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COMPARATIVE OBSERVATIONS OF THE SEASONAL GROWTH RELATED TO THE REPRODUCTIVE STRATEGY OF AN ANADROMOUS FISH *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 (PISCES: CYPRINIDAE) IN TWO LAKES OF NORTHERN GREECE

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ABSTRACT

Seasonal growth (lengthwise and weightwise), condition factor, gonadosomatic index and time and place of reproduction of *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 (Pisces: Cyprinidae) were studied comparatively in two Greek Lakes (Volvi and Vistonis) which constitute the southwestern limit of the species distribution. Age was determined from scales. By following lengthwise and weightwise seasonal growth it was found that highest growth takes place in the period from the summer months to autumn ones. From autumn months to winter the growth of the fish is limited or non-existent, whereas from winter to spring there is an increase in growth, which is interrupted by reproduction. The interruption of the growth caused by winter occurs in Lake Vistonis two months earlier than in Lake Volvi. Condition factor in both fish populations exhibits some significant variations during the annual life cycle. Reproduction of the species takes place in the invader torrents in both lake

systems. In Lake Volvi occurs mainly in May, whereas the migration of the fishes from the lake towards the torrents begins during the first ten days of April. In Lake Vistonis reproduction and reproductive migration both begin a little earlier.

KEY WORDS : Cyprinidae, *Chalcalburnus chalcoides macedonicus*, Lakes Volvi & Vistonis (Greece), seasonal growth, reproduction

INTRODUCTION

In Europe and Greece the genus *Chalcalburnus* includes two species: *Chalcalburnus belvica* (Karaman, 1924) and *Chalcalburnus chalcoides* (Guldenstadt, 1772). *Chalcalburnus belvica* is endemic in Lake Prespa (ECONOMIDIS, 1986). *Chalcalburnus chaldoides* is represented in Greece by the endemic subspecies *Chalcalburnus chalcoides* Stephanidis, 1971 that occurs in Lake Volvi, where it is known with the common name "Yelartza" (STEPHANIDIS, 1937, 1971; ECONOMIDIS, 1973, 1991). It also occurs in Lake Vistonis and in Lake Mitrikou and Filiouris river system, where it is known with the common name "Alaya" (ECONOMIDIS, 1973, 1974, 1991; ECONOMIDIS and SINIS, 1988). Biogeographically the Strymonas - Evros section of the Ponto-Caspian province, in which Lakes Volvi and Vistonis belong (Fig.1), constitutes the southwestern distribution limit of the species (ECONOMIDIS and SINIS, 1982).

There are many reports mentioning that the species *Chalcalburnus chalcoides* migrates to the sea for feeding (MARTI, 1930; LOSAKOV, 1963; KOZLOVSKIJ and SUCHANOVA, 1968; BADENKO and ANDROSJUK, 1970; TRIFONOV, 1975). In general the species *Chalcalburnus chalcoides* is an anadromous fish, as regards its reproduction habits, remaining in river, lake, estuarine or lagoon ecosystems during the whole annual cycle, and it is invading in the inflowing rivers or torrents only for reproduction (HECKEL and KNER, 1858; DRENSKY, 1943; BERG, 1949; BANARESCU, 1961, 1964).

In this study has been examined the seasonal lengthwise and weightwise growth, the condition factor, the gonadosomatic index, the sexual maturity, the reproduction period and place of the endemic subspecies *Chalcalburnus chalcoides macedonicus* in Lakes Volvi and Vistonis comparatively.

Fig.1 - The ecosystems of Lakes Volvi and Vistonis in Northern Greece

MATERIALS AND METHODS

Fish samples were taken monthly from lakes Volvi and Vistonis, from September 1983 to October 1984. Lake Volvi (Macedonia, Greece) has a surface area of 68.6 km^2 and an altimeter difference of +37 m from the level of the sea. It has an average depth of 13.6 m and a maximum of

23.5 m. Its waters overflow in the River Richios that flows in the sea into Strymonikos Gulf. Lake Vistonis (Thrace, Greece) has a surface area of 45 km^2 and an altimeter difference of +0.1 m from the level of the sea. It has an average depth of 2.5 m and a maximum of 3.7 m. The southern part of the lake has brackish waters since the lake is connected to the sea with the Porto-Lagos Lagoon. Both lakes are full up mainly from the waters of torrents. Lake Volvi is an eutrophic lake (SINIS, 1981; MOUSTAKA-GOUNI, 1988; ZARFDJIAN, 1989; OIKONOMIDIS, 1991) while Lake Vistonis is hypertrophic (KILIKIDIS *et al.*, 1984; FOTIS *et al.*, 1976, 1985).

Monthly fish samples were caught using nets with a mesh size of 14-50 mm, and were grouped by season for the determination of seasonal growth. The growth of fishes in the annual cycle was determinate on monthly and seasonal basis. The seasonally concentration of the data (every three months) was made to secure statistically important data from bigger numbers of fishes per age and sex group and for the best realization and analytical determination of the growth. In total 672 fishes were caught from Lake Volvi and 586 from Lake Vistonis. Fishes were preserved in formalin solution (5%) immediately after capture and before carried to the laboratory for measurements.

