Importance of riparian rove beetles (Coleoptera: Staphylinidae) as indicators for restoration processes

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Abstract

Rove beetles are an important component of the terrestrial arthropod communities of river banks. Species adapted to this dynamic habitat are highly specialized and stenotopic. Riparian staphylinid assemblages may be grouped into characteristic guilds according to their morphology and mode of life. Among the riparian specialists occur many rare and threatened species. These constitute useful indicators with high susceptibility to natural changes or anthropogenic impact. The rove beetle fauna of the River Lech, which is exceptionally diverse, and of the River Adige, which is impoverished, are analysed in view of restoration measures. Results from first monitorings of experimental revitalization measures on the River Adige are presented. Predictions about the changes in rove beetle assemblages on the river Lech and some of its tributaries after removal of sediment retention dams are attempted.

Keywords: river restoration, Coleoptera, Staphylinidae, riparian habitats, Alps, Austria, Italy

Introduction

The European Water Framework Directive aims at ecological integrity of river-floodplain systems based on hydromorphological and biotic parameters, the evaluation of which must reach beyond the active channel and its shoreline to include the surroundings (JUNGWIRTH et al. 2002). Most work in the past concentrated on aquatic groups, but investigations about terrestrial riverine arthropods and their correlation with the dynamic processes in flood plains have increased considerably during the last decades (e.g. ARMBRUSTER & REICH 2001, HERING 1995, HERING & PLACHTER 1997, MANDERBACH & REICH 1995, NIEMEIER et al. 1997, PAETZOLD et al. 2005, PLACHTER 1986). The fauna of dynamic riverine landscapes worldwide is reviewed by ROBINSON et al. (2002), the ecology of braided rivers by TOCKNER et al. (2006), and the riparian beetle fauna in Germany by KÖHLER (2000).

Rove beetles (Staphylinidae), ground beetles (Carabidae), spiders (Araneae), to a lesser degree ants (Formicidae) and running bugs (Saldidae), account for about 95% of the terrestrial arthropod communities

along river shores in Europe (e.g. KÜHNELT 1943, BOUMEZZOUGH 1983, BOUMEZZOUGH & MUSSO 1983, MANDERBACH & REICH 1995, PAETZOLD et al. 2005). Nevertheless, terrestrial arthropods have rarely been considered in the concepts for restoration measures. It is common practice to use (only) ground beetles as bioindicators, although they cannot always be assumed to show the same kind of response to changes as other taxonomic groups (RAINIO & NIEMELÄ 2003). Few investigations have treated all relevant arthropod groups at species level (e.g. PLACHTER 1986). The increase of knowledge about riparian staphylinid assemblages in the Alps has reached the stage where characteristic patterns can be recognized and used for the assessment of habitat quality (GERARDI & ZANETTI 1995, KAHLEN 1995, KAHLEN 2003, SCHATZ 1996, SCHATZ et al. 1990). Certainly the role of rove beetles within the riparian communities, especially the hypogeic zone (TOCKNER et al. 2006), has been largely disregarded until now.

A recent study in northern Italy (South Tyrol) encompassed (nearly) all biotic components of the flood plain of the river Adige ("Lebensraum Etsch": GALLMETZER et al. 2005, GLASER 2005, KOPF 2005, SCHATZ H. 2005, SCHATZ I. 2005, STEINBERGER 2005). Several projects in western Austria focussed on the River Lech (North Tyrol) as one of the last near-natural, braided rivers in the Alps ("Lech-Life": MORITZ et al. 2004, MUHAR et al. 2003, SCHATZ et al. 2003a). Results are used as a base for restoration measures carried out at present and in the near future. The importance of rove beetles as indicators for such measures will be emphasized in the present contribution.

Methods

A standardized combination of sampling methods during at least one full year by a team of workers specialized for the relevant arthropod taxa was applied on all the investigated streams and rivers in the western Austrian Alps and South Tyrol (Italy). This included pitfall trapping above high water mark, time-catches by hand, and sediment washing on the banks up to the water-line, as well as sifting of flood debris or plant litter, and extraction of litter samples. The riparian vegetation was sampled by sweep netting and beating of branches. Samples were chosen (from experience) for maximum species numbers instead of randomly, in order to obtain fairly complete species inventaries, including the strictly riparian and interstitial species in the amphibic zone.

Relative abundances are expressed as presence, frequency, and dominance values. Criteria for the assessment of habitat quality are species richness, diversity of guilds present, degree of stenotopy, and presence of rare and threatened species (red lists).

Habitat specificity of riparian rove beetles

Stenotopic ripicolous rove beetle species have habitat requirements which limit their occurrence to microhabitats within the river shore. The highest proportions of these species are observed close to the shoreline, with values above 60% at species level (Fig. 1) and well above 80% at individual level (KOPF et al 1999, PAETZOLD et al. 2005). Extreme abiotic and biotic conditions lead to special adaptations. Parameters determining habitat preference are mostly connected to river dynamics, such as incidence of disturbances, grain size of sediment, availability of food, and microclimate, all of which must accommodate the requirements for the whole life cycle of a species. Many biological data are still missing, but life histories and habitat preferences of many species are known from well documented collectings during the past decades (compiled by HORION 1963, 1965, 1967, KOCH 1989, KÖHLER 2000, LOTT 2003).

