Ground Beetle Communities (Coleoptera: Carabidae) on the Banks of Two Rivers in the Eastern Carpathians, the Ukraine

Stephan Niemeier, Michael Reich and Harald Plachter

Synopsis

We studied the ground beetle communities (Coleoptera: Carabidae) on the river banks of two rivers in the Western Ukraine: the Upper Dniester river (4 sites) and the Stryj river (1 site). 13 009 Individuals, representing 80 species, were collected on defined plots within five habitat types. Mean abundance during summer and autumn 1995 ranged between 89,6 ind./m^2 (s = 52,2) on the outer banks of Dniester IV and 0,2 ind./m^2 (s = 0,3) on the mudbanks of Dniester III. The ground beetle communities of the 4 Dniester sites differ significantly from the site at the Stryj river, probably due to variations in flood frequency and magnitude. The species sets of the Ukrainian sites are compared to sites at the Isar, Lech and Danube rivers (Germany, Bavaria). Generally, the sets of stenotopic riparian species of the Ukrainian sites are very similar to those of the Upper Isar. At sites along lower reaches of Isar, Lech and Danube, although at comparable altitudes above sea level, only fragment variants of the communities recorded from the Ukrainian rivers are present, probably due to river regulation.

Ground beetles, Carabidae, floodplains, Ukraine, Dniester, Stryj, Carpathians

Carabidae, Aue, Ukraine, Dniester, Stryj, Karpaten

1 Introduction

Floodplains of large rivers rank among the world's most endangered ecosystems. More than two thirds of the total discharge of the 139 largest river systems in the northern third of the world is strongly or moderately affected by straightening, fragmentation of the river channels by dams and changes of hydrology (DYNESIUS & NILSSON 1994). Reservoirs, dams, embankments, drainage and straightening of rivers are not only leading to incision of the river-bed and lowering of the ground water table, but also to a disconnection of the interactions between the river and the floodplain (BAXTER 1977, PETTS & al. 1989, PLACHTER 1993, REICH 1994). Landuse and management in the former Soviet Union was different to that in Western and Central Europe until about 1990. In fact, river regulation in this area suffered massive impacts by reservoirs and longitudinal embankments too, mainly on the plains (DYNESIUS & NILSSON 1994). But low population densities and a lack of financial and technological resources resulted in a low level of structural impact on rivers in many other regions. As far as hydrological dynamics are concerned, these rivers are therefore in a fairly natural state.

The immense ecological changes in Central European rivers and their floodplains, caused by human impacts during the past decades, are fairly well recorded (eg. CIPRA 1992). But it is very difficult to specify the significance of single factors or groups of factors, for structural and substantial impacts have always been present in combination. We therefore investigated two river stretches in colline landscapes in the Western Ukraine, both unchanged or hardly affected by structural impacts, with regard to the effects of water management measures on the invertebrate fauna of the river banks. To assess the significance of these impacts, the results were compared to data from Central European alpine and prealpine rivers. We focused on the ground beetle communities (Carabidae) because of their sensitive reaction to changes in hydrological regime and habitat configuration (PLACHTER 1986a & b, HERING 1995, MANDERBACH & REICH 1995).

2 Study sites and methods

The study sites are located on the floodplains of the Upper Dniester river near the village Starij Sambir and of the Stryj river approximately 10 km upstream from the town Stryj, at the foot of the Ukrainian Carpathians (Fig. 1).

The investigation areas are situated in the transition of montane to colline range (386 m above sea level, Dniester I, to 324 m, Dniester IV, and 309 m, Stryj). The incline of the Dniester river lies between 5,8 ‰ in the upper area to 2,3 ‰ in the Precarpathian lowlands. The Stryj river incline is about 5,8 ‰. The floodplain of the Dniester river is between 70 m (Dniester I) and more than 500 m (Dniester IV) wide. The Stryj floodplain extends to about 600 m.

