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EFFECTS OF BEAVER DAMS ON INVERTEBRATE DRIFT IN FOREST STREAMS

UTJECAJ DABROVIH BRANA NA DRIFT BESKRALJEŠNJAKA U ŠUMSKIM POTOCIMA

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Abstract

We aimed to assess the effects of beaver dams on the invertebrate drift fauna in five central Swedish boreal forest streams. Each stream was sampled once during the autumn, with drift traps placed upstream and downstream of the beaver dams. Drift densities (numbers/100 m^3 water) were calculated. The invertebrates were determined, dried and weighed. No significant differences were noted in total drift densities or in the drift densities of pelagic species. The drift densities of benthic species were higher upstream of the dam, mainly because Ephemeroptera were more abundant in the upstream part. No significant difference was observed in diversity or dry weight. The functional feeding group ratio: filtering collectors/gathering collectors was significantly higher downstream of the dam.

KEY WORDS: stream invertebrates, drift fauna, beaver dam, beaver pond

Introduction
Uvod

Eurasian beaver was reintroduced to Sweden beginning in 1922. By early 1990´s the population had increased to over 100 000 individuals and beaver again occurred over a large part of the country's landscapes (Hartman 2011).

The construction of dams by beavers alters the ecosystem in many ways (Naiman et al. 1988; Rosell et al 2005; Baskin et al. 2011, Zav'yalov 2011). Also, the cutting and decay of trees causes a substantial input of wood to the water, and zones with a more open canopy are created (Naiman et al. 1986). The alteration of the ecosystem by beaver is larger in low order streams (Naiman et al. 1986). In beaver ponds, typical running-water invertebrate taxa may be replaced by a community more similar to lakes or slow-running water (Sprules 1940; McDowell & Naiman 1986; Naiman et al. 1988; Rosell et al 2005). In central Sweden, typical pond taxa like Dytiscidae and Corixidae were abundant in high numbers in the pond (Rosell & Pedersen 1999). Sprules (1940) in Ontario, Canada, and Nummi (1989) in Finland found that larval densities of Ephemeroptera, Trichoptera and Plecoptera decreased in the over-dammed river bed, but the number of Chironomidae increased. The site immediately downstream of a beaver dam in USA exhibited lower Plecoptera and Trichoptera densities than upstream, but the total invertebrate, Diptera, Ephemeroptera and predator densities were higher immediately downstream of the beaver dam (Smith et al. 1991).

Beaver activities influence community functioning by increasing the absolute importance of collectors and predators, while decreasing the importance of shredders and scrapers at impounded sites. The dams can be an important

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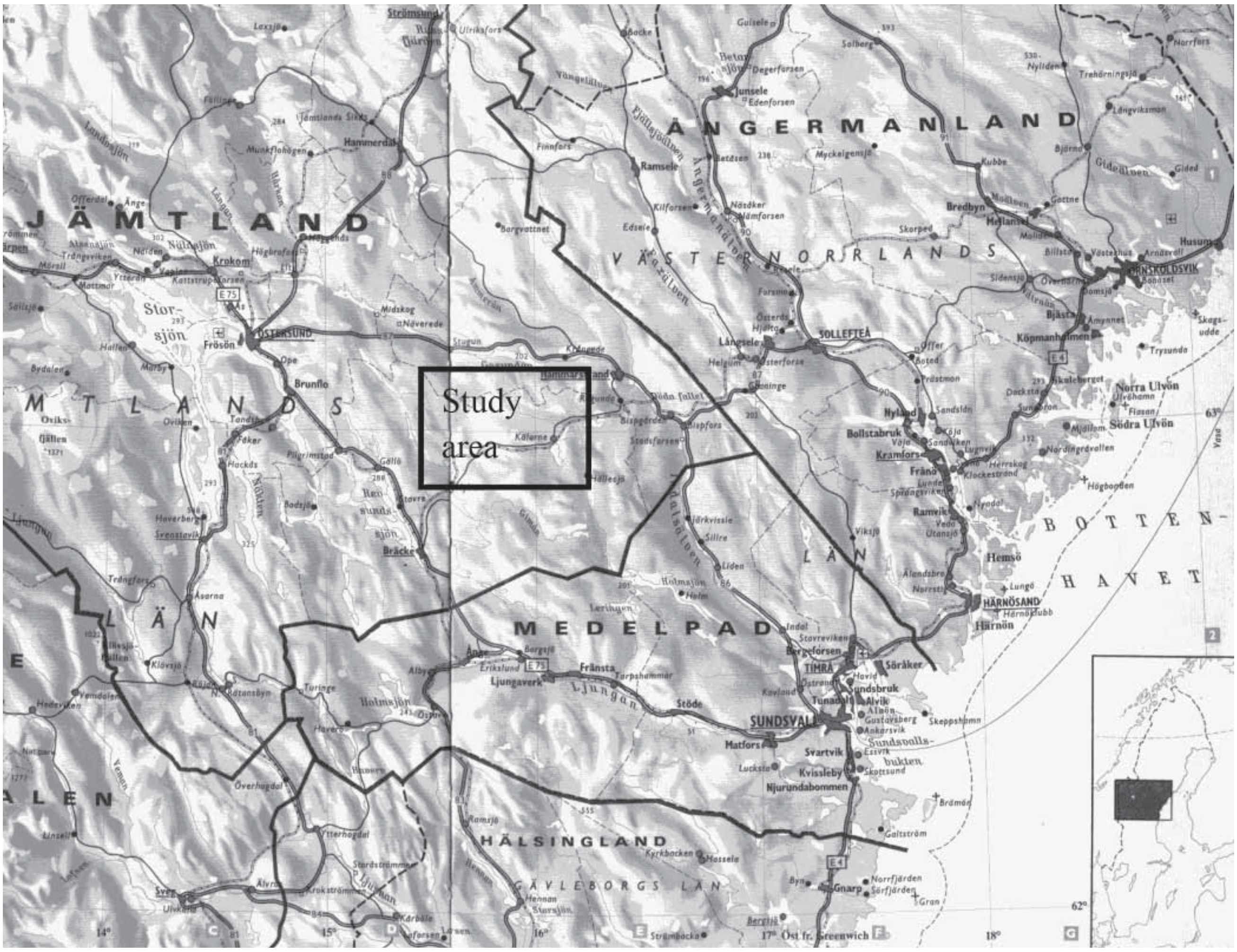

