

FACULTY OF NATURAL SCIENCES, COMENIUS UNIVERSITY
BRATISLAVA, SLOVAKIA

PLENIPOTENTIARY OF THE SLOVAK REPUBLIC
FOR CONSTRUCTION AND OPERATION
OF GABČÍKOVO – NAGYMAROS HYDROPOWER PROJECT

GABČÍKOVO – NAGYMAROS HYDROPOWER PROJECT

**GABČÍKOVO PART OF THE HYDROELECTRIC
POWER PROJECT
ENVIRONMENTAL IMPACT REVIEW**

(Evaluation Based on two Year Monitoring)

Scientific editor Prof. Igor Mucha



Bratislava 1995

DIVERSITY AND SURVIVAL OF CARABID COMMUNITIES IN THE AREA AFFECTED BY THE BARRAGE SYSTEM GABČÍKOVĀ

Zbyšek ŠUSTEK

Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, 84206 Bratislava, SLOVAKIA

CONCLUSIONS The changes in representation of individual ecological groups of Carabidae in the within-dike area of the Danube during the period 1986-1994 show that the drainage process has started in this area, and resulted in initial stages of community succession tending to rise of ecologically less valuable heterogeneous ecotonal communities. This succession started as early before the diversion of the Danube main flow as a result of long-term continuous decrease of average ground water level, climatic fluctuations and various human activities in the past. In 1992-1994, after the Danube diversion it was considerably accelerated. The further development of the Carabidae communities has three alternatives characterised briefly as

- increase of the dominance of mesohygrophilous species and the decrease of the dominance or extinction of polyhygrophilous species,
- the vanishing hygrophilous species may be partially substituted by some tolerant species,
- preservation of more or less a species spectrum characteristic for floodplain forests, with lower alpha-diversity.

INITIAL STATE OF THE COMMUNITIES IN THE STUDIED AREA

The communities in the within-dike area belong to two subtypes characterised by Šustek in [4]. These two subtypes are characterised by the absence of more eurytopic mesohygrophilous species of the genera *Carabus* (*C. ullrichi* and *C. coriaceus*) and a high dominance of *Platynus assimilis* and the presence of many hygrophilous species represented as the subdominant or recedent species. The first subtype is characterised by a co-dominance of *Platynus assimilis* with *Patrobus atrorufus* and *Asaphidion flavipes*. The second subtype is characterised by a co-dominance of *Platynus assimilis* with *Carabus granulatus*, *Pterostichus niger* and *Pterostichus melanarius*.

The studied communities are further characterised by a low dominance of hygrophilous species preferring eutrophic swampy substrates like *Agonum moestum*, *Pterostichus nigrata*, *Pterostichus anthracinus* or *Oodes heliopioides*. Almost no xenocoenous species occurred in the studied localities until 1989-1990. The total one year catch in ten traps counts approximately 1000 individuals. The species number in individual sampling plots moves from 30 to 35 species. In spite of the almost total replacement of the original natural willow-poplar stands by monocultures of various poplar cultivars the state of the Carabidae communities might be considered as natural. Their structure corresponded to the cyclic catastrophic climax state of the ecosystems in the within-dike area.

CHANGES IN THE STUDIED COMMUNITIES DURING THE PERIOD 1986-1994

The changes observed in a series of six years (1986-1992) of regular pitfall trap catches of Carabids in the within-dike area of the Danube can be characterised from four aspects:

1. beginning of gradual penetration of xenocoenous species from the surrounding fields,
2. decrease of abundance or local extinction of the most hygrophilous species,
3. increase of abundance of tolerant and little hygrophilous species,
4. visible shifts in occurrence foci of individual species in dependence of changes of moisture gradient in each sampling plot.

The xenocoenous species in floodplain forests in the Danube within-dike area may be represented by two groups of species. The first group includes mesohygrophilous forest species, which do not occur in extensive floodplains or which inhabit only the sporadically flooded forest of the group of geobiocoens *Ulm Fraxineta carpinea*, growing on floodplain margins. The second group includes heliophilous species inhabiting fields, meadows, ruderals, etc. These species occur in natural forests of any type at most only as occasional migrants in a very limited number of individuals. The mesohygrophilous forest species did not and do not occur in the within-dike zone, neither their spreading into studied areas is probable in the near future because of negligible representation, isolation and large distance of suitable migration sources. The species of the second group, represented in this article illustratively by the two most abundant and expansive species *Pseudophonus rufipes* and *Poecilus cupreus* (Tab. 1), did not occur, up to 1991, in the studied area in an extent exceeding the normal state in other natural