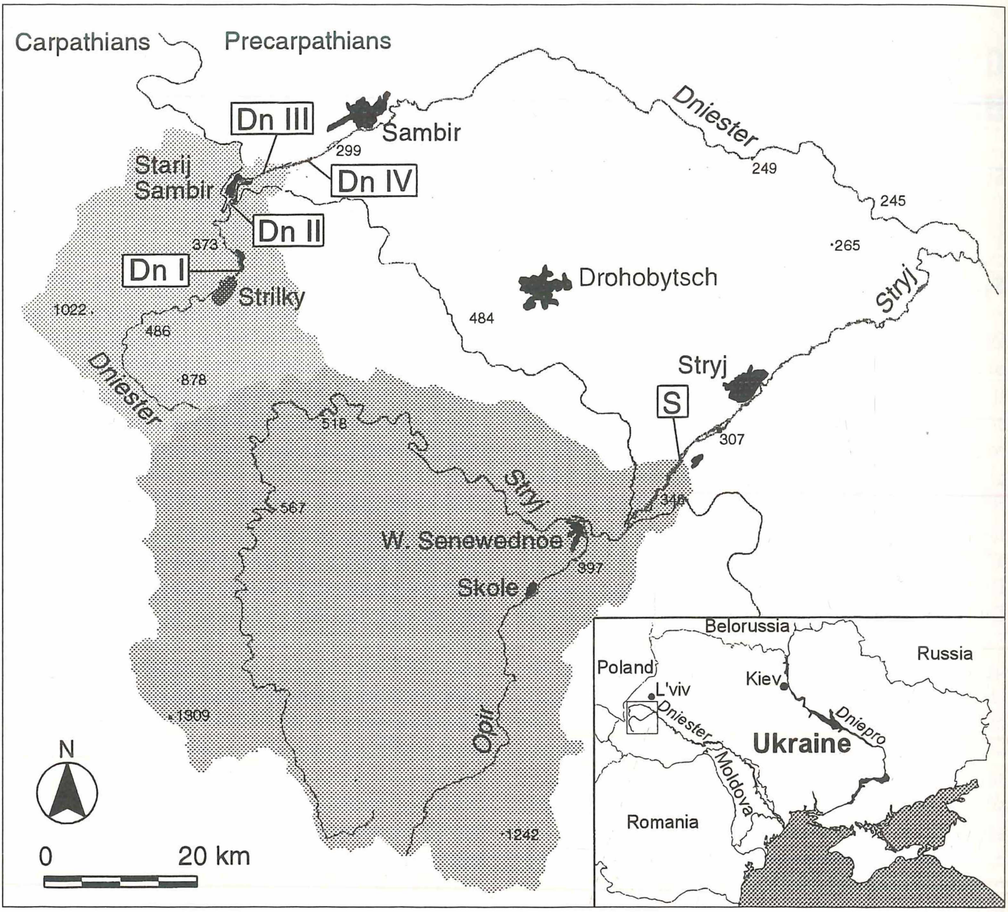

Fig. 1

Map of the study sites in the Eastern Carpathians, Ukraine. Dn I - Dn IV = study sites at the Dniester, S = study site at the Stryj. Catchment areas of the Upper Dniester and the Stryj are shaded.

Neither rivers are affected by dams or embankments upstream. The river Stryj has a larger headwater catchment (~ 3300 km^2 at the study site) than the Dniester river (850 km^2 at Sambir). Therefore, they differ considerably in hydrological characteristics (Tab. 1). A higher mean annual discharge, a larger amplitude between high water and low water level and more frequent flood events give the river Stryj higher habitat dynamics on its floodplains. For both rivers the most violent spring floods occur in early May. Regarding the water regime, the Stryj fits more into the classification of a mountainous river, whereas the Dniester has more of a low mountain range character (GUSTARD 1992, KARL & al. 1977, WARD 1992).

All study sites are situated on gravel banks or gravel bars. Vegetation is absent or only sparsely present. Five habitat types are distinguished in cross-sections along the floodplain (Fig. 2):

- **outer banks**: steep gravel banks, mainly consisting of coarse gravel (> 63 mm in diameter). Vegetation cover is less than 10 %.
- **lower point bars**: flat gravel bars without vegetation, frequently inundated. Consisting of more fine-grained gravel (2–63 mm in diameter) at the Dniester river, and of coarse gravel at Stryj river.
- **upper point bars**: flat gravel bars, not inundated at mean annual discharge. Variable portions of gravel and fine sediments (< 2 mm in diameter). Vegetation constituted at the Dniester river mainly by *Barbarea-vulgaris-Artemisia-absinthium*-communities, at the Stryj river by pioneer communities, dominated by *Echium vulgare.*
- **lower floodplain terraces**: gravel bars, which are flooded only at high water level. Vegetation cover 5 to 50 %.

