cent was eliminated in consequence of natural mortality and exploitation while 52 per cent survived annually. The 48 per cent biomass of dead fish is balanced by the growth in weight and by the natural recruitment to the exploited phase so that the mean biomass attains about 28.6 per cent of surplus production.

Discussion

Studying the growth and population structure of asps caught at five different areas of Lake Balaton it was established that apart from smaller variations the fishable part of the population has the very same structure at various areas of the lake. By direct measurements within the age groups already significant size differences can be found indicating the diversity of food supplies of certain water areas. According to the mean standard lengths measured the annual growth in length of the age-groups is smoothed, but in the environs of Fonyód and especially in the Keszthely Bay it is stepped *(Fig. 5)*. The growth of age-groups up to 5+ and 6+ is slower as compared to previous years of age. From this fact the following conclusion can be drawn: the food supply of these areas fills the food requirement especially of older fish.

Annual marks on the scales of asp inhabiting Lake Balaton develop in a more distinguished manner than that of pike-perch and bream (Bíró, 1970; Bíró and Garádi, 1974). Such a distinct isolation of annuli explicitly indicates the seasonal growth of asp being a pelagic predator in Lake Balaton. It is highly probable that in winter time their food consumption decreases in contrast to the vegetation period when the availability of prey fishes is higher and

their distribution is more homogenous. For the intensive growth of asp its pelagic pattern of life is favourable as to the benthic and littoral species, because the competition for food in the pelagial is much less.

For the relationship between the standard lengths and the lateral radii of scales a linear regression have been calculated. By this relationship 7.89 cm was obtained for mean standard length, which gives the size measurable in time of "key-scale" formation. There were no significant differences found in the annual growth in standard length back-calculated from the scales of asp caught at five different areas of the lake. Their development is usually uniform. Analyzing the growth in length of different age groups by year class strengths different growth rates have been experienced in age groups up to 6+ and then from 7+ upward especially in the Keszthely Bay. This difference is probably due to feeding relations. Because the mean growth in length of asp can be described exactly by BERTALANFFY's(1938, 1957) model. Maximum standard length attained in Lake Balaton was $L_{\infty} = 68.2$ cm and the mean rate of growth was $K = 0.1518$. According to studies by BACKIEL (1964) and BAUCH (1955) the same values observed in River Vistula (Poland) and in Ammer- and Chiemsee (Germany) were 110 and 70 cm, and 0.0804 and 0.2059. In relation to these and other data published (ČIHAŘ, 1960; DYK, 1956; PUSHKIN, 1968; ZERNOV, 1961) the asp inhabiting Lake Balaton can be characterized by a moderate growth *(Table IX)*. Minor differences in parameters obtained for various areas of Lake Balaton apart from feeding can be in close connection with the quality of water. The relatively clear water in NE-basin of Lake Balaton seems to be more favourable for the rapid development of asp.

The overwhelming majority of 11 metric tons of asp harvested annually is represented by age groups 4+ to 6+. Their ratio at various areas of the lake is just the same. Total instantaneous mortality coefficient of age groups 4+ to 9+ was estimated according to the "catch curve". On an average, the annual mortality proved to be 48 per cent and hardly differs from that 47 per cent published by BACKIEL (1964) for River Vistula. Survival rate of age groups 4+ to 9+ was assessed to be 52 per cent, and varied between 45 and 55 per cent. The same rate in different age groups of asp living in River Vistula are greatly variable: between age groups 4+ and 5+ 89.7 per cent, in 5+ − 6+ year-old ones 77.5 per cent and finally in 7+ − 13+ year-old specimens 53 per cent. Rates of mortality and survival of asps inhabiting Lake Balaton and River Vistula hardly differ from one another indicating near production rate values of the fishable parts of the populations. By age groups 4+ to 10+ of asp living in Lake Balaton about 28.6 per cent of their average biomass is produced annually, while those 4+ to 12+ year-old ones consisting the catchable part of the population inhabiting River Vistula can produce about 39 per cent of their average biomass. Comparing the 28.6 per cent production rate to the data published on $P/\overline{B}$ ratio of pike-perch population (50 per cent) consisted of age groups 3+ to 9+ (BIRÓ, 1975a), or to that of bream (72.6 per cent) population represented by 3+ to 7+ yeard-old specimens (BÍRÓ and GARÁDI, 1974) even to that of bleak population (71.8 per cent) consisted of age groups 1+ to 5+ respectively (BÍRÓ, 1975b) by all means it seems to be low.