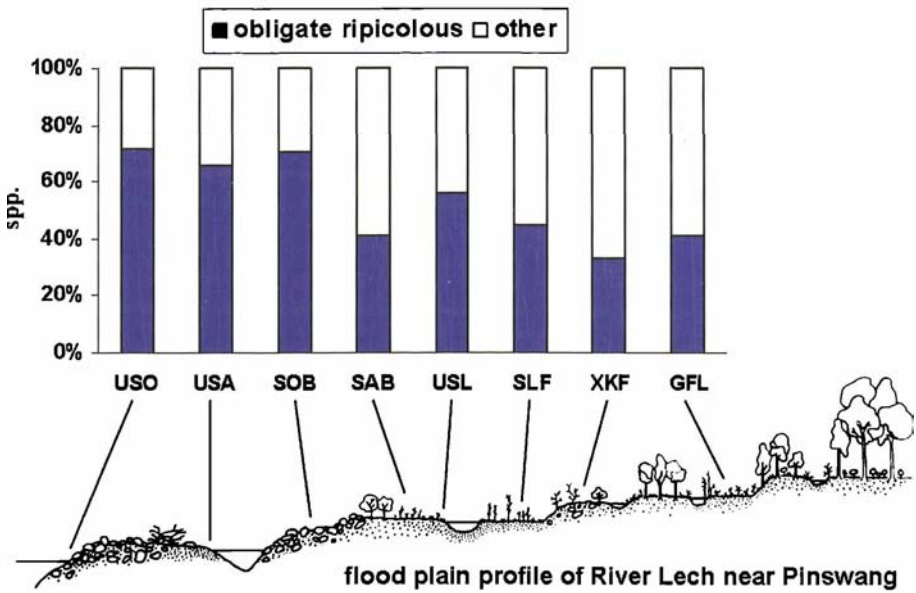

Fig. 1: Percentages of stenotopic ripicolous species of rove beetles (Staphylinidae) in riparian microhabitats on the River Lech near Pinswang (1998/99). USO: gravel shoreline, USA: sand shoreline, SOB: gravel bar, SAB: sand bar, USL: muddy shoreline of backwater, SLF: mudflat, XKF: xerothermic flat, GFL: grass flat.

Riparian staphylinid assemblages may be grouped into characteristic guilds, for microhabitat as well as food, according to their mode of life and morphology. Guilds, as defined in previous studies, reflect the way riparian rove beetles move, feed, disperse, and react to flooding events (SCHATZ I. 2005, SCHATZ et al. 2003b). Examples of representative species from the guilds referred to in this contribution are presented:

Diurnal epigeic predators, large eyed, macropterous (guild I): *Paederidus rubrothoracicus* and *P. rubrothoracicus* are both diurnal and highly active predators with visual orientation. They are ecological vicariants occurring on coarse and fine sediments respectively. *P. rubrothoracicus* is the more stenotopic species, restricted to gravel shores of braided alpine rivers (Fig. 2). Due to loss of habitat it is considered an endangered species in North and South Tyrol (KAHLEN 1987, KAHLEN et al. 1994).

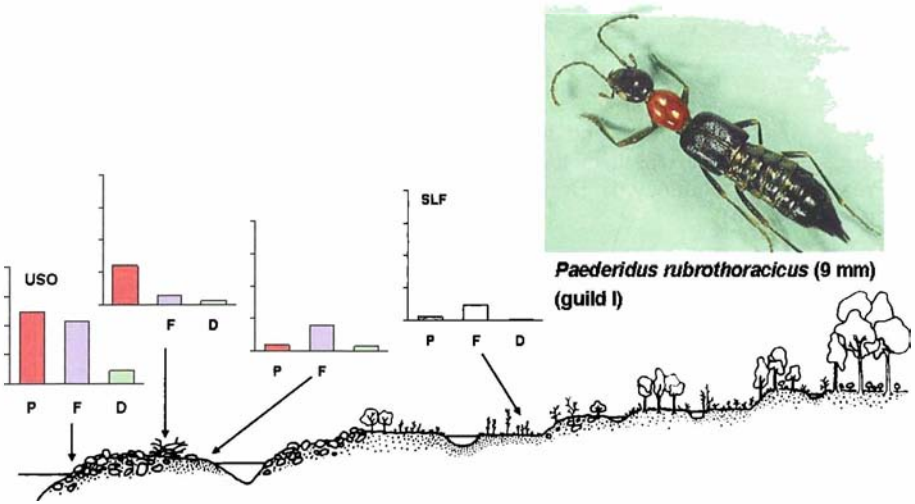

Fig. 2: Habitat specificity and preference of *Paederidus rubrothoracicus* (Staphylinidae), a representative of guild I, in the flood plain of the River Lech near Pinswang. P: Presence, F: Frequency, D: Dominance (y-axis: 100%). USO: gravel shoreline, USA: sand shoreline, UGE: plant debris (flotsam), SLF: mudflat.

Interstitial sediment dwellers, hypogeic, small, macropterous (guild II):

Aloconota spp. are the most frequent inhabitants of interstitial spaces in unsaturated riverine sediments, especially coarse sand and fine gravel. *Aloconota cambrica* is a montane species, widely distributed in the Alps, with marked habitat specificity (Fig. 3). Other important genera belonging to this guild are *Hydrosmecta, Ochthephilus, Thinobius*.