River		Dniester		Stryj & Opir	Upper Isar	
Station		Strilky	Sambir	W. Senewednoe & Skole	Mitten-wald	Bad Tölz
Period		1985–1989		1985–1989	1931–1960	
	LDD (m^3/s)	0,2	0,5	4,9	2,3	5,0
Summer	MLDD (m^3/s)	1,4	4,6	15,7	4,2	9,1
Winter	MLDD (m^3/s)	0,8	2,2	6,9	8,1	13,2
Year	MLDD (m^3/s)	0,8	2,2	6,9	4,2	8,9
Summer	MDD (m^3/s)	6,3	13,3	73,7	7,4	25,0
Winter	MDD (m^3/s)	4,6	8,9	40,9	16,8	44,7
Year	**MDD (m^3/s)**	**5,5**	**11,1**	**57,3**	**12,2**	**34,9**
Summer	MHDD (m^3/s)	70,6	151,7	722,8	22,1	187,0
Winter	MHDD (m^3/s)	29,5	56,1	434,7	55,5	435,0
Year	MHDD (m^3/s)	70,6	155,0	777,6	56,1	441,0
Summer	HDD (m^3/s)	145,0	233,0	1722,0	62,4	552,0
Winter	HDD (m^3/s)	41,0	69,1	736,0	125,0	897,0
Year	HDD (m^3/s)	145,0	233,0	1722,0	125,0	897,0
	MHDD/MLDD	91,7	69,5	113,2	13,5	49,4

Table 1
Hydrological characteristics of the rivers Dniester, Stryj and Isar; LDD = Lowest daily discharge, MLDD = Mean lowest daily discharge, MDD = Mean daily discharge, MHDD = Mean highest daily discharge, HDD = Highest daily discharge, MHDD/MLDD = Amplitude between highest and lowest daily discharge. Sources: UKRAINIAN STATE HYDROLOGICAL STATIONS of the district L'viv 1995, pers. comm., BAYERISCHES STAATSMINISTERIUM FÜR LANDESENTWICKLUNG UND UMWELTFRAGEN 1979. Data from Stryj river downstream the Opir are not available. Therefore the sum of the discharges of the Upper Stryj and the Opir are given. Location of the Ukrainian stations at Dniester, Stryi and the tributary Opir see Fig. 1.

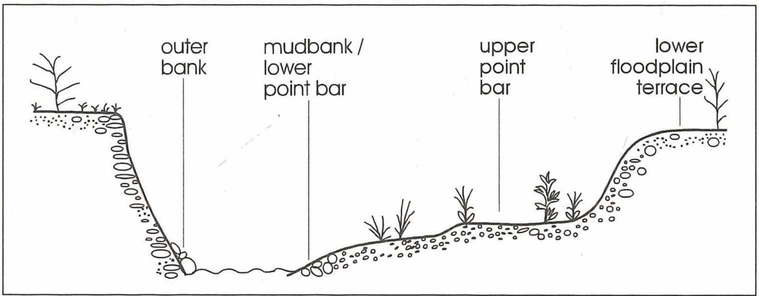

Fig. 2
Schematic cross-section of the Dniester and Stryj floodplains, classifying five types of habitats.

- **mudbanks**: similar position to the lower point bar but with a layer of at least 2 cm of mud. Vegetation dominated by *Polygonum spec.*, which covers 2 to 5 % of the area.

All study sites were investigated three times between the beginning of June and end of September 1995. Quantitative investigations of the invertebrates were conducted by individual catches on defined plots (2,51 m^2) (MANDERBACH & REICH 1995). For every habitat type and study site 15 plots were sampled, except the habitat mudbank (6 plots/ study site). Nomenclature is used according to KRYZHANOVSKIJ & al. (1995).

The significance of the difference of ground beetle abundances between habitats was tested by the MANN-WHITNEY-U-test. The qualitative comparison of species sets is based on SØRENSEN's index and the quantitative one on percentage similarity according to RENKONEN. For the latter, mean abundances in the habitats of each study site were used. Cluster analyses were conducted with PC-Ord (UPGMA-linkage).

3 Results

3.1 General differences

In total, 13 009 ground beetles from 80 species were collected. Between 42 and 58 species had been present at the study sites at Dniester river, but only 27 at the study site at Stryi river (Table 2). Only one species, *Amara equestris* (DFT.), was exclusively recorded from the Stryi river.

Table 2
Number of riparian ground beetle species in the study sites Dniester (Dn) I to IV and Stryj. – Riparian species include eurytopic and stenotopic species clearly associated with river banks according to BURMEISTER (1939), KOCH (1989) and WALDERT (1991).

