Distribution and the impact of outfield drainage on carabids (*Coleoptera, Carabidae*) in north western Eysturoy, Faroe Islands

Útbreiðsla av svartaklukkum (Coleoptera, Carabidae) *í Útnyrðingseysturoy og hvussu ávirkast hon av avveiting*

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Abstract

During an Environmental Impact Assessment (EIA), Carabidae was one of the factors used to assess the impact of land drainage for hydropower. The areas investigated were outfields; these areas included a broad range of habitats, and therefore the distribution of Carabidae in the areas in question provided information about the distribution of Carabidae as a whole, which this paper aims to describe. Fourteen of the 26 previously recorded Carabidae species were found. One species *Agonum fuliginosum* was recorded for the first time in the Faroe Islands. Another Carabidae *Bembidion bruxellense* was recorded for the first time in Eysturoy. Altitude and season were seen to influence the abundance of some carabids and this is related to the distribution of preferred habitats and to reproductive cycles. The distribution of Carabidae and the effects of outfield drainage are discussed in this paper.

Úrtak

Ein árinskanning varð gjørd fyri at finna fram til, hvussu avveiting av lendi kann ávirka lívverurnar í lendinum. Eitt nú vórðu svartaklukkur kannaðar. Kannaðu økini, ið øll vóru uttangarðs, fevndu um ymisk sløg av lendi. Tí gav hendan kanning nógva vitan um útbreiðslu hjá svartaklukkum yvirhøvur, ið eisini er ætlanin at lýsa við hesi grein. Fjúrtan av teim 26 kendu svartaklukkusløgunum vórðu funnin. Eitt slag varð skrásett fyri fyrstu ferð í Føroyum, *Agonum fuliginosum*. Ein onnur svartaklukka *Bembidion bruxellense* varð skrásett fyri fyrstu ferð í Eysturoy. Hædd og árstíð høvdu ávirkan á útbreiðsluna av svartaklukkunum. Hetta varð sett í samband við aðra vitan um sløgini, eitt nú hvørji búøki tey nýta og nær á árinum tey makast.

Introduction

The Faroese carabids are regarded as being of northwest european origin (Bengtson, 1981). Hitherto 26 species of carabidae have been recorded in the Faroe Islands (Bengtson, 1982). These 26 species were already described in 1930 by West (1930), who was working with material mainly collected by Danish zoologists through the mid 1920s. Since a Norvegian/ Swedish team in 1978 and 1979 made a survey covering all the islands except the smallest one (Bengtson, 1981; 1982), no major work examining the distribution of carabidae in the Faroe Islands has been printed in any scientific paper. The Norvegian/Swedish team found 18 of the 26 species, which is probably related to the fact that they did not have such extensive cover of habitats as did the earlier investigations, and that some of the 8 remaining species are rare. Shetland, our neighbour to the south is about the same size as the Faroe Islands (1400 km^2), but have more than 55 species of carabidae (Bengtson, 1981). This can be explanied by Shetland being closer to the mainland pool from where the carabidae are dispersing (Bengtson, 1981). Bengtson (1982) shows results which West (1930) presented in The Zoology of the Faroes; he lists all the 26 known species of carabidae in the Faroes at that time with reference to geographical distribution, and he finds that 15 of the species are common and widely distributed within the islands.

Map 1. *Faroe Islands. The location of the island Eysturoy is shown. Darkest shades are areas above 600 m altitude, medium shades are areas above 300 m altitude, and areas with no shade are below 300 m altitude.*

Results presented in this paper come from an Environmental Impact Assessment (EIA) dealing with the impact of draining of land on the distribution of carabid-communities. The field work was done in summer 2007. The structure af the carabidae community was used to assess the state of the environment in question (Fosaa *et al.*, 2008). Carabidae are commonly found in different habitats and distribution of this family of beetles is a good indicator of the state of the environment (Luff 1996; Rainio and Niemelä 2003). As carabidae are one of the best researched insects in the Faroe Islands (Bengtson 1981; 1982); this gives better possibilities for making comparisons.

The aim of this paper is to be a supplement to the already excisting works on the distribution of carabidae in the Faroes and is meant as a purely faunistic paper increasing the knowledge of the distribution of carabids, with reference to habitat. Possible effects from draining are also included.

Material and Methods

Description og the area

The study area is in the island Eysturoy in the northern and the central part of the Faroe Islands, see Map 1. Three different areas with different drainage histories were examined. Eiði 1 the older drained (OD) area has been drained since 1987, and Eiði 3 the newly

Map 2. *The map shows the locations of the pitfall-traps. ES 1, ES 13 and ES 31 refer to the intakes at the rivers where pitfall-traps were placed, these are the localities from the OD area (Eiði-1). NS 53, NS 57 and NS 66 refer to intakes at the localities from the UD area (Eiði-2). Ff 1, Ff 2 and Ff 3 refers to the intakes at the rivers in the the ND area (Eiði-3g). Altitudes as in map 1.*

drained (ND) area has been drained since 2000, and lastly Eiði 2 an undrained (UD) area was examined (see Map 2). The drained study sites are situated on the NW part of the island Eysturoy, which is the next largest island in the Faroe Islands. The drained areas are used as catchment areas for a hydropower plant. The two drained areas face in different directions, the older drained area is facing southwest, while the newer drained area is facing northeast. The undrained area is in direct continuation of the older drained area, and thus also facing south west (Map 2).

The Faroe Islands are an archipelago situated between the Shetland Islands and Iceland (approx. 62°N, 7°W). There are 18 basaltic islands ranging in size from 1 to 374 km^2 (total area:1400 km^2), and the highest peaks of the different islands reach 370-880 m a.s.l. The climate is highly oceanic. The main vegetation types in the study areas are heaths, moss heath, blanket mires and mires. The geology of the areas is different, since a geological intrusion a so called sill is the major part of the undrained area. The area is treeless as the whole Faroe Islands, and has been treeless since the last iceage (Jóhansen, 1985). The warmest months in the Faroe Islands are July and August with 11°C (lowland), while February is the coldest with a mean of 4°C (lowland). The mean precipitation of the lowland is 1500 mm per year. The mean precipitations reflect the topography of the islands such that the costal area receive 1000 mm per year, increasing to more than 3000 mm per year in the central parts (Cappelen and Laursen 1998).