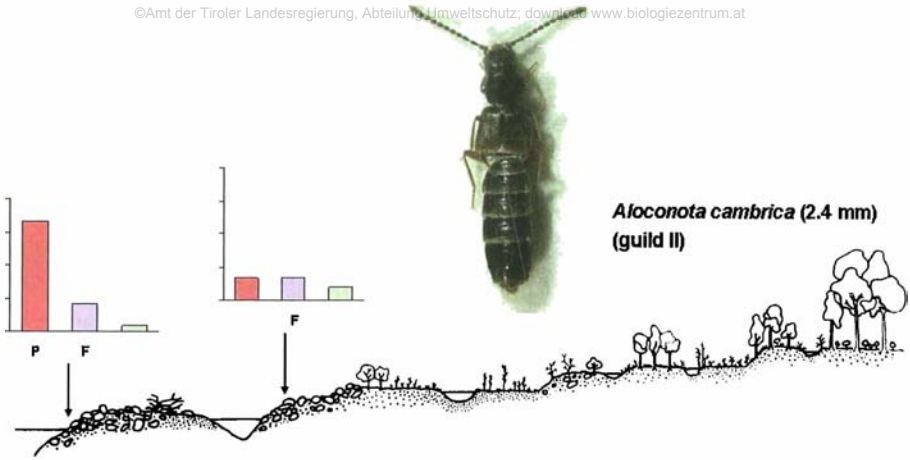

Fig. 3: Habitat specificity and preference of *Aloconota cambrica* (Staphylinidae), a representative of guild II, in the flood plain of the River Lech near Pinswang. P: Presence, F: Frequency, D: Dominance (y-axis: 100%). USO: gravel shoreline, SOB: gravel bar.

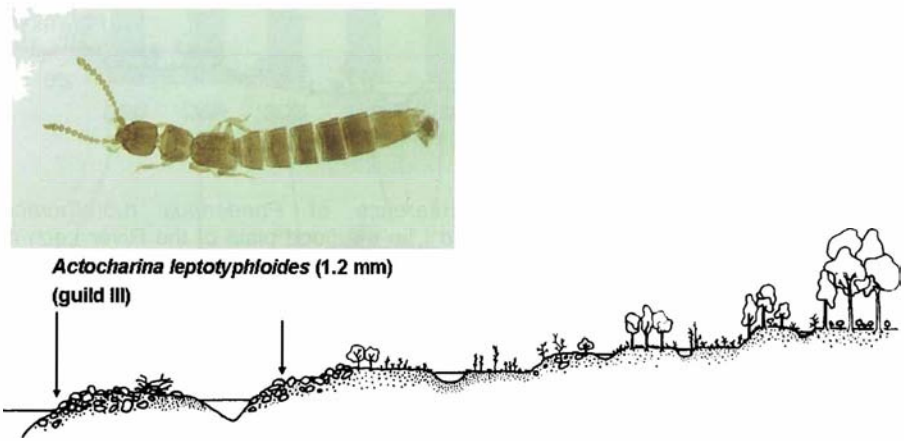

Fig. 4: Habitat specificity of *Actocharina leptotyphloides* (Staphylinidae), a representative of guild III, in the flood plain of the River Lech. USO: gravel shoreline, SOB: gravel bar.

Interstitial sediment dwellers, hypogeic, minute, apterous or brachypterous (guild III):
Actocharina leptotyphloides is a rarity in the Eastern Alps, where it occurs on lowland to montane rivers and streams in limestone. It seems to have disappeared from the River Adige in South Tyrol, but is still present in the floodplain of the River Lech (Fig. 4).

Burrowers in moist sand, silt or loam, feeding on algae, macropterous (guild IV):
Bledius is the *predominant* genus in this well defined and easily recognized guild. *Bledius fontinalis* occurs in the Alps from the montane to the alpine zone (Fig. 5).

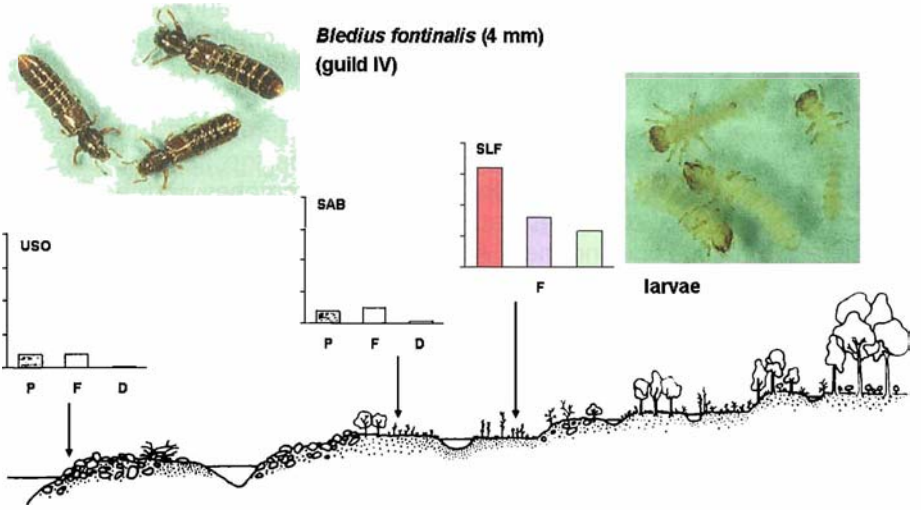

Fig. 5: Habitat specificity and preference of *Bledius fontinalis* (Staphylinidae), a representative of guild IV, in the flood plain of the River Lech near Pinswang. P: Presence, F: Frequency, D: Dominance (y-axis: 100%). USO: gravel shoreline, SAB: sand bar, SLF: mudflat.

Obligate ripicoles attracted to flotsam, macropterous or dimorphic (guild V):
Many species of rove beetles belonging to various genera aggregate in flotsam and plant debris accumulated on exposed riverine sediments and banks by floodings. They belong to different feeding types (predators, scavengers, fungivores) and are opportunistic colonizers, dispersing by flight or by floating on flotsam. Nevertheless they are closely bound to riverine habitats.

Semiaquatic ripicoles, flattened, macropterous or dimorphic (guild VI):

Geodromicus suturalis is almost exclusively found in coarse sediment or on rocky shores at *the* waterline and even in submerged moss (Fig. 6). Under

such conditions it may be quite frequent, but due to habitat loss it is considered a threatened species in North and South Tyrol (KAHLEN 1987, KAHLEN et al. 1994).

