Spatial distribution of Coleoptera species on exposed riverine sediments (ERS) along the small river Mjöån with suggestions for management practices to increase biodiversity

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Jeppsson, N.: Spatial distribution of Coleoptera species on exposed riverine sediments (ERS) along the small river Mjöån with suggestions for management practices to increase biodiversity. [**Rumslig fördelning av skalbaggsarter på "exponerade å-sediment" (ERS) längs den mindre Mjöån med förslag på skötselåtgärder för att öka biodiversiteten.**] – Entomologisk Tidskrift 140 (3–4): 177–188. Björnlunda, Sweden 2020. ISSN 0013-886x.

From the sandy shores of Mjöå river in Southern Sweden beetles were collected from eight sites during one season, using both pitfall traps and splashing combined with hand picking. Altogether 508 individuals from 53 species were registered. Soil samples were taken from each spot to analyse organic content, distribution of grain size fractions and density of mineral soil. The eight spots differed concerning soil properties. Among a selection of twelve species, compared by using data from collection by splashing method, both PCA and cluster analysis revealed differences in beetle assemblages. The most obvious pattern was a discrepancy between digging and non-digging species. The differences are believed to at least partly be caused by differences in proportion of the smallest grain fraction (< 0,125 mm) with a negative correlation between number of individuals of *Dyschirius thoracicus* and the proportion of fraction < 0,125 mm grains. The results show that the species have different abiotic preferences. Since the total area of available shores are rather small, and added to that a differentiation in microhabitats, the favourable conditions for each species is even smaller. To possibly extend the area for ERS species, enhancing erosion of the brinks by cattle grazing and/or removal of root systems from trees growing along the river could be tried.

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Riparian zone ecosystems are varied due to differences in soil, water velocity, surrounding forests, etc., but also because of complex interactions between terrestrial and aquatic components (Gregory et al. 1991). For instance, inundation frequency generally affects the biodiversity among ground living beetles and specifically disfavours the larger taxa in parts with higher inundation frequencies (Skalski et al. 2012). Furthermore, the aquatic component contributes, through the delivery of prey, to the shore living carnivorous organisms (Hering 1998, Paetzhold et al. 2005). The physical properties of the soil; e.g. grain size and moisture are also important factors that has shown to affect different digging beetle species of the genus *Bembidion* differently (Andersen 1978), explained by adaptations in anatomy of e.g. claws and spurs but also by

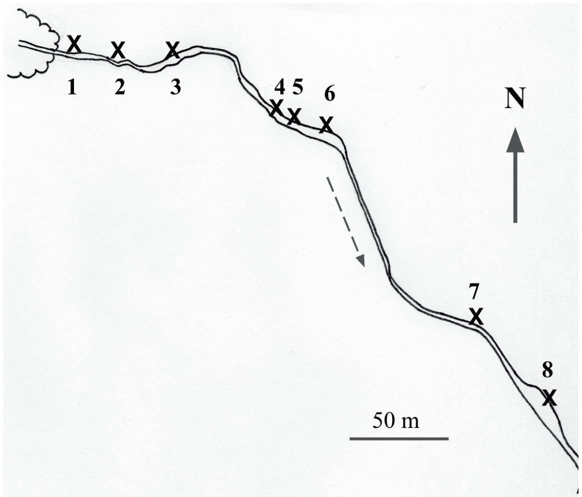

Figure 1. Map showing the location of sites 1-8 along the Mjöå river (dashed arrow shows water flow direction).

Figur 1. Karta som visar fördelningen av punkt 1-8 längs Mjöån (streckad pil anger åns flödesriktning).

variations in digging behaviour. Species richness has shown to be positively correlated with the phi value (i.e. a measure of grain size composition) of a riverbank (Sadler et al. 2004). Even the subsurface zone plays a role by serving as a hideout refuge for the above ground living organisms (Langhans & Tockner 2014). The distribution of beetle species over different microhabitats has been shown to be stable over time (Bates et al. 2007). Besides the natural spatiotemporal variation, there are also impacts from human activities, e.g. the construction of dams for hydroelectric production (Lindroth 1972). Any exploitation of habitats could lead to isolation and/or fragmentation, risking loss of biodiversity as suggested by Andersen & Hanssen (2005).