forest ecosystems. In 1991 and 1992 *P. rufipes* started to occur more frequently and in a slightly higher number of individuals. However, after putting the Gabčíkovo hydroelectric power plant into operation, in 1993, the number of individuals and occurrence frequency increased markedly and in *P. rufipes* this trend continued in 1994 too. The penetration of these species with its up to date intensity can not still influence the Carabid communities in the floodplain forests considerably, but it is to be considered as one of the serious warning signals of the start of degradation processes in these ecosystems. In the strong damaged floodplain forests in other places the xenocous species represent even 40% of Carabids [4]. Their penetration is stimulated by the earlier fall of leaves caused by the dry weather in July and August and a gradual decrease of humidity and ground water level, clear cutting, construction of forest roads and other human activities in the studied area.

The decrease of abundance or local extinction of the most hygrophilous species represents a general tendency in the whole studied area. In this article it is illustrated by three strongly hygrophilous species of the genus *Agonum* (Tab. 3) in the sampling plot in Kráľovská lúka (Fig. 1). These species prefer permanently moist swampy habitats. The most hygrophilous *A. fuliginosum* occurred homogeneously along the whole ca. 400 m long sampling line in 1986-1989, when this locality was flooded more times a year for one or two weeks. Since 1990 this species disappeared at all. A little less hygrophilous *Agonum micans* left the moderately elevated part of the sampling plot and moved to the lower part around the remainder of a former oxbow (traps 1-4). The abundance of *Agonum moestum*, inhabiting in 1989 the moderately elevated part of the sampling line, and missing in the lower part being repeatedly flooded for a longer time, decreased already between 1986 and 1989, and similarly to the precedent species, this species moved to the moderately lower part around the oxbow shores. *Bembidion dentellum* is a characteristic inhabitant of the loamy shores of rivers. It is not a typical inhabitant of floodplain forests. It appeared here above after floods in 1987-88 and 1991-92. In 1989 it occurred homogeneously along the whole sampling line, while in 1992 and 1993 it concentrated in the lower parts.

The hygrophilous, but widely tolerant *Carabus granulatus* occurred, in the past, mostly in the moderately elevated area. Since 1990 it was spreading also to the moister lower parts. The moderately hygrophilous *Pterostichus melanarius* and *P. niger* occurred, until 1992, along the whole trapping line irregularly, and in a small number of individuals, with a slight preference for drier parts. After 1992, the abundance of both species increased strikingly along the whole sampling line, with an evident preference for the moister lower parts.

The high increase of the abundance of *P. melanarius* and *P. niger* in all study plots (Tab. 2) represents since 1991 a general trend. The increase of their abundance was made possible by more facts. Among the hygrophilous Carabids, *P. niger* and *P. melanarius* have the lowest requirements on moisture and both species are usually the first species, which indicate an increase of humidity in mesohygrophilous habitats. In addition, especially *P. melanarius* is an eurytopic tolerant species living frequently also in the fields and rudelars, and in a lower number of individuals, even in some more humid submontane forests. Both species are relatively good fliers and migrants, and in some cases they appear (or disappear) suddenly in high numbers without an apparent reason [5]. Furthermore, *P. melanarius* has, in contrast to almost all central European Carabids, a plastic reproductive cycle. All these properties allow them to colonise rapidly new habitats, even in the interior of the cities (Bratislava, Kamenné námestie square!![3]). It is probable that the rapid increase of their abundance in 1991 was stimulated also by the flood in August. Immediately after this flood, they belonged to the first species being active on extensive areas covered by deposited silt. Also immigrants from the adjacent fields might play a role.

It is to be accentuated that in the floodplain forest Horni les near Lednica na Morave *P. niger*, *P. melanarius* and *Carabus granulatus* were the only species, which tolerated the stop of regular spring floods and an average decrease of ground water level at 1.5 m [5].

A BRIEF PROGNOSIS OF FURTHER SUCCESSION OF THE CARABID COMMUNITIES

The comparison of various anthropogenically influenced Carabid communities in the floodplain forests shows that the drainage or other anthropogenic interference in the remainders of natural floodplain forests may result in three basic directions of succession.