Guilds are useful to compare the fauna of river systems, even from different zoogeographical regions, avoiding bias by variant faunal composition (Fig. 7). In comparison with other rivers in the Alps, the rove beetle fauna of the River Lech in North Tyrol is exceptionally diverse, in species numbers as well as in guilds. The River Adige in South Tyrol harbours an impoverished fauna with a divergent composition of riverine guilds. The River Tagliamento is the most natural large river in the Alps and can be regarded as a model for comparisons. The difference between the two rivers on the southern edge of the Alps is evident. Species numbers within guilds I, II, and IV are reduced to half on the Adige, only guild V reaches a similar species number as on the Tagliamento. Guild II is the most significant indicator for a healthy hypogeic zone with interstitial spaces in exposed sediments of coarse grain size. Guild IV is present in moist sand or loam and riverine fen. Guild I requires open banks of coarse or fine sediment and guild V is the least susceptible to changes, as long as there are deposits of organic debris on the banks. The Tyrolean stretch of the River Lech is situated at a higher altitude and in a different climatic zone (northern Alps), which may explain the lower species numbers, but in its composition the guild structure is comparable to the Tagliamento, with a marked prevalence of guild II. Further analysis reveals some shifts in species composition: The phytophagous mud burrowers (guild IV) are composed of 7 species belonging to the genus *Bledius* on the River Lech, 14 on the Tagliamento, but only 3 could be encountered on the Adige. From the 10 *Bledius* species recorded downstream from Merano around 1863 (GREDLER 1863), only two are still present. Three have disappeared from South Tyrol, and five occur recently only on the River Eisack (PEEZ & KAHLEN 1977). The genus *Bledius* on the Adige is partially replaced by *Carpelimus* and *Platystethus*.

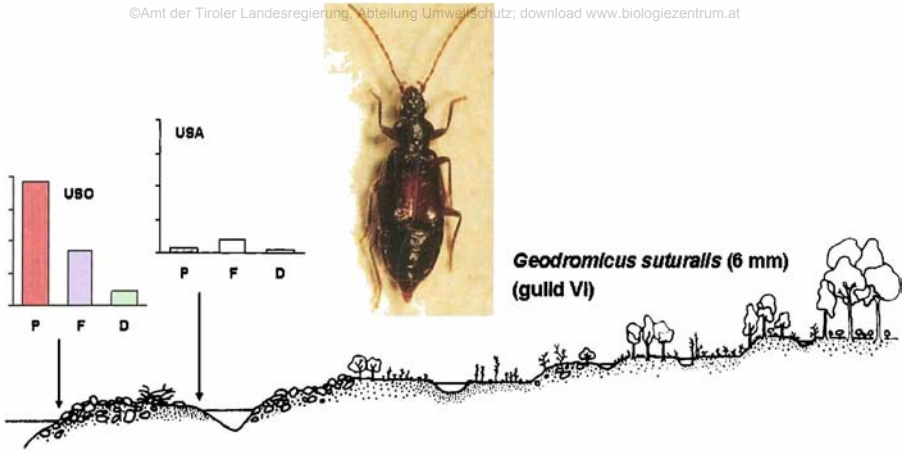

Fig. 6: Habitat specificity and preference of Geodromicus suturalis (Staphylinidae), a representative of guild VI, in the flood plain of the River Lech near Pinswang. P: Presence, F: Frequency, D: Dominance (y-axis: 100%). USO: gravel shoreline, USA: sand shoreline.

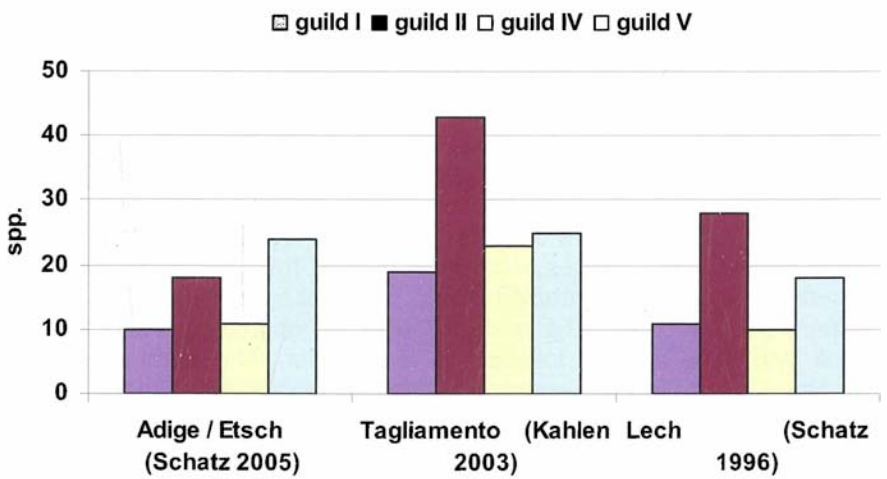

Fig. 7: Composition of riparian staphylinid guilds in the floodplains of some rivers with differing anthropogenic impact in the Alps (Austria, Italy). Definition of guilds: see text.