Production rate of the harvestable part of population through the modification of its structure, also influenced by the selectivity of the nets used. The regressions between the selectivity indexes obtained for mean length and

TABLE IX

Growth in standard length of asp in different waters

No.	Basin	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	Author, year of publication
1.	Ammersee and Chiemsee	15.0	27.0	37.0	46.0	53.0	59.0	64.0	67.0	70.0	72.0	–	BAUCH, 1955 after WAGLER
2.	Aral Sea	10.3	19.6	28.1	36.1	42.3	47.8	52.0	57.9	58.8	–	–	BERG, 1949 after NIKOLSKIJ 1940
3.	Dnieper	8.0	16.6	24.9	31.8	–	–	–	–	–	–	–	KOSTJUCHENKO, 1963*
4.	Don	11.1	21.9	31.3	38.4	–	–	–	–	–	–	–	ZERNOV, 1961
5.	Kama Reservoir	7.3	13.8	21.3	27.8	33.5	37.8	41.4	43.3	45.4	47.7	–	PUSHKIN, 1968
6.	Kujbishev Reservoir	8.5	25.8	33.0	38.9	45.9	–	–	–	–	–	–	KOPTEVA, 1964*
7.	River Neva	7.5	15.2	22.5	29.2	35.6	40.7	44.7	–	–	–	–	ZHUKOV, 1958*
8.	West-Dvina	7.4	15.0	22.1	29.0	36.0	40.8	45.5	49.9	54.4	57.8	–	PENAZ and SEVTSOVA, 1964*
9.	Rybinsk Reservoir	7.5	12.9	20.0	25.7	28.3	37.3	43.2	48.1	53.0	–	–	SVETOVIDOVA, 1960*
10.	Sapshug Reservoir	13.4	22.6	28.6	32.4	–	–	–	–	–	–	–	ZERNOV, 1961
11.	Seddin-See	12.0	22.0	40.0	50.0	57.0	64.0	65.0	–	–	–	–	BAUCH, 1955
12.	Slapy Reservoir	10.7	16.5	21.2	28.1	36.2	43.3	50.6	–	–	–	–	ČIHAŘ, 1960
13.	Stienitz-See	10.0	16.0	25.0	34.0	–	–	–	–	–	–	–	BAUCH, 1955
14.	Tsiksk Reservoir	12.3	25.9	36.2	44.9	52.5	57.3	–	–	–	–	–	SHAPOSHNIKOVA, 1959*
15.	River Ural	11.8	22.6	32.2	35.4	42.4	46.0	–	–	–	–	–	SHAPOSHNIKOVA, 1964*
16.	River Vistula	8.5	14.8	23.3	29.0	36.3	42.4	46.0	51.0	56.3	–	–	BACKIEL, 1964
17.	Middle-Volga	6.8	13.2	19.0	25.2	34.5	38.5	42.0	45.0	–	–	–	KOPTEVA, 1964*
18.	Lake Balaton	9.6	20.6	29.0	34.8	39.2	43.4	47.4	50.4	52.9	56.5	60.2	Present investigation (* cit. PUSHKIN, 1968)

age retained in 50 per cent, as well as the rates of mortality assessed for the exploited part of the asp population were found to be significant or highly significant. Knowing the selective effects of commercial fisheries on the size and age structure of the population, a desirable increase of the ratio of production to biomass can be achieved by the intensification of catches.

Summary

Length and age distribution of asps (496 specimens in 1974, and 217 specimens in 1975), caught at five different areas of Lake Balaton, as well as their growth have been studied. Mortality and production of the harvestable part of population and the selective effects of commercial fisheries on the population structure have also been studied.

1) Standard length of 80–85 per cent of asps caught in Lake Balaton ranged between 32 and 46 cm, on an average it was 42.2 cm. Length distribution or fish originated from different areas of the lake was asymmetrical.

2) The b regression coefficient included in the length–weight relationship was calculated to be 2.5985.

