ENVIRONMENTAL PROBLEMS AFFECTING THE SUCCESS OF THE REPRODUCTION OF ANADROMOUS FISH SPECIES IN LAKE'S VOLVI SYSTEM

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EXTENDED ABSTRACT

The conservation of fish fauna and fish populations in inland waters constitutes a worldwide problem in our days, due to the pollution and the exhaustion of their stocks. In the majority of Greek lake ecosystems the recent qualitative and quantitative changes of the waters received from the draining basin, have not only influenced their hydrologic or abiotic environmental character, but also contributed at the differentiation of the composition of their fish fauna and populations and threaten vulnerable fish species. These changes consist an important impact when the draining basin waters constitute suitable places for reproduction of vulnerable anadromous fish species.

The fish fauna of the lake's Volvi system includes 23 fish species. Two of them, the species *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 (Gelartza) and *Vimba melanops* (Heckel, 1841) (Malamida), are generally characterized as "running water" species for their reproduction strategy and "lacustrine" for the rest of their biological cycle.

In this paper was studied the relative abundance of the fish populations for the above species in lake Volvi, during an annual circle and their spawning maturation in the lake ecosystem. It was also examined and confirmed their migratory passage from the lake system into the invading torrents for reproduction purposes and were identified the most important environmental problems that are directly related both to these torrent areas and to the success of reproduction.

From this research it was concluded that the integrated management of the sensitive lake ecosystems, as that of lake's Volvi, should not only aim at the protection of the lake itself, but also to the maintenance of the vulnerable river systems, invading in them. These areas constitute particularly important habitats for endangered fish species and their protection is decisive not only for the preservation of their populations but also for the survival of the species.

Key words: anadromous fish, fish reproduction, *Chalcalburnus chalcoides*, *Vimba melanops*, environmental problems, lakes, Lake Volvi.

1. INTRODUCTION

The conservation of fish fauna and fish populations in inland waters constitutes a worldwide problem in our days, due to the pollution and the exhaustion of their natural stocks. In the majority of Greek lake ecosystems the recent qualitative and quantitative

changes of the waters received from the draining basin, have not only influenced their hydrologic or abiotic environmental character, but also contributed at the differentiation of the composition of their fish fauna and fish populations and the threatened vulnerable fish species. These changes provoke an important impact when the draining basin waters constitute suitable places for reproduction of vulnerable 'anadromous' fish species.
The fish fauna of lake Volvi ecosystem includes 23 fish species [1, 2]. Two of them belong in the category of 'anadromous' species, that means they require for their reproduction flowing waters, while during the rest of their biological circle they prefer to remain at stationary water bodies as the lake systems. One of these two fish species is the endemic subspecies *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971, known with the common name 'Gelartza' around the lake's Volvi area. This subspecies constitutes significant heritage for the ecosystems of lakes Volvi and Vjstonis in Greece. Its disappearance will represent loss not only for the above ecosystems, but furthermore to the entire planet, as they do not exist anywhere else. In the same category of fish species in lake's Volvi system is also included the species *Vimba melanops* (Heckel, 1837), known in this area with the common name 'Malamida'. This species has a wider spread in the area of Eastern Macedonia and Thrace in Greece. Even if the populations of the species are in danger in lake's Volvi ecosystem, in general it is not considered as a 'threatened' type of the fish species, probably for the reason that its population in other ecosystems do not face up to important dangers.
In this paper is presented a part of the results of a research program that was financed by the 'Development Agency for Thessalonica's Prefecture', titled 'Study of the fish fauna, fisheries and fishery biology of the most common fish species in lakes Volvi and Koronia'. The main object of this program was the estimation of the areas and the time period of the reproduction of the most profitable fish species in the above lake ecosystems, the study of their reproduction biology and the environmental or fishery problems they face up to.