Figure 1 Area of the research in Jämtland county, eastern Sweden (smaller scale insert in the right corner)
Slika 1. Područje istraživanja u okrugu Jämtland u istočnoj Švedskoj (umetak desno prikazuje područje u sitnijem mjerilu).

substratum for certain taxa. In Alberta, Clifford et. al. (1993) found larger proportions of simuliid larvae on the dam than at the main stream sites indicating that beaver dams may be important for maintaining a lotic (flowing water) fauna in slow moving, low gradient streams. McDowell & Naiman (1986) found greater density and biomass in beaver ponds compared to riffles in spring and summer, but found no difference in autumn. Sprules (1940) found fewer insects (both number and taxa) emerging from a beaver pond compared to the same area when it was a preimpounded riffle. Naiman et. al. (1988) on the other hand found that the total number of species in beaver ponds appear to be similar to those in the natural stream channel.

Stream-dwelling organisms are often transported downstream in the water column in substantial numbers, and this phenomenon has been called drift (Allan 1995). The drift is composed of benthic animals, emerging or emerged insects on the water and planktonic species (Bailey 1966). The high numbers of drifting planktonic animals from lake outlets is well known (Allan 1995). The input of terrestrial animals in the drift can be substantial. Of the benthic fauna, Ephemeroptera, some Diptera and some Plecoptera and Trichoptera are the most common, in roughly that order. At a given time there is only a small percentage of the bottom fauna (less than 0.01 %) found in the water column above a unit area of bottom (Allan 1995; Elliott 1967). Drifting invertebrates are important food for some fish species (Allan 1995). Since pools serve as depositional regions, one might think that pools (and ponds created by beaver) could serve as a major brake on drift. Bailey (1966) claimed that pools trapped drift. Waters (1962) could see that drift out of the pool was about 20% less than drift of the riffles, suggesting some trapping in the pools, but other studies (e.g. Elliott 1967) give very little support to the proposition that pools trap drifting individuals.

Our purpose was to study how beaver activity affects the invertebrate drift of small boreal streams in central Sweden. This is an aspect of beaver activity that so far has been given very little attention. The following predictions were made:

1. The drift densities of benthic animals are expected to be lower downstream than upstream of the pond. The amount of drifting invertebrates decreases with decreasing water velocity (Elliott 1967; Everest & Chapman 1972). Reservoirs effectively block the drift of benthic species which cannot survive in a lentic (still water) environment (Ward & Stanford 1980). Gönczi et al. (1986) found that the drift of benthic animals below hydro-power dams was reduced compared to rivers with no dams.

2. It is likely that the amount of pelagic invertebrates in the drift is higher downstream than upstream of the pond. When a stream is dammed, the lotic taxa of the benthos are expected to be replaced by organisms preferring a lentic environment (Baxter 1977). In beaver ponds lotic taxa may be replaced by lentic (Sprules 1940; Macdowell & Naiman 1986; Naiman et al.1988).

3. The drift densities of Plecoptera should be lower downstream of the pond. Plecoptera have been shown to decrease in the original stream bed after impoundment (Sprules 1940; Baxter 1977; Nummi 1989). In the site immediately downstream of the dam, Smith et. al. (1991) found lower densities of Plecoptera. Plecoptera are typically reduced or absent below dams (Ward and Stanford 1980).

4. It is likely that the functional feeding group ratio of filtering collectors to gathering collectors is higher downstream the dam. Clifford et al. (1993) found that the fauna of the wood and debris dams shows similarities to the fauna of lake outlets, and filter-feeding Simuliidae were abundant in high densities. Streams below reservoirs are characterised by a predominance of filter-feeding Trichoptera and Simuliidae (Ward & Stanford 1980). The pond accumulates large amount of fine particulate organic matter in the sediment so the amount of FPOM deposited in benthos (the food for gathering collectors) downstream of the dam probably is reduced (Naiman et. al 1986).

Study area
Područje istraživanja

The study was performed in central Sweden (63°N, 15,30–16°E), in the eastern parts of the county of Jämtland (Fig. 1). The beaver dams are located in the drainage basins of river Indalsälven and river Ljungan, at 270–380 m above sea level. The landscape is hilly with the highest peaks reaching an altitude of over 500 m. Mean temperature in January is –10 °C and in July +15 °C. The precipitation is 700 mm per year. The dominant tree species are Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and birch (*Betula* spp). Along the streamside there is also alder (*Alnus incana*) and small numbers of rowan (*Sorbus aucuparia*), bird-cherry (*Prunus padus*) and sallow (*Salix caprea*). There is intensive forestry in the region, and the amount of old-growth stands is thus very low. According to local hunters, the first beavers were observed in the area during the 1950s. Today beaver is very abundant in the area, and most of the permanently flowing streams have or have had beaver present since late 1970's, i.e. 20 years before the study (Andreas Redin, personal observation). Fish fauna present in small streams in this area is generally brown trout (*Salmo trutta*) and minnow (*Phoxinus*