For the reproduction study, nets were placed exactly at the point where torrents discharged into the two lake ecosystems. The fish nets had mesh sizes 18-28 mm. Nets were placed at right angles to the torrent bank and parallel with the shoreline of the lake and the torrent inlet, to form an artificial barrier in order to catch any fish that tried to enter the torrent. Nets were checked daily from the date of their installation for fishes, which have been caught trying to enter the river. In total, 140 individual fish from Lake Volvi and 136 from Lake Vistonis were caught trying to invade into the torrents for reproduction.

Fish scales were used for the determination of age. The scales of this fish species producing the best results in age and growth determination (SMIRNOV, 1929; TROICKIJ, 1949; SUCHANOVA, 1959; POPOVA, 1961; SCERBUCHA, 1965; BITECHINA and MALESKO, 1970; ABDURAKHMANOV, 1975). The scales removed from the left side of each fish, from an area just in front of the dorsal fin and above of the lateral line. Scale were cleaned in 8% NaOH (TESCH, 1971) and age was determinate with the aid of a projector (magnification X 42.2).

The net body weight was calculated by subtracting the weight of the alimentary canal and the gonads from the total body weight (LAGLER, 1972; RICHARD *et al.*, 1983).

In this study, Clark's condition factor was calculated according to NIKOLSKI (1963). The gonadosomatic index (GSI) was calculated for each fish individually as follows: GSI = (Q X 100) : G, where Q is the weight of the gonads and G is the fish net body weight (NIKOLSKI, 1963).

Table 1

Mean fork lengths (FL) in mm of the fish seasonally, at the ages 4+, 5+ and 6+, according to sex and independently it, in Lakes Volvi and Vistonis

Season	Age	Lake Volvi				Lake Vistonis			
		N	X	SX	95% C.I.	N	X	SX	95% C.I.
0	1	2	3	4	5	6	7	8	9
MALES									
Autumn 1983	4+	9	180.70	3.27	173.16-188.24	13	167.50	2.47	162.12-172.88
	5+	7	193.60	5.58	179.95-207.25	62	185.60	0.67	184.26-186.94
	6+	-	-	-	-	11	193.90	1.36	190.87-196.93
Winter 1983-1984	4+	11	169.80	3.07	162.96-176.64	7	166.90	3.96	157.21-176.59
	5+	15	177.40	1.50	174.18-180.62	36	187.80	0.83	186.12-189.48
	6+	3	189.60	4.05	189.60-189.60	8	198.80	1.41	195.47-202.13
Spring 1984	4+	9	165.60	2.73	159.30-171.90	12	163.00	1.53	159.63-166.37
	5+	14	174.10	1.39	171.10-177.10	6	166.60	3.14	158.53-174.67
	6+	4	184.70	4.15	171.49-197.91	2	186.20	1.21	186.20-186.20
Summer 1984	4+	10	147.70	1.71	143.83-151.57	38	154.20	1.09	151.99-156.41
	5+	11	178.30	1.42	175.14-181.46	27	170.60	1.54	167.43-173.77
	6+	9	186.80	1.73	182.81-190.79	4	185.10	1.80	179.37-190.83
Autumn 1984	4+	2	169.50	2.34	169.50-169.50	6	164.20	1.18	161.17-167.23
	5+	5	181.60	1.56	177.27-185.93	21	178.00	1.22	175.46-180.54
	6+	2	189.40	1.13	189.40-189.40	5	196.30	2.90	188.25-204.35
FEMALES									
Autumn 1983	4+	32	183.70	1.91	179.80-187.60	5	171.00	2.77	163.31-178.69
	5+	5	200.00	1.44	197.03-202.97	45	188.40	0.86	186.67-190.13
	6+	6	211.60	1.96	206.56-216.64	23	200.50	0.98	198.47-202.53

(to be continued)

0	1	2	3	4	5	6	7	8	9
Winter 1983-1984	4+	21	174.00	2.01	169.81-178.19	1	165.20	0.00	165.20-165.20
	5+	54	180.70	1.02	178.65-182.75	29	189.00	1.00	186.95-191.05
	6+	27	191.00	1.10	188.74-193.26	30	199.70	0.66	198.35-201.05
Spring 1984	4+	32	161.80	1.89	157.94-165.66	12	160.50	3.55	152.69-168.31
	5+	55	174.50	0.90	172.70-176.30	11	173.90	3.22	166.73-181.07
	6+	16	184.50	2.20	179.81-189.19	2	190.10	11.06	190.10-190.10
Summer 1984	4+	40	154.90	1.61	151.64-158.16	30	158.00	0.91	156.14-159.86
	5+	23	175.70	1.58	172.42-178-98	27	171.60	1.37	168.78-174.42
	6+	21	186.10	2.16	181.59-190.61	10	185.40	0.79	183.61-187.19
Autumn 1984	4+	11	164.50	2.29	159.40-169.60	4	162.90	4.95	147.15-178.65
	5+	20	178.70	1.19	176.21-181.19	14	178.20	1.74	174.45-181.95
	6+	15	192.90	1.68	189.30-196.50	14	196.00	1.34	193.11-198.89