1. If a floodplain forest has a direct contact with drier types of the floodplain forests growing on the margins of alluvia or with mesohygrophilous stands outside the alluvium, the succession can result in the increase of the dominance of mesohygrophilous species and the decrease of the dominance or extinction of polyhygrophilous species. Polyhygrophilous species can eventually survive in small patches in terrain depressions. In such a way a community, which would be natural at other places, especially on margins of floodplain forests, arises. An inevitable precondition for such a direction of succession is, however, the preservation of the stand integrity on a sufficient area. A variety of this direction of succession are those communities, where the mesohygrophilous *Carabus coriaceus* (a species exhibiting a wider tolerance to higher humidity) reaches an enormous abundance and autodominant position due to lack of competition pressure from other similarly sized species [4]. Because *Carabus coriaceus* occurs sporadically also in the within-dike area, this variety of succession may be, in future, probable at those places in this area, which will preserve a higher humidity. This type of secondary communities occurs at more places in Slovakia and Moravia. In some places along the Váh river lower flow the eurytopic *Carabus scheidleri* was found to play the role of *C. coriaceus*. So especially in

surrounding of confluence of VŠh and Little Danube an other variety of a secundar Carabid community might arise.

If any of the above preconditions is not fulfilled, the vanishing hygrophilous species may be partially replaced by some tolerant species (see above). However, in dependence on the progress of the forest stand disintegration an invasion of more or less heliophilous or xerophilous species of open land will start. After a time such species can reach a considerable quantitative representation. In this way an ecologically heterogenous ecotonal community arises. In the most damaged floodplain forests the abundance of almost all species can be very low and the community consists mostly of immigrants. The changes observed in the study area up to present suggest that just this direction of the succession will be the most probable in the majority of the within-dike area.

At some places (mostly large urban parks in alluvia), where the regular floods were stopped, but the ground water level remained relatively high, and the community is exposed to continuous influence of other anthropogenic disturbing factors a Carabid community arises, which preserves more or less a species spectrum characteristic for floodplain forests, but with a low alpha-diversity. Such communities are characterised by a very high dominance of *Platynus assimilis* and *Patrobis excavatus* or, less frequently, by *Platynus assimilis* and *Nebria brevicollis*. This direction of succession is also possible in some more humid of the within-dike area, which will remain more humid.

4. A completely different problem is represented by the highly specialized and dynamic Carabid communities inhabiting narrow zones on sandy, loamy or gravelly terraces in direct contact with water tabel. The fluctuating water level in the Danube branches offered excelent conditions for their development. The constantly high water level in the branches supplied for in intake device limits considerably the extent of microhabitats suitable for these communities and their survival chance in the remainders of the Danube inland delta.

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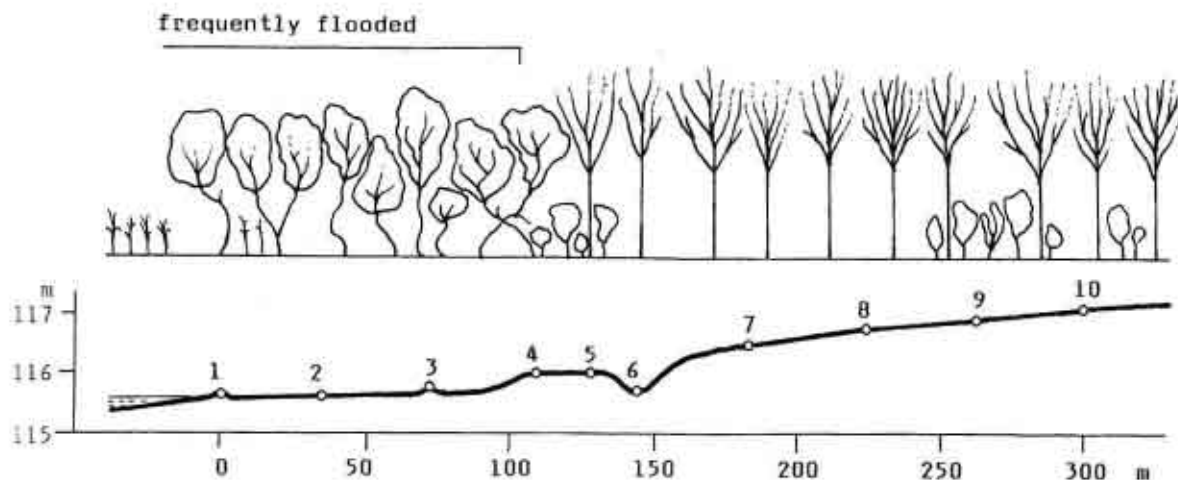


