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EUTROPHICATION AND AQUATIC WEEVILS (COLEOPTERA: CURCULIONOIDEA, CURCULIONIDAE)

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ABSTRACT. Reservoirs of water-supply are interesting lake ecosystems, which succesively replaced former river ecosystems. Using biological monitoring they could be good «experimental» objects, because the manner of their formation and management are different.

That's the case with Gruža Reservoir, formed in Central Serbia, twenty years ago. Researches of this territory started much earlier. Unfortunately, bad planning and managing caused the lake to die out. All variables indicating the eutrophication (physical – the water transparency; chemical – the presence of phosphorus, oxygen distribution during the summer; biological – the quantity of chlorophil-a, phyto- and zooplankton, benthic macroinvertebrates, macrophytes) are high and classify this lake into eutrophic and hypertrophic categories.

Yet, this is not necessarily bad for all the participants in biocenose. The weevils assembly, particularly the aquatic species, grows up, and develops following the macrophytes. This means that the weevils species which prefer host plants from mesotrophic and meso- to eutrophic (nitrophilic) categories, can develop bigger populations, i.e. dominate [*Rhinoncus perpendicularis* (Reich.), *Rh. castor* (F.), *Rh. pericarpius* (L.) and *Bagous bagdatensis* Pic]. In other words, direct connection between host-plant trophic level (regarding the nitrogen presence in the soil) and big weevil population is evident.

INTRODUCTION

What is eutrophication?

The most precise definition of eutrophication, containing cause, process and effects, is the one given by Environment Agency of UK Government: »The enrichment of water by nutrients, stimulating an array of symptomatic changes including increased production of algae and/or higher plants, which can adveresely affect the diversity of the biological system, the quality of the water and the uses to which the water may be put.» (www.environment-agency.gov.uk/commondata/105385/eutrophication.pdf)

The carrying out of nutrients from sediments by run-off into surface waters is natural eutrophication (www.enviroliteracy.org/article.php/410.html). It is a process by which lakes ecosystems become more productive and gradually age (www.umanitoba.ca/institutes/fisheries/eutro.html). But, the cultural (anthropogenic) eutrophication includes water pollution caused by excessive plant nutrients. It is much faster than natural one. Thousands of lakes all around the world are victims of it. (www.umanitoba.ca/institutes/fisheries/eutro.html)

Essential elements for aquatic biota growing are nitrogen (N), carbon (C) and phosphorus (P). Eutrophication reserches abroad focused primarily on the third one, since the first two are difficult for following in the processes of exchanging between the atmosphere and water (SHARPLEY et al., 2003). During the 1970's, a very serious Canadian experiment lasted a few years, and it proved that phosphorous is the main nutrient for stimulation of bluegreen algae «blooming» (www.umanitoba.ca/institutes/fisheries/eutro.html). The biggest problem is phosphorus captured in arable lands, which has been concentrating for many years (www.internat.naturvardsverket.se/index.php3?main=/documents/pollutants/overgod/eutroe.html).

Latterly, much attention has been paid to nitrogen. Artificial fertilisers as well as farmyard manure are very rich in nitrogen. Highly mobile nitrogen compounds in the environment, unlike phosphorus, cannot be deposed (www.internat.naturvardsverket.se/index.php3?main=/documents/pollutants/overgod/eutroe.html). In England and Wales, 70% of nitrogen inputs to fresh waters come from diffuse sources [agriculture (particularly emission of ammonia from livestock husbandry), precipitation and urban runoff (concrete NO_x emissions from vehicles and power stations)], and 30% from point sources (urban waste waters, sewage, industrial effluents) (www.environment-agency.gov.uk/commondata/105385/eutrophication.pdf).

The Gruža Reservoir is in fact a good model of rapid eutrophication development.

Using the results from earlier studies, particularly botanical ones, in this work we are trying to discover if there is an influence of eutrophication on weevil assembly.