MALES + FEMALES

Autumn 1983	4+	41	183.00	1.64	179.69-186.31	18	168.50	1.93	164.43-172.57
	5+	32	198.60	1.68	195.17-202.03	107	186.80	0.54	185.73-187.87
	6+	6	211.60	1.96	206.56-216.64	34	198.40	0.96	197.30-199.50
Winter 1983-1984	4+	32	172.50	1.70	169.03-175.97	8	166.70	3.39	158.69-174.71
	5+	69	180.00	0.88	178.24-181.74	65	188.30	0.64	187.02-189.58
	6+	30	19.08	1.04	188.67-192.93	38	199.50	0.60	198.28-200.72
Spring 1984	4+	41	162.60	1.59	159.39-165.81	24	161.70	1.89	157.79-165.61
	5+	69	174.40	0.77	172.86-175.94	17	171.30	2.45	166.11-176.49
	6+	20	184.60	1.90	180.62-188.58	4	188.10	4.65	173.30-202.90
Summer 1984	4+	50	153.50	1.40	150.69-156.31	68	155.90	0.76	154.38-157.42
	5+	34	176.60	1.17	174.22-178.98	54	171.10	1.02	169.05-173.15
	6+	30	186.40	1.59	183.15-189.65	14	185.30	0.72	183.74-186.86
Autumn 1984	4+	13	165.30	1.99	160.96-169.64	10	163.60	1.96	159.17-168.03
	5+	25	179.30	1.02	177.19-181.41	35	178.10	0.99	176.09-180.11
	6+	17	192.50	1.50	189.32-195.68	19	196.10	1.19	193.60-198.60

Gonad's sexual maturity stages were specified according to the Kesteven's sexual maturity scale (BAGENAL and BRAUM, 1971).

The statistical comparison of mean values, wherever it was considered necessary, were effected by the application of the Fisher PLSD and T test at a significance level of 95%.

RESULTS AND DISCUSSIONS

Seasonal lengthwise growth

The fluctuations of mean length of the three most dominant age classes (IV, V and VI), which were examined, are given in table 1 for the fish of lakes Volvi and Vistonis. The period of most intense lengthwise growth is from the end of summer and it carries on until late of autumn. From spring months to summer months the same rate of growth is not observed for all examined ages. During spring months there is a particular tendency for lengthwise growth that is observed mainly at ages 5+ and 6+. During the same period, age 4+ demonstrates a phenomenal reduction in mean values of length as a result of the entrance of fish from the previous age classes (III) into it. The growth rate however at this age class is one of the highest. The results of this high growth are not perceivable during the spring months but from early summer months and it is continued until late autumn. The main period of fish growth starts from early summer (June) and it is continued until late autumn (November for Lake Volvi and October for Lake Vistonis).

From autumn until winter there is a marked reduction in growth, which essentially stops in winter. By comparing the mean values of length during the winter months of each one age class, with those in the spring time of the next age class, it can be observed that lengthwise growth also occurs from winter to spring.

Statistical comparison of the mean values with the Fischer PLSD test confirm the above observations.

Seasonal weightwise growth

The combined monthly per season mean net weights for each one of the age classes under examination (IV, V and VI) are presented in table 2 for the fish from lakes Volvi and Vistonis. Based on this data it is evident that the variation in seasonal growth in terms of weight does not differ essentially from that of length. The most intense growth periods occurs during the summer months and it carries on until late autumn, when the maximum mean net body weights are observed for ages 4+, 5+ and 6+ for the fishes in both lakes.

Table 2

Mean net weights NWL) in g of the fish seasonally, at the ages 4+, 5+ and 6+, according to sex and independently it, in Lakes Volvi and Vistonis

Season	Age	Lake Volvi				Lake Vistonis			
		N	X	SX	95% C.I.	N	X	SX	95% C.I.
0	1	2	3	4	5	6	7	8	9
MALES									
Autumn 1983	4+	9	64.48	4.87	53.25 - 75.71	13	64.35	4.16	55.29 - 73.41
	5+	7	82.37	8.23	62.23 - 102.51	62	86.98	1.11	84.76 - 89.20
	6+	-	-	-	-	11	101.57	2.95	95.00 - 108.14
Winter 1983-1984	4+	11	58.72	3.68	50.52 - 66.92	7	57.69	4.28	47.22 - 68.16
	5+	15	64.45	1.94	60.29 - 68.61	36	85.35	1.20	82.91 - 87.79
	6+	3	79.53	6.15	79.53 - 79.53	8	104.35	5.03	97.18 - 111.52
Spring 1984	4+	9	50.78	2.26	45.57 - 55.99	12	60.09	2.35	54.92 - 65.26
	5+	14	60.81	2.21	56.94 - 65.58	6	65.15	3.41	56.38 - 73.92
	6+	4	74.30	5.96	55.34 - 93.26	2	93.85	2.66	93.85 - 93.85
Summer 1984	4+	10	30.88	1.29	27.96 - 33.88	38	43.43	1.16	41.08 - 45.78
	5+	11	62.02	1.87	57.85 - 66.19	27	61.93	2.18	57.45 - 66.41
	6+	9	64.89	2.07	60.12 - 69.66	4	76.00	3.65	64.39 - 87.61