Lambeets et al. (2008) stressed the importance of conservation of river shore habitats due to their high heterogeneity both within and among gravel banks. In Sweden, among 275 species in a compilation of red listed organisms from all taxonomic kingdoms occurring on freshwater shores, the beetles (Coleoptera) were listed at the top as the richest in taxa with altogether 47 species (Bjelke & Sundberg 2014). In Scandinavia the highest number of riparian beetles (defined as having their main or exclusive occurrence on ERS) is found in the north (Andersen & Hanssen 2005) with maximum numbers in the north of Norway with > 40 species, while the province Skåne in southernmost Sweden hosts only 16–23 species. Some taxa are threatened, for instance the ERS specialist *Bembidion litorale* Olivier has a documented history of decline in southern Sweden (Andersen & Hanssen 2005) based on a compilation of records from different publications. The main aim of the present study was to investigate the distribution of beetle species on exposed riverine sediments on shores along 400 m of a small river. A secondary aim was to suggest what can be done for the conservation of the biodiversity.

Material and methods

Site studied

The study area is situated along Mjöå river, within the Kristianstads Vattenrike Biosphere Reserve, in the North-eastern part of the province Skåne in the south of Sweden. From its source Mjöå river flows approximately 30 km with approximately 50% through agricultural area in its closest vicinities (Almlöf 2008), until it reaches the larger Helgeå river. The study area is located approximately 1 km from the river mouth and surrounded by grazed meadows, however not grazed every year. The beetle collection and soil sampling were performed during 2018 at altogether eight sites; site no. 1 at 55.908080 N, 14.175249 E, and additional sites no. 2–8 within approximately 400 meters downstream (Fig. 1). These sites were chosen since they were spread out over a part of the river with sandy shores and expected to represent a variation in soil properties. Along this part of the river water velocity does not vary much, resulting in a quite straight channel with no extreme meanders.

Recorded soil properties

Organic content

From each site (Fig. 1) soil samples (5x5 cm and 1 cm deep) were taken. The soil samples were dried by heating at 110°C in an oven for 4 hours. Then approximately 6 g dried soil sample was heated at 600°C in a furnace for two hours to combust the organic component in order to determine the percentage of organic content.

Proportion of soil fractions recorded by sieving
From each site a soil sample (20x20 cm square and 2 cm depth) was taken and dried to 110°C in an oven for three hours. The samples (approximately 400 g each) were then sieved individually (sieves of > 4.0, > 2.0, > 1.0, > 0.5, > 0.25, > 0.125 and < 0.125 mm). The resulting fractions were weighed.

Density of mineral soil samples
The densities of soil samples were measured in order to relate to the packing of grains of the soil samples. Dried soil samples (of approximately 17–20 ml, the same dried samples as for sieving described above) were added to a graded 50 ml glass tube. The tube was manually shaken for the mineral particles to settle until the volume was constant. The volume was recorded at a precision of ± 0.05 ml and the mass of the content was weighed. The density was calculated as mass divided by volume.

Collection of beetles
This investigation focused on Coleoptera (mainly Carabidae and Staphylinidae) species occurring on riverbanks. Both predatory riparian carabids and staphylinids choose aquatic insects as prey to a major extent (Paetzhold et al 2005) and can be assumed to be specialized to exposed riverine sediments. Different collection methods can be used for terrestrial arthropods depending on which taxonomic groups are going to be studied. Ground living insects can, for instance, be collected by using pitfall traps (Zou et al. 2012). Zou et al. (2012) also stated that no method is unbiased and sometimes a combination of methods is to be recommended. Manual search in transects (Baiocchi et al. 2012) or in quadrats (Andersen 1995) has also been suggested for ground living insects since trap collection may cause bias by favouring larger sized beetles. In the present study with quite small riverbank areas I chose to combine pitfall traps with splashing.

Pitfall traps
Circular plastic cups with the diameter 8.5 cm and a depth of 6.5 cm were used. They were dug into the sandy shore at approximately 30 cm from the water edge with the opening at the same level as the ground level. Approximately a quarter of a decilitre of sand was poured into the cup to provide shelter for the beetles. To increase the efficiency of capturing a wooden stick (35 cm long, profile 2.5x2.5 cm) was placed between the pitfall trap and