Investigated locality

Confronted with increasing problem of water supply due to growing industry and settlement, Kragujevac city, decided in 1974 to dam the Gruža River on middle flow, 10km upstream of Pajsijevići village (MILOVANOVIĆ, NIKOLIĆ & ĐURAN, 1995). The accumulation started working in 1985 (ČOMIĆ, 1989). Now it is a lake approximately 10km long and 0.2-1.5km wide (Fig. 1). It has got 934ha surface, and 64.6 milions of m^3 of water. A protective zone of 1450ha surrounds it. (MILOJEVIĆ, LJUBISAVLJEVIĆ & ĐUKIĆ, 1995)

Unfortunately, problems with accumulation living started at the moment of its formation. The accumulation is mostly placed on fertile flatland, in a valley between the mountains Rudnik (1132m a.s.l.), Gledićke Planine (807m a.s.l.) and Kotlenik (748m a.s.l.) (Fig. 1), and the result is that two thirds of the north part of lake surface are only 2-9m deep (MILOJEVIĆ, LJUBISAVLJEVIĆ & ĐUKIĆ, 1995), i.e. have a puddle-like character, muddy littoral, many inlets. Rural soil surface which has not been properly cleaned and the old main road Kragujevac-Čačak are covered with water. The pioneer species settled very quickly on this new lake habitat (OSTOJIĆ, 2002). But, destructive processes on the bottom started at the same time. Today this dimictical lake ecosystem is only twenty years old, but has got strong eutrophication (OSTOJIĆ, 2000; ĆURČIĆ, 2003).