2. MATERIALS AND METHODS

For the estimation of the 'relative abundance' of the fish population in both of the lake ecosystems data were assembled from fish samplings with gill-nets having different mesh sizes. For the needs of this study there was used two gill net sampling units. Each sampling unit consists of nine different nets, having different mesh sizes, a length of 50 m and a height of 2 m. The mesh sizes of the gill nets used were: 16, 20, 24, 28, 34, 40, 50, 60 and 70 mm therefore they ensured fishing all of the fish sizes. The distribution of the nets in each 'net sampling unit' was with definite order. Between the nets of each mesh size there was a distance of 2 m, for avoiding the 'spill-over' phenomenon.
The fish samplings were carried out in two sampling stations in lake Volvi. The first one took place in the Eastern sub basin of the lake (Station A) and the second in its Western one (Station B). The nets were placed always in vertical site to the coastal line and for a certain time period, for keeping the same fishing effort during each fish sampling.
Samplings were on monthly basis for a complete year period. From each gill net was recorded the number of individuals from each fish species that was fished and the total biomass from all the individuals of each fish net and each fish species. Afterwards, the fresh fish samples were taken to the fishery laboratory of F.R.I., where other body measurements were performed. The collected data was recorded in a spreadsheet with the Ms-EXCEL software program for further statistical analysis purposes.
In order to study the time period of reproduction of the fish populations the same gill nets sampling method, as described above was used in the same fish sampling stations. For the needs of this part of the research, from the caught fish was also determined the sex, it was defined and recorded the weight of their gonads and it was observed also their sexual maturity stages, using the Kesteven's scale [3]. Finally, it was defined the

reproduction period of each fish species using the 'Gonadosomatic index' (GSI) [3], along with visual and fish sampling confirmation in the areas of the species reproduction during their reproduction period for their exact definition.

3. RESULTS AND DISCUSSION

From both of the sampling stations (A and B) during the monthly samplings in lake Volvi there were fished 11 different fish species, presented in Table 1, with the monthly fluctuation of their percentage in the total catch.

Table 1. Monthly fluctuations of the relative abundance of the fished samples in lake Volvi.

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OKT	NOV	DEC	TOTAL ABUND	%
Abramis brama	4,5	3,5	4,5	3,0	22,2	14,1	22,2	2,0	11,6	10,1	1,0	1,0	198	1,40
Alburnus alburnus				100,0									4	0,03
Alosa macedonica	1,5	7,1	0,7	0,4	12,3	12,6	20,8	6,3	20,2	16,5	0,6	0,8	2.525	17,85
Carassius gibelio	1,1	3,7	11,6	5,2	7,5	2,6	7,1	7,9	29,6	15,0	3,7	4,9	267	1,89
Ch. chalcoides	1,1	5,7	35,6		2,3	6,9	14,9	2,3	6,9	10,3	10,3	3,4	87	0,61
Cyprinus carpio				12,5	37,5	4,2	20,8	8,3	8,3	8,3			24	0,17
Esox lucius			50,0	25,0							25,0		4	0,03
Perca fluviatilis										100,0			3	0,02
Rutilus rutilus	2,2	5,0	5,6	10,5	12,7	9,2	11,5	23,4	5,7	4,8	5,7	3,6	10.872	76,84
Sc.erythrophthalmus	3,8	15,4	19,2		15,4		11,5				23,1	11,5	26	0,18
Vimba melanops	0,7	14,5	6,5	2,2	26,1	3,6	2,9	22,5	5,1	10,9	2,2	2,9	138	0,98
TOTAL													14.148	100