Sampling

To collect carabids we used pitfall-traps. They were made of plastic-beakers (7 cm diameter, 10 cm deep) containing 2 dl formalin solution (3.5 % vol). The bakers were inserted into a hole, the upper edge at soil surface level. A lid was placed over the cups (we used stones), taking care that the lid did not stop the insects from entering the traps (Sutherland, 2002). It was decided to place the pitfall traps along rivers. This is because the riverside banks are likely much affected by draining, since it is at the rivers that SEV (National Electricity Supplier) has placed the water intakes. Three rivers in each area were chosen in a way that enabled us to place traps as long as possible down towards the coast-line, but so that we were still in the outfields. At 5 or 6 altitudes a.s.l. stations containing 5 pitfall-traps were placed on

Stations with pitfall-traps	**ES 1**	**ES 13**	**ES 31**	**NS 53**	**NS 57**	**NS 66**	**Ff 1**	**Ff 2**	**Ff 3**
Altitude above sea level	163 157 128 118 78	182 175 130 70 10	195 183 150 100 70	238 215 200 170 125 57	250 220 160 110 70 6	230 220 170 120 70	211 190 157 90 70 68	210 205 156 125 92 50	180 177 150

***Table1.** Details of localities were pitfall-traps were set up, see map1. Pit traps were set up on both eastern (e) and western (w) riwerside banks. Altitude is in meters.*

both riversides (see Map 2). It was only possible to have 6 stations at one river in each area; this was because it was not desirable to come too close to inhabited areas. We did not want our formalin containing traps to be near playing children. The lowest altitude used was 6 m and the highest was 250 m. In the OD and ND area one station was placed right above the intake, one right below the intake, and then at certain distances (50m altitude) downwards, as far down as possible. The same was done in the UD area but here stations were above and below planned intakes. Intakes refers to the place in the river where SEV takes the water or plans to. At each station we placed 5 pitfall-traps at 1 m distance in a line outwards from the riverbank; this was done on both sides of the river, see Table 1 and Map 2. The traps were intended to reveal if there was any difference between places where SEV has taken the water and not. The season was July and August 2007, during which pitfall-traps were emtied regularly (every 2 to 3 weeks), though

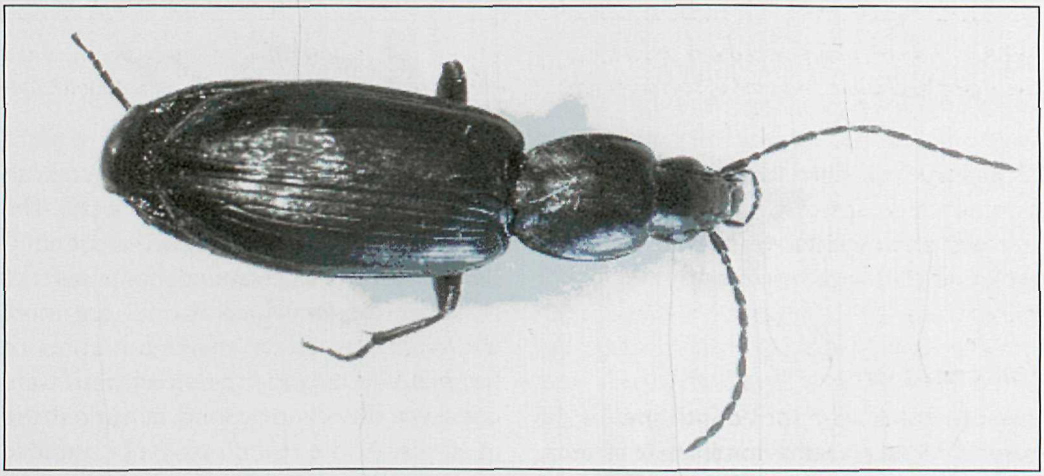

Fig. 1 Agonum fuliginosum *found in the outfield above the village Funningur. New to the Faroes.*

	OD-AREA (Eiði 1)							
	Above 150 altitude		Below 150 altitude		First part of season		Later part of season	
	Date: 1, 3, 15, 20 aug-2007 N=23		Date: 1, 3, 15, 20 aug-2007 N=36		Date: 1 - 3 aug 2007 N=30		Date: 15 - 20 aug 2007 N=29	
	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)
Agonum fuliginosum	0	0.0	0	0.0	0	0.0	0	0.0
Bembion bruxellense	0	0.0	0	0.0	0	0.0	0	0.0
Calathus fuscipes	23	4.9	111	14.4	93	13.4	41	7.9
Calathus melanocephalus	9	1.9	1	0.4	9	1.5	1	0.5
Carabus problematicus	60	18.8	135	17.9	62	8.1	133	28.7
Loricera pilicornis	1	0.3	0	0.0	0	0.0	1	0.3
Nebria rufescens	23	5.6	38	5.2	30	4.6	31	6.2
Nebria salina	81	25.3	178	23.0	106	19.8	153	28.0
Notiophilus biguttatus	9	2.2	11	1.5	9	1.6	11	1.9
Patrobus atrorufus	45	11.6	136	20.0	117	20.2	64	13.0
Patrobus sepentrionis	73	22.6	47	6.7	102	18.7	18	6.9
Pterostichus adstrictus	3	0.7	14	2.8	13	3.5	4	0.4
Pterostichus diligens	1	0.5	4	1.1	1	0.4	4	1.3
Pterostichus nigrita	2	1.0	3	0.3	2	0.2	3	0.9
Trechus obtusus	18	4.7	38	6.7	35	7.9	21	3.8
SUM	348	100.0	716	100.0	579	100.0	485	100.0

Table 2. *Numbers and percentage abundance of carabidae collected in OD area. Data are presented according to altitude and part of season. N refers to number of stations, each containing 5 pit-fall traps.*

it was not possible to emty all stations equally many times. Therefore N is not equal in the statistics. Pitfall-traps were set up in 94 localities, altogether this resulted in 470 pitfall-traps.

Data analysis

The carabidae were sorted into species. To reveal which carabidae dominate in an area, the numbers of individuals of the different species of carabidae in each sample were calculated to percentage abundance (%). The investigated areas might have different numbers of individuals, so abundance in percent makes it clearer which species are most abundant. Because of the high number of samples and because the pitfall traps were equally undisturbed by wind, rain and sheep in all places, the real number of carabidae were used in statistics, and not any trans-