Autumn 1984	4+	2	53.05	0.65	53.05 - 53.05	6	56.00	1.69	51.66 - 60.34
	5+	5	70.38	2.42	63.66 - 77.10	21	75.10	2.15	70.62 - 79.58
	6+	2	80.20	1.00	80.20 - 80.20	5	105.20	4.82	103.64 - 106.40

FEMALES

Autumn 1983	4+	32	67.28	2.49	62.20 - 72.36	5	65.66	2.36	59.11 - 72.21
	5+	25	90.09	3.04	83.82 - 96.29	45	90.96	1.63	87.68 - 94.24
	6+	6	113.57	2.34	107.55 - 119.59	23	110.14	2.08	105.83 - 114.45

(to be continued)

0	1	2	3	4	5	6	7	8	9
Winter 1983-1984	4+	21	59.55	1.86	55.67 - 63.43	1	52.20	0.00	52.20 - 52.20
	5+	54	67.90	1.30	65.29 - 70.51	29	85.79	1.80	82.10 - 89.48
	6+	27	82.36	1.59	79.09 - 85.63	30	102.00	1.30	99.34 - 104.66
Spring 1984	4+	32	46.83	2.19	42.36 - 51.30	12	52.12	3.45	44.53 - 59.71
	5+	55	60.00	1.11	57.77 - 62.23	11	67.16	5.17	55.64 - 78.68
	6+	16	72.94	3.20	66.12 - 79.76	2	94.05	15.69	94.05 - 94.05
Summer 1984	4+	40	36.72	0.88	34.94 - 38.50	30	45.16	1.32	42.46 - 47.86
	5+	23	56.69	1.80	52.96 - 60.42	27	59.84	1.74	56.26 - 63.42
	6+	21	69.35	2.52	64.09 - 74.61	10	78.77	1.06	76.37 - 81.17
Autumn 1984	4+	11	46.52	2.30	41.40 - 51.64	4	56.97	6.76	35.46 - 78.48
	5+	20	62.74	1.19	60.25 - 65.23	14	73.69	2.17	69.00 - 78.38
	6+	15	79.13	1.44	76.04 - 82.22	14	99.27	2.67	93.50 - 105.04

MALES + FEMALES

Autumn 1983	4+	41	66.66	2.20	62.21 - 71.11	18	64.71	3.03	59.48 - 69.94
	5+	32	88.40	2.96	82.36 - 94.08	107	88.65	0.96	87.06 - 90.24
	6+	6	113.57	2.34	107.55 - 119.59	34	107.37	1.81	104.31 - 110.43
Winter 1983-1984	4+	32	59.26	1.72	55.75 - 62.77	8	57.00	3.76	48.50 - 65.50
	5+	69	67.15	1.11	64.94 - 69.36	65	85.55	1.03	83.49 - 87.61
	6+	30	82.08	1.53	78.95 - 85.21	38	102.49	1.20	100.06 - 104.92
Spring 1984	4+	41	47.70	1.78	44.10 - 51.30	24	56.10	2.20	51.57 - 60.63
	5+	69	60.16	0.98	58.20 - 62.12	17	66.45	3.49	59.05 - 73.87
	6+	20	73.71	2.76	97.43 - 78.99	4	93.95	6.48	73.35 - 113.95
Summer 1984	4+	50	35.55	0.82	33.90 - 37.20	68	44.20	0.87	42.46 - 45.94
	5+	34	58.41	1.41	55.54 - 61.28	54	60.88	1.39	58.09 - 63.67
	6+	30	68.01	2.37	63.16 - 72.86	14	77.98	1.25	75.28 - 80.68
Autumn 1984	4+	13	47.52	2.04	43.07 - 51.97	10	56.39	2.66	50.37 - 62.41
	5+	25	64.27	1.22	61.75 - 66.79	35	74.53	1.53	71.42 - 77.64
	6+	17	79.26	1.27	76.57 - 81.95	19	100.78	2.35	95.84 - 105.72

During the winter month's period, weight increase stops and in some cases, especially in Lake Volvi, even decreases. Fish weights decrease also from spring months to the beginning of summer. An increase in fish weight is observed in both of the fish populations examined from the end of the winter to the beginning of spring. This is evident only from the analytical mean net weight values of the winter and those of the spring, because in March for Lake Volvi and April for Lake Vistonis, we have the formation of the new annulus and the fishes are changing age class (KOKKINAKIS, 1992).

In general it can be noted that the populations of *Chalcalburnus chalcoides macedonicus* in the ecosystems of Lakes Volvi and Vistonis, have an intense weightwise growth that takes place from the summer months to the autumn, as well as from the winter months to the spring. From spring to the summer months, a reduction in the weight of the fish is observed. This is a result of the entrance of fish from the previous age classes into the next ones. In addition, a cessation in the growth of weight of fish in the same age class is observed from autumn to winter.