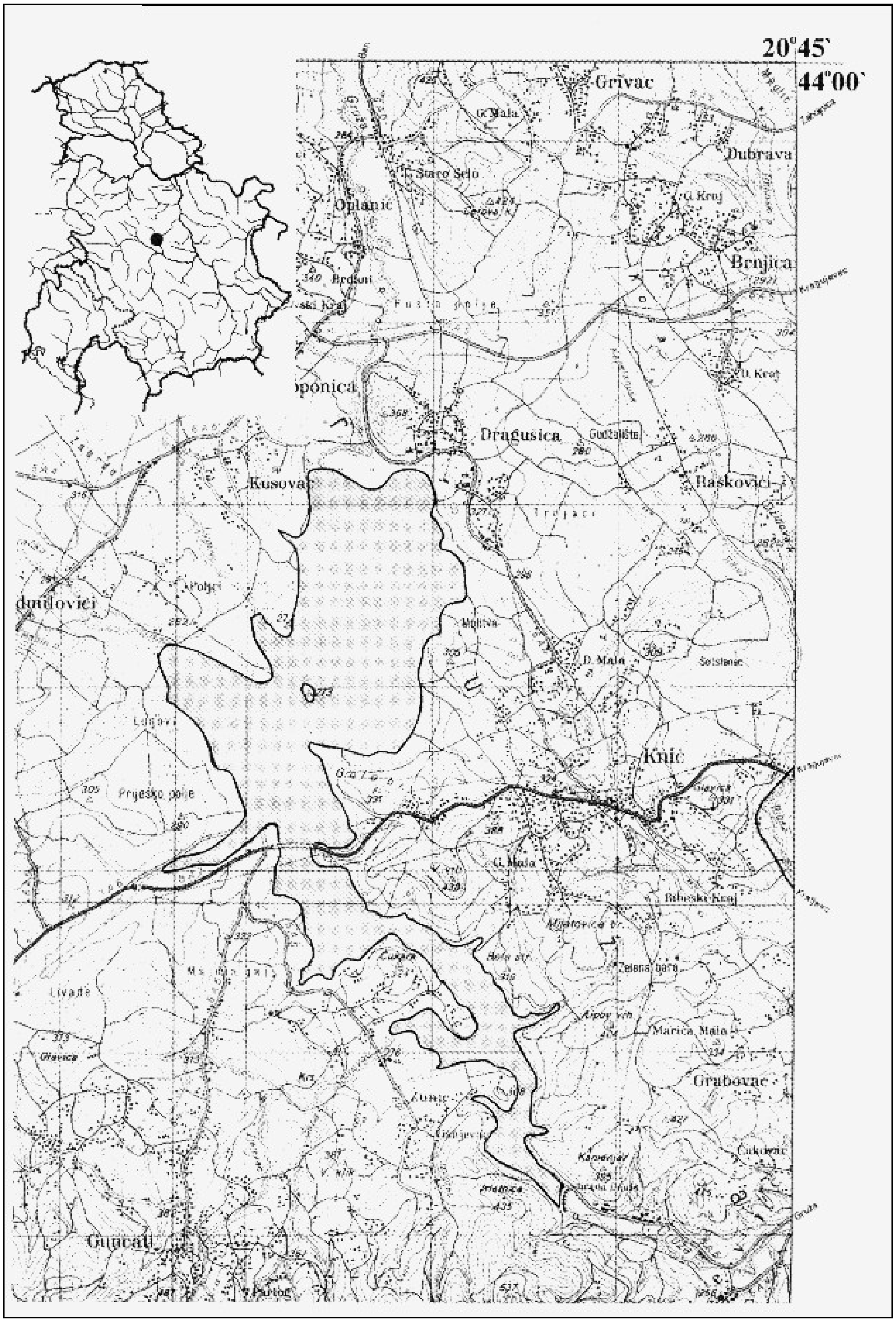


Fig. 1: Position of Gruža Reservoir

In the practice all forms of agricultural activities are classified in Nonpoint Source Pollution. They are very difficult for identification and control. About 56% of surface of Gruža river basin is cultivable soil. Using of pesticides and artificial fertilizers is not controlled even on territory of the zone of the first (highest) Gruža Reservoir protection (ĆURČIĆ, 2003) (Fig. 2).

Figure 2: Gruža Reservoir's surrounding (by Dr Svetlana Ćurčić)

MATERIAL AND METHODS

Nowadays (May 15th 2001 and June 20th 2002), the weevils have been studied for the first time on Gruža Reservoir's surrounding.

In the early morning (6:00-10:00 h) adult weevils (Coleoptera: Curculionoidea) were collected in inlets and surrounding meadows, neglected land, boundaries etc., on the localities Molitva and Trnjaci (between Knić and Dragušica) and Priješko Polje (right bank of lake) (Fig. 1), by various techniques (sweeping and shaking of plants, rinsing of submersed plants, beating of the branches of trees and bushes, mowing of the ground floor of vegetation etc.). Material was killed by ethil-acetat. Many keys were used for species identification: ALONSO-ZARAZAGA, 1990; ANGELOV 1976, 1978, 1979, 1980, 1981; DIECKMANN, 1972, 1980, 1983; FREUDE *et al.* 1981, 1983; SMRECZYŃSKI, 1974. Used nomenclature is the one recommended in the latest world catalogue of families and genera of weevils (ALONSO-ZARAZAGA & LYAL (1999).

The sex was determined for each specimen.

All material is kept in the collection on the Faculty of Science in Kragujevac.

RESULTS AND DISCUSSION

The total of 466 adult weevils was collected. Females were more numerous (247). Taxonomically, there are 70 species, from six families (Rhynchitidae, Apionidae, Nanophyidae, Raymondionymidae, Erirhinidae, and Curculionidae) (Pešić, 2004).