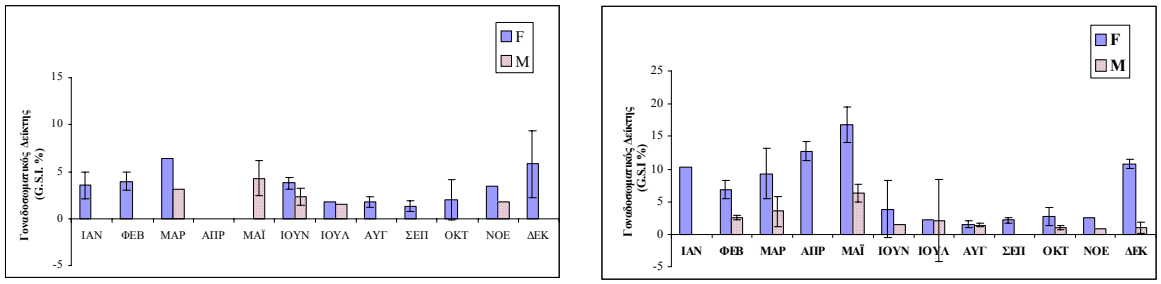
The predominant fish species, from the point of view of their 'occurrence' in each sampling, was the roach *Rutilus rutilus* (Linnaeus, 1758), the Macedonian shad *Alosa macedonica* (Vinciguerra, 1921), the goldfish *Carassius auratus* (Linnaeus, 1758), the carp bream *Abramis brama* (Linnaeus, 1758), and the Macedonian vimba *Vimba melanops* (Heckel, 1837) that were caught during all of the sampling months (Tab. 1). The species Danube bleak or 'Gelartza' *Chalcalburnus chalcoides macedonicus* (Stephanidis, 1971) followed with presence in 11 monthly samplings (except of April), the common carp *Cyprinus carpio* (Linnaeus, 1758) present in 7 monthly samplings and the common rudd *Scardinius erythrophthalmus* (Linnaeus, 1758) present in 7 monthly samplings. The Northern pike *Esox lucius* Linnaeus, 1758 following with presence in 3 monthly samplings, and finally, only one presence in the monthly samplings was registered for the common bleak *Alburnus alburnus* (Linnaeus, 1758) and the European perch *Perca fluviatilis* Linnaeus, 1758. The fish species with the bigger abundance from all the samplings it was the *R. rutilus* with 76,84 %, while the same species presents the bigger abundance in all the monthly samples, occupying always more than 50 % in the total catch (Tab. 1).

The participation of *V. melanops* in the total catch of the fish samplings was 0,98 % with the lower value in November and the higher one in May. During the same month was presented also the higher abundance of the species, having 36 individuals and a percentage of 26,09 % in the total sampling catch, that followed by the August sampling with 22,46 % in the total catch. The species *Ch. chalcoides macedonicus* had a higher presence in March samplings and during this month the 35,63 % of its total catch (31 individuals).

The number of the fish species caught in each monthly sampling presented uniformity. The number of the fish species in each monthly sampling varied usually from 7 to 8 species. This uniformity was owed from that a big number of fish species caught (6 from the total 11) they were presented in all the monthly samplings, while some of them were migrating for reproduction in the neighbouring inflowing the lake torrents, as also some other species was very rare.

The higher value of Gonadosomatjc Index (GCI) for the species *Ch. chalcoides* was observed for the females at March, where the mean value was 6,4±0 and for the males in

May, where it was 4,3±1,8 (Fig 1a). In the sampling of April it was not caught any samples, pointing out that the majority of the fish population has already migrated in the invading the lake torrents for reproduction. From July, is also observed for both of the sexes an abrupt reduction of the GSI values. During April we did not have any fish samples of the above species, while in the fish sampling of May were caught only male individuals. This indicates the movement of the bigger part of this fish species population in the invading the lake torrents for reproduction as also pointed out from [4]. During the summer months the reproduction was finished and the majority of this species fish population has returned back in the lake system. The gonads of the fishes during this period are very small and were found to be mainly at the 'absorption' stage. During autumn the GSI presents low values, while an increase of values occur over again after October, when mainly starts the generation of the new sexual material (Fig. 1a).



a b

Figure 1. Monthly fluctuations of the Gonadosomatic Index (GSI) of the species *Ch. chalcoides* (a) *Vimba melanops* (b).

The higher value of GSI for the species *V. melanops* is also observed for both of the sexes at May (Fig. 1b), with a mean price of 16,8 ± 2,7 for the females and 6,3 ± 1,4 for the males. After the sampling of May it was realized a movement of the majority of the fish population of the species in the invading the lake Volvi torrents. During June in both of the sexes of the species observed a vertical reduction of the values of GSI, which reaches their minimum values in August. During the summer months the reproduction of the fishes has finished to a large extent, the fish gonads are small and in the 'absorption' stage, while GSI receives its smaller values (Fig. 1b). The increase of the gonad size of the fishes begins from December, when begins also the intense preparation for the next reproduction.

As accrued from the above, the main season of reproduction of the fish species *Ch. chalcoides macedonicus* is estimated between the months April, May and June. From the study of the sexual maturity stages, it was realised that the higher percentage of the fish population in the May sample was in stage VI, where as well occurs the reproduction of the species. Respectively, the main reproduction period of the species *V. melanops* is estimated between May and June, in the areas of invading the lake Volvi torrents.