Statistical comparisons of the mean values with the Fisher PLSD test confirm the above observations.

Condition factor

The description of the seasonal growth of the fish is more explicit and is not influenced by the gonads and food consumption if it is presented by the condition factor. The values of condition factor were calculated separately for the males and the females of the monthly samplings (Fig. 2).

For the fish of Lake Volvi the results demonstrated that there is an increase in condition factor from September until December. During the rest of the winter months, the values of condition factor increase slightly or remain relatively constant for both sexes. In April, a slight increase is observed for both sexes, while in May the condition factor falls quite abruptly. This decrease could be attributed to reproductive activity that takes place at this time (HTUN HAN, 1978). The data prices start again to increase from June. This increase is clearer after the end of summer, from September, and it holds out during all autumn months.

For the fish of Lake Vistonis the values of condition factor are quite high in September. During the winter months, a variation in the values of condition factor is observed. The values however remain at quite high levels and they can characterize by significant fluctuations. In May the condition factor falls abruptly for both sexes also for the reason of reproduction. This decrease holds out during June and July. One new increase of the condition factor starts from August and holds out during all autumn months.

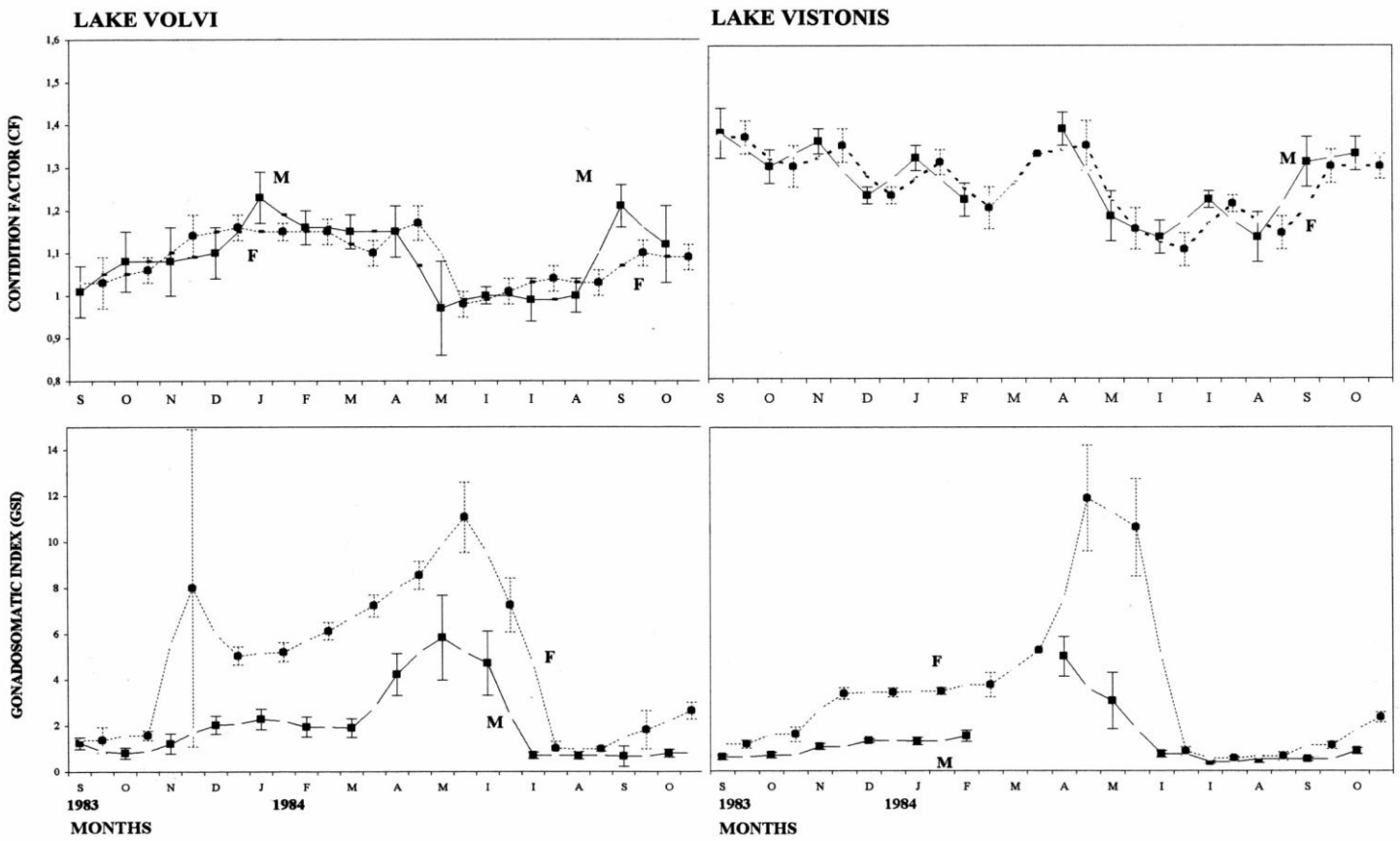

Fig.2 - Monthly fluctuations of the condition factor (CF) and gonadosomatic index (GSI), according to sex, in Lakes Volvi and Vistonis

From the comparison of the monthly values of condition factor according to sex for the two lakes, it observed that the values for the males and females of Lake Vistonis are higher than the respective values of Lake Volvi. After application of the t test (Table 3), it was found that the differences were statistically significant for a probability of 5%. Statistically non-significant differences were observed only in September 1984 for males and in February 1984 for females.