Experimental restoration measures on the River Adige in Alto Adige / South Tyrol (Italy)

The River Adige suffers from massive anthropogenic impact: channelization and bank protection, as well as daily peak hydropower effects and silt accumulation (WERTH 2003). An investigation of selected riverine habitats between Merano and Salorno revealed an impoverished arthropod fauna with isolated remnants of characteristic riverine species assemblages (GLASER 2005, KOPF 2005, SCHATZ H. 2005, SCHATZ I. 2005, STEINBERGER 2005). Wooded river banks and relict stands of alluvial forest are mostly cut off from the hydrological regime and are populated by untypical, xeric rove beetle communities. The only site of the floodplain with a braided section and exposed riverine sediments is situated near Merano, at the confluence with the River Passer (km 73 of the River Adige. Fig. 8). This serves as a reference area for the restoration experiment. About 6 km downstream near Lana (km 79) the protected and steep river banks, overgrown with woody vegetation and heavily shaded, were opened, lowered and widened during winter and spring 2003. A peninsula and sidearm were artificially created, containing flat and steep stretches of gravel shore as well as sand and gravel terraces at different levels above the water level (Fig. 9). Vegetation was absent in spring, but plant succession progressed rapidly on the higher ground during summer. By October the higher terraces were covered (up to 30%) by a waist-high herb, grass and shrub layer (MAIR & ZEMMER 2005). Silt accumulation threatens to fill up the sidearm if left alone.

The arthropod community along the shoreline, on the higher terraces as well as in the adjacent wooded river bank was sampled monthly from May to November 2003. Standardized sampling methods allow comparisons with river stretches of similar or differing habitats situated at distances from one up to 40 km.

The new habitat, from the shoreline to the higher open river bank, was colonized immediately by macropterous pioneer species with good dispersal capacity. First arrivals are obligate riparian species as well as xero-tolerant and thermophilous species. The phenology of rove beetles during the first months of succession is shown in Fig. 10. Most species had arrived by July at the peak of activity and abundance. After a drop in august a second, lower peak with new arrivals followed in September. The number of species recorded only once as single specimens was 19 (46%), while 22 (54%) species were caught on separate dates or in several specimens. Diversity is high, with 41 species in only 136 individuals. In other words, every 3rd rove beetle caught belongs to another species! From the total species assemblage 25 (61%) are listed in the red data book. The complete species lists for the habitat types, the detailed analyses and evaluation of the different sites are given in SCHATZ I. (2005).

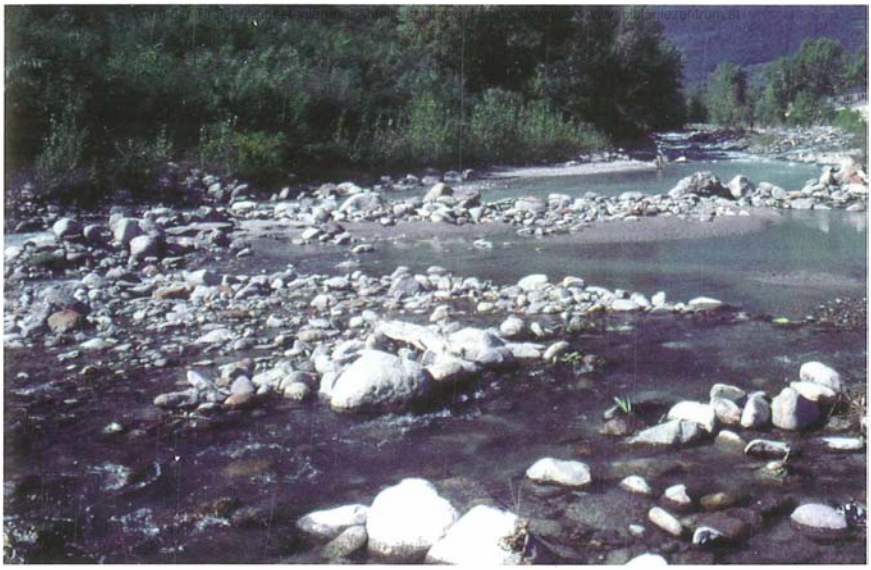

Fig. 8: Braided section of River Adige near Merano (South Tyrol, Italy), km 73. (Foto Irene Schatz)

Fig. 9: Experimental restoration site on the River Adige near Lana in construction (2003). (Foto: Irene Schatz)

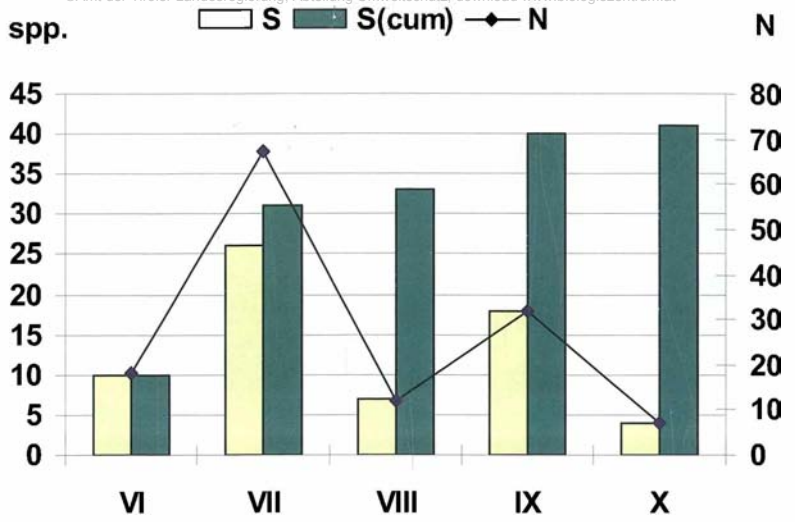

Fig. 10: Phenology of early rove beetle (Staphylinidae) succession on a restored gravel bank on the River Adige (Lana, Italy) in 2003. (S: species number, S(cum): cumulative species number, N: individuals captured).