Table 1. Description of the streams in the study. The mean flow was calculated based on an average annual runoff of 9 l per km^2 and s (Meili 1986).
Tablica 1. Opis istraživanih potoka. Temeljeno na kalkulaciji srednjeg godišnjeg protoka od 9 l na km^2 u sekundi

Stream Potok	Stream order Raspored potoka	Drainage area Područje sljeva	Mean flow Srednja brzina toka	Width of stream Širina potoka	Length of pond Dužina jezera	Distance to upstream lake/wetland Udaljenost od uzvodnih jezera/vodenih staništa	Characteristics Značajke
Rismyrbäcken	2	12 km^2	108 l/s	1,6 m	90 m + 45 m	100 m (w)	Peat extraction in bogs Vađenje močvarnog treseta.
Holmsjöån	1	5 km^2	45 l/s	1,4 m	40 m	400 m (l)	Decaying dam. Intermediate age (ca 5 years) Raspadajuće brana srednje starosti, približno 5 godina.
Kroktjärns-bäcken	2	6 km^2	54 l/s	1,2 m	100 m	800 (l)	Beaver construction on timber-floating dam. Decaying. Oldest dam. Dabrova brana na plutajućem drvnom materijalu, u raspadajućem stanju Najstarija brana.
Norrån	4	45 km^2	405 l/s	3,0 m	70 m	800 (l)	Low dam (0,5 m) Niska brana (0,5 m)
Lötbergstjärn-bäcken	1	2,5 km^2	22 l/s	0,6 m	100 m	–	Dam in road culvert. Recently built. Brana u odvodnom kanalu, nedavno izgrađena.

Figure 2 Positioning of drift samplers in the upstream site at Norrån (A) and a picture of a beaver dam in Holmsjöån (B). Photo: Stig Redin (A) and Andreas Redin (B)

Slika 2. Fiksiranje kečera za praćenje drifta na uzvodnoj poziciji na potoku Norrån (A) i snimak dabrove brane na potoku Holmsjöån (B). Foto Stig Redin (A) i Andreas Redin (B)

phoxinus). In Norrån also pike (*Esox lucius*) and bullhead (*Cottus gobio*) occurred (Sjöberg & Hägglund 2011).

Samples were taken from five first- to fourth-order streams, with quite different drainage areas and medium year flows (Table 1). The sites where field work was undertaken had to fill certain criteria. First, they should have a beaver dam that raised the water level substantially (Fig. 2B). Streams with small beaver dams raising the water level less than 0.5 m were not considered. The area downstream of the dam had to have a certain minimum water velocity for the functioning of the drift samplers (Fig. 3). To avoid dealing with large lake effects (which would make any possible effects of the dam more difficult to detect), we avoided beaver dams close to lake outlets. The amount of beaver activity was estimated by looking after signs of foraging activity or tracks

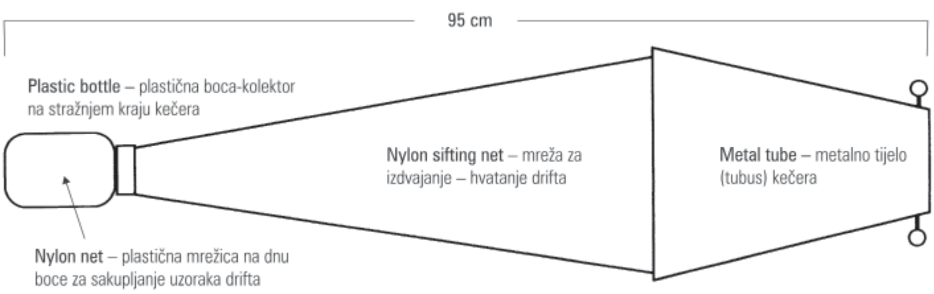

Figure 3 Drift sampler viewed from above.

Slika 3. Kolektor (kečer) za sakupljanje drifta (pogled odozgo)

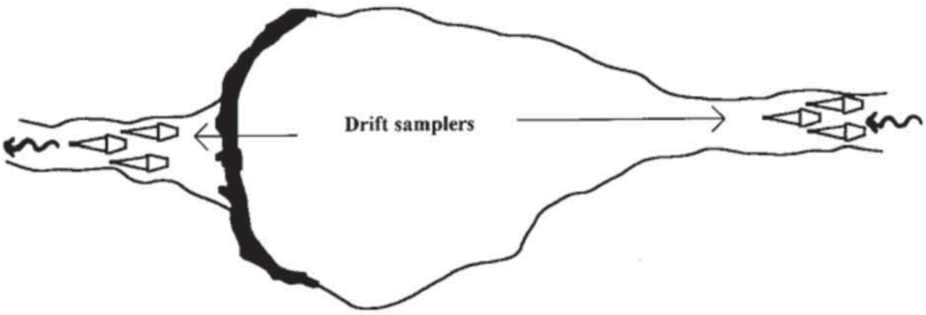

Figure 4 Placement of the drift samplers.
Slika 4. Mjesto postavljanja hvatača biološkog drifta (lijevo – nizvodno, desno – uzvodno)

in the mud. Combined with the condition of the dams and observations of any recent construction activity on them provided a good picture of whether beaver were present or not.