	UD-AREA (Eiði 2)							
	Above 125 altitude		Below 125 altitude		First part of season		Later part of season	
	Date: 24 July & 3, 22, 23-aug-2007 N=42		Date: 24 July & 3, 22, 23-aug-2007 N=56		Date: 24 July & 08-aug-2007 N=65		Date: 22 & 23-aug-2007 N=33	
	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)
Agonum fuliginosum	0	0.0	0	0.0	0	0.0	0	0.0
Bembion bruxellense	0	0.0	1	0.1	1	0.0	0	0.0
Calathus fuscipes	48	4.9	141	25.9	153	17.0	36	7.9
Calathus melanocephalus	1	0.1	24	2.8	25	1.9	0	0.0
Carabus problematicus	50	5.3	60	10.8	51	4.8	59	13.4
Loricera pilicornis	1	0.1	2	0.4	3	0.3	0	0.0
Nebria rufescens	74	9.2	17	4.3	73	8.5	18	4.4
Nebria salina	287	38.8	107	22.2	204	26.1	190	42.7
Notiophilus biguttatus	35	7.3	13	4.7	24	3.7	24	11.0
Patrobus atrorufus	48	10.7	36	10.8	64	13.2	20	6.0
Patrobus sepentrionis	57	11.5	16	6.2	64	12.6	9	2.5
Pterostichus adstrictus	5	1.4	7	1.5	10	1.4	2	1.3
Pterostichus diligens	1	0.4	4	0.7	3	0.7	2	0.3
Pterostichus nigrita	7	2.1	23	7.1	13	3.1	17	6.5
Trechus obtusus	49	8.2	16	2.6	46	6.7	19	4.0
SUM	663	100.0	467	100.0	734	100.0	396	100.0

Table 3. *Numbers and percentile abundance of carabidae collected in UD area. Data are presented according to altitude and part of season. N referes to the number of stations, each containing 5 pitfall traps.*

formed numbers. Data were separated according to season and altitude. This was done because the vegetation and temperature change from lowest to highest altitude and carabidae have different preferences regarding vegetation and temperature (Lindroth, 1985; 1986 and Thiele, 1977). Carabidae also have different activity peaks which usually are associated with reproduction (Lindroth, 1985; 1986 and Thiele, 1977). Therefore data were divided between early part of the season and late part of season. The data was divided so that N was distributed as equally as possible between later and earlier part of season and between altitudes, see Tables 2, 3 and 4. As the data could not be transformed into a normal distribution, nonparametric analyses were performed. Differences in altitude and seasonality were tested by Mann-Whitney test, while when compar-

	ND-AREA (Eiði 3)							
	Above 157 altitude		Below 156 altitude		First part of season		Later part of season	
	Date: July 26 & Aug 2, 3, 10, 22, 23-2007 N=32		Date: July 26 & Aug 2, 3, 10, 22, 23-2007 N=36		Date: July 26 & Aug and 3-2007 N=30		Date: August 10, 22 & 23-2007 N=38	
	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)	Number of individuals	Percentage abundance (%)
Agonum fuliginosum	1	0.1	3	0.3	4	0.5	0	0.0
Bembion bruxellense	0	0.0	0	0.0	0	0.0	0	0.0
Calathus fuscipes	0	0.0	0	0.0	0	0.0	0	0.0
Calathus melanocephalus	0	0.0	4	1.0	3	0.8	1	0.2
Carabus problematicus	50	7.4	29	6.2	34	6.2	47	7.0
Loricera pilicornis	9	1.7	0	0.0	5	1.0	4	0.6
Nebria rufescens	89	13.8	28	5.8	49	9.0	76	10.4
Nebria salina	198	27.7	100	19.5	85	15.7	224	29.8
Notiophilus biguttatus	57	9.3	35	6.4	23	3.6	75	11.5
Patrobus atrorufus	13	2.7	50	14.1	21	6.5	42	10.2
Patrobus sepentrionis	149	20.6	89	18.8	183	30.8	67	10.7
Pterostichus adstrictus	7	1.1	7	1.9	11	2.6	3	0.6
Pterostichus diligens	0	0.0	1	0.5	1	0.6	0	0.0
Pterostichus nigrita	2	0.2	10	1.5	7	1.1	5	0.7
Trechus obtusus	93	15.4	116	23.9	104	21.7	113	18.2
SUM	668	100.0	472	100.0	530	100.0	396	100.0

Table 4. *Numbers and percentile abundance of carabidae collected in ND area. Data are presented according to altitude and part of season. N referes to the number of stations, each containing 5 pitfall traps.*

ing the three areas Kruskal-Wallis test was used. To explain the significant differences found in Kruskal-Wallis tests the different groups were pair-wise analysed with Mann-Whitney.

Results

Alltogether 3334 carabidae were collected; consisting of 15 species. Below all the found species are listed in alphabetic order. For each species the localities where they have been found are given, these localities – ES, NS and Ff – can be seen in Map 2. The number refers to altitude and letters e and w refere to south-eastern and north-western riverside respectively, see Map 2 and Table 1. Also some notes on the preferred habitats are presented. Maps showing the distribution of each species are included.

Agonum fuliginosum (Fig. 1 and Fig. A1)
Only found in 2 localities (Ff-3: 150w & 180w). This is the first record of *Agonum fuliginosum* in the Faroe Islands, it was found in relatively wet habitats

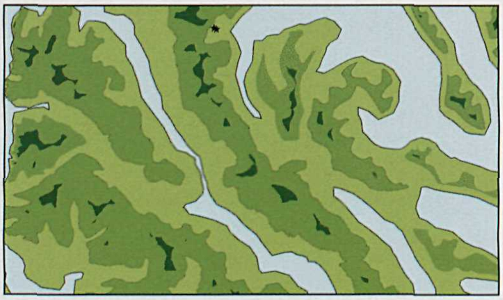

Fig. 1A. *Agonum fuliginosum.*

Bembidion bruxellense (Fig. A2)
Only found in 1 locality (NS-53: 125w). This is the first record of *Bembion bruxellense* in Eysturoy. Only one specimen was found.

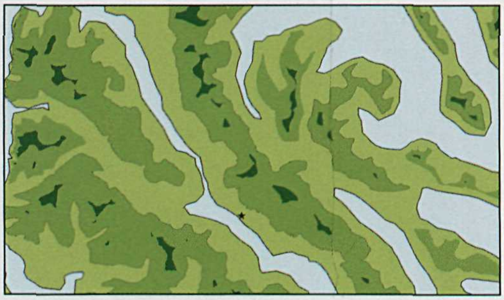

Fig. A2. *Bembidion bruxellense.*

Calathus fuscipes. (Fig. A3)
Found in 38 localities (ES-1: 78e, 78w, 118w, 128e. ES-13: 10e, 10w, 70e, 70w, 130e, 130w, 175e, 175w, 182w. ES-31: 70w, 100e, 100w, 150e, 183w. NS-53: 57w, 125e, 125w, 170e, 170w, 200w, 215e, 215w, 238e, 238w. Ns-57: 6e, 6w, 70e, 70w, 110e, 110w, 160w. NS-66: 70e, 120e, 120w. *Calathus fuscipes* was only found on the western side of Eysturoy, and was more abundant in the lower altitudes.