	Dn I	Dn II	Dn III	Dn IV	Dniester, total	Stryj
Total number of species (n = 80)	48	58	42	48	79	27
Riparian species	44	46	35	43	63	27
Stenotopic riparian species	14	18	18	16	19	15

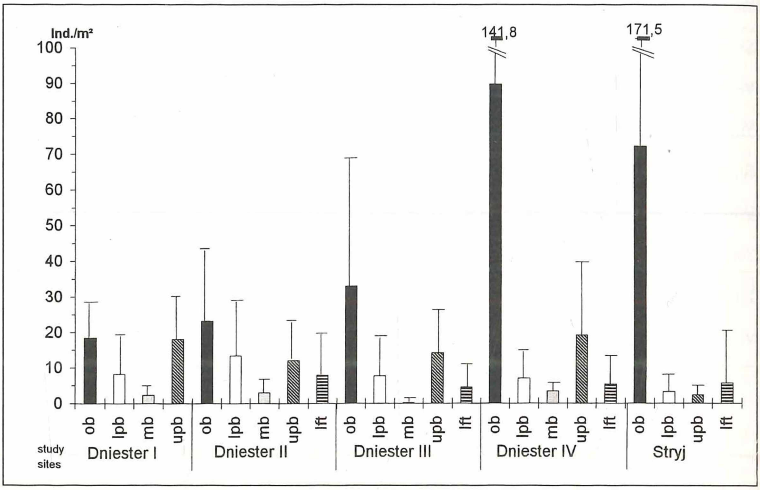

Fig. 3
Mean abundances of ground beetles in the habitats. ob = outer banks, lpb = lower point bars, mb = mudbanks, upb = upper point bars, lft = lower floodplain terraces. Standard deviation is given above the columns.

The ground beetle assemblages of the Dniester and the Stryj river differ considerably. At the Dniester river, more stenotopic riparian species were present, but at the Stryj river the proportion of riparian species is much higher (56 %). Species numbers per habitat type were consistantly higher at the Dniester sites than at the Stryj site.

3.2 Abundances

On the outer banks ground beetle abundances were significantly higher ($p \leq 0,03$) than on the lower point bars and the mudbanks (Fig. 3). Mean abundance ranged between 89,6 ind./m^2 (s = 52,2; n = 15) on the outer banks of Dniester IV and 0,2 ind./m^2 (s = 0,3; n = 6) on the mudbanks of Dniester III. The higher abundances on the outer banks compared to the upper point bars are only significant at the study sites Dniester IV and Stryj ($p < 0,0001$).

3.3 Spatial differenciation of the communities

We selected the 38 most frequent species (at least 8 ind./species) which include the stenotopic riparian species occuring in low densities, but exclude only randomly collected species. Cluster analysis divides this set into two major groups (Fig. 4). Group I comprises species which mainly occur right on the waterfront (outer banks, lower point bars and mudbanks), while species inhabiting irregularily or rarely flooded habitats (upper point bars, lower floodplain terraces) are arranged in group II.

3.4 Habitat preferences

Species sets of the defined habitat types only differ significantly near to the water-line. *Bembidion scapulare* and *Bembidion ruficorne* are almost exclusively restricted to the outer banks of the Stryj river (see group 1 in Fig. 4). Further species were present at both rivers but clearly prefer habitats near to the water-line, too (group 2 in Fig. 4). Group 3 comprises species preferring lower point bars. The habitat preferences of *Clivina collaris* and *Tachys micros*, arranged in group 4, are vague. Group 5 mainly consists of species, which are affiliated to mudbanks. Thus, at the Stryj river, some of these species are missing (*Elaphrus riparius, Dyschirius digitatus, Agonum marginatum, Bembidion azurescens*) or occur only in very low densities (*Bembidion varium, Bembidion articulatum*). Species of group 7 prefer the upper point bars and the lower floodplain ter-