3) The linear regression between the standard lengths and the lateral radii of scales cuts 7.9 mm from the abscissa which indicates the size measurable in time of "key-scale" formation. Annual marks on the scales of fish in age groups 3+ to 11+ are definitely differentiated from each other, and the annual growth of lateral radii of scales is uniform. The growth both in measured and back-calculated standard lengths is also uniform. Different rates of growth were observed in age groups up to 6+ and then from 7+ upward especially in the Keszthely Bay. Maximum standard length that could be attained in Lake Balaton on an average was estimated to be $L_\infty = 68.2$ cm, and coefficient of rate of growth proved to be $K = 0.1518$. Their areal deviations have been insignificant.

4) The overwhelming majority of asps caught in Lake Balaton was represented by specimens belonging to age groups 4+ to 6+. Instantaneous total mortality coefficient calculated for the most intensively exploited part of the population (age groups 4+ to 9+) on an average was $Z = 0.6460$. Its areal deviations have been significant. The assessed rate of survival on an average was 52 per cent, hence the average annual mortality was 48 per cent.

5) Average biomass of asps in the sample covering age groups 4+ to 10+ was $B = 526.7$ kg which produced 150.6 kg a year, hence the $P/\overline{B}$ ratio on an average amounted to 28.6 per cent.

6) 50 per cent length retention of 1000 m seine nets used in Lake Balaton was found at 38.7 cm standard length of the fish, which has been accompanied by a mean age of 4.3 year. The regressions between the instantaneous total mortality coefficients (Z) and the 50 per cent selectivity index obtained for mean standard length ($\overline{L}$), as well as between the average annual mortality (A) and the selectivity index calculated for mean age ($\bar{t}$) are highly significant ($P \ll 0.001$).

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A RAGADOZÓ ŐN (*ASPIUS ASPIUS* L.) NÖVEKEDÉSE A BALATONBAN ÉS A HALÁSZAT SZELEKTÍV HATÁSA AZ ÁLLOMÁNYSTRUKTÚRÁRA

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Összefoglalás

Vizsgáltuk a Balaton 5 különböző vízterületéről származó ragadozó őnök méret- és kormegoszlását (1974-ben 496 db-ot, 1975-ben 217 db-ot), pikkelyeik alapján növekedésüket. Tanulmányoztuk a halászható állomány mortalitását, produkcióját és a szelektív halászat állományt szabályozó hatását.

1. A Balatonból kifogott őnök 80—85%-a 32—46 cm törzshosszúságú, átlagméretük 42,2 cm. A különböző vízterületről származó halak méretmegoszlása aszimmetrikus.

2. A testhossz–testsúly relatív összefüggésében a regressziós együttható b = = 2,5985 volt.

3. A törzshosszak és laterális pikkely-rádiuszok lineáris regressziója kb. 7,9 mm-es törzshossznál jelzi a pikkelyképződés kezdetét. A 3+ — 11+ korcsoportú halak pikkelyein az évgyűrűk határozottan elkülönülnek, a pikkelyátmérők évenkénti növekedése egyenletes. Hasonlóan egyenletes a mért és a visszaszámított törzshosszak növekedése is. A 6+ korcsoportig, majd a 7+-tól fölfelé főleg a Keszthelyi-öbölben eltérés tapasztalható a méretgyarapodás sebességében. Az elérhető maximális méret a Balatonban átlagosan L_∞ = 68,2 cm, a növekedés-sebesség állandója K = 0,1518 volt, területi eltérésük nem szignifikáns.

4. A Balatonból kifogott őnök túlnyomó többségét a 4+ — 6+ korcsoportba sorolt példányok alkotják. A halászattal intenzíven kihasznált 4+ — 9+ állományrészre számított pillanatnyi teljes mortalitás együttható szignifikáns területi eltérésekkel Z = = 0,6460 volt. A túlélés becsült értéke átlagosan 52%, innét az átlagos éves mortalitás 48%.

5. Mintánkban a 4+ — 10+ korcsoporthoz tartozó őnök átlagos biomasszája B = 526,7 kg, évente 150,6 kg-ot termelt; a P/$\overline{B}$-arány átlagosan 28,6% volt.

6. A Balatonon alkalmazott 1000 méteres kerítőhálók 50%-ban a 38,7 cm törzshosszúságú őnöket tartják vissza, ezek kora átlagosan 4,3 év. A pillanatnyi teljes mortalitási együttható (Z) és az átlagméretre számított 50%-os szelektivitási index ($\overline{L}$), továbbá az éves átlagos mortalitás (A) és az átlagkorra meghatározott szelektivitási index ($\bar{t}$) regressziói igen erősen szignifikánsak ($P \ll 0{,}001$).