For this work, the focus is on the aquatic part of weevils assembly. It contains eight species, 192 specimens (Tab. 1). From family Erirhinidae is *Notaris scirpi* (Fabricius, 1792). All the others are from family Curculionidae: *Bagous bagdatensis* Pic, 1904 (=*B. wagneri* Dieckmann, 1964), *B. collignensis* (Herbst, 1795) (=*B. claudicans* Angelov, 1957), *Phytobius* (=*Litodactylus*) *leucogaster* (Marsham, 1802) (=*Ph. myriophylli* Gyllenhal, 1813), *Rhinoncus castor* Fabricius, 1792, *Rh. inconspectus* (Herbst, 1795), *Rh. pericarpius* (Linnaeus, 1758) and *Rh. perpendicularis* (Reich, 1797). Geographically, it is important that *Notaris scirpi* and *Rhinoncus castor* were registered on Kragujevac's territory for the first time (Pešić, 2000).

Tab. 1: Aquatic weevils from Gruža Reservoir and their host plant(s)
with ecological index for nitrogen (N) (N_a - average N)

weevil species	**nr. specim.**	**host plant(s) ***	**N****	**N_a**
Notaris scirpi (F.)	1	*Typha* sp.	3	
		Scirpus sp.	2	2.5
		Carex sp.	2-3	
Bagous bagdatensis Pic***	25	*Alisma plantago-aquatica*	3	
		Butomus umbellatus	4	
		Ceratophylum demersum	5	
		Carex sp.	2-3	
		Myriophyllum spicatum	3	3.4
		Lemna minor	3	
		Lythrum salicaria	3	
		Glyceria sp.	3	
		Polygonum sp.	4	
Bagous collignensis (Hbst.)	4	*Equisetum* sp.	2	2
Phytobius leucogaster (Marsh.)	1	*Myriophyllum spicatum*	3	3
Rhinoncus castor (F.)	33	*Rumex* sp.	3	3
Rhinoncus inconspectus (Hbst.)	3	*Polygonum amphibium*	4	4
Rhinoncus pericarpius (L.)	31	*Rumex* sp.	3	3
Rhinoncus perpendicularis (Reich.)	94	*Polygonum* sp.	4	4

*Literatural data from cited keys for species identification, plus Buckingham & Bennet, 1981; Caldara & O'Brien, 1995; Poiras, 1998.
** Kojić, Popović & Karadžić, 1997.
***The host plant(s) for *Bagous bagdatensis* stil is/are unknown. Comparing the plant lists of Holecova (1993) and Topuzović & Pavlović (2003) we took this list of possible hosts and added our finding plant – *Polygonum* (Pešić, 2004).

The weevils are exclusively phytophagous. According to the spectrum of plants for feeding they can range from polyphagous to monophagous (Pešić, 1997). The situation is similar with the aquatic weevils, but many of them have developed exclusive relations with only one host plant (Tab. 1). Using the rich feeding source represented in macrophytes and other vascular flora, some species developed very numerous populations. We found connection between plant trophic level according to the nitrogen preference and big weevil populations.

The eutrophication is a process definitely confirmed by the results of the research (OSTOJIĆ, 2000; ĆURČIĆ, 2003) in ecosystem of Gruža Reservoir lake: low water transparency, low dissolved oxygen (during summer hypolimnion stays anaerobic), concentration of phosphorus, chlorophyll-a production, blue-green algae blooming, rapid development of zooplankton community, poor benthos.

Indirectly, we can get the picture about nitrogen in the water of Gruža Lake based on the changing situation of nitrogenfixatoring bacteria during a period of time. Their maximum activity during the lake aging moved from spring (ČOMIĆ, 1989) to summer and early autumn, and had two peaks (ĆURČIĆ, 2003) related to intensive decomposition of deceased plankton.

Concerning macrophytes communities, we can follow their development over a period of time, thanks to scientific data, collected way before the Reservoir's formation (PANČIĆ, 1884; RUDSKI, 1949; VELJOVIĆ, 1967; VELJOVIĆ & MARKOVIĆ, 1984). For our study the starting point are the data from 1985 (the third year of accumulation charging, but the first of its functioning as a finished Reservoir for Kragujevac watersupply) (VELJOVIĆ, MARKOVIĆ & VUKOMANOVIĆ, 1986). The list of vascular flora contained 27 species. Their names and trophical status regarding preference of soil richness in available nitrogen (N) are given in Tab. 2. Six species are signed by asterisk, because they were not present in the latest floristic list (TOPUZOVIĆ & PAVLOVIĆ, 2003), but they are still on Gruža lake terrains (according to the personal communication with authors).