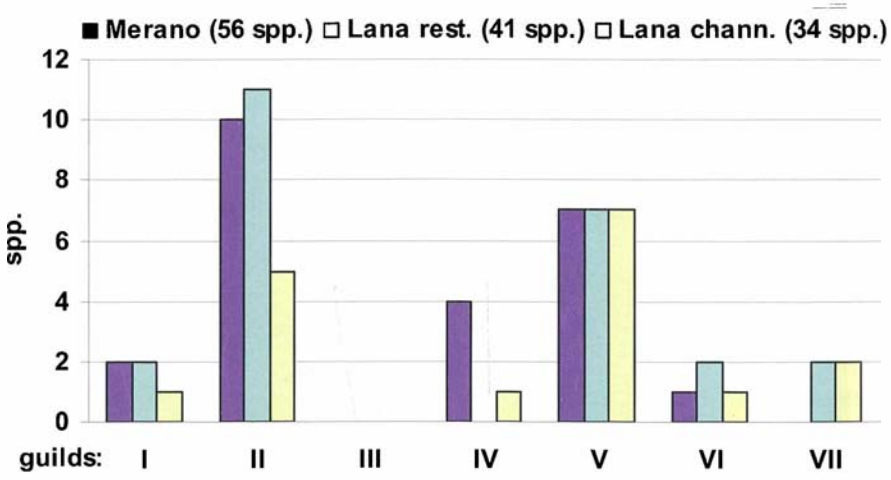

Fig. 11: Composition of riparian guilds of rove beetles (Staphylinidae) on the River Adige (Italy). Merano: reference site with exposed riverine sediments, Lana rest.: site of restoration experiment, Lana chann.: adjacent channelized stretch, (total species number). Definition of guilds: see text.

The dominant guild consists of the interstitial dwellers of small size, adapted to live in wet sand and gravel. Of the 9 species in this category the majority are rare and / or threatened (*Aloconota insecta, Hydrosmecta longula, Scopaeus gracilis, Scopaeus ryei, Taxicera dolomitana*), others are still fairly common (*Aloconota cambrica, A. sulcifrons*) or less stenotopic (*Atheta hygrotopora, Scopaeus laevigatus*). The xero-tolerant or thermophilous species also include rare species (*Scopaeus debilis, Atheta testaceipes, Falagrioma thoracica*). Riparian species attracted to detritus (guild V) are present with three strictly stenotopic ripicoles (*Neobisnius lathrobioides, Paocyusa longitarsis, Tachyporus austriacus*) and some widely distributed species. The diurnal predators of medium size (guild I) are represented by one specialist (*Paederidus rubrothoracicus*) and one eurytopic ripicole (*Stenus comma*). Altogether the pioneer rove beetle assemblage amounts to five different guilds.

The adjacent steep, woody river bank is much less diverse (21 spp.) and comparatively sparsely populated (N=113). It is characterized by eurytopic forest species (*Xantholinus tricolor, Habrocerus capillaricornis, Tachyporus abdominalis, Bythinus reichenbachi*), some of them rare (*Ilyobates mech*) or listed in the red data book (*Ocypus brunnipes*). The dominant species is the common *Atheta fungi*. A few ripicoles are also present (*Taxicera dolomitana, Parocyusa rubicunda, Sepedophilus constans*), which are encountered on the adjacent shores with dense vegetation. Similarity with the experimental site is very low (7% species in common with the shoreline, 25% with higher terraces).

A comparison of the restored habitat with reference areas can be summarized through the guild composition (Fig. 11). The natural and braided reference site (Merano, km 73) is very similar to the experimental site in this respect. The higher species number (S = 56) is to be expected considering the much larger area and heterogenous mosaic of habitats. Both sites share 21 species, among these some very rare and endangered obligate ripicoles, mostly from guild II, as well as guild V and VI. The genus *Bledius* is notably absent in both sites, but the mud burrowers (guild IV) are present in Merano (*Platystethus, Carpelimus*), while Lana offered only very limited areas of moist, fine-grained sediments.

The channelized river downstream (Lana, km 80-85) features massive bank protection with steep banks shaded by vegetation. Even at low water levels only narrow strips of gravel and silt are exposed. In relation to the short stretch of restored riparian habitat at Lana the cumulative species number and diversity of rove beetles along the five kilometers is comparatively low (34 spp., N=287). From the 14 spp. in common only 4 are obligate ripicoles with high habitat specificity, and the interstitial dwellers are reduced to half. Guild IV is barely present (*Platystethus*). Most of the early colonizers in the restored site (km 79) were not encountered in the channelized stretches of the river downstream, which is significant for the consideration of source areas.

The nearest populations which can be assumed to serve as a source for colonization of the new habitat by specialized inhabitants of gravel shores

are situated at a distance of 2 to 6 km (the reference site near Merano at km 73, and possibly the confluence with a tributary (Valschauerbach) at about 3 km distance. Some obligate ripicoles may have arrived from these areas (*Geodromicus suturalis, Hydrosmecta longula, Neobisnius lathrobioides, Scopaeus gracilis, Sc. ryei*). The origin of other species is unclear, although their distribution in the Alps suggests a migration from upstream. There is no indication how far the single specimen of *Paederidus rubrothoracicus* travelled, as this species was not found elsewhere during the present study. *Aloconota cambrica* was also found at km 109 downstream, but only with a few chance specimens. This species is very common along mountain streams at higher elevations. In the planary zone, it is replaced by species with wider altitudinal distributions (*A. sulcifrons, A. insecta*). A third group of ripicolous species may have arrived from the adjacent river stretches, where they were also encountered (*Aloconota insecta, A. sulcifrons, Ocalea picata, Parocyusa longitarsis, Tachyusa coarctata, T. constricta, Taxicera dolomitana*).