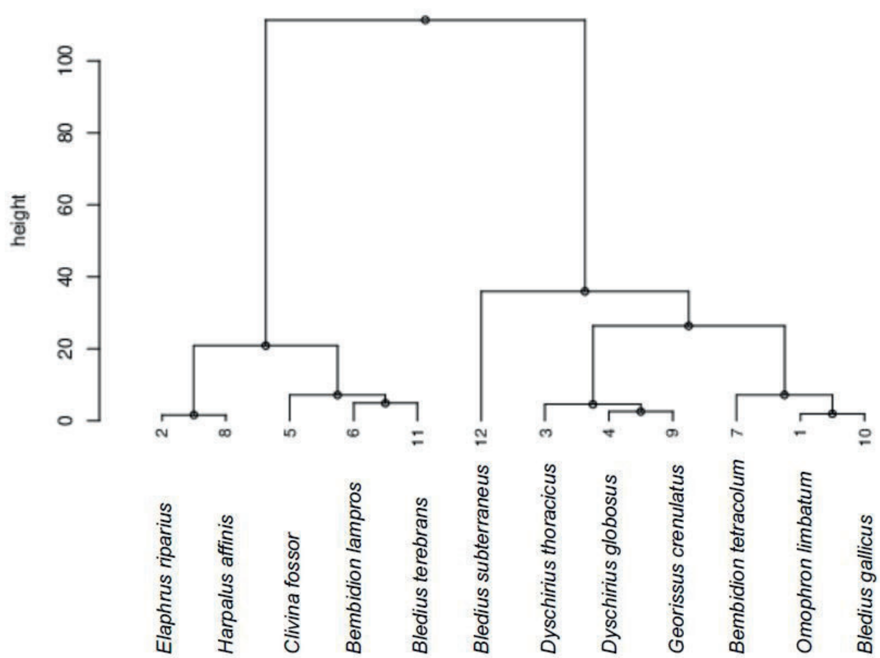

Figure 2. Dendrogram of beetle assemblages, produced from a cluster analysis based on the soil preference for each individual of the beetle species.

Figur 2. Dendrogram över skalbaggsgrupperingar från en klusteranalys baserad på markpreferenser för varje individ av skalbaggsarterna.

Table 1. Recorded number of individuals of beetle species selected for statistical comparisons, collected by splashing (May 28, June 10, June 28, data pooled, data from Appendix 1, d = digger, n = non-digger). The bottom rows show recorded soil properties. Shadows indicate roughly magnitude of these data; transparent = lower third, light grey = medium third, darker grey = upper third.

Tabell 1. Sammanställning över de skalbaggsarter som analyserades statistiskt. Insamlade med vattenbegjutning (28:e maj, 10:e juni, 28:e juni, data sammanslagna, hämtade från Appendix 1, d = grävande arter, n = icke-grävande arter). Nedre raderna visar markprovernas egenskaper. Skuggningen visar grovt värdenas fördelning; transparent = undre tredjedel, ljusgrå = mitten tredjedel, mörkgrå = övre tredjedel.

		Site number								
Species	digger / non digger	1	2	3	4	5	6	7	8	Total
Omophron limbatum	d	0	1	3	2	3	6	0	0	15
Elaphrus riparius	n	0	0	0	0	0	4	0	4	8
Dyschirius thoracicus	d	5	10	4	5	10	0	2	0	36
Dyschirius globosus	d	0	0	0	1	2	1	0	0	4
Clivina fossor	d	0	0	0	0	0	7	6	0	13
Bembidion lampros	n	3	0	0	1	0	3	1	4	12
Bembidion tetracolum	n	0	1	1	4	0	0	1	2	9
Harpalus affinis	n	0	0	0	0	0	0	0	4	4
Georissus crenulatus	n	0	1	1	19	10	0	3	0	34
Bledius gallicus	d	0	1	0	0	5	2	5	2	15
Bledius terebrans	d	0	0	0	0	0	0	4	0	4
Bledius subterraneus	d	0	0	3	0	3	0	0	0	6
Sum no of species		2	6	5	8	6	6	8	5	12
Sum no of individuals		8	14	12	32	33	23	22	16	160
grain > 0.25 (%)		25.8	22.2	40.0	19.5	44.7	0.0	10.9	0.0	
grain > 0.125 (%)		69.8	76.4	59.0	75.0	53.3	88.2	84.1	90.4	
grain < 0.125 (%)		4.4	1.4	1.0	5.5	1.9	11.8	5.0	9.6	
organic content (%)		2.2	2.1	2.0	3.0	3.0	9.0	3.3	8.8	
soil density (g/ml)		1.34	1.46	1.45	1.29	1.39	1.01	1.25	1.05	

the water edge, in order to force all beetles passing along the water edge to follow the wooden stick up to the pitfall trap. The traps, that were dry, were placed (May 12, July 3) before dusk to be retrieved the following day after dawn, and all beetles were collected for determination of species. The very characteristic *Omophron limbatum* (Fig. 3) was identified, counted and instantly released.