Tab. 2: The vascular flora of accumulation Gruža in 1985
(according VELJOVIĆ, MARKOVIĆ & VUKOMANOVIĆ, 1986)

	s p e c i e s	**N**		**s p e c i e s**	**N**
1.	*Alisma plantago aquatica* L.	3	15.	**Leonurus marrubiastrum* L.	4
2.	*Bidens tripartitus* L.	4	16.	*Lycopus europaeus* L.	3
3.	*Ceratophilum submersum* L.	5	17.	*Lysimachia numularia* L.	3
4.	**Cyperus fuscus* L.	3	18.	*Lysimachia vulgaris* L.	3
5.	*Epilobium hirsutum* L.	2	19.	*Lythrum salicaria* L.	3
6.	**Equisetum arvense* L.	3	20.	*Potamogeton crispus* L.	3
7.	*Equisetum palustre* L.	2	21.	*Potamogeton fluitans* Roth.	3
8.	**Gratiola officinalis* L.	2	22.	*Potamogeton pusillus* L.	4
9.	*Heleocharis palustris* Lindb.	2	23.	**Schoenoplectus lacustris* Palla.	3
10.	**Juncus articulatus* L.	2	24.	*Scirpus silvaticus* L.	2
11.	*Juncus conglomeratus* L.	3	25.	*Typha angustifolia* L.	3
12.	*Juncus effusus* L.	3	26.	*Typha latifolia* L.	3
13.	*Lemna gibba* L.	4	27.	*Veronica beccabunga* L.	4
14.	*Lemna minor* L.	3	-	**on the average**	**3.01**

The trophical status was on average 3.01. This pioneer stage of the swamp and bog phytocenoses, has changed during the past twenty years.

Today, the eutrophication caused the lake to become overgrown with aquatic and semi aquatic plants. Among 162 vascular plant species, registered during the three years of investigation (1999-2002) on the shoreline of Gruža Reservoir, only 0.76% are oligotrophic, 12.12% are in transition from oligotrophic to mesotrophic, 58.33% are mesotrophic, 25% are transitional to eutrophic, and 3.79% are eutrophic (TOPUZOVIĆ & PAVLOVIĆ, 2003). There are 28 macrophytes (TOPUZOVIĆ & PAVLOVIĆ, 2003), and their trophical status is on average 3.32. These values, compared with those from 1985, represent one more confirmation of the increase of total trophical status of the lake.

The aquatic part of weevil assembly is completely in accord with this situation (Tab. 1; Fig. 2): the center of gravity has moved to the higher values of N. This becomes more obvious if we compare numbers of collected weevil species and trophic status of their hosts (Fig. 3). Mass presence of *Rhinoncus perpendicularis* (94 specimens), *Rh. castor* (33), *Rh. pericarpius* (31) and *Bagous bagdatensis* (25) is an obvious consequence of the presence of nitrophilic macrophytes, i.e. of eutrophication (Figs. 2 and 3). It could be a sign of a dangerous transformation of ecosystem, because very numerous populations of several species lead to decrease of the quality of the habitat, and means simplification of biocenose.