Fig. 1. Arrangement of 10 pitfall traps along a moisture and vegetation gradient (seminatural Salicetum with admixed reed on the margins and poplar monoculture) in Kráfovská lúka (abscissa - length of traps line and distance between traps, ordinate - altitude)

Locality	Pseudophonus rufipes							Psephenus cupreus						
	1986	1989	1990	1991	1992	1993	1994	1986	1989	1990	1991	1992	1993	1994
Wrušov	-	6	0	0	0	2	17	-	0	0	0	0	5	0
Šulaj	-	-	-	1	6	8	7	-	-	-	0	3	0	0
Bodická brána	-	-	-	1	0	6	7	-	-	-	0	0	1	1
Kráf. lúka	1	0	0	1	0	0	-	0	2	2	0	0	17	-
Istragov	-	0	0	1	1	2	-	-	0	0	0	0	1	-

Tab. 1. Increase in intensity of penetration of two xenocoenous Carabidae species into five floodplain forest communities in the within-dike area.

Locality	Pterostichus melanarius							Pterostichus niger						
	1986	1989	1990	1991	1992	1993	1994	1986	1989	1990	1991	1992	1993	1994
Wrušov	-	1	3	17	8	11	19	-	8	16	16	108	13	27
Šulaj	-	-	-	172	46	501	117	-	-	-	31	194	467	86
Bodická brána	-	-	-	140	208	553	261	-	-	-	140	592	390	201
Kráf. lúka	16	7	6	28	71	233	-	10	35	11	13	147	768	-
Istragov	-	2	50	41	36	54	-	-	1	49	102	108	62	-

Tab. 2. Increase of the abundance of two moderately hygrophilous Carabidae species in five floodplain forest communities in the within-dike area.

Species	Year	Sampling points on the moisture and vegetation gradient									
		1	2	3	4	5	6	7	8	9	10
<i>A. fuliginosum</i>	86	4	5	-	1	2	-	2	2	1	-
	89	1	2	5	1	7	2	1	-	1	2
	90	-	-	-	-	-	-	-	-	-	-
	91	-	-	-	-	-	-	-	-	-	-
	92	-	-	-	-	-	-	-	-	-	-
<i>A. micans</i>	86	-	-	-	-	2	2	-	-	-	-
	89	-	1	-	5	10	8	1	3	1	1
	90	4	-	2	-	-	5	2	1	2	1
	91	-	-	2	-	-	6	-	1	-	-
	92	9	5	6	12	2	5	1	1	1	-
<i>A. moestum</i>	86	-	-	-	7	12	38	9	3	5	-
	89	-	-	-	-	1	-	2	1	1	-
	90	-	-	-	1	2	7	1	-	1	-
	91	-	-	-	-	1	-	-	1	1	-
	92	2	1	-	-	4	-	1	-	1	-
<i>B. dentellus</i>	86	-	-	-	1	-	-	-	-	-	-
	89	4	3	3	1	1	2	1	2	8	-
	90	-	-	-	-	-	-	-	-	-	-
	91	-	-	-	-	-	1	2	1	-	-
	92	6	21	2	7	-	-	-	1	-	-
<i>C. granulatus</i>	86	7	1	3	-	-	21	8	2	1	1
	89	-	0	6	6	25	7	8	7	3	18
	90	9	10	13	2	35	59	4	6	2	13
	91	-	29	9	9	14	-	18	9	-	-
	92	8	23	41	24	36	91	31	79	24	37
<i>P. niger</i>	86	1	1	2	-	2	9	1	-	-	-
	89	-	-	-	-	1	-	1	7	3	45
	90	-	-	2	2	-	5	1	-	-	-
	91	-	-	-	-	-	7	1	5	-	-
	92	1	20	8	32	27	9	15	13	7	10
<i>P. melanarius</i>	86	-	-	1	-	-	15	1	-	-	-
	89	-	-	-	-	1	-	-	1	-	5
	90	-	-	-	-	-	-	-	1	1	1
	91	2	-	1	-	12	2	4	3	2	1
	92	-	6	5	7	18	3	11	6	2	8
93	13	8	69	9	78	10	12	28	1	7	

Tab. 3. Changes in the representation and spatial distribution of four strongly hygrophilous species (*Agonum fuliginosum*, *A. micans*, *A. moestum* and *Bembidion dentellum*) and of one tolerant (*Carabus granulatus*) and two moderately hygrophilous (*Pterostichus niger* and *P. melanarius*) species along the moisture and vegetation gradient in Královská lúka.