Revitalization on the Alperschonbach

A stretch of the Alperschonbach, a tributary of the river Lech (North Tyrol, Austria), was revitalized by substantial widening of the river bed just above the village of Bach at the confluence with the River Lech in 1995-1998. Within the outer dams essential for flood protection the river was given more space and there are now gravel beds, islands and exposed sediments of different grain size (Fig. 12). A study with the aim of assessing changes in the terrestrial riparian arthropod fauna during the year following the restoration measures was carried out in 2002. Unfortunately there was no continuous monitoring, before and after the changes. Instead, a comparable stream nearby, the Namloser Bach with natural banks upstream and a fortified stretch downstream, was used as reference, as well as the known species assemblages in the floodplain of the river Lech (KOPF et al. 1999, MORITZ et al. 2004, SCHATZ 1996).

The observed rove beetle assemblage along the shoreline as well as on the newly established sand and gravel beds consisted mostly of ripicolous species typical for natural river banks. Trivial species from adjacent habitats were few. Species richness (36 spp.) and the percentage of stenotopic ripicoles (67%) was at a level typical for natural shores, and at the same level as on the Namloser Bach (34 spp., 68%). In addition to the expected changes in species composition some rare and endangered species were present (*Brachygluta pandellei, Hygrogeus aemulus, Ischnopoda umbratica*). In total, 14 species from the red lists benefit. The obligate ripicolous rove beetles belong to 6 guilds. The restoration measures specially favour the interstitial species in coarse sand and gravel (guild II: *Aloconota currax, A. ernestinae, Apimela mulsanti, Ochthephilus rosenhaueri, Scopaeus ryei, Thinobius peezi, Thinodromus dilatatus*). Open muddy flats attract the sand and mud burrowers (guild IV: *Bledius agricultor, B. erraticus, B. fontinalis, B.*

longulus). The comparison with the Namloser Bach shows an almost identical guild composition (Fig. 13).

Fig. 12: Restored riverbank of the Alperschonbach near Bach (1060 m), with detail of *Bledius*-colony (right). (Fotos: Irene Schatz, 2002)

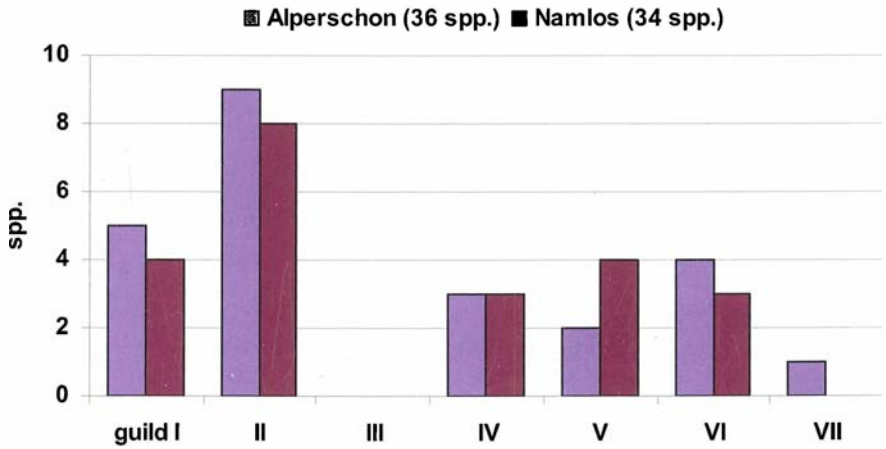

Fig. 13: Comparison of riparian guilds of rove beetles (Staphylinidae) on the restored Alperschonerbach and the reference site on the Namloser Bach (North Tyrol, Austria), (total species number). Definition of guilds: see text.

Fig. 14: Floodplain with braided section of the Hornbach (North Tyrol, Austria), upstream of the sediment retention dam, 990 m. (Foto: Irene Schatz, 2002)

Fig. 15: Canyon of the Hornbach (North Tyrol, Austria), downstream of the sediment retention dam, 980 m. (Foto: Irene Schatz, 2002)

Removal of sediment retention dams

One question of the Lech-Life project concerned the consequences for the riparian fauna after removal of the sediment retention dams in tributaries of the River Lech (Schwarzwasserbach, Hornbach, Brentersbach) to make up for its bedload deficit (SCHATZ et al. 2003a). In order to make some predictions the fauna in the wide areas of exposed sediments behind the sediment traps was compared to the fauna in the canyons downstream. The stream Hornbach may serve as an example (Figs 14, 15).

Species richness is higher in the much wider braided stretch upstream. The species with specific habitat requirements belong to five different guilds. Macropterous interstitial dwellers and mud burrowers are well represented. The percentages of stenotopic ripicoles and threatened species are higher downstream, but actual species numbers are lower. The percentage of riverine specialists calculated from abundance values is highest in the canyons of all studied streams (70-80%, 85% on the Brentersbach). Furthermore, the most sensitive indicator species for natural stream banks were encountered in the canyons. Only four versus five guilds were present in the Hornbach downstream, but further analysis at species level reveals some interesting details: two apterous and microphthalmous representatives of the highly specialized hypogeic guild III (*Actocharina leptotyphloides, Scopaeus championi*; Fig. 16) were found in the downstream stretch. Obviously they have very poor dispersal capacities, and probably migrated into the Hornbach valley from the river Lech, where they occur regularly in the wide floodplain of the braided section. It appears that they were not able to overcome the barrier of the Hornbach sediment retention dam and reach the large areas of exposed sediments upstream.

Discussion

Rove beetles are an important component of the arthropod communities along river banks. Diversity in terms of species numbers and guilds of Staphylinidae within the riverine arthropod community is always highest as compared to the ground beetles and the spiders. Abundance may vary widely, amounting to about 20-70% of the fauna, according to microhabitat (see literature data compiled in SCHATZ et al. 2003b). The reason lies in the fact that populations are highly aggregated in space and time, shifting continuously within the dynamic riverine habitat mosaic (DESENDER & SEGERS 1985, DIETERICH 1996, PAETZOLD et al. 2005, PLACHTER 1986). The usually applied random sampling does not take this fact into consideration. Furthermore, trapping and semi-automatic sampling devices lead to hypogeic species mostly being underrepresented. This becomes obvious when comparing species lists from studies with different methodology and faunistic catalogs from the region. The unsaturated sediment with interstitial spaces, the hypogeic zone, is probably a very important, hitherto underrated compartment of the riverine habitat, especially for rove beetles (DIETERICH 1996, TOCKNER et al. 2006).

