Article

Epigeus macroinvertebrates species assemblages along a successional gradient in Hailuotu Island (Bothnia Bay), Finland

Adolfo A. Del Rio Mora

Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo., Unidad San Juanito Itzícuaro, C.P. 58330, Morelia, Michoacán., México

E-mail: aadelrio54@gmail.com

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Abstract

Epigeus macroinvertebrates were collected during summer time in 2007, by using pitfall traps in different sites representing vegetation patches situated on land uplift area on successional gradients in the dune shore of Bothnian on the island of Hailuoto, Northern part of the Gulf of Bothnia, Finland. The sites were divided into six vegetation patches types or open sands, all of them localized on early, deflation zone and late successional stages or ecological subgroups: 1) *Empetrum* patches or microsites (small-scale element distribution in soil-plant-systems in patches of *Empetrum nigrum*, in early succession; 2) *Empetrum nigrum* patches in deflation zone; 3) open sand in early succession; 4) open sand in deflation zone; 5) *Empetrum nigrum* patches in late succession, and 6) open sand in late succession. A total of 19034 specimens belonging to 14 species of Insecta and only one group to Aranea species were caught and identified. Afterwards they were grouped by trophic groups as follows: herbivores, predators and detritivores and calculated their richness, abundance, diversity and evenness for each vegetation type. The data obtained were analyzed by different analytical methods and relevant between them as MRPP for the purpose of identifying the possible differences between groups and habitats, which denoted no statistically significant between the 6 environmental types, but if for the case of composition or populations general diversity as abundance, richness, evenness, diversity. It is enclosed too Correspondence Analysis (CA) and cluster analysis for epigeus invertebrates species assemblages. As a support to analysis of results we added on ended the species-accumulation curve and estimation curves Chao1 and Jacknife2 for all ecological types.

Keywords epigeus invertebrates; patches; succession; diversity; richness; *Empetrum nigrum ssp. hermaphroditum* (Hagerup) Böche.

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1 Introduction

Soil invertebrates are fundamentally in essential processes for the habitat in which they are developed. They can alter primary production, the structure of the ground, the landlords of microbial activity, the dynamics of the organic matter and the cycle of nutrients (Berg and Staaf, 1981; Petersen and Lurton, 1982; Slansky and Rodriguez, 1987; McClaugherty et al., 1982).

Spatio-temporal variability of the community in turn has important implications for the study system, which is a coastal forest strip located on the Hailotu Island-Bothnia bay -with a strong successional gradient, which changes in species composition and trophic structure of soil invertebrate communities should affect species interactions and food web dynamics (Doblas, 2007; Doblas et al., 2008, 2009a, b, c; Niemelä, 1997; 1999; Similä et al., 2002).

Longer-term studies regarding macroinvertebrates associated with vegetation patches, with emphasis on Carabids species- have argued that the overall change in the species distribution is caused mostly by climatic factors and that effects of human influences seem to be secondary (Hengeveld, 1985).

Microhabitats are common on island ecosystems where the flora and fauna which is grouped in patches, which are potentially maintained by complex interrelationships involving their own soil invertebrates that live there, depending on that vegetation grouped for protection and life cycles and in turn serve to disperse the owner plant community in the ecosystem(Borges et al., 2004; Koricheva et al., 2000; Kouki et al., 2001).

Different from aboveground invertebrates, soil invertebrate species, their interrelationships and spatial distribution has been little studied until today (Zhang 2008, 2011a, b). Between the Arthropod group in coastal habits, the spiders are known to respond sensitively to environmental and structural changes, which makes them suitable to study organism–habitat relationships (Wise, 1993; Bell et al., 2001; Oxbrough et al., 2005; Hendrickx et al., 2007), in coastal habitats in particular.

Spiders constitute one of the most abundant and species–rich arthropod orders. They range among the most numerous arthropods in all kinds of habitat types (Basset, 1991; Coddington et al., 1991; Borges and Brown, 2004). Spider species occupy a wide array of spatial and temporal niches. Their occurrence is frequently related to environmental factors (Hatley and MacMahon, 1980; Schmidt et al., 2005; Entling et al., 2007; Finch et al., 2008)

Poor establishment and reduced seedling growth of Scots pine (*Pinus silvestris* L.) in northern Sweden is related to an allelopathic inhibition by the dwarf shrub *Empetrum hermaphroditum* Hagerup. Indoor bioassays with green and brown leaves of *Empetrum* have strong negative effects on rooting ability, radicle elongation, and growth of Scots pine seedlings. Bioassays with soil samples show that phytotoxic substances leached from *Empetrum* foliage accumulate in the soil (Rautio and Markkola, 2006).