Table 3

Comparison of the monthly condition factor values with t-test
at a significant level of 95%, of the fish in Lakes Volvi and Vistonis

		MALES			**FEMALES**		
		Lakes Volvi - Vistonis			**Lakes Volvi - Vistonis**		
		t			**t**		
1983	S	9.899	> 2.010	+	10.550	> 2.021	+
	O	6.812	> 2.048	+	9.347	> 2.020	+
	N	7.413	> 2.021	+	7.47	> 1.960	+
	D	5.890	> 2.074	+	4.317	> 2.000	+
1984	J	3.694	> 2.040	+	10.36	> 1.960	+
	F	2.989	> 2.080	+	2.008	> 2.010	-
	M	-	-		-	-	
	A	8.808	> 2.048	+	4.316	> 2.000	+
	M	3.557	> 2.069	+	5.873	> 2.000	+
	J	6.770	> 2.262	+	3.217	> 1.980	+
	J	8.290	> 1.960	+	10.62	> 1.960	+
	A	4.424	> 2.040	+	4.999	> 2.021	+
	S	1.553	> 2.093	-	8.242	> 2.021	+
	O	6.034	> 0.64	+	9.208	> 2.010	+

Gonadosomatic index

Mean monthly values of gonadosomatic index were calculated according to sex and they are presented in figure 2.

The maximum values of gonadosomatic index in Lake Volvi are observed for both sexes in May with values of 5.83 □ 0.67 for males and 11.07 □ 0.75 for females. The increase of the index values is abrupt for the males in April, whereas for the females it is smoother and more prolonged and begins in February. In this lake from May until September for males, and until August for females, an abrupt decrease in the values of the index is observed, with values falling to 0.67 □ 0.11 for the males and 1.00 □ 0.05 for the females.

In Lake Vistonis the changes in the values of the gonadosomatic index follow a similar time course. Maximum values of the index are observed in April for both sexes with a value of 4.99 □ 0.41 for males and 11.90 □ 1.00 for females. This increase is followed by an abrupt reduction from June until September for the males and until August for the females. The index has very low values during the summer while an increase begins to occur in September.

Temporal variation in the stages of sexual maturity

Most of the fish are usually concentrated around of one sexual maturity stage, with small deviations towards the previous and following stages (Fig. 3). During the autumn of 1983, it can be seen that all the fish of the both populations are in the initial stages of maturity. In November almost all the fish are in stage III, and only a very small percentage have reached stage IV.

During the winter months, the population of Lake Volvi has reached stage IV and in February, only a small part of the population has advanced to stage V. From spring onwards the population has reached stage VI and the full sexual maturity. During the summer, the fish are either in the stages of sexual maturity in which the gonads are absorbed (>VI), or in the next stage (after the completion of absorption) in which the gonads begin to reform (stage II). In September and during the beginning of autumn the population enters stages in which the gonads are reformed, that is, in stage II onwards.

In Lake Vistonis during the autumn the level of sexual maturity does not surpass stage III, whereas during the winter most of the population has reached stage IV (Fig. 3). During spring it is evident that the population has advanced to stages demonstrating reproductive maturity, and a part of the population has already begun to reproduce. April was the month with the highest percentage of the fish in the sample in stage VI, the stage in which reproduction occurs. In summer, the population is either in the stage of absorbing the gonads or has begun their reformation. By early autumn the absorption of the gonads has already complete and the fish are in stages II and III.

Time and place of reproduction

The gonadosomatic index and the stages of sexual maturity indicating that reproduction of *Chalcalburnus chalcoides macedonicus* occurs in the spring, starting in the beginning of April in Lake Volvi and a little earlier, in the middle of March in Lake Vistonis. The migration of the fish from the lake into the rivers starts in general just before reproduction.