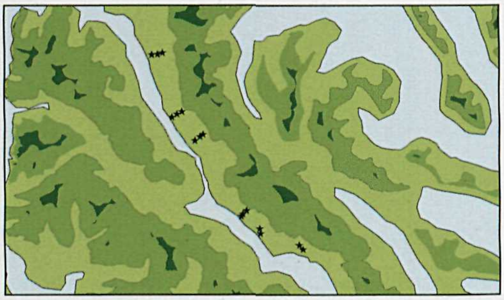

Fig. A3. *Calathus fuscipes.*

Calathus melanocephalus (Fig. A4)
Found i 6 localities (ES-13: 175e. ES-31: 183w. NS-53: 57w, 125w, 215w. Ff-2: 92w). *Calathus melanocephalus* was found in grassland habitats and never abundant.

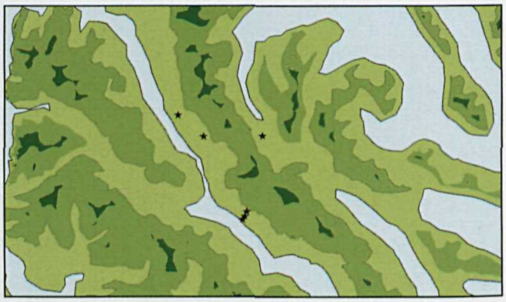

Fig. A4. *Calathus melanocephalus.*

Carabus problematicus (Fig. A5)
Found in 32 localities (ES-1:78w. ES-13: 70e, 70w, 130e, 130w, 175e, 175w, 182w. ES-31: 70w, 100e, 100w, 150e, 150w, 183e, 183w, 195e, 195w. NS-53: 57e, 57w, 125e, 125w, 170e, 170e, 215e, 215w, 238e. NS-57: 110e, 160w. ES-66: 70e, 70w, 120e, 120w, 220e, 220w, 230e, 230w. Ff-1: 68e, 68w, 70e, 70w, 90e, 157e, 157w, 190e, 190w, 211e, 211w. Ff-2: 92w, 156e, 156w. Ff-3: 150w, 177e, 177w, 180e, 180w. Although *Carabus. problematicus* was found in many different habitats, its

abundance was highest in localities dominated by *Calluna vulgaris*.

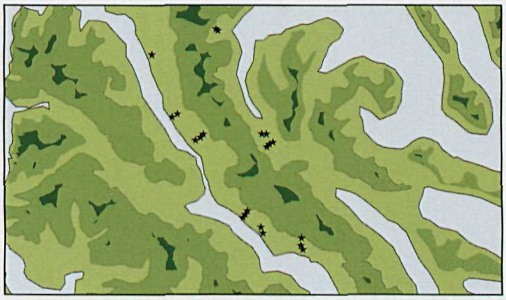

Fig. A5. *Carabus problematicus.*

Loricera pilicornis (Fig. A6)
Found in 8 localities (Es-31: 183w. NS-53: 57e. NS-57: 6w. Ff-2: 205e, 210e. Ff-3: 177e, 177w, 180w). *Loricera. pilicornis* was found in grassland habitats, but never abundant.

Fig. A6. *Loricera pilicornis.*

Nebris rufescens (Fig. A7)
Found in 57 localities: ES-1: 78e, 78v, 128e, 157v, 163e, 163v. ES-13: 10e, 70e, 70v, 130e, 130v, 175e,182v. ES-31: 100e, 183e. NS-53: 57e, 125e, 125v, 170e, 170v, 200v, 215e, 215v, 238v. NS-57: 70e, 110e, 110v, 160v, 220e, 250e. NS-66: 220e, 220v, 230e, 230v. Ff-1: 68v, 90v, 157e, 157v, 190e, 190v, 211e, 211v. Ff-2: 50e, 50v, 92e, 92v, 125e, 156e, 156v, 205e, 205v, 210e, 210v. Ff-3: 177e, 177v, 180e, 180v. *Nebria rufescens* was found in many kinds of habitats, but was most abundant in relatively dry areas characterized by grasses and gravel/stones.

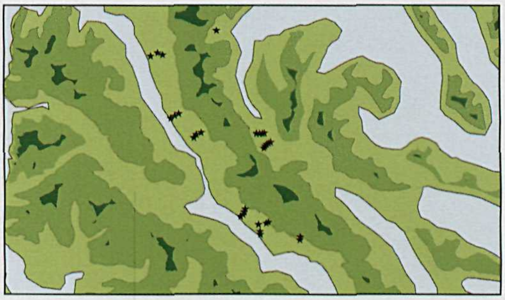

Fig. A7. *Nebria rufescens.*

Nebria salina (Fig. A8)
Found in 79 localities: ES-1: 78e, 78w, 118w, 128w, 157e, 157w, 163e, 163w. ES-13: 10e, 10w, 70e, 70w, 130e, 130w, 182e, 182w. ES-31: 70e, 100e, 100w, 150e, 150w, 183e, 183w, 195w. NS-53: 57e, 57w, 125e, 125w, 170e, 170w, 200w, 215e, 215w, 238e, 238w. NS-57: 6e, 6w, 70e, 70w, 110e, 110w, 160e, 160w, 220e, 220w, 230e, 230w. NS-66: 120e, 120w, 220e, 220w, 230e, 230w. Ff-1: 68e, 68w, 70e, 70w, 90e, 90w, 157e, 157w, 190e, 190w, 211e, 211w. Ff-2: 92e, 92w, 125e, 125w, 156w, 205e, 210e, 210w. Ff-3: 150e, 150w, 177e, 177w, 180e, 180w. *Nebria salina* was representet in all kinds of habitats, but its abundance was highest in habitats that were relatively dry and dominated by grasses.

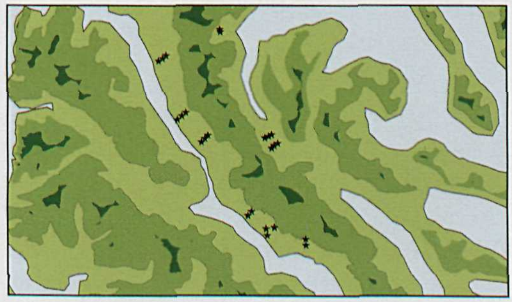

Fig. A8. *Nebria salina.*

Notiophilus biguttatus (Fig. A9)
Found in 32 localities (ES-1: 78e, 163e. ES-13: 10w, 70e, 70w, 130e, 130w. ES-31: 70e, 150e, 183w, 195e. Ff-1: 68e, 68w, 70e, 90w, 157e, 157w,190e, 190w, 211w. Ff-2: 50e, 50w, 92e, 92w, 156e, 156w, 205e, 210e, 210w. Ff-3: 150w, 180e, 180w. *Notiophilus biguttatus* was found in different kind of localities.