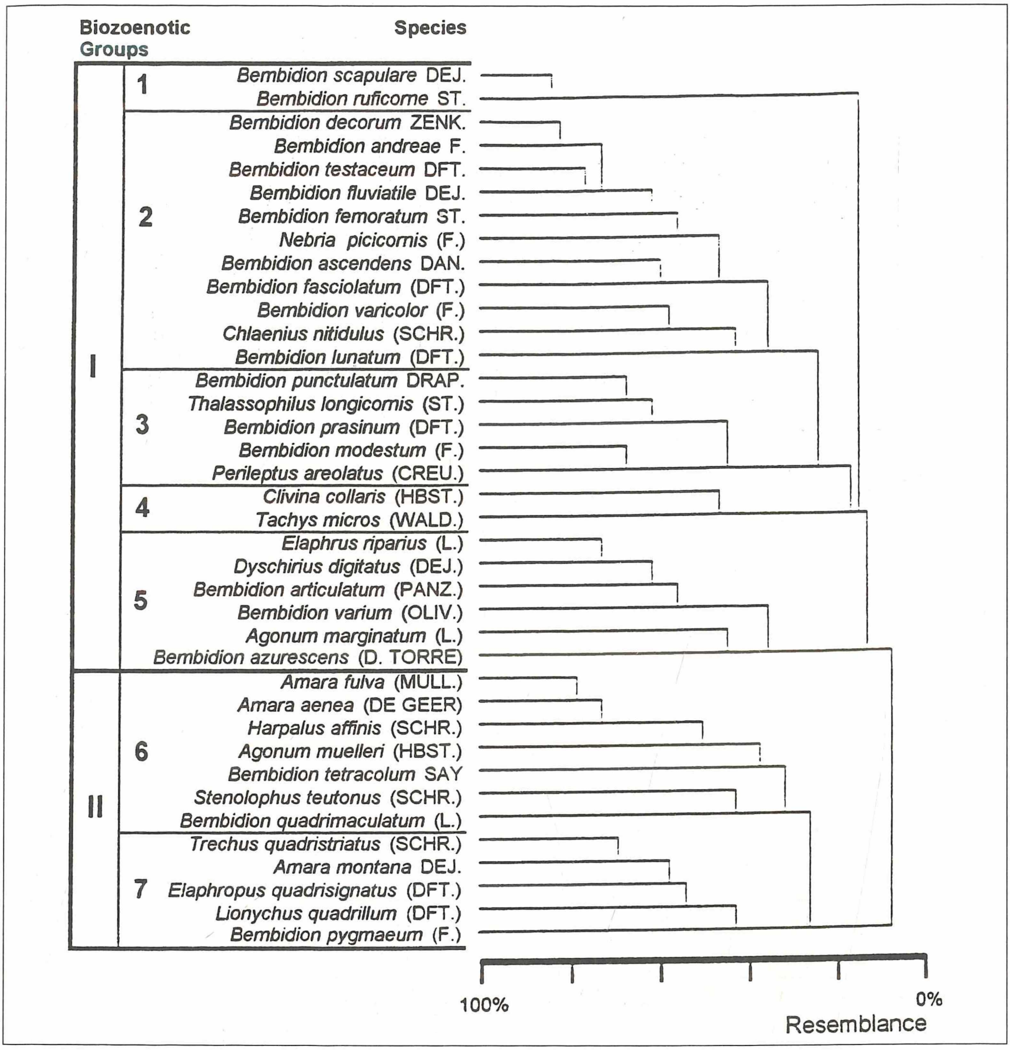

Fig. 4
Clusters of similiar occurences of ground beetle species (at least 8 individuals recorded) in the five habitat types of each study site at Dniester and Stryj. Based on percentage similarity (RENKONEN index) of the mean abundances of the species. UPGMA-Linkage. Cophenetic coefficient CI = 0.7768. 23 stations of habitats, 38 species.

races and avoid frequently flooded habitats. Set 6 comprises species which occur more randomly. They are recorded from all habitat types but moderately prefer upper point bars and lower floodplain terraces.

4 Comparison with river banks at Isar, Lech and Danube

Valid data on ground beetle communities are already available from river banks of the Isar, Lech and Upper Danube rivers (Bavaria, Germany) (MANDERBACH & REICH 1995, PLACHTER 1986a & b). The authors used comparable methods (individual catches). The habitat configurations especially on the Isar are very similar to that of the Dniester and Stryj river, although the alitudes differ considerably (cf. Fig. 5).

Data from different sites at these river systems are compared by cluster analysis (Fig. 5). In general, the species sets are quite similar, indicating their affiliation to the same biogeographical realm (BURMEISTER 1939; WALTER & BRECKLE 1994).