Known to as alone that Mycelial fungal biomass in the soil in the vicinity of the seedling roots is higher in *Empetrum* than in empty patches and increased along the succession. In Scots pine roots both the diversity of ectomycorrhizal morphotypes and proportion of root tips colonized by suilloid morphotypes with abundant external mycelia were in mid succession higher and in late succession lower in seedlings grown in *Empetrum* patches compared to patches without *Empetrum*. In the harsh conditions of the dune shore in the early and mid succession *Empetrum* is suggested to promote Scots pine seedling establishment by providing mechanical and physical shelter whereas in late succession negative interactions (competition and allelopathy) between the shrub and the Scots pine are dominating. This fact was the first findings/results that an ericoid mycorrhizal shrub could enhance the performance of both the ECM host and its fungal symbionts (Rautio and Markkola, 2006).

On the same, relative importance of positive and negative interactions between plant species and their epigeus arthropofauna associated with them may change along disturbance and resource gradients, so positive interactions are suggested to prevail in low resource, low productivity (high stress) conditions and negative interactions in high resource availability. Mountain crowberry (*Empetrum nigrum* ssp. *hermaphroditum)* is known to have allelopathic impacts on both Scots pine (*Pinus sylvestris*) and its ectomycorrhizal symbionts.

On primary succession gradients in the dune shore of Bothnian Bay, however, Scots pine seedlings are founded to occur more abundantly in *Empetrum* patches in early and mid succession stages, whereas patches without *Empetrum* are preferred in late succession, however, as it is seem to, this is not reflected on the number of seedlings or natural regeneration at all these places, which could be due to high pine seed depredation by carabids and what before has been widely researched (Lindroth, 1985, 1986; Nystrand and Granström, 2002), although for the study area little details are knew about epigeus invertebrate assemblages and their abundance at the different environmental types along the successional gradient at Hailotu Island.

The main focus of this study was determine the actual structure and diversity of the soil macroinvertebrates community under conditions of a successional gradient in Hailotu Island (Bothnia Bay) where is common the growing of native vegetation and pioneers distributed in patches or microsites, since is not clear even the real impact of the macroarthropod assemblages on the native vegetation on study area.

2 Methodology

2.1 Study area and caught insects

The study was carried out in northern Finland on the island of Hailuoto 65º03´N, 24º36´E) on two separate sites around two°03´N, 24° (65 kilometres from each others. Both sites are situating on land uplift area on a deflation basin behind the dune zone on poor, sandy soil without podsol formation. Vegetation is patchy, consisting of dwarf shrubs (*Empetrum nigrum, Vaccinium uliginosum*) lichens (*Cladonia spp.*, *Cladina spp.*, *Stereocaulon sp*.) and mosses (*Racomitrium canescens*, *Polytrichum piliferum*, *P. juniperinum*). Sparsely distributed young Scots pines are the dominant tree species. Humus layer is patchy and very thin (0.5–1.0 cm), if present. The mineral soil is acidic (pH 4.8), and organic matter and total nitrogen content are low (0.2% and < 0.01% of soil dry mass, respectively).

2.2 Trials

Epigeus macroinvertebrates were collected during summer time 2007 year, by using pitfall traps(total 120), for it the trial sites were divided into six vegetation patches types or open sands, all them localized on early, deflation zone and late successional stages or ecological subgropups: 1) *Empetrum* patches in early succession (Eesu); 2) *Empetrum* patches in deflation zone (Edefbas); 3) open sand in early succession (OpSesu); 4) open sand in deflation zone (OpSdefb); 5) *Empetrum* patches in late succession (Elatsu), and 6) open sand in late succession (OpSlatsu). All pitfalls trials of medial size (9 cm diameter of 11 cm in height) and made of plastic were baited with a solution of water mixed with NaCl. Later they were dried, mounted, identified and grouped by trophic groups as follows: herbivores, predators and detritivores and calculated their richness, abundance, diversity and evenness for each vegetation type.

All the specimens collected during the study are in the collection of the Zoological Oulu University Museum, Oulu, Finland.

2.3 Analysis of the results

We assume the pitfalls were equally efficient in catching soil invertebrates in the different 6 succesional gradient in the forest type described before and growing in coast zone, because all the sample points of them were homogenous in general structure. Therefore it is suggested that the differences in the catch among sites should reflect real differences in the abundances of epigeus individuals, specie groups and habitats. For the composition analysis species were selected according their abundance as minimum 2 specimens,

To evaluate the consistency of the differences in species composition of the soil arthropofauna under successional gradient, we used the nonparametric statistical test multiple response permutation (MRPP) with Blossom w2008.04.02; and the structure of epigeus invertebrate assemblages by detrended correspondence analysis (DCA) with Multivariate Statistical Package 3.1 (Kovach, 1999).

The values of abundance, richness, diversity and evenness were analyzed by two ways ANOVA with Minitab15.

Insect caught by pitfall traps were pooled for each site and species richness was estimated for each successional type (6), as well as for the regional data set using the nonparametric estimators Chao 1 and Jacknife 2. Accumulation curves were generated after 100 randomizations using Estimate S 8.0 (Colwell, 2006).

Chao1 gives an estimate of the absolute number of species in an assemblage based on the number of rare species (singletons and doubletons) in a sample, and it is the ratio between observed and estimated richness(Sorensen et al., 2002; Scharff et al., 2003).