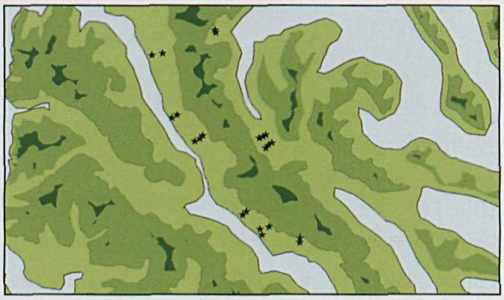

Fig. A9. *Notiophilus biguttatus.*

Patrobus atrorufus (Fig. A10)
Found in 70 localities (ES-1: 78e, 78w, 118e, 118w, 128e, 157w, 163e, 163w. ES-13: 10e, 10w, 70e, 70w, 130e,130w,175e, 175w, 182e. ES-31: 70e, 70w, 100e, 100w, 150e, 150w, 183e, 183w, 195e, 195w. NS-53: 57e, 57w, 125e, 125w, 170e, 170w, 200w, 215e, 215w, 238e. NS-57: 6e, 6w, 110e, 160e, 160w, 250e, 250w. NS-66: 70e, 70w, 120e, 120w, 170e, 220e, 230e. Ff-1: 68e, 68w, 70e, 70w, 90e, 90w, 157e, 157w, 190e. Ff-2: 50e, 50w, 92e, 92w, 156e, 205e, 210e, 210w. Ff- 3: 150e, 180w). *Patrobus atrorufus* was found in most kinds of habitats, but was most abundant in habitats characterized by relatively wet grass.

Fig. A10. *Patrobus atrorufus.*

Patrobus septentrionis (Fig. A11)
Found in 67 localities (ES-1: 78e, 118w, 128e, 157e, 157w, 163e, 163w. ES-13: 130e, 130w, 175e, 175w, 182e, 182w. ES-31: 70e, 100e, 100w, 150e, 150w, 183e, 183w, 195e, 195w. NS-53: 200w, 215w, 238e. NS-57: 6w, 110e, 110w, 160e, 160w, 220w, 250e, 250w. NS-66: 70e, 120e, 120w, 170w, 220e, 220w. Ff-1: 68e, 68w, 70e, 70w, 90e, 90w, 157e, 157w, 190e, 190w, 211e, 211w. Ff-2: 50e, 50w, 92e, 92w, 125w, 156e, 156w, 205e, 205w, 210e, 210w. Ff-3: 150e, 150w, 177e, 180e, 180w). *Patrobus septentrionis* was found in most kind of habitats, but its abundance is highest in habitats dominated by *Calluna vulgaris* or if no *C. vulgaris* is present then the more humid gras heats.

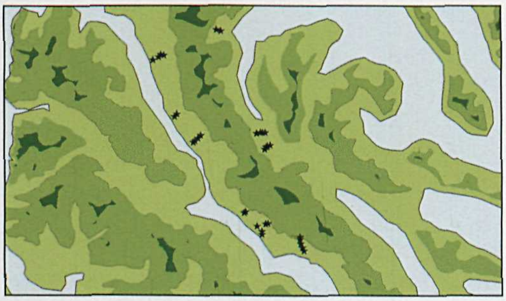

Fig. A11. *Patrobus septentrionis.*

Pterostichus adstrictus (Fig. A12)
Found in 26 localities (ES-1: 118w, 128w. ES-13: 70w, 130e, 130w, 175w. ES-31: 70w, 100w, 150e, 195e. NS-53: 57e, 200e. NS-57: 110e. NS-66: 120w, 220e, 220w. Ff-1: 68w. Ff-2: 50e, 92e,92w, 125w, 156w. Ff-3: 150w, 177w, 180e, 180w). *Pterostichus adstrictus* was never

abundant, and was mostly associated with habitats dominated by grasses.

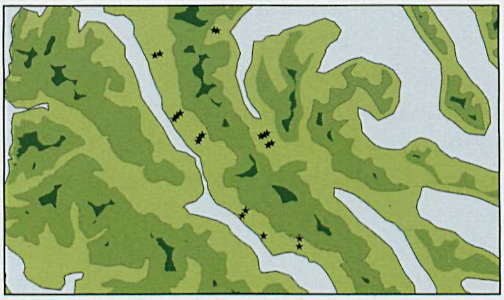

Fig. A12. Pterostichus adstrictus.

Pterostichus diligens (Fig. A13)
Found in 10 localities (ES-1: 118w, 128w. ES-13: 10w, 130w, 175w. ES-31: 70e, 70w. NS-53: 57w. NS-57: 6w. Ff-1: 68e). *Pterostichus diligens* was newer abundant and occurred mostly on wetter grassland.

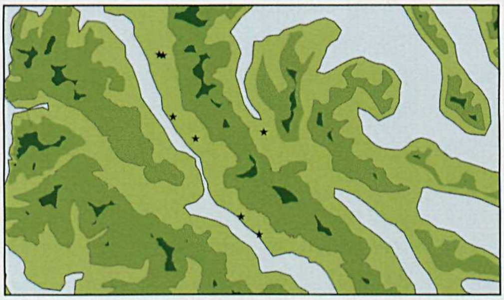

Fig. A13. Pterostichus diligens.

Pterostichus nigrita (Fig. A14)
Found in 21 locations (ES-1: 163w. ES-13: 130e, 182e. ES-31: 100w, 150w. NS-57: 6w, 110w, 250e. NS-66: 70e. 70w, 120e, 120w, 170e, 170w, 220e. Ff-1: 68w, 70w. Ff-2: 50w. Ff-3: 150w, 177e, 180e). *Pterostichus nigrita* was usually not abundant, except once when in wet habitats containing *Calluna vulgaris*.

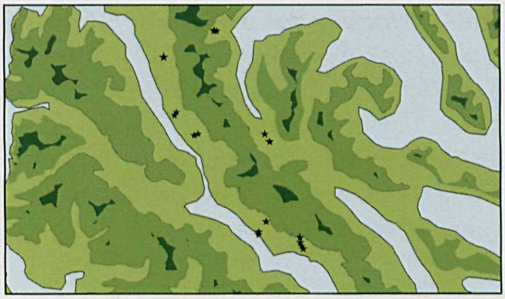

Fig. A14. Pterostichus nigrita.

Trechus obtusus (Fig. A15)
Found in 69 locations (ES-1: 78e, 78w, 118e, 128e, 128w, 157w, 163e, 163w. ES-13: 10e, 10w, 70e, 70w, 130e, 130w, 175e, 175w, 182e. ES-31: 70e, 70w, 150w, 183e, 183w, 195e, 195w. NS-53: 125e, 170e, 170w, 200w, 215e, 215w. NS-57: 6e, 110e, 110w, 160e, 220e, 220w, 250e. NS-66: 120w, 170e, 230e, 230w. Ff-1: 68e, 68w, 70e, 70w, 90e, 90w, 157e, 157w, 190e, 211e, 211w. Ff-2: 50e, 50w, 92e, 92w, 125e, 156e, 156w, 205e, 205w, 210e, 210w. Ff-3: 150e, 150w, 177e, 177w, 180e, 180w. *Trechus obtusus* was found in most kind of habitas, but its abundance was highest in relatively wet grassland.