Mass fish migration in the invading torrents in lake Volvi system, except of the present research, has also recorded and during the ancient years in the torrent Pazarouda [5]. The season where was realised this mass migration of fishes was determined during the ancient months "Anthestirion" and "Elafivolion", that is from 15 February until 15 April.

The mass migration of the 'anadromous' fishes from the lake in the invading torrents starts just before the reproduction period and it was defined from the present research to be the beginning of month April, when in addition took place the fishing of the first individuals that were entering in the reproduction areas in the invading the lake system torrents. This fact is confirmed from bibliographic data about the lake Volvi [1, 2, 4], from information taken from the fishermen of the lake and moreover from international bibliography references about both of these species. It is reported that the above type of migration for reproduction occurs also for both of the above species; in the most of the ecosystems they live [6, 7, 8, 9, 10, 11, 12]. Therefore, as reproduction areas for the

above fish species accrued from this study all the invading the lake Volvi torrents. As the main reproduction area for the species was defined the 'Pazarouda' torrent, following from the torrents of 'Holomontas', 'Vamvakia' and 'Derveni'.
Both of the 'anadromous' fish species of lake Volvi have been disappeared from the neighbouring lake Koronia, still from the period where the two lakes systems were connected by the torrent Derveni, for the reason of the limited invading torrents in lake Koronia as also due to the small water supply of the existing ones. The absence of *Ch. chalcoides* and *V. melanops* from the system of lake Koronia is also confirmed by older bibliographic reports [1, 4] and attributed also there the same reasons as the lack of appreciable invading torrents in this ecosystem and consequently the absence of suitable regions for the reproduction of the above fish species.
The places where the reproduction mainly takes place in the system of lake Volvi, as accrued from this study, are locating usual in the middle flow area of invading the lake torrents, while they can extend to the upper or the lower flow of them. The reproduction of the above species does not take place in the areas of the estuaries of these torrents or in the mountainous areas of their springs.
The areas where the fishes are laying their eggs in these torrents have in general a gravel or sandy riverbed. From bibliographic data is reported that in order to support artificially the natural reproduction of these species, are transported in the areas of reproduction shingles or bivalve shells of the clam *Cardium* [13, 14]. The reproduction areas of these species in the torrents invading in lake Volvi are mainly places with shadow from aquatic vegetation or by the leafage of riverside plants, while bibliographically reported that aiming in the improvement of these areas vegetation can be planted along the river side or suitable canes can be placed for the shadowing of these areas [13, 14].
From the evidence of the sexual maturity stages of females and males fish in both of the species, it was realised that the first sexual maturity in the majority of the two fish populations appears at age 3+. Sexually mature fishes are also recorded at age 2+, but they constituted a very low percentage of the total population.

4. CONCLUSIONS

The species *Ch. chalcoides macedonicus* and *V. melanops*, are migrating for reproduction from the lake Volvi system in the invading torrents. Consequently, the success of their reproductive circle depends mainly from the quantity and the quality of waters that invade into in the lake. In lake Volvi ecosystem the rivers that invade in the lake show profoundly changed supplies of water. These fluctuations are attributed in the climatic conditions that prevailed during the last wintry period, for the reason that their waters springing mainly from the rainfalls and snowfalls of previous winter. The supply of their water however depends also from its usage for various agricultural needs, while with the irrigation are removed big quantities of the water of these torrents. After the rapid increase of the irrigated agricultural areas during the last years, except of the reduction of the amounts of the water of these torrents, has also increased the environmental pollution that derives from the usage of fertilizers, pesticides, weedy killers and other chemical preparations used in modern agriculture.
All the above, with many other anthropogenic interventions, for example like the excessive sand removal from the torrent's bed and other technical arrangements at the torrents, like a lot of technical constructions as dams or bridges aiming mainly to flood protection that have been built there, are adding in the factors that limiting the areas of natural reproduction of these two fish species. Thus, it is obvious that even if the fish populations of the above species were much bigger during past, in our days have been significantly decreased, mainly due to the restriction and the degrading of their reproduction areas. Bibliographically was also reported that the construction of dams for

the creation of artificial lakes, induced the disappearance of these species from these ecosystems, precisely for the reason that it was prevented their passage to the reproduction areas [8, 10]. It is also the fact, thus not that intense, in the examined system of lake Volvi.