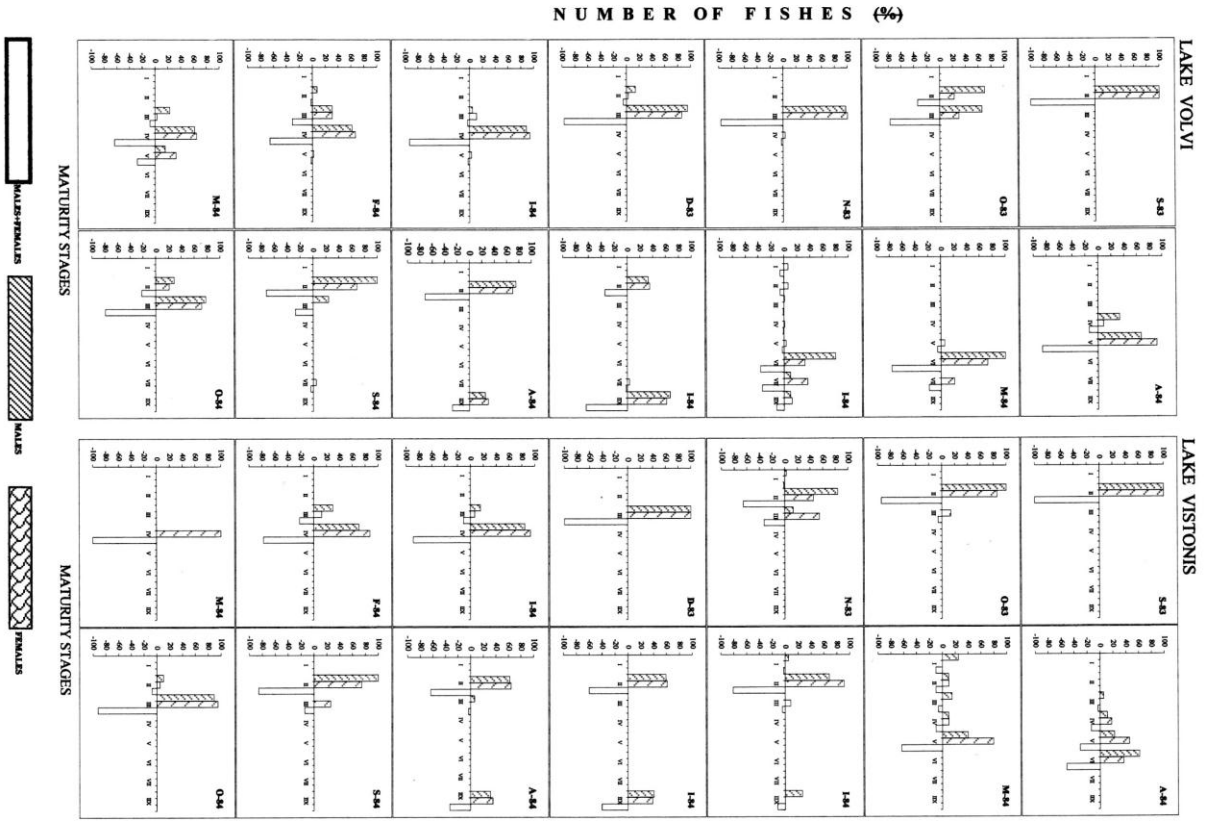

Fig.3 - Monthly frequency distributions of the fish (%) in maturity stages (MS), according to sex and independently it, in Lakes Volvi and Vistonis

In Lake Volvi the first fish heading towards the reproduction areas, where is the invader torrents, were captured at the first week of April. In Lake Vistonis the reproduction started after the first ten days of March.

Reproduction occurs mainly in the middle of the river flow but it spreads towards the upper or even the lower part of the flow, depending on the prevailing conditions. However, reproduction never occurs in the estuarine area of the river into the lake or at the river's springs. The temperature of the water of streams entering Lake Volvi at the beginning of the reproductive period was 15-16^{0}C at the estuarine and 12^{0}C in the upper flow.

CONCLUSIONS

Seasonal growth

The study of the seasonal growth showed that no significant differences occurred between the sexes either between age classes or between the two fish populations of *Chalcalburnus chalcoides macedonicus* examined. Rapid growth was observed during the summer and autumn months, both in terms of length and weight, again for the both of the populations. This is due to the fact that the fish populations in general feed intensively during the summer and autumn months. Intense feeding occurs in order to recover from reproduction and due to the favourable feeding and climatic conditions that prevail (LE CREN, 1947, 1951; MANN, 1973; JOBLING, 1983).

During the autumn and winter months the growth of the fish is limited or even non-existent for the most of the fishes of the Northern hemisphere (NIKOLSKI, 1963, 1969) and the same happens for *Chalcalburnus chalcoides macedonicus*. An increase in growth is observed again in the spring, which is interrupted by reproduction. Growth of the fish during the spring months, results from intense feeding that takes place to enable the formation of the gonads. The reduction and the interruption of growth essentially reflect exhaustion resulting from the reproductive process (NIKOLSKI, 1963, 1969).

During the winter months, the interruption of the growth of fish in Lake Vistonis occurs two months earlier than in Lake Volvi. The shallower depth of Lake Vistonis can explain this. Correspondingly, the quite high and relatively stable values of fish length and weight during the winter period in this lake indicate a small and conservative continuation of growth during this period. This is verified and explained by the fact that fish populations migrate in areas with warmer waters during the winter months as some covered channels in the northern part of the lake.