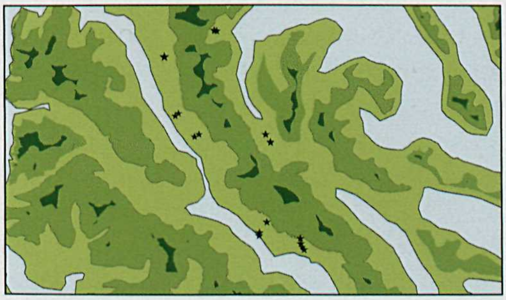

Fig. A15. Trechus obtusus.

OD area
Thirteen species were found in the OD area see Table 2. From Table 2 we see that *Nebria*

salina, *Patrobus septentrionis* and *Carabus problematicus* are the most abundant species above 150 m altitude; *Patrobus atrorufus* is also quite abundant. Below 150 m altitude *Nebria salina*, *Patrobus atrorufus*, *Carabus problematicus* and *Calathus fuscipes* were the most abundant species.

UD area

Fourteen species were found in the UD area (Eiði 2) see Table 3. From Table 3 we see that *Nebria salina* is the most abundant species above 125 m altitude followed by *Patrobus septentrionis*, *Patrobus atrorufus*, *Nebria rufescens* and *Trechus obtusus*, which all have an abundance between 8.2 and 11.5 percent. Below 125 m altitude the most abundant species are *Calathus fuscipes* and *Nebria salina; Carabus problematicus* and *Patrobus septentrionis* are also quite abundant

ND area

Thirteen species were found in the ND area see Table 4. From Table 4 we see that *Nebria salina* is the most abundant species above 157 m altitude, followed by *Patrobus septentrionis*; *Nebria refescens*, *Trechus obtusus* and to some degree *Notiophilus biguttatus* are also abundant. Below 125 m altitude *Trechus obtusus* is the most abundant species followed by *Nebria salina* and *Patrobus septentrionis*; *Patrobus atrorufus* is also abundant.

Influence of altitude

Calatus fuscipes was found to be significantly more abundant at the lower altitudes, this was seen both in the OD (P=0.000) and UD (P=0.003) area see Tables 2 and 3. Both *Nebria salina* and *Nebria rufescens* were significantly more abundant at the higher altitudes, this was seen in the UD area (P=0.013 and P=0.015 respectively) and ND area (P=0.007 and P=0.000 respectively), but not in the OD area, see Tables 2, 3 and 4. *Patrobus atrorufus* was also significantly (P=0.002) more abundant at the lower altitudes, this was seen in the OD area (P=0.043) and ND area (P=0.003), but not in the UD area, see Tables 2, 3 and 4. *Patrobus septentrionis* was found to be significantly (P=0.0025) more abundant at the higher altitudes in the OD area, but no difference was found in the ND and UD area. *Trechus obtusus* was found to be significantly (P=0.006) more abundant at the higher altitudes in the UD area, but no difference was found in the OD and ND area. No other species were found to have significantly different distribution regarding altitude except *Loricera pilicornis* which was found to be significantly more abundant at higher altitudes; but since we found so few *Loricera pilicornis* (see Tables 2, 3 and 4), we decided not to regard this result as valid.

Influence of season

Calathus fuscipes and *Patrobus septentrionis* were both significantly (P=0.05 and P=0.000 respectively) more abundant in the early part of the season; this was seen both in the OD and UD area regarding *Calathus fuscipes* and in all 3 areas regarding *Patrobus septentrionis*, see Tables 2, 3 and 4. *Carabus problematicus*, *Nebria salina* and *Notiophilus biguttatus* were all found to be significantly (P=0.001; P=0.000 and P=0.001 respectively) more abundant in the late part of the season, this was seen for *Nebria salina* in all areas, for *Carabus problematicus* in OD and UD and for *Notiophilus biguttatus* in ND and

UD, see Tables 2, 3 and 4. To test whether differences found in seasonality could be due to small differences in number of sampling days a Mann – Whitney test was performed with the number of each carabidae species calculated as individuals per trap per day. This did not change the results.

Comparing OD, ND and UD

Area had major effect on the distribution of *Calathus fuscipes* (P<0.001); no specimen was found in the ND area, more *Calathus fuscipes* were found in the UD area compared with the OD area, but the difference was not significant, see Tables 2 and 3.

Area had significant (P=0.007) effect on distribution of *Carbus problematicus*. Most *Carabus problematicus* were found in the OD area, see Tables 2 and 3.. There was only a significant difference between the UD and the OD area (P = 0.002). However, this difference is explained by a high frequency at an particular river in the OD area, and thus does not represent the area as a whole.

Distribution of *Nebria rufescens* was significantly (P=0.006) affected by area, and most were found in the ND area compared with the two other areas, see Tables 2 and 3. There was no significant difference between the OD and the UD area.

Area had significant (P<0.001) effect on distribution of *Notiophilus biguttatus*, and most were found in the ND area compared with the two other areas, see Tables 2 and 3. There was no significant difference between the OD and the UD area.

Distribution of *Patrobus atrorufus* was significantly (P<0.001) affected by area, and most were found in the OD area compared with the two other areas, see Tables 2 and 3. There was no significant difference between the UD and the ND area.

Distribution of *Patrobus septentrionis* was also significantly (P<0.001) affected by area, and most were found in the ND area, see Tables 2, 3 and 4. All three areas differed significantly from each other.

Discussion

Regarding species our results resamble those by Bengtson (1981), except that a new species to the Faroe Islands was recorded (*Agonum fuliginosum*). According to literature, this is a common species in wet environments (Lindroth, 1986). Our specimen was found in the outfield above Funningur; the altitudes were 150 m and 180 m. The areas where we found *Agonum fuliginosum* are relatively wet. Alltogrether 15 species of carabidae were found. Species most abundant in our work were also described as most abundant species in the work by Bengtson (1981; 1982); one exception is *Carabus problematicus* which was not one of the most abundant in the work by Bengtson (1981). This is because a relatively high percentage of our area was covered by heather, which is a preferable habitat to *C. problematicus* (Lindroth, 1985 and Cole *et al.*, 2006). One of the carabidae species *Bembidion bruxellense* has not been recorded from Eysturoy before. *B. bruxellense* is known from most of Europe, and is described as occurring on most kind of soil where the vegetation is not too dense (Lindroth,1985). West (1930) recorded *Bembidion bruxellense* on two islands: Suðuroy and Streymoy. Bengtson (1981) found no *B. bruxellense* although covering all the islands but the smallest one. The present investigation only found one specimen, so it seems that *Bembidion bruxellense* is quite rare in the Faroe Islands.