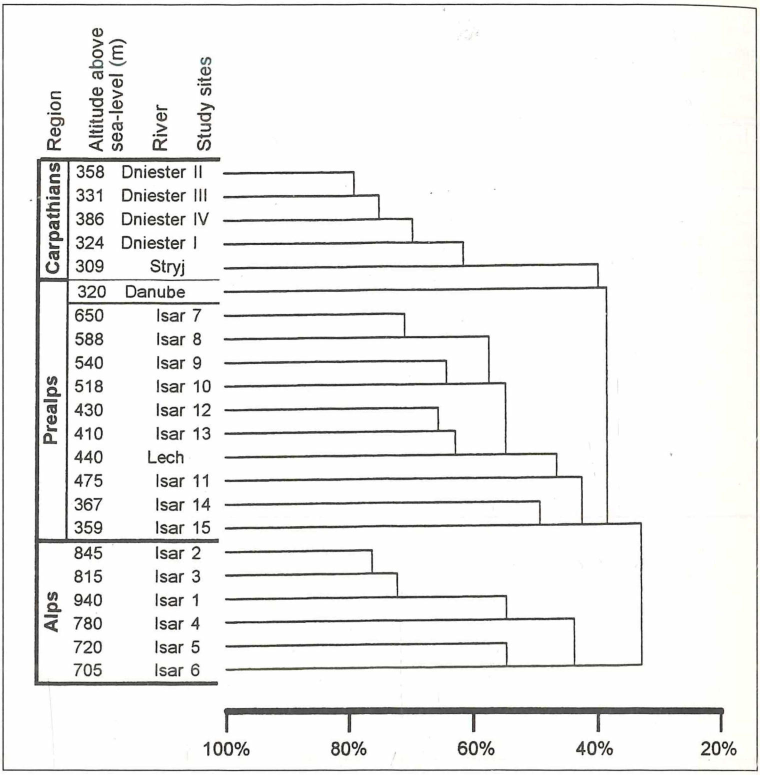

Fig. 5
Cluster of similarity of ground beetle communities (SØRENSEN-Index) of the study sites at Dniester, Stryj and Isar. Location of the sites of investigation cf. Table 3. UPGMA-Linkage. Cophenetic coefficient CI = 0.8012. 20 study sites, based on 128 species. Lines between river and study sites separate groups of most similiar species sets.

The Carpathian sites are grouped together with the Danube site, and show higher similarities to the prealpine sites of Isar and Lech than to the alpine ones.

However, many stenotopic riparian species which are at the German rivers restricted to the upper sites of the Isar river are present at the Ukrainian rivers at lower altitudes, too (eg. *Bembidion fasciolatum, Bembidion modestum, Bembidion scapulare, Nebria picicornis, Perileptus areolatus* or *Thalassophilus longicornis*).

Most of the species which were not found at the Dniester or the Stryj river are as well restricted to the upper sites of the Isar river. They might be really adapted to alpine environments (eg. *Asaphidion caraboides, Bembidion complanatum, Bembidion distinguendum, Bembidion longipes, Bembidion terminale* or *Elaphrus ullrichi*) (Table 3).

5 Discussion

Although many species are present at both Ukrainian rivers, the ground beetle communities of the Dniester and the Stryj river differ considerably. Presumably, the determining factors are the different river morphology and the more frequent and higher floods of the Stryj river. The high abundances of ground beetles on the outer banks might be caused by a better food supply. On the outer banks current velocity is generally higher. Therefore, the biomass of aquatic insects emerging or drifting ashore may increase. Riparian ground beetles mainly feed on aquatic insects along the shore line (HERING & PLACHTER 1997).

Generally, the stenotopic riparian species of the Ukrainian sites resemble very much those of the Isar and the Lech river (MANDERBACH & REICH 1995, PLACHTER 1986a & b, WALDERT 1991). The Ukrainian rivers, especially the Stryj river are almost not affected by river regulations. Thus, the species found there, could be regarded as the »natural« set of ground beetles at the lower reaches of mountainous rivers. Compared to this, the species sets of the lower reaches of the Isar river as well as the Lech and Danube sites has to be regarded as »fragment variants« of the previous natural ones. Most stenotopic riparian species are missing there. The fact that many of them are present at the Eastern Carpathian rivers raises doubts as to whether their current classification as »montane« species is correct (BURMEISTER 1939, FREUDE & al. 1976, KOCH 1989, MARGGI 1992).

The situation at the Dniester and the Stryj rivers once again indicates the importance of natural flood dynamics and channel morphology for the composition of riparian communities (PLACHTER 1996). Both rivers belong to the few European river systems still not substantially impacted by weirs and dams. Thus, the protection of the given state is of importance beyond the region.

Acknowledgements

This investigation was conducted within the international research programme »Ecological Analysis and Nature Conservation Evaluation of the Landscapes of

Table 3

Stenotopic riparian species of the Dniester (Dn I - Dn IV) and the Stryj river (S) compared with data from the Isar (Is 1 – Is 15), the Lech (Le) and the Danube river (Da). Data from MANDERBACH & REICH (1995) (Site code of the original publication: M I - M V), PLACHTER (1986 a & b) (Site code: P 1 – P 12). The sites at the Isar river are listed according to decending altitude. M I to M V are situated in the alpine region, P 10 is on an altitude of about 359 m above sea level. Classification according to BURMEISTER (1939), KOCH (1989) and WALDERT (1991).