Splashing combined with hand picking

Since many species are digging and mostly active by night the individuals were handpicked after splashing a part of the sediments measuring a rectangle with a breadth of 50 cm and covering 40–160 cm from the water edge. Water was applied in small portions with a handheld water pitcher during daytime (May 28, June 10, June 28) and continued until no more beetles emerged.

Table 2. Distribution of variance between the different components when PCA was used to compare the 8 different sampling plots regarding occurrence of the beetle species.

Tabell 2. Fördelning av varians mellan komponenterna ur en principalkomponentanalys (PCA) där de 8 olika insamlingspunkterna jämfördes avseende på insamlade skalbaggsarter.

Component	% of variance	cumulative %
1	31.8	31.8
2	20.4	52.2
3	17.2	69.4
4	13.1	82.5
5	10.8	93.3
6	4.9	98.2
7	1.8	100.0

Results

Altogether 284 individuals of 21 species were collected in pitfall traps and 224 individuals of 43 species by splashing followed by hand picking. Considering that the results from the two methods partly overlapped altogether 508 individuals of 53 species were registered (full list in Appendix 1). From the beetles collected by splashing 12 species (selected as being considered using ERS for their survival and found in numbers by ≥ 4) were used for further statistical analysis, and among these 7 can be classified as diggers and 5 as non-diggers (Table 1).

A principal component analysis (PCA) based on a comparison of the eight sampling sites concerning their composition of species sampled by splashing revealed that 5 components were needed to describe > 90% of the variation (Table 2). The first component described most of the variation (31.8%) and was positively correlated (Table 3) with *Dyschirius*

Figure 3. Specimens of *Omophron limbatum* (Fabricius 1777) were caught and released after counting.

Figur 3. Exemplar av *Omophron limbatum* (Fabricius 1777), klotöpare, fångades och släpptes efter räkning.

Table 3. Correlations between the different species within each component (PCA).

Tabell 3. Korrelationer mellan de olika arterna för varje komponent under PCA.

	Component						
Species	1	2	3	4	5	6	7
Omophron limbatum	0.25	-0.47	-0.70	0.15	-0.41	0.18	-0.07
Elaphrus riparius	-0.71	-0.25	-0.60	0.15	0.18	0.09	-0.13
Dyschirius thoracicus	0.87	0.01	-0.06	-0.18	0.34	-0.27	-0.15
Dyschirius globosus	0.63	-0.28	-0.51	0.41	0.22	-0.17	0.08
Clivina fossor	-0.34	-0.83	0.11	0.32	-0.27	0.03	-0.03
Bembidion lampros	-0.84	-0.01	-0.32	0.07	0.16	-0.27	0.29
Bembidion tetracolum	-0.07	0.68	0.10	0.67	-0.04	0.25	-0.09
Harpalus affinis	-0.63	0.29	-0.22	0.01	0.65	0.21	-0.07
Georissus crenulatus	0.57	0.34	-0.03	0.73	0.02	-0.05	0.12
Bledius gallicus	0.20	-0.70	0.24	0.20	0.61	0.02	-0.06
Bledius terebrans	-0.13	-0.47	0.81	0.25	0.09	0.25	0.08
Bledius subterraneus	0.70	-0.10	-0.23	-0.36	0.18	0.49	0.22

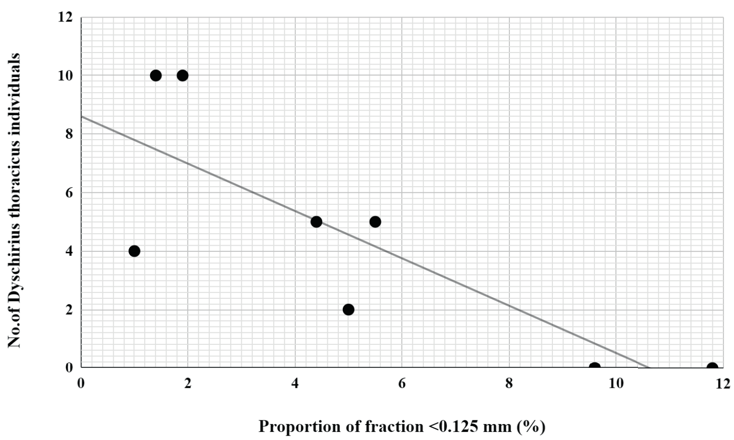

Figure 4. Scattergram showing how number of *Dyschirius thoracicus* individuals collected by splashing (all dates pooled) dependant on proportion of fraction <0.125 mm (sample from May 6) for the 8 sites (r2 = 0.646, p < 0.01 n = 8).