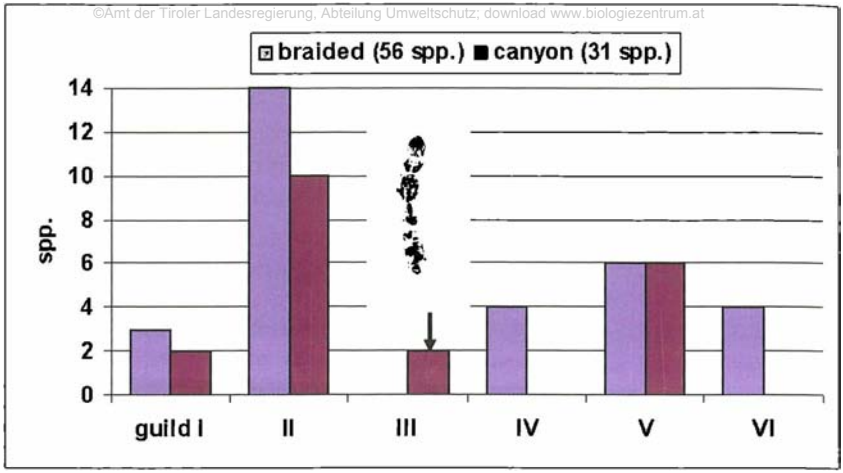

Fig. 16: Comparison of riparian guilds of rove beetles (Staphylinidae) on the Hornbach (North Tyrol, Austria): braided section upstream of sediment retention dam and canyon downstream (total species number). Definition of guilds: see text. Guild III: *Actocharina leptotyphloides* (insert), *Scopaeus championi*.

In comparison with other rivers in the Alps the upper flood plain of the River Lech in North Tyrol is still fairly natural with braided sections (WALDERT 1991). Accordingly, the rove beetle fauna is exceptionally rich, in species numbers as well as in guilds (SCHATZ 1996). The potential for successful restoration of locally deteriorated riverine habitats is probably not limited by interruptions of the river continuum.

In contrast, the River Adige in South Tyrol suffers from massive anthropogenic impact and its riverine fauna is impoverished, not only in terms of species diversity, but also in the composition of staphylinid guilds (SCHATZ I. 2005). Nevertheless, rapid colonization occurred at the experimental site during the first summer following the restoration measures. Pioneer species assemblages consist typically of small-sized and macropterous species (KUNZE & KACHE 1998). Quick colonization is also observed in stenotopic ground beetles (BONN & KLEINWÄCHTER 1999, GÜNTHER & ASSMANN 2005), and by staphylinids on experimental new gravel deposits isolated from remnants of riparian habitats (ARMBRUSTER & REICH 2001). High diversity is a known phenomenon of early succession stages. Species composition was as diverse and rich in obligate ripicoles in the experimental restoration site as in the natural and braided section with exposed sediments upriver. A similar pattern appears in the carabid beetles, with a species assemblage including all the rare species of the braided section except one (*Anchomenus cyaneus*) (KOPF 2005). The spider community consists mostly of common species from surrounding agricultural

land, but the two most notable character species for natural gravel shores (*Pardosa wagleri, Arctosa cinerea*) were also present (STEINBERGER 2005). Source areas are probably the braided sections upstream and recolonization may be facilitated by floating plant debris in a downstream direction, even for species with poor dispersal capacity (KUNZE & KACHE 1998, TOCKNER et al. 2006). Whether the new gravel bank will continue to support the ripicolous species assemblage will depend from disturbances of plant succession and periodic flooding as positive impacts (GÜNTHER & ASSMANN 2005), as well as on (negative) silt accumulation due to daily peak hydropower effects (SCHATZ et al. 2003b).

As a consequence of specialization and therefore limitation to natural riverine habitats and due to progressive loss of these habitats in Central Europe, more than 60% of the riparian beetle species in general, and rove beetles in particular, can be found in the red lists of the respective regions (KÖHLER 2000, SCHATZ I. 2005, WOHLGEMUTH-VON REICHE & GRUBE 1999). Faunistic analyses reveal similar proportions of rare species (e.g. SADLER et al. 2004). Therefore, restoration measures benefiting rare and threatened species are of considerable conservation value (ANDERSEN & HANSSEN 2005, SADLER et al. 2004).

Riparian rove beetles are suitable for assessments of habitat quality and useful bioindicators for restoration processes: they are the most diverse group and show a high degree of habitat specificity due to specialized modes of life. Stenotopic ripicolous species are very susceptible to natural changes or human impact. The guild of the interstitial dwellers is the most significant indicator for the hypogeic zone at the shoreline. Lack of exposed riverine sediments, reduced river dynamics essential for frequent rearrangement, and silt accumulation choking the interstices, often caused by daily peak hydropower effects, are the main threat to this guild. The guild of the mud burrowers feeding on algae can be considered a good indicator for riverine habitats somewhat removed from the immediate water's edge. It suffers most from loss of riverine fen.

Most stenotopic riverine rove beetle species being vagile, instant reactions to changes (natural or anthropogenic) are possible. Even isolated habitats in disrupted river systems may be quickly recolonized by species with good dispersal capacity. This applies to most riverine guilds, but some flightless and rare hypogeic forms depend on the river continuum.

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