Materials and methods
Metoda rada

Drift samples were taken during the autumn of 1997, from August 29 to September 4. Each stream was sampled once during 4 hours, from 19.00 to 23.00 (daylight savings time). Six drift samplers (Figs. 2A, 3) were used. Three were placed downstream of the beaver dam within a distance of 1,5–4 m from the dam, depending on where most of the water had returned to the main stream bed. The other three were placed immediately upstream of the pond (Fig. 4). The samplers were held in position with iron rods driven into the stream bed.

All samples were preserved in 70% alcohol and then handsorted in the laboratory. Samples were weighed on a Mettler AD 160 balance after drying at 60° for 24 h. Drift density was calculated as the number of individuals in 100 m^3 of water. Animals already dead at the time of the catch were not included. The animals were divided into a benthic and a pelagic group, with both free-swimming and planktonic animals. Emerging water insects and terrestrial animals were placed in separate groups.

Benthic insects were divided into functional feeding groups according to keys in Merritt & Cummins (1996) and Merritt & Cummins (1978). Functional feeding group ratios are responsive to changes in food resource base (e.g., algae, litter, fine organics, prey) and are a useful ecological tool, indicative of various ecosystem parameters (Table 2). The following ratios were calculated: predators/total of all groups, filtering collectors/gathering collectors, shredders/total collectors and scrapers+filtering collectors/shredders+ gathering collectors.

Habitat features were measured at each site. Water temperature was measured with a digital thermometer. To measure pH, indicator paper was used (Merck Spezialindikator pH 4,0–7,0). The height, width and length of the beaver dam were measured. Water velocity was measured by timing a weighted float over a marked distance. The bottom substrate was also categorised by ocular inspection at each site.

Table 2. Examples of indications of feeding group ratios (from Merritt & Cummins 1996)
Tablica 2. Primjeri značenja pojedinih omjera između funkcionalnih grupa (prema Merrit i Cummins 1996)

Functional feeding group ratio Omjer organizama prema hranidbenim skupinama	Ecosystem parameter Parametri ekosustava
Predators to Total of all other groups Predatori u odnosu na sve ostale skupine	Shows relative importance of predators to all other functional feeding groups. Indicates top-down predator control. Pokazuje relativnu značajnost predatora prema svima ostalim funkcionalnim hranidbenim skupinama.
Filtering Collectors to Gathering Collectors Filtratori sitnih čestica organske tvari u odnosu na sakupljače detritusa	FPOM (fine particulate organic matter) in transport to FPOM deposited in benthos. Shows high amount of FPOM in transport relative to deposit phase. Fine čestice organske tvari (FPOM) u odnosu na FPOM deponiran u bentosu. Ukazuje na visoki udio FPOM u transport u odnosu na fazu depozicije.
Scrapers+Filtering Collectors to Shredders+Gathering Collectors Strugači+filtratori sitne čestične organske tvari u odnosu na usitnjivače+sakupljače detritusa	Substrate stability. High ratio indicates low relative abundance of deposit-feeding groups, hence low stability of deposits. Stabilnost supstrata. Visoki omjer ukazuje na malu relativnu abundance organizama koji se hrane organskim depozitom, što dalje ukazuje na nisku stabilnost depozita.
Shredders to total Collectors Usitnjivači u odnosu na ukupne sakupljače	CPOM (coarse particulate organic matter) to FPOM. Indicates high presence of non-processed detritus relative to processed. CPOM (grube čestice organske tvari) u odnosu na FPOM (fine čestice organske tvari) ukazuje na visoku prisutnost neprocesuiranog detritusa u odnosu na procesuirani

The drift sampler (Fig. 3) was made of a metal tube with an opening diameter of 12 cm, which gave an effective sampling area of 113 cm^2. The tapered net had a mesh aperture of 0.5 mm (Elliott 1970). At the back of the net, a 500 ml plastic bottle was fixed with a net at the bottom.

The residuals were tested for normality (Shapiro-Wilk W Test) and for equality of variance (O' Brien test) to see if conditions were met for using Anova. A Two Way Anova test was used for the statistical analysis of all parameters except the functional feeding group ratios, where the residuals were not normally distributed. Drift densities were transformed with the fourth root (Allan & Russek 1985). The Friedman test was used for the functional feeding group ratios and before testing, the data from the three drift traps in each site were combined. Data from Lötbergstjärnbäcken were excluded from the functional feeding group ratios because there were so few individuals in this stream.

Results
Rezultati

Temperature and pH were only measured in the upstream part in every stream. Both pH and temperature were highest in the largest stream, Norrån (Table 3). The bottom substrate and water velocity varied both between different streams, and between the upstream and downstream sampling points (Table 3).

A total number of 3882 and 1758 animals were caught in the upstream and downstream parts respectively. In Kroktjärnbäcken, which had the highest catches (Fig. 5), the to-

Table 4. Main results from statistical tests of differences in sampled variables between upstream and downstream areas. * = 0,05>p>0,005; ** = p<0,005; n.s. = not significant. For all Anova tests, both effect of up/downstream position (df=1) and of stream (df=4) as well as interaction terms (df=4).

Tablica 4 Glavni rezultati statističkih testova utvrđenih različitih vrijednosti praćenih varijabli između lovnih postaja smještenih uzvodno i nizvodno od ujezerenih dijelova potoka sa dabrovim branama. * = 0,05>p>0,005; ** = p<0,005; n.s. = nije značajno. U svim provedenim Anova testiranjima obuhvaćena su oba učinka pozicije mjesta uzorkovanja uzvodno i nizvodno (df=1), potoka (df=4) kao i njihova međudjelovanja (df=4).