Figur 4. Spridningsdiagram som visar hur antalet insamlade (vattenbegjutning) individer av *Dyschirius thoracicus* (individer från alla datum sammanräknade) beror av andel fraktion < 0,125 mm (prov från 6:e maj) för de 8 punkterna (r2 = 0,646, p < 0,01 n = 8).

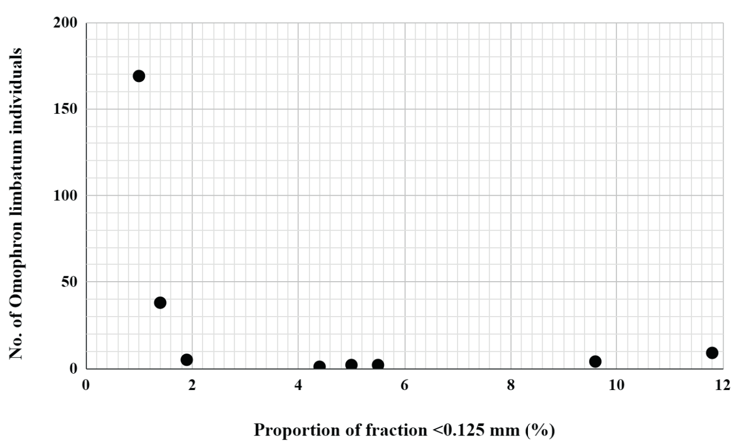

Figure 5. Scattergram showing how the number of *Omophron limbatum* dependant on proportion of sand grain fraction < 0.125 mm. Beetles collected with pitfall traps on May 12 and July 3 (data pooled).

Figur 5. Spridningsdiagram som visar hur antalet individer av *Omophron limbatum* beror på andel av fraktion < 0,125 mm. Insamlade med fallfälla 12:e maj och 3:e juli (data sammanslagna).

Table 4. Correlations between occurrence of Dyschirius thoracicus and soil properties.

Tabell 4. Samband mellan uppträdandet av Dyschirius thoracicus och markegenskaper.

property	correlation	r^2	n	p
grain <0.125	neg	0.646	8	<0.01 **
0.125 < grain < 0.25	neg	0.493	8	<0.05 *
0.25 < grain < 0.5	pos	0.565	8	<0.01 **
org cont	neg	0.522	8	<0.05 *
density	pos	0.682	8	<0.01 **

thoracicus, *Dyschirius globosus* and *Bledius subterraneous* (all diggers) and contrastingly negatively correlated with *Elaphrus riparius*, *Bembidion lampros* and *Harpalus affinis* (all non-diggers). The second component described additionally 20% of the variation, and here *Bembidion tetracolum* (a non-digger) was positively correlated, whereas *Clivina fossor* and *Bledius gallicus* (both diggers) were negatively correlated.

A cluster analysis was performed by comparing the different species calculated averaged for all soil properties. The species were joined in groups that were more or less closely/distantly related according to the dendrogram (Fig. 2). Since the 36 individuals of *Dyschirius thoracicus* were spread out over 6 of the 8 different sites it allowed to test for correlations with soil properties (Table 4, Fig. 4).

Among the individuals caught by pitfall traps *Omophron limbatum* dominated with 230 individuals out of totally 261 with the majority of these caught at two sites, which made these data hard to analyse statistically (the data can be found in Appendix 1). It can, however, be noted that these were caught at sites with the lowest proportion of fraction < 0.125 mm grains (Fig. 5).

Discussion

The PCA revealed that several components were needed to describe the variance, hence indicating differences in distribution patterns among species which agrees with e.g. Bates et al. (2007). This, and the formation of branches in the dendrogram (Fig. 2) which illustrates the formation of beetle species into communities, show that there are differences in the assemblages of beetle species between the different sampling sites over quite small distances of the river. This shows that there is a diversity of microhabitats.