Jacknife2 has been found to perform quite well in extrapolation of species richness with greater precision, less bias, and less dependence on sample size than other estimators (Petersen et al., 2003; Chiarucci et al., 2003; Finch et al., 2008.).

The average abundance was measured in number of individuals by trap and the richness as species number of traps per group.

To calculate the *Diversity* was used the Shannon Index: $H = - \sum p_i \log p_i$; this index considers simultaneously Richness and Evenness, and their values vary between zero, when a single species, and the logarithm of Richness (S), where all species are represented with the same number of individuals (Magurran, 1988). The Evenness was calculated using Pielou index (Magurran, 1988): $J' = H'/Hmax = H'/\ln S$ which measures the proportion of the diversity observed in relation to the expected maximum diversity and its values vary between 0 and 1, the last value corresponds to situations where all species are equally abundant (Moreno, 2001).

3 Results and Discussion

3.1 Species caught and their distribution by successional stages

A total of 19034 specimens belong to 14 species of Insecta and only one group to Araneae species. As shown in Fig. 1, the largest number of individuals (soil invertebrates) collected during the study corresponded to the patches OpSlatsu, followed by Elatsu, while in the other vegetable strata had similar amounts of catch specimens (Eesu, Edefbas, OpSesu and OpSdefb patches). This greater number of specimens collected in the first two layers correspond to patches mentioned are the preferential microhabitats *Lassius niger* ant (Hymenoptera: Formicidae) and also can be seen in Fig. 2.

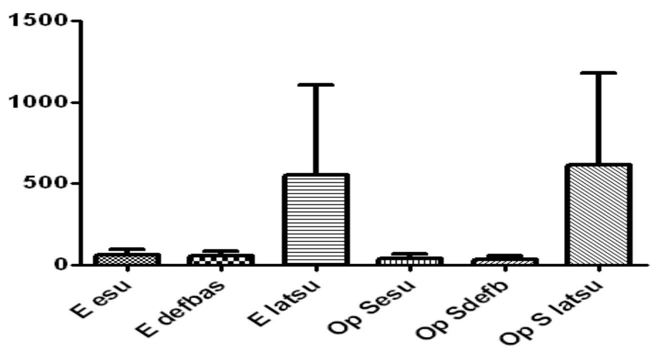

Fig. 1 Total number of epigeus invertebrates specimens caught (Mean with SEM). Hailuoto Island (Bothnia Bay, Summer 2007). *Empetrum* patches in early succession (Eesu), *Empetrum* patches in deflation zone (Edefbas), open sand in early succession (OpSesu), open sand in deflation zone (OpSdefb), *Empetrum* patches in late succession (Elatsu) and open sand in late succession (OpSlatsu).

The arthropods collected and according to their habits and abundance were classified in: herbivores (8), predators (5) and detritivores (2), taking for it the antecedents registered for each species according to literature review (Slansky and Rodriguez, 1987). We listed below the habit groups, scientific names and their corresponding abbreviations (left) are referenced along the manuscript:

Predators

Carabidae

(**cer**) *Calathus erratus*

(**cme**) *Calathus melanocephalus*

(**aqu**) *Amara quenseli*

(**cma**) *Cymindis macularis*

(**hru**) *Harpalus rufipes*

Detritivores

(**lhi**) *Lagria hirta* (Lagriidae)

(**bopul**)*Bolitochara pulchra* (Staphylinidae)

Herbivores

(**ln**) Lasius niger (Formicidae)

(**mma**) *Myrmeleotettix maculatus* (Acrididae)

(**aspp**) *Aphrodes spp* (Cicadellidae)

(**ptr**) *Planaphrodes trifasciata*(Cicadellidae)

(**ar**)Araneae (soil spider)

(**ono**) *Otiorhynchus nodosus*(Curculionidae)

(**oov**) *Otiorhynchus ovatus*(Curculionidae)

(**hab**) *Hylobius abietis* (Curculionidae)

The results (Fig. 2) reveal the logical dominance of herbivore species on other types of feeding consumers representatives of ecosystem unstable dunes and near seashore, where the accumulation of organic matter could be limited, which explain the few presence of invertebrate detritivores, although many of the soil spiders (Araneae), for example, could be grouped as herbivores-detritivores and more even as predators; Some species of them have been reported in coastal grassy vegetation and detritus, in sandy sites with low vegetation and in clay shores and stones (Heimer and Nentwig, 1991).

Moreover, seem to be the population model is simple and continue on seaboard coast: cycle beginning richness of herbivores and predators from *Empetrum* early succession patches and keeping stable on next stage (Edefbas) and lowing for the case of the predators; on *Empetrum* late succession there a apparent equilibrium between richness of herbivores and predator but significantly low of the two first successional stages. When open sand early succession newly is raised the herbivores and predator tough no as in Eesu and Edefb patches and ending decrease both fully on open late successional stage, where the ant colonies are prevalent. Occurs, this system is not close and part of these populations come of the natural emigration process, mostly from the develop forests near to the coastal zone (see fauna composition and species richness).