Variable Varijabla	Sign. level Razina statističke značajnosti
Ephemeropthera drift density – Gustoća drifta Ephemeropthera	**
Diptera drift density – Gustoća drifta Diptera	n.s
Trichoptera drift density – Gustoća drifta Trichoptera	n.s
Plecoptera drift density – Gustoća drifta Plecoptera	n.s
Total drift density – Ukupna gustoća drifta	n.s
Benthic drift density – Gustoća drifta bentičkih vrsta	*
Pelagic drift density – Gustoća drifta pelagičkih vrsta	n.s
Dry weight – Suha tvar	n.s
Total diversity – Ukupna raznovrsnost	n.s
Benthic diversity – Raznovrsnost bentičkih vrsta	n.s
Pelagic diversity – Raznovrsnost pelagičnih vrsta	n.s
% predators – % grabežljivaca	n.s
Filtering collectors/ gathering collectors Filtratori sitne čestične organske tvari/sakupljači detritusa	*
Shredders/collectors – Usitnjivači/sakupljači	n.s
Scrapers + filtering collectors/ shredders + gathering collectors – Strugači + filtratori sitne čestične organske tvari/usitnjivači + sakupljači detritusa	n.s

Table 3. Bottom substrate, water velocity, depth, pH and temperature in the studied streams.

Tablica 3. Supstrat dna, brzina vode, dubina, pH i temperature potoka na kojima je obavljeno istraživanje.

Stream Potok	Sampling point Mjesto uzorkovanja	Bottom substrate Supstrat dna	Velocity Brzina	Depth Dubina	pH	Temp (C°) Temperatura (C°)
Rismyrbäcken	upstream uzvodno	pebbles and gravel krupni šljunak i šljunak	0,40 m/s	25 cm	6,5	15,3
	downstream nizvodno	boulders and gravel krupno kamenje i šljunak	0,52 m/s	50 cm		
Holmsjöån	upstream uzvodno	cobbles and gravel manje kamenje i šljunak	0,30 m/s	20 cm	6,1	15,8
	downstream nizvodno	boulder, cobbles and gravel krupno i manje kamenje, i šljuinak	0,39 m/s	20 cm		
Kroktjärnbäcken	upstream uzvodno	cobbles and gravel manje kamenje i šljunak	0,53 m/s	25 cm	6,1	14,2
	downstream nizvodno	boulders and gravel krupno kamenje i šljunak	0,31 m/s	50 cm		
Norrån	upstream uzvodno	boulders and gravel krupno kamenje i šljunak	0,45 m/s	50 cm	7,0	16,5
	downstream nizvodno	pebbles, gravel and sand krupni šljunak, šljunak i pijesak	0,58 m/s	40 cm		
Lötbergstjärnbäcken	upstream uzvodno	boulders and gravel krupno kamenje i šljunak	0,22 m/s	15 cm	6,1	11,2
	downstream nizvodno	gravel and sand šljunak i pijesak	0,23 m/s	15 cm		