Condition factor

The monthly observation of the condition factor of both populations showed some significant changes during the annual cycle. In both lakes where the species was studied, there is an increase in values of condition factor from the end of the summer until the beginning of winter as it happens for the most of the fishes of the Northern hemisphere. This increase is the result of the intense feeding carried out by fish in the temperate zone during the summer and autumn in preparation for winter (NIKOLSKI, 1963, 1969; HTUN-HAN, 1978; JOBLING, 1983). During the winter, the values of condition factor are relatively stable and quite high, which indicates that the wintering conditions of fish in the ecosystems under study are quite favourable. In Lake Vistonis there is a quite intense fluctuation of the values during the autumn and winter, without however any market decreases. The condition factor of fish in Lake Vistonis is always significantly greater than that of fish in Lake Volvi. This demonstrates the instability of the shallow and eutrophic ecosystem of Lake Vistonis in comparison to that of Lake Volvi. It should also be mentioned that during the winter the fish population of Lake Vistonis takes refuge in canals in the northern part of the lake because of the very low temperatures of the lake water (KILIKIDIS *et al.*, 1984). The temperature of the water in the canals is higher due to the presence of vegetation, but mainly because the incoming water comes from artesian wells (16^0C). Towards the end of winter and in the beginning of spring values of condition factor tend to increase again. This results from the fact that fish feed intensively before reproduction (WOOTON *et al.*, 1978; WILSON and PITHER, 1983). At the end of spring and during the summer the values of condition factor are at a minimum in both fish populations, reflecting the exhaustion of fish after reproduction (HTUN-HAN, 1978; GOLDSPINK, 1978, 1979).

Reproduction

Chalcalburnus chalcoides macedonicus is a migratory and anadromous species that returns to the rivers of the lake ecosystems in which it lives for reproduction. The same behaviour is demonstrated by other related species and subspecies such as: *Chalcalburnus chalcoides aralensis* (SMIRNOV, 1929), *Chalcalburnus chalcoides mento* (BANARESCU, 1964), *Chalcalburnus chalcoides schischkove* (KARPENKO, 1972), *Chalcalburnus tarichi* (AKSIRAY, 1982), *Chalcalburnus chalcoides carinatus* (GELDIAY and KAHSBAUER, 1975), *Chalcalburnus chalcoides mandrenensis* (DRENSKY, 1943), *Chalcalburnus chalcoides danubicus* (LOSAKOV, 1963), *Chalcalburnus chalcoides derjugini* (PAVLOV and SCHERBUCHA, 1965).

There are many reports reporting that the species migrates to the sea to feed (MAPTI, 1930; TRIFONOV, 1957; MOVCAN and ZUKINSKIJ, 1959; LOSAKOV, 1963; KOZLOVSKIJ and SUCHANOVA, 1968; BADENKO and ANDROSJUK, 1970). The two populations of the subspecies examined here remain in the lake environment of the ecosystems in which they live and do not migrate to the sea, even though both lake ecosystems have constant access to it. Corresponding behaviour, whereby fish remain exclusively in the lake environment, has been observed for other

members of the species (KASYMOV, 1956, 1975; ABDURACHMANOV, 1975; BITECHINA *et al.*, 1978). POPOVA (1961) showed experimentally that the species adjusts well when confined exclusively in fresh water. The species has sometimes been accidentally isolated from the sea by the construction of dams to form reservoirs (ABDURACHMANOV, 1975; KASYMOV, 1975). In these cases, an initial decrease in fecundity was observed. Fecundity however, gradually regained its normal levels, thus demonstrating the satisfactory adaptability of the species to a holobiotic way of life (POPOVA, 1961; ABDURACHMANOV, 1975).

The river regions in which the fish take refuge to reproduce have a rapid water flow, a stony riverbed and are usually shaded by the river bank vegetation. Thus, according to the classification of BALON (1975), *Chalcalburnus chalcoides macedonicus* is a lithophilic species that leaves its eggs on the riverbed and does not protect them. The reproduction areas are the same as those described for the species elsewhere (SUCHANOVA, 1959; POPOVA, 1961; SUCHOVERCHOV and TIMOFEJENKO, 1961; SCHERBUCHA, 1965; ABDURACHMANOV and ISMAILOV, 1971; LOSAKOV, 1973; ABDURACHMANOV, 1975; BITECHINA and MALESKO, 1970).

Reproduction of *Chalcalburnus chalcoides macedonicus* in Lake Volvi occurs mainly in May and the migration from the lake to the rivers begins during the first ten days of April. The mass migration of fish in Lake Volvi happens in the Stream Pazarouda and it was recorded from the ancient times by the Greek Athenaeus in his book *Dipnosofiste*, volume VIII, pages 334-345 (ATHENAEUS, 200-300 A.D.). Athenaeus also reports the season in which the mass fish migration takes place. It occurred during the months □Anthestirion□ and □Elafivolion□ that is, from 15/2 - 15/3 and from 15/3 - 15/4, respectively.

In Lake Vistonis both migration and reproduction begin a little earlier. This happens why the majority of the fish population in this lake during the winter period remains in natural and artificial channels in the northern part of the lake, where the water conditions are more stable from the lake's ecosystem. From these areas they start their reproduction migration to the upper flow of the streams that discharge there.

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