Consequently, it becomes clear that such types of environmental problems acquire vital significance not only for the size of the population of the species having a specific reproduction circle, but for their survival as well. Particularly for the sub species *Ch. chalcoides macedonicus*, it is not an exaggeration to say that the population of this endemic subspecies has reached already its critical point, and possibly this will lead to its absence from this ecosystem in the near future.

REFERENCES

1. Economidis, P.S. and Sinis A.I. (1982) 'Les poissons du système des Lacs Koronia et Volvi (Macédoine, Grèce) considérations systématiques zoo-géographiques'*. Biol. Gallo-Hellenica,* 9, 291-316.
2. Kokkinakis A.K., Koutrakis E.T., Eleftheriadis E.A., Bobori D.C. and Economidis P.S. (1999) 'Fresh water fish in the Western Strymonikos coastal zone (Macedonia, Greece) with two new records', *Proc. 8th Intern. Congr. Zoog. Ecol. Greece Adj. Reg.,* 72.
3. Bagenal T.B. and Braum E. (1971) Eggs and Early Life History, In: Methods for Assessment of Fish Production in Fresh Waters, by: RICKER W.E., *Blackwell Scientific Publications*. Oxford and Edinburgh.
4. Kokkinakis A.K. (1992) 'Comparative study of the biology and dynamics of the fish *Chalcalburnus chalcoides macedonicus* Stephanidis, 1971 (Pisces: Cyprinidae) in the systems Volvi and Vistonis', AUTH, Doctorate thesis, 192 pp.
5. Athenaeus (2nd-3rd century A.D.) 'Deipnosophistae', VIII, 334e, 18-10. (English translation by: C.B. Gulick, ed., Heinemerun 1969).
6. Beling D. & Himmelreich H. (1940) 'Ribi r. Berdi i Obitocnoi', (Die fische der flusse Berda und Obytotschnaia), *Dopovidi AN USSR*, 10, 8p.
7. Trifonov G.P. (1957) 'Kvoprosu o tybochozjajstvennom osvojenii Simferopolskogo vodochranilisca' (In Russian – Aquaculture topics in the Simferoupoli lagoon), *Tr. Karadagskoj boil. Stancii, AN USSR*, 14, 47-69.
8. Losakov A.S. (1973) 'Morphology and ecology of the "shemaya" (*Chalcalburnus chalcoides* (Guld.)) of the Berda River', *J. Ichthyol,* 497 – 504, (Engl. Transl. *Vopr. Ikhtiol.*, 13, 4(81), 603-610.
9. Berg L.S. (1965) 'Freshwater fishes of the U.S.S.R. and adjacent countries', Academy of Sciences of the U.S.S.R., Zoological Institute, Vol. III., Translated from Russian (Israel Program for Scientific Translations). 510 p.
10. Kasymov A.G. (1975) 'Meroprijatija po povyseniju zapasov semai v Mengecaurskom vodochranilisce, (In Russian – Safety measures for the propagation of the species semaya in artificial lakes), *Rybn. Chozj.*, 10, 31-32.
11. Abdurachmanov Y.A. (1975) 'Transformation of the diadromous Kura shemaya *Chalcalburnus chalcoides* into a land - locked population in the Mingechaur reservoir', *J. Ichthyol.,* 189-196*,* (Engl. Transl. *Vopr. Ikhtiol*., 15, 2(91), 211-218).
12. Aksiray F. (1982) 'Die umweltfaktoren, die Verbreitung und Entwicklung von *Chalcalburnus tarichi* (Pall. 1881) (Pisces: Cyprinidae) in Burdur-See Begrenzen', *Water Res.,* 16(7), 1107-1112.
13. Koslovskij D.A. and Y.R. Suchanova (1968) 'Ecologiceskij metod vosproi-zvodstva rybca I semai. (In Russian - An ecological method for the reproduction of the species ribtsa and semaya), *Rybn. Chozj*, 11, 23-24.
14. Bitechina V.A., Karpenko G.I. and Proskurina Y.S. (1978) 'Razvedenije rybca i semai na ozere solenom, Kuban. (The culture of shemaia and vimba in the Solenoye Lake, Kuban). *Tr. Vses. Nauc-issl. Inst. Morskogo rubnogo chozj. I okeanogr., Moskva,* 131, 138-152