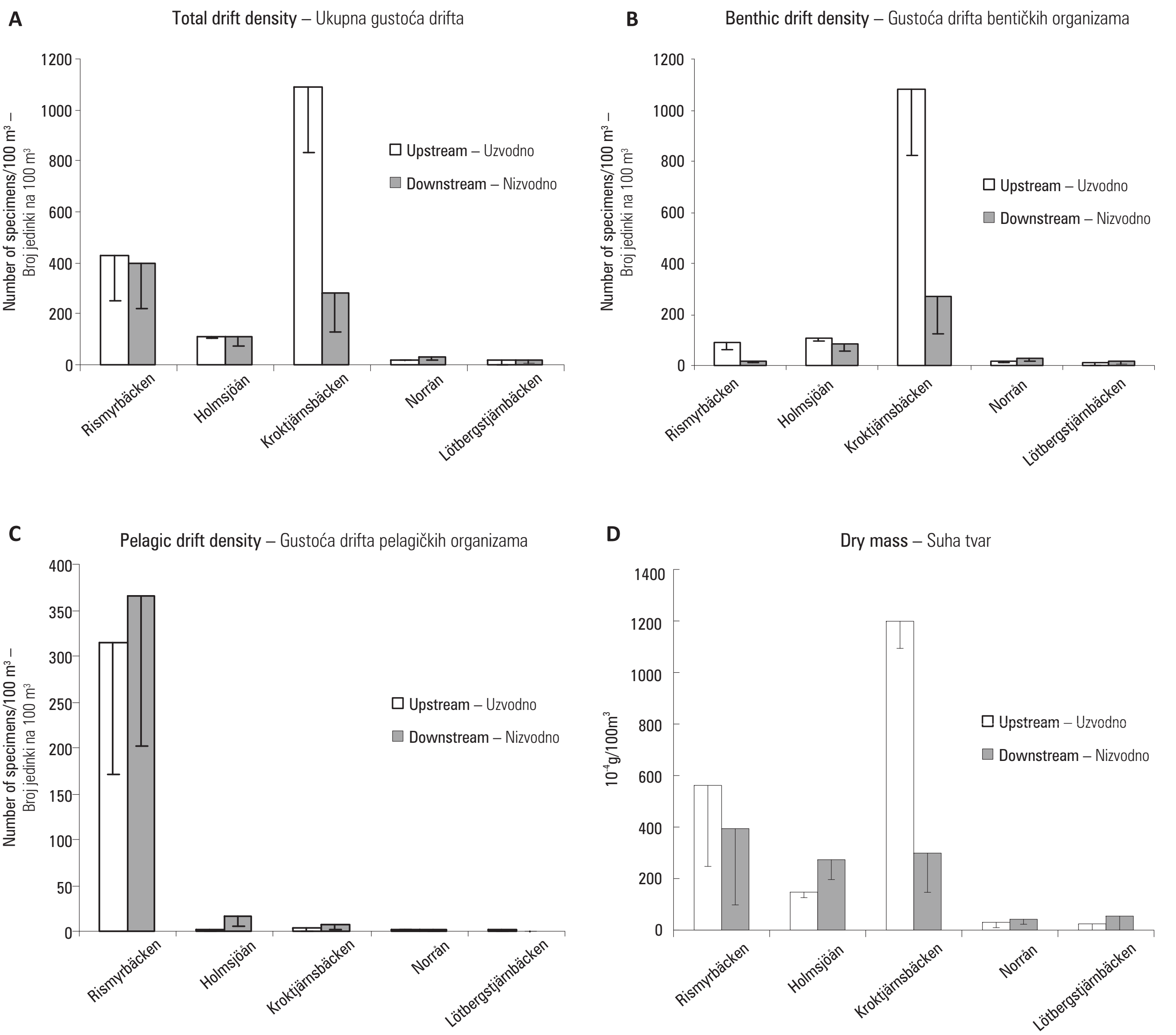

Figure 5 The mean total drift density (a), mean drift density of benthic (b) and pelagic (c) species, and total dry weight (d). The bars show the estimated number of drifting individuals per 100 m^3 of water at the site during the period of sampling. Error bars are 1 S.E. (only lower part shown.)
Slika 5. Srednja vrijednost ukupne gustoće drifta (a), gustoće drifta bentičkih (b), pelagičnih (c) vrsta i ukupne suhe tvari (d). Stupci predstavljaju procijenjeni broj jedinki na 100 m^3 vode na lokaciji u razdoblju istraživanja. Granice pouzdanosti (1 S:E) na grafikonima su prikazane samo donje vrijednosti.

tal drift densities exceeded 1000 individuals/100 m^3 in two of the drift traps in the upstream part. In Lötbergstjärnbäcken, which had the lowest catches, no animals were caught in one of the traps in the upstream part. In Kroktjärnbäcken the family Leptophlebiidae was very abundant. The Ephemeropteran dominance was not that pronounced in the other streams. Among the pelagic group, Cladocera on average was very dominant, but most of them were found in Rismyrbäcken. In the other streams the number of Cladocera was low.

The drift differed significantly between the streams for most of the variables, and that the interaction between stream and the part analyzed was significantly different in most cases (Table 4). No significant difference between the upstream and downstream area was noted in the total drift densities (Fig. 5). The drift densities of benthic species were however significantly higher at the sites upstream of the dams. In this study no significant difference in the drift density of pelagic species was observed.

The drift densities of Ephemeroptera (Fig. 6) were significantly higher upstream of the beaver dams. For Diptera, Trichoptera and Plecoptera no significant difference was observed.

Diversity was studied as the number of aquatic genera identified. A total of 45 taxa were identified across all sites (table 5). No significant difference was observed in total diversity or in diversity of benthic and pelagic species. There was no significant difference in dry weight (Fig. 5).

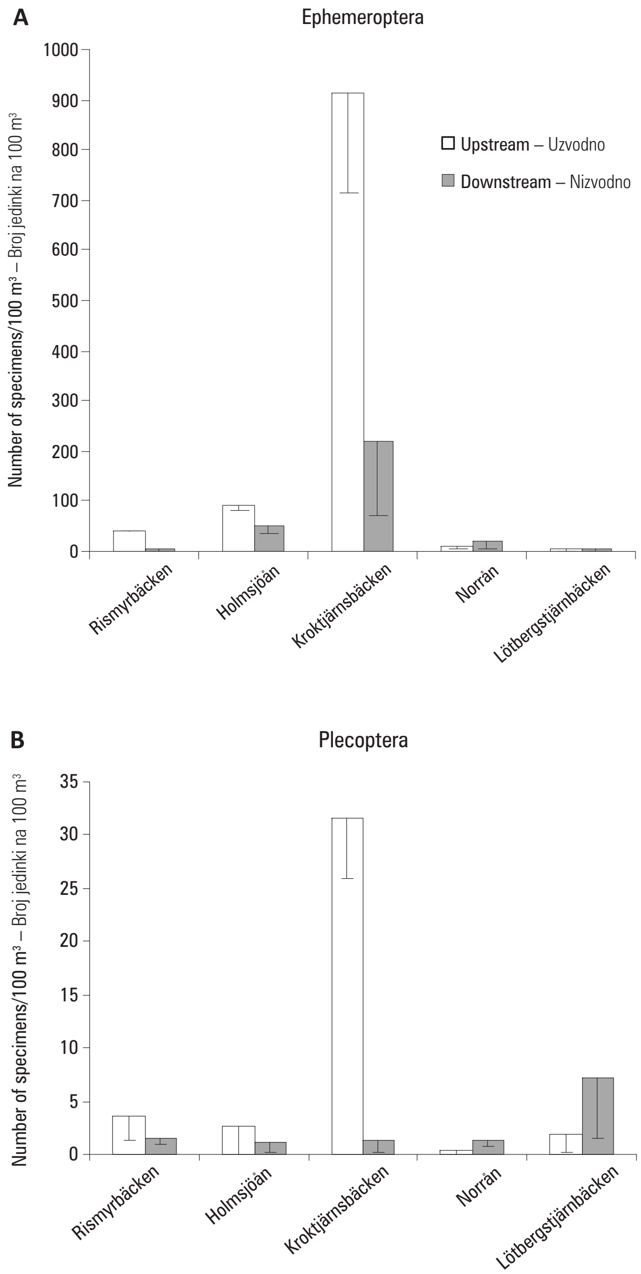

Figure 6 The mean drift densities for Ephemeroptera (a) and Plecoptera (b). Error bars are 1 S.E.