Region	Carpathians					Alps						Prealps										
Study sites	Dn I	Dn II	Dn III	Dn IV	S	Is 1	Is 2	Is 3	Is 4	Is 5	Is 6	Is 7	Is 8	Is 9	Is 10	Is 11	Is 12	Is 13	Is 14	Is 15	Le	Da
Site code of the original publication						M I	M II	M III	P 1	M IV	M V	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	P 11	P 12
Bembidion andreae (F.)	x	x	x	x	x	x	x	x	x		x	x	x	x	x						x	
Bembidion ascendens DANIEL	x	x	x	x	x	x	x	x		x	x	x	x	x			x	x		x		
Bembidion atroviolaceus DUFOUR			x			x																
Bembidion azurescens TORRE		x	x	x			x	x														
Bembidion decorum (ZENKER)	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Bembidion fasciolatum (DFT.)	x	x	x	x	x	x	x	x	x			x	x	x			x	x	x		x	
Bembidion modestum (F.)	x	x	x	x	x			x														
Bembidion punctulatum DRAP.	x	x	x	x	x							x	x	x	x		x	x	x	x	x	x
Bembidion ruficorne ST.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Bembidion scapulare DEJ.	x	x	x	x	x	x	x	x														
Bembidion testaceum DFT.	x	x	x	x	x	x	x	x	x	x		x	x	x	x				x	x	x	x
Bembidion varicolor (F.)	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	
Lionychus quadrillum (DFT.)	x	x	x	x	x																	x
Nebria picicornis (F.)	x	x	x	x		x	x	x	x	x	x	x	x								x	
Perileptus areolatus (CREU.)	x	x	x	x	x					x			x									x
Thalassophilus longicornis (ST.)	x	x	x	x	x			x	x													
Bembidion fluviatile DEJ.		x	x	x	x																	
Bembidion foraminosum ST.		x			x																	
Elaphropus diabrachys (KOL.)		x	x																			
Asaphidion caraboides (SCHR.)						x	x	x														
Bembidion complanatum HEER						x																
Bembidion conforme DEJ.						x	x	x	x	x	x	x	x								x	
Bembidion decoratum (DFT.)									x	x	x	x	x	x	x	x	x	x	x		x	
Bembidion distinguendum DU VAL.							x	x	x													
Bembidion doderoi GANGLB.								x														
Bembidion fulvipes ST.						x	x	x	x			x										
Bembidion geniculatum HEER						x				x												
Bembidion longipes DANIEL						x																
Bembidion monticola ST.						x	x	x					x	x				x				
Bembidion schüppeli DEJ:													x	x	x		x	x				
Bembidion terminale HEER						x	x	x	x													
Bembidion tibiale (DFT.)						x	x	x	x	x	x	x		x		x	x	x	x			
Dyschirius similis PETRI						x	x	x														
Dyschirius uliginosus PUTZ.								x														
Elaphrus ullrichi REDT.						x		x														
Nebria gyllenhali SCHOEN.																					x	
number of stenotopic riparian species	14	18	18	16	15	20	18	23	13	11	9	13	14	12	8	4	9	9	7	4	9	4
number of recorded species (n = 128)	48	58	42	48	27	30	30	33	19	20	20	27	38	26	19	22	33	22	34	19	27	20

the Upper and Central Dniester river and its contributaries«, funded by the German Ministery for Science, Education, Research and Technology (BMBF, grant No. 0339 560) and the Donors Association for the Promotion of Science and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft). We are very grateful to R. Manderbach, Prof. Dr. G. Müller-Motzfeld and Dr. F. Hieke for taxonomic guidance. Mr. J. Audsley stylistically revised the manuscript.

References

BAXTER, R.M., 1977: Environmental effects of dams and impoundments. – Ann. Rev. Ecol. Syst. 8: 255–283.

BAYERISCHES STAATSMINISTERIUM FÜR LANDESENTWICKLUNG UND UMWELTFRAGEN, ed., 1979: Wasserwirtschaftlicher Rahmenplan Isar. – 2 Bd., München.

BURMEISTER, F., 1939: Biologie, Ökologie und Verbreitung der europäischen Käfer, Bd. 1, Adephaga. – Krefeld: 307 S.

CIPRA (ed.) 1992: Die letzten naturnahen Alpenflüsse. – Kleine Schriften Internationale Alpenschutz-Kommission 11/92: 1–71.