The two ecological groups, diggers and non-diggers, exhibited contrasting patterns. This is reasonable since the diggers are most likely to respond more strongly to certain grain sizes due to different morphological adaptations related to their digging behaviour, as described for *Bembidion* species by Andersen (1978). In contrast, the non-digging species hunt for prey on the soil surface and will hence be to a lesser extent directly affected by e.g. grain composition. The non-diggers seem to be more spread out or favouring the sites with smaller grain sizes where also higher contents of organic material were found, or it could just as well be a preference for high organic content. Differences in distribution along rivers due to differences in grain sizes has, however, previously been indicated for both diggers and non-diggers (Lindroth 1992b).

For the *Dyschirius* species only *Dyschirius thoracicus*, an ERS specialist (Lindroth 1992a), was found in numbers and it was spread out along the river negatively correlated with the proportion of fraction < 0.125 mm (Fig. 4). And totally lacking from the sites with the highest content of that fraction. This agrees with Lindroth (1992a) who classifies this species as the least stenotopic among the *Dyschirius* species allied with *Bledius* prey species (Lindroth 1992a). Still, it prefers grain size of 0.2–0.6 mm but can do with 0.02–0.2 (Lindroth 1992b). In contrast the two species *D. intermedius* and *D. politus* were found (only single specimens, site 8, Table 1) where there is a large proportion of fraction < 0.125, and where no *D. thoracicus* were caught. *Dyschirius intermedius* and *D. politus* prefers loam mixed fine sand 0.2–0.02 mm (Lindroth 1992b). The strong correlations with the proportion of the fine fraction (< 0.125 mm) can, however, be intuitively understood (could be a factor affecting the living condition for a digging species) since this fraction in this study showed a strong negative correlation with mineral soil density ($r^2 = 0.977$, $n = 8$, $p < 0.001$), assuming packing has an impact on digging capability of the different species of beetles. From the two major branches of the dendrogram one contains *Harpalus affinis*, *Clivina fossor* and *Bembidion lampros*, i.e. species that are not ERS specialists. More pronounced ERS specialists are in the other branch. Yet other factors that could explain the differences in beetle distributions besides the ones studied here are humidity (Lindroth 1992b, Andersen 1978), as well as the occurrence of other species. e.g. members of the genus *Bledius* as prey for some *Dyschirius* species (Lindroth 1992b).

The discrepancy found between collection by pitfall traps versus splashing as collection method is most likely explained by the fact that pitfall trap as a method rather represents activity than population density as mentioned by Kotze et al. (2011), but could also partly be explained by pitfall traps were not as efficient for most species agreeing with Andersen (1995). Only *Omophron limbatum* was collected in substantial numbers with altogether 230 individuals recorded (Appendix 1), and even comparing pitfall traps with splashing collection the results within this species are very inconsistent. The lower numbers recorded by splashing might be due to that the species diurnally hibernate buried in sand at the edge of the onset of vegetation (Lindroth 1992a), which is above where I made collection by splashing. Still, for this species there seems to be a preference during nocturnal hunting for low proportion of < 0.125 mm fraction pointing to a preference for a certain microhabitat (Fig. 5). Altogether can be concluded that among the beetles studied there are differences in distribution over the 8 sampling sites within the 400 m of shore habitats along the river. Since ERS is a scarce habitat in the vicinities consequently each microhabitat is even scarcer and of very limited size.

Occurrence of scarce beetles and need for management considerations

The large total number of beetle species found in this study is not comparable with the numbers of species (16–23 species for southern Sweden) mentioned by Andersen & Hansen (2005), since they included only ERS specialists whereas my data includes all beetle species found on the river banks.

In the present study two species on the national red list were found; *Dyschirius intermedius* Putzeys (near threatened), which prefers loam (Lindroth 1992a) and was recorded with 1 individual at site no. 8 with the highest proportion of < 0.125 mm grain size, and *Dryops nitidulus* Heer (data deficient), with 1 individual found. The latter species is reported to thrive in or at water on vegetation, and on fallen twigs and branches (ArtDatabanken 2019) and is not considered to be an ERS specialist. *Stenolophus teutonus* Schrank, which previously was at the national red list, was recorded with one individual in the present study (but previously regularly found, own observations). Analysing records from the national database Artportalen with spontaneous observations from Sweden (i.e. in this case southernmost Sweden, from where the species has been reported) out of 20 localities with records of *Stenolophus teutonus* (Artportalen 2009–2018), 17 localities (85%) were from sand pits, lime quarries or similar (i.e. anthropogenic habitats). Such habitats may serve as a refuge for at least some ERS species (Andersen & Hanssen 2005). The fact that some beetle species have the capability to utilize such environments will most likely make them less vulnerable from a conservation point of view. The low number of *Stenolophus teutonus* records in natural habitats, however, indicates that these suitable natural shore habitats are scarce and that the habitat itself needs conservation considerations.