Slika 6. Aritmetička sredina gustoće drifta kod reda Ephemeroptera (a) i Plecoptera (b).

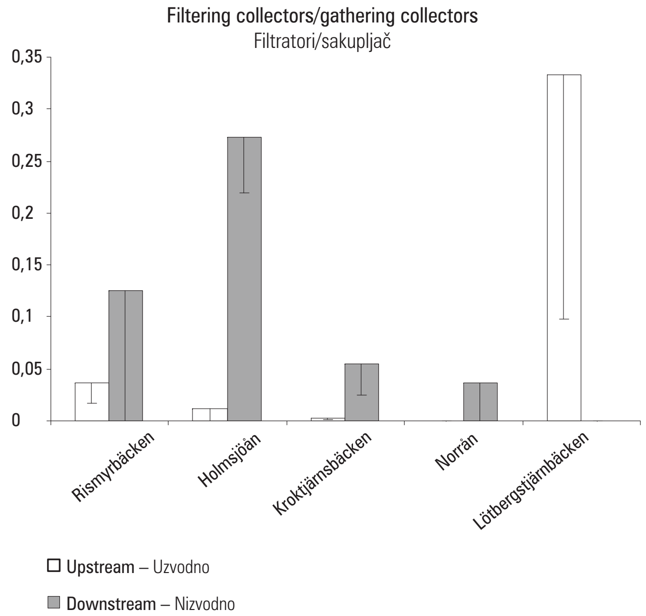

Figure 7. The mean of the ratio between functional feeding groups filtering collectors and gathering collectors. Error bars are 1 S.E.

Slika 7. Aritmetička sredina omjera između funkcionalnih hrandibenih skupina filtratora sitne čestične organske tvari i sakupljača detritusa

The ratio filtering collectors/gathering collectors (Fig. 7) was significantly higher downstream the dam, but for the other ratios no significant differences were noted.

Discussion
Rasprava

Beaver activity certainly alters the habitat and makes it potentially very unique (McDowell and Naiman 1986). The drift of the downstream sites is likely to receive animals from all these different beaver altered habitats – pond, dam, and downstream reach – and perhaps also from the area upstream the pond since drift distances can be quite long (Allan 1995).

Drift density of benthic species: Our first prediction, that the density of drifting benthos would be lower downstream the dams, was upheld. The significantly higher drift density of benthic species in the upstream part comes largely from more Ephemeroptera. This could be a result of: 1) the ponds trapping drifting individuals 2) reduced entry to the drift from the beaver pond or 3) reduced entry to the drift from the area downstream the dam. McDowell & Naiman (1986), Nummi (1989) & Sprules (1940) found that larval densities of Ephemeroptera decreased in the over-dammed river bed. There is no absolute correlation between the benthic community and the drift fauna. Certain genera can be present in high numbers but contribute very little to the drift, and vice versa (Bailey 1966). Sjöberg (unpublished.data) found Ephemeroptera in the ponds, but of the genera *Cloëon* that prefers slow-running waters and possibly is not a drift-prone taxon. The third explanation is not likely since Smith et al. (1991) found higher densities of Ephemeroptera downstream the pond. Sjöberg (unpublished data.) could detect no difference in Ephemeropteran density at the downstream site. Reduced entry from the pond caused by reduction and/ or change to genera which drift little is a possible explanation for the lower Ephemeropteran drift densities. If, however, all the Ephemeroptera that enter the pond would pass through, there would be no difference in drift density. Some trapping and maybe more importantly, predation from fish in the pond is also likely to occur and contribute to the result.

Table 5. Composition of the drift in the studied streams
Tablica 5 Sastav drifta u istraživanim potocima

Bottom fauna – fauna dna		Upstream – uzvodno		Downstream – nizvodno	
		numbers – broj	% of bottom fauna – % faune dna	numbers – broj	% of bottom fauna – % faune dna
Mollusca	Gastropoda	5	0,16	4	0,54
	Lamellibranchiata			2	0,27
Annelida	Oligochaeta	3	0,09	25	3,36
Arachnida	Acari	15	0,47	5	0,67
	Other	1	0,03		
Ephemeroptera	Baetidae	70	2,19	49	6,59
	Leptophlebiidae	2429	75,98	428	57,60
	Heptagenidae	111	3,47	15	2,02
	Ephemeridae	2	0,06	1	0,13
Trichoptera	Hydroptilidae	279	8,73	2	0,27
	Limnephilidae	36	1,13	24	3,23
	Rhyacophilidae	4	0,13	5	0,67
	Polycentropodidae	9	0,28	14	1,88
	Others	4	0,13	2	0,27
Plecoptera	Nemouridae	74	2,31	12	1,62
	Taeniopterygidae	2	0,06	2	0,27
	Leuctridae	17	0,53	5	0,67
	Perlodidae	3	0,09	1	0,13
Diptera	Chironomidae	115	3,60	107	14,40
	Simuliidae	5	0,16	35	4,71
	Others	1	0,03	1	0,13
Coleoptera	Elmidae	4	0,13		
	Others		0,00	1	0,13
Odonata		8	0,25		
Others				3	0,40
Total number of bottom fauna – Ukupna fauna bentosa		3197	100,00	743	100,00
Pelagic fauna – pelagička fauna		numbers – broj	% of bottom fauna – % faune dna	numbers – broj	% of bottom fauna – % faune dna
Diptera	Culicidae	4	0,63		
	Others	3	0,48	1	0,10
Crustacea	Cladocera	595	94,29	937	96,10
	Cyclopidae	1	0,16	7	0,72
Heteroptera	Corixidae	14	2,22	12	1,23
Coleoptera	Dytiscidae	10	1,58	18	1,85
	Other	1	0,16		
Others - Ostalo		3	0,48		
Total number of pelagic fauna – Ukupno pelagičkih vrsta		631	100,00	975	100,00
Emerging – pri izlasku					
Diptera		9		13	
Terrestrial – kopnena fauna		45		27	