The reason for us getting fewer species than Bengtson (1981) is related to the fact that our work does not cover as many habitats as does the work by Bengtson (1981) where places like infields and higher mountains also were investigated. Bengtson (1981) found many species in the infields which were not covered in this project.

The difference in abundance shown by some species between the early part of season and later part of season, and also regarding altitude, is likely related to reproductive cycle and habitat preference. All carabids have difference in abundance during the year but our season-cover was not long enough to see it all (Lindroth, 1985 and 1986). *Patrobus septentrionis* is a biennial species, which overwinters as adult; the new *P. septentrionis* emerge in mid summer (June to August) and adults are usually collected in June and July (Lindroth, 1985; Erikstad *et al.*, 1989). Carabids that reproduce the year after emergence often show little activity after emergence, this is an adaption to preserve the mandibles – used when eating – for the breeding season the next year (Butterfield, 1996). So the reason for the lesser abundance of *Patrobus septentrionis* in the later part of the season might be related to low activety.

Calathus fuscipes imagines emerge in early sommer, so the higher catch of this species in the earlier part of the season, which is mid-summer, might be related to its emergence (Lindroth, 1986). Butterfield (1996) finds that at 305 m and 430 m altitudes in northern England new *Calathus fuscipes* emerge in late July and they overwinter to enter the breeding season the following spring. It is very likely that *Calathus fuscipes* also has a biennial reproductive circle in the present areas, since there is a relation between northern climate and biennial reproductive cycle (Lindroth, 1985; 1986: Butterfield 1996). So the higher abundance of *Calatus fuscipes* in the early part of the season might be related to the emergance of new *C. fuscipes* in July.

Nebria salina emerges in the spring, and after a while enters a state of dormancy during mid-summer but starts activity again in the late summer in combination with reproduction (Lindroth, 1985). The activity found by us in late summer by *Nebria salina* is likely associated with reproduction and is an explanation of the higher abundance of *N. salina* in the late part of the season compared to the early part. *Notiophilus biguttatus* breeds in the spring and the new beetles emerge in summer and autum (Lindroth, 1985); this is possibly the reason for us collecting more *N. biguttatus* in the late part of the season

Carabus problematicus has a biennial cycle in northern climates with the adults emerging in the late summer and breeding in the autumn the year after (Lindroth, 1985), this explains the higher abundance of *Carabus problematicus* in the later part of the season.

The distribution shown by *Calathus fuscipes* only being found on the southwest facing slopes is likely related to them being relatively warmloving and preferring relatively dry habitats (Ashworth, 1973; Lindroth, 1986; Butterfield, 1996). *Calathus fuscipes* had significantly higher abundance on the lower altitudes, which also is related to the preferred conditions described above. More, but not significantly more *C. fuscipes* were found in the UD area than the OD area, this can be related to the UD area being more dominated by grassland than the OD area (Fosaa *et al.*, 2008 and Lindroth, 1986). Hansen (2006) collecting in pitfall traps at different altitudes in an outfield finds *Patrobus septentrionis* to be more abundant at higher altitudes than lower altitudes, which is in good agreement with Lindroth (1985) who describes *Patrobus septentrionis* as a common species in Scandinavia, occuring in mountains above the timber limit, preferring marshes and meadows. Bengtson (1981) found *Patrobus septentrionis* also to be abundant in infield localities; most infield localities are meadows, which make these localities suitable to *Patrobus septentrionis*. The results from us regarding altitude is likely related to the fact that *Calluna vulgaris*, which also is a highly preferable vegitation type to *P. septentrionis* (Lindroth, 1985), is more common at the higher altitudes in the OD area.

One possible reason for *Patrobus atrorufus* being more abundant at the lower altitudes in the drained OD and ND areas can be that the lower areas are more humid than the upper areas, making these areas suitable to *Patrobus atrorufus* (Lindroth, 1985). The uppermost stations are situated just above the intake, which makes them relatively humid, but just below the water is taken by SEV, therefore most of the upper stations are relatively dry. So in the OD and ND areas the rivers are being slowly filled again at the lowest altitudes; this causes the river banks to become more humid at the stations situated at low altitudes, and according to Lindroth (1985) *Patrobus atrorufus* likes to stay close to water. Another reason – considering the OD area – is the distribution of vegetation. *Patrobus atrorufus* is more associated with grassland than heather (Fosaa *et al.*, 2008). Heather is more abundant in the upper areas, and grassland more abundant in the lower areas; *Patrobus septentrionis* is quite dominating in the upper areas and according to Bengtson (1982) *Patrobus atrorufus* and *Patrobus septentrionus*, which both are very similar in size (Lindroth, 1985), only show low to moderate overlap in habitat utilisation. So competition, vegetation type and probably influence from draining affect the distribution of *Patrobus atrorufus* in the OD area. The upper areas in the ND area are very steep which makes them relatively dry because of runoff, though the whole area is quite humid because if its aspect. But further down the area is less steep and as mensioned earlier the rivers are reciving some water again, also the grass is taller in places. No heather is in the ND area and the vegetation is very similar. *Patrobus septentrionis* is also quite dominating in the ND area both on the upper areas and lower areas; see Table 4, so it does not seem as if *Patrobus septentrionis* is capable of excluding *Patrobus atrorufus* from the lover areas in the ND area. It seems likely that structure of vegetation and humidity, which is affected by draining control the distribution of *Patrobus atrorufus*. Also the nearness of open water is likely important (Lindroth, 1985), since some water has entered the rivers again at the lower areas.

The steepnes of the higher altitudes in ND are also one likely important reason for *Nebria rufescens* and *Nebria salina* being significantly more abundant at the higher alttudes in the ND area, *N. rufescens* dominating the more stony areas while *N. salina* is dominating areas with less gravel and stones and more grass, which is in good accordance with results from Danielsen and Hansen (2000), Sadler and Dugmore (1995) and describtions by Lindroth (1986).

The reason for *Nebria salina* being significantly more abundant at the higher altitudes in UD area – even though the lower areas are suitable – might be competition from *Calathus fuscipes* at the lower altitudes. These two species are quite similar in size *Calathus fuscipes* being a bit larger (10-14.4 mm) than *Nebria salina* (10-13.5 mm) (Lindroth, 1985; 1986). General principles of coexistence predict that species that are equal in size do not share the same habitat if they use the same resourses. Bengtson (1982) working with habitat utilisation and niche breadths found that there was very little overlap between *Nebria salina* and *Calathus fuscipes*. This, together with our results point to *C. fuscipes* excluding *N. salina* from areas where *C. fuscipes* dominates. An explanation for *Nebria rufescens* being more abundant at the higer altitudes in the UD area can be related to the riversides and banks having more stones and gravel in the higher altitude areas, this is one of *Nebria rufescens´* prefered habitats (Lindroth, 1985) and also corresponds well with results from Danielsen and Hansen (2000).