Fig. 2: Correlation between weevil species and trophic
(average ecological index for nitrogen - Na) of their host plant(s)

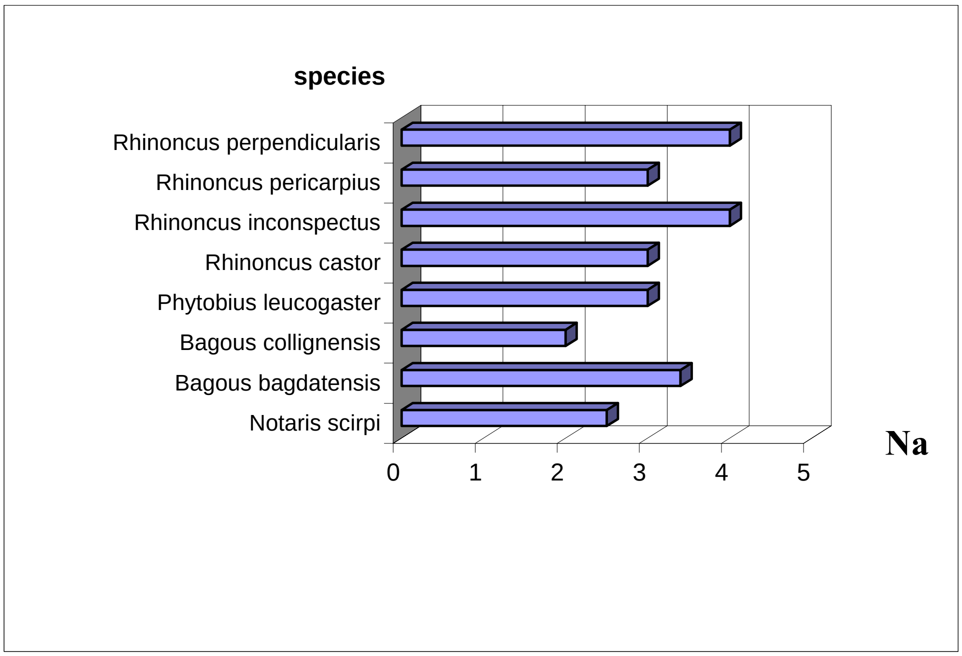
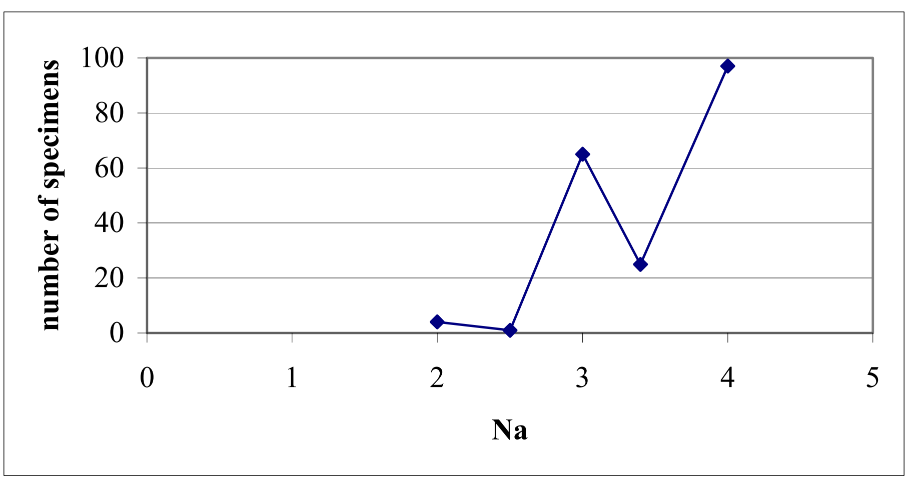


Fig. 3: Correlation between number of weevil specimens and trophic
(average ecological index for nitrogen - Na) of host plant(s)



CONCLUSION

Moderate eutrophication is not entirely negative whereas heavy eutrophication eliminates species (www.internat.naturvardsverket.se/index.php3?main=/documents/pollutants/overgod/eutroe.html).

The eutrophication of lake Gruža ecosystem has definitely got a strong and evident influence on weevil settlement composition, qualitatively as well as quantitatively.

If the way it is used does not change [particularly the water pollution from arable lands (Fig.2)], the future of artificial lake ecosystem of Gruža Reservoir is not bright. In other words, this young lake could soon be transformed, due to speedy aging, into hyper- and distrophic bog, and die.

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