A broader collection by using different methods would probably have yielded a higher number of both species and individuals. During previous years (2009–2017) excursions in the study area also other species have been recorded (own observations). Out of these records some are worth mentioning. *Bembidion ruficolle* Panzer (near threatened), another species from the red data list and certainly an ERS specialist, was recorded at site 3 on July 13, 2016 (1 individual). This species is mentioned as stenotopic by Lindroth (1992a) with a preference for 0.2– 0.6 mm grain size (Lindroth 1992b). Another less frequently reported beetle species is *Bledius talpa* Gyllenhal that was recorded from just outside a bit further upstream on riverbanks shaded by alders.

Management considerations

To favour a higher biodiversity among arthropods abandoned wetlands should be grazed (Zahn et al. 2007). Too extensive cattle grazing has, however, proven to negatively affect beetle communities on exposed riverine sediments (Bates et al. 2006). The area of the present study seems to have been grazed with sufficient intensity to prevent from too much vegetation along the river, but far from causing any trampling damages that has been identified as a problem (Kaufmann & Krueger 1984, Sinnadurai 2014). Close to site no. 1 there is a starting point for a fence hindering grazing cattle to reach the river. Upstream where the fence starts very abruptly there is high vegetation of e.g. grasses and nettles hanging over the river shores and with root systems, hindering fracturing of the vertical banks. Trampling by cattle is crucial in increasing fracturing of stream banks (Kaufmann & Krueger 1984) which in turn is needed to produce more shallow sand banks. Obviously, there seems to be a demand for grazing. However, with a concern for overgrazing suggesting that there is an optimum level and a request for a "rest-rotation scheme" as suggested by Kaufmann & Krueger (1984).

To extend the area of suitable environments and ensure a variety of microhabitats for the wide range of riparian beetles that are already present in the surroundings the efforts could focus on:

1. Remove alders, with roots, along the river to favour the formation of sand banks by water erosion. Care must be taken to avoid negative effects on other organism populations demanding the shadowing from the alders, for instance in fish community by favouring pike and disfavour trout species (Almlöf 2008). In addition, *Dryops nitidulus* is dependent on wooden material falling into the river. Furthermore, the production of invertebrates living in the canopies of the alders will serve as prey for the predator insects living on the sandy shores further downstream.

2. When selecting sites for restoration, soil samples can be taken along the river in order to select certain soil characteristics considering the preferences of the target species or to ensure a variation in microhabitats. Permanent effects can be expected since distribution of species is stable over time (Bates et al. 2007).

3. Manage the vegetation on river slopes by cattle grazing but avoid too extensive trampling because it could harm the sensitive sandy slopes. Save some vertical brinks since they may be inhabited by additional species.

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Sammanfattning

På sandstränder längs Mjöån i södra Sverige inventerades skalbaggar på åtta punkter genom fångst med fallfällor och med vattenbegjutning efterföljt av handplockning. Tillsammans registrerades 508 individer av 53 arter. Markprover togs från punkterna för att analysera innehåll av organiskt material, fördelning av sandkornstorlekar och densiteten av mineraljorden. De åtta punkterna skiljde sig åt ifråga om mark-karaktärer. Bland de mest talrika arterna, fångade genom vattenbegjutning, skiljde sig arterna sig arternas fördelning åt vid analys med hjälp av PCA och kluster analys. Till exempel så skilde sig grävande och icke-grävande arter åt. Skillnaderna tros främst bero på skillnader i inblandning av < 0,125 mm kornstorlek. Arten *Dyschirius thoracicus* visade en negativ korrelation med andelen inblandning av kornstorlek < 0,125 mm mineralkorn. Resultaten visar att arterna har olika preferenser för olika abiotiska faktorer. Eftersom totalarean av tillgängliga stränder är liten innebär då en differentiering i mikrohabitat att de olika arternas favorithabitat är ännu mindre. För att förbättra livsbetingelserna för de sandbankslevande skalbaggarna kan man till exempel fokusera på att öka erosionen på brinkarna genom att öka betestrycket från boskap och/eller avlägsna rotsystem från strandnära träd.