The upper altitude areas in the OD area contain more heather, while grasses become increasingly more dominant in the lower altitudes, which could make the lover altitudes better suitable to *Nebria* salina and *Nebria rufescens*, compared to the upper altitudes (Lindroth, 1985). The OD area shows sign of drying up (Fosaa *et al.*, 2008); therefore differences in distribution according to altitudes that might have been are cancelled because the upper heather influenced areas have become drier (Fosaa *et al.*, 2008), which makes them better suited to *Nebria salina* and *Nebria rufescens* (Lindroth, 1985). Also one of the rivers that pit-fall traps were placed along in this area did not have so much heather at the upper altitudes compared to the lower altitudes, which minimizes differences in habitat structure.

Hansen (2006) also found more *Trechus obtusus* at higher altitudes; the present finding of higher abundance of *T. obtusus* at the higher altitudes in the UD area might be related to the fact that the lower elevations in the UD area are a lot steeper than the higher altitudes, therefore the lower elevation might be drier as a whole. Also the lower altitudes in UD area appeared to be heavily grazed because of the very short vegetation and high presence of sheepdroppings; and therefore minimizing shelter in the vegetation. All this reduces the favourable conditions to *Trechus obtusus* at the lower altitudes (Lindroth, 1985).

The association between vegetation and carabidae in the 3 areas is summarized in Table 5.

Typically *Nebria salina, Nebria rufescens, Patrobus septentrionis, Patrobus atrorufus* and *Trechus obtusus* were among the dominating species. *Carabus problematicus* was only among the dominating in the OD area and in the lower altitudes in the UD area and *Calathus fuscipes* dominated in the lower altitudes in the OD and UD area (Tables 2, 3 and 4). The higher abundance of *Carabus problematicus* in the OD area is related to

	Higher altitude areas		**Lower altide areas**	
Area → **Vegetation ↓**	OD and UD	ND	OD and UD	ND
Heath*	*Patrobus septentrionis, Carabus problematicus*	No heather	*Carabus problematicus,* and sometimes *Pterostichus nigrita*	No heather
Relatively dry grassland**	*Nebria salina*	*Nebria salina, Patrobus septentroinis, Nebria rufescens*	*Nebria salina, Calathus fuscipes*	*Trechus obtusus, Nebria salina, Patrobus septentrionis*
Relatively dry grassland mixed with gravel***	*Calathus fuscipes, Nebria salina, Nebria rufescens*	*Nebria salina, Patrobus septentrionis*	*Calathus fuscipes*	*Nebria salina*
Wet grassland partly meadow-like****	*Patrobus atrorufus, Trechus obtusus*	*Trechus obtusus, Patrobus septentrionis*	*Patrobus atrorufus, Trechus obtusus*	*Patrobus atrorufus, Trechus obtusus*

Table 5. *The dominant carabidae in the different vegetation types in the OD area, ND area and the UD area. The different kind of vegetations are presented in the column to the left.*

** Calluna vulgaris heath, ** contains Racomitrium heath, *** also contains Racomitrium heath, but mixed with stones and gravel. **** Wet grassland, wet meadow, sometimes a bit of mire is included, because Eiði-3 was facing north the area was usually more humid that those areas facing west. For vegetation explanation, see (Fosaa et al., 2008).*

this area having more heather than the other areas (Fosaa *et al.*, 2008; Lindroth, 1985). The *Calluna vulgaris* preference by larger carabidae has also been shown by Cole *et al.* (2006) and Brose (2003). The high abundance of heather in the OD area has been associated to this area being drained; see Fosaa *et al.* (2008). Therefore the distribution of

Carabus problematicus might be affected by draining. The degree of dominance by *Nebria salina* was seen to change between the areas, *N. salina* dominated most on the the UD area. This can be related to heather-loving carabids (e.g. *Patrobus septentrionis* and *Carabus problematicus*) occupying relatively large part of OD compared to the UD area, see Tables 2 and 3. As a whole the ND area is more humid than the UD area because of its aspect; This might explain why species like *Patrobus septentrionis, Patrobus atrorufus and Trechus obtusus* occupy a larger part of ND area than of UD area (Lindroth, 1985), see Table 4. No heather was in the ND area, only grass heath, which was grazed; this can lead to easier access to collembola (Cole *et al.*, 2002), and since *Notiophilus biguttatus* is a collembola specialist (Cole *et al.*, 2006), the easier access to collembola is a likely explanation for *N. biguttatus* having higher abundance in the ND area.

Lindroth (1985) among other things describes *Nebria rufescens* as a cold loving species, which might explain why it was more abundant in the colder north-east facing ND area than the other two. Even though we found that *Patrobus atrorufus* was significantly more abundant at the lower altitudes in both the OD and ND area, many more were found at the higher altidudes in the OD area compared to the ND area, see Tables 2 and 4. This can be one reason for the higher abundance of *Patrobus atrorufus* in the OD area as a whole compared to the rest. The heather in the OD area might create some shade, which also is important to *Patrobus atrorufus* (Lindroth, 1985). By looking at the OD and the ND area, both appear to be suitable to *Patrobus septentrionis*; a high proportin of the OD area was heather, while a high proportion of the ND are is meadowlike. Both kinds of habitat are preferred by *P. septentrionis* (Lindroth, 1985), but the OD area is drier and shows signs of drying up (Fossa *et al.*, 2008). This might partly explain the higher abundance of *Patrobus septentrionis* in the ND area, since *P. septentrionis* is described as prefering some humidity (Lindroth, 1985).

Conclusion

Fifteen species were found, 14 of which have been found before. One species *Agonum fuliginosum* was recorded for the first time in the Faroe Islands, and another, *Bembidion bruxellense*, was recorded for the first time in Eysturoy. Most of the species that were dominating were among the dominating species in all areas. The distribution in time and space reflects the habitat preferences and the reproductive cycle of the carabidae. It is difficult to define any effect from draining because we do not know how the areas looked like before, so the differences found might have been there before. The abundance seen by some carabidae according to altitude points to effect from draining; these were *Nebria salina, Nebria rufescens, Patrobus septentrionis* and *Patrobus atrorufus*, and also the higher abundance of *Carabus problematicus* in the OD area points to an effect from draining. Effects can be related to changes in humidity and vegetation, like an increase in heather in some areas because of draining.

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