Drift density of pelagic species: The second prediction, that the amount of pelagic invertebrates would be higher downstream of the dam, was not supported. In the ponds, typical running water taxa may be replaced by pond taxa (Sprules 1940; Nummi 1989; McDowell & Naiman 1986). Since we did not take any insect samples from the ponds *per se* we cannot say for sure that lentic taxa were abundant. In only one of our five streams was the dam made quite recently (Lötbergstjärnbäcken). In the other, older, ponds it is likely that a more lentic fauna has developed. No overall significant difference was, however, observed in drift densities of pelagic species between upstream and downstream sites. There may be suitable habitats for lentic invertebrates in slow-running parts and in lakes further upstream of the sampling point above the dam. Although we tried to find beaver dams far from lake outlets there might still be some lake effects in our results. It is likely that the distance to wetlands and lakes upstream overrides the local production of pelagic fauna in the pond itself (see Table 1).

Plecoptera: The third prediction, that drift of Plecoptera would be reduced downstream of the dam, was not supported by a statistically-significant difference. The results thus do not agree with the idea that the reduction of Plecoptera in the benthos of ponds and reservoirs (Sprules 1940; Ward & Stanford 1980; McDowell & Naiman 1986; Nummi 1989) and in the area downstream the dam (Ward & Stanford 1980; Smith et al. 1991) would reduce the Plecopteran drift densities.

Functional feeding groups: The fourth prediction, that the functional feeding group ratio filtering collectors to gathering collectors should be higher in the sites downstream the dams, was supported. The wood and debris dam created by beaver are often a suitable habitat for filtering collectors (Clifford et al. 1993). Streams below reservoirs are characterised by a predominance of filter-feeding Trichoptera and Simuliidae (Ward & Stanford 1980). FPOM is deposited in large amounts in the benthos of the beaver dam (Naiman et al. 1986). Gathering collectors that feed on FPOM in deposit are likely to have their food resource decreased in the downstream area.

Conclusions
Zaključci

Drift sampling is rapid and relatively easy and appears to be a useful method for studying effects of beaver activities on the stream community. Although it does not directly mirror the composition of benthos, it can be seen as an indicator of the conditions, and also gives a direct picture of food availability for salmonid fish.

Although the numbers of streams we investigated was not large, the functional group approach and analysis of trophic group ratios (Merritt & Cummins 1996) is, we suggest, a promising avenue for future studies, and allows testing of *a priori* hypotheses as we do here.

There was no general trapping of drifting animals in ponds created by beaver, so the area downstream the dam can have a rather rich drift. The drift densities of benthic animals are however reduced downstream of beaver dams, and beaver ponds in this case seem to have the same general effect on drift as large water power station reservoirs (Gönczi et al. 1986).

The drift differed considerably among the studied streams. The effects on the invertebrate drift are likely to differ considerably with the size of the stream, as well as the size and age of the dam. Finally, the condition of the dam and the distance to the nearest upstream lake may also impact the composition of the drift downstream.

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Sažetak

Cilj istraživanja bio je utvrditi imaju li dabrove brane utjecaj na drift beskralješnjaka u 5 šumskih potoka na području središnje Švedske. Uzorci su na svakom potoku prikupljani u jesen, koristeći kečere za hvatanje drifta postavljene uzvodno i nizvodno od ujezerenih dijelova potoka zajaženih dabrovim branama. Ulovi beskralješnjaka su osušeni, vagani i determinirani te je izračunata gustoća drifta (broj uzoraka/100 m^3 vode). Uočeno je da nema značajne razlike u ukupnoj gustoći drifta kao i u gustoći drifta pelagičkih vrsta uzvodno i nizvodno od dabrovih brana. Gustoća drifta bentičkih vrsta bila je viša u dijelovima potoka uzvodno od dabrovih brana, uglavnom iz razloga što su vrste iz reda Ephemeroptera bile jače zastupljene u uzvodnim dijelovima. Nije zabilježena značajna razlika u suhoj tvari i raznolikosti vrsta. Utvrđen je sljedeći omjer organizama prema funkcionalnim hranidbenim skupinama: odnos broja filtratora koji skupljaju sitnu čestičnu organsku tvar u odnosu na brojnost sakupljača detritusa značajno je veći u korist prvih u dijelu vodotoka nizvodno od pozicije dabrove brane.

KLJUČNE RIJEČI: vodeni beskralješnjaci, faunalni drift, dabrova brana, dabrovo jezero

Errata corrige

U prošlom broju Šumarskog lista (9–10/2013, str. 447–459) u članku "Utjecaj navodnjavanja i mikroreljefa u rasadniku na morfološke značajke šumskih sadnica hrasta lužnjaka (*Quercus robur* L.) i kitnjaka (*Quercus petraea* L.)", grupe autora (Drvodelić et al.), potkrala se sitematska pogreška kod pisanja znanstvenog naziva hrasta kitnjaka: umjesto "*Quercus petraea* L." treba stajati "*Quercus petraea* (Mattuschka) Liebl."

Originalni STIHL lanci za pile: vrhunska kvaliteta i pouzdanost

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