DYNESIUS, M. & C. NILSSON, 1994: Fragmentation and flow regulation of river systems in the northern third of the world. – Science 266: 753–762.

FREUDE, H., K. W. HARDE & G. A. LOHSE, 1976: Die Käfer Mitteleuropas, Bd. 2, Adephaga 1. – Krefeld: 302 S.

GUSTARD, A., 1992: Analysis of river regimes. – In: P. CALOW & G. E. PETTS, eds.: The rivers handbook, Vol. 1: 29–47, Blackwell Scient. Publ., London etc.

HERING, D., 1995: Nahrung und Nahrungskonkurrenz von Laufkäfern und Ameisen in einer nordalpinen Wildflußaue. – Arch. Hydrobiol. Suppl. 101 (Large Rivers 9): 439–453.

HERING, D. & H. PLACHTER, 1997: Riparian ground beetles (Coleoptera, Carabidae) preying on aquatic invertebrates: a feeding strategy in alpine floodplains. – Oecologia 110 (accepted)

KARL, J., J. MANGELSDORF & K. SCHEURMANN, 1977: Die Isar, ein Gebirgsfluß zwischen Natur und Zivilisation. – Jb. Ver. Schutz d. Bergwelt 42: 175–214.

KOCH, K., 1989: Die Käfer Mitteleuropas, Ökologie 1. – Krefeld: 440 S.

KRYZHANOVSKIJ, O. L., I.A. BELOUSOV, I. I. KABAK, B. M. KATAEV, K. V. MAKAROV & V. G. SHILENKOV, 1995: A checklist of the groundbeetles of Russia and adjacent lands (Insecta, Coleoptera, Carabidae). – Pensoft Series Faunistica No. 3, Sofia-Moscow: 271 S.

MANDERBACH, R. & M. REICH, 1995: Auswirkungen großer Querbauwerke auf die Laufkäferzönosen (Coleopterea, Carabidae) von Umlagerungsstrecken der Oberen Isar. – Arch. Hydrobiol. Suppl. 101 (Large Rivers 9): 573–588.

MARGGI, W.A., 1992: Faunistik der Sandlaufkäfer und Laufkäfer der Schweiz (Cicindelidae & Carabidae) Coleoptera 1. – Documenta Faunistica Helvetiae 13: 477 S.

PETTS, G. E., H. MÖLLER & A. L. ROUX, eds., 1989: Historical change of large alluvial rivers: Western Europe. – John Wiley & Sons, Chichester: 355 S.

PLACHTER, H., 1986 a: Composition of the Carabid beetle fauna of natural riverbanks and of manmade secondary habitats. – In: BOER, P. J. den, M. L. LUFF, D. MOSSAKOWSKI & F. WEBER, eds.: Carabid Beetles. Their adaptions and dynamics: 509–538; G. Fischer Verlag, Stuttgart.

PLACHTER, H., 1986 b: Die Fauna der Kies- und Schotterbänke dealpiner Flüsse und Empfehlungen für ihren Schutz. – Ber. Akad. f. Naturschutz u. Landschaftspfl. 10: 119–147.

PLACHTER, H., 1993: Alpine Wildflüsse. – Garten und Landschaft 4/1993: 47–52.

PLACHTER, H., 1996: Bedeutung und Schutz ökologischer Prozesse. – Verh. Ges. Ökol. 26: 287–303.

REICH, M., 1994: Les impacts de l'incision des rivières des alpes bavaroises sur les communautés terrestres de leur lit majeur. – Revue Géographie Lyon 69: 25–30.

WALDERT, R., 1991: Auswirkungen von wasserbaulichen Maßnahmen am Lech auf die Insektenfauna flußtypischer Biozönosen. – Augsburger Ökol. Schriften 2: 109–120.

WALTER, H. & S.-W. BRECKLE, 1994: Ökologie der Erde Bd. 3. Spezielle Ökologie der gemäßigten und arktischen Zonen Euro-Nordasiens. – Gustav Fischer Verlag, Stuttgart: 726 S.

WARD, J. V., 1992: A mountain river. – In: P. CALOW & G. E. PETTS, eds.: The rivers handbook, Vol. 1: 493–510, Blackwell Scient. Publ., London etc.

Address

Dipl. Biol. S. Niemeier
Dr. M. Reich
Prof. Dr. H. Plachter
Philipps-Universität Marburg
Faculty of Biology
Department for Nature Conservation
Lahnberge
D-35032 Marburg, Germany