Appendix 1. Table of all recorded beetles in the study, divided into the 8 collection sites and collection method (records from all dates pooled). Abbreviations used: p t = method pitfall trap, spl = method splashing, Oe = *Oedostethus*, NT = near threatened, DD = data deficient (ArtDatabanken 2015).

Tabell över samtliga i studien noterade skalbaggar, uppdelade på de 8 punkterna och på insamlingsmetod (observationer från olika datum sammanslagna). Förkortningar: p t = metod fallfälla, spl = metod vattenbegjutning, Oe = *Oedostethus*, NT = nära hotad, DD = kunskap saknas (ArtDatabanken 2015).

	Site number																		
	1		2		3		4		5		6		7		8		Tot		Overall total
Species	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	
Omophron limbatum	1		38	1	169	3	2	2	5	3	9	6	2		4		230	15	245
Elaphrus riparius									1		3	4	1		4	4	9	8	17
Dyschirius thoracicus	1	5		10		4		5		10	1			2			2	36	38
Dyschirius intermedius[NT]																1	0	1	1
Dyschirius politus															1		1	0	1
Dyschirius globosus								1		2		1					0	4	4
Clivina fossor												7	1	6			1	13	14
Asaphidion flavipes															2		2	0	2
Bembidion lampros		3						1				3		1	3	4	3	12	15
Bembidion properans	1			1				2							1		2	3	5
Bembidion articulatum											1						1	0	1
Bembidion tetracolum	3		3	1	1	1	1	4			1		2	1	4	2	15	9	24
Bembidion gilvipes		1															0	1	1
Bembidion obliquum								1									0	1	1
Poecilus versicolor								1	1		1		1	1	3		6	2	8
Pterostichus vernalis							1										1	0	1
Pterostichus nigrita							1										1	0	1
Pterostichus strenuus											1						1	0	1
Pterostichus diligens													1				1	0	1
Agonum viduum														1	2		2	1	3
Agonum moestum								1		1			1				1	2	3
Harpalus affinis															1	4	1	4	5
Stenolophus teutonus										1							0	1	1
Georissus crenulatus				1		1		19		10				3			0	34	34
Cercyon bifenestratus				1						1		1					0	3	3
Cercyon sp.										1							0	1	1
Helophorus aequalis										1		1					0	2	2
Cymbiodita marginella														1			0	1	1

	Site number																		
	1		2		3		4		5		6		7		8		Tot		Overall total
Species	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	p t	spl	
Laccobius minutus												1					0	1	1
Bledius gallicus				1						5		2		5		2	0	15	15
Bledius terebrans														4			0	4	4
Bledius subterraneus						3				3							0	6	6
Carpelimus bilineatus														1			0	1	1
Stenus juno		1															0	1	1
Stenus biguttatus		2				1											0	3	3
Stenus boops																1	0	1	1
Stenus sp.			1					1						1			1	2	3
Lathrobiium fulvipenne		1															0	1	1
Xantholinus longiventris																1	0	1	1
Philonthus fumarius										2							0	2	2
Philonthus quisquiliarius		1						1				1					0	3	3
Gabrius sp.												1		1			0	2	2
Oe. quadripustulatus																1	0	1	1
Negastrius pulchellus		1				1											0	2	2
Heterocerus sp.										1							0	1	1
Phaedon armoraciae												2					0	2	2
Coccidula rufa		1				1											0	2	2
Hippuriphila modeerii		2						4									0	6	6
Otiorhynchus tristis								1									0	1	1
Grypus equiseti		1								1							0	2	2
Notaris acridulus		1												9			0	10	10
Dryops ernesti	2																2	0	2
Dryops nitidulus[DD]	1																1	0	1
Sum no of species	6	12	3	7	2	8	4	14	3	14	7	12	7	14	10	9	21	43	
Sum no of species/spot	17		8		8		16		17		17		18		15				
Sum no of individuals	9	20	42	16	170	15	5	44	7	42	17	30	9	37	25	20	284	224	
Sum no of ind/spot	29		58		185		49		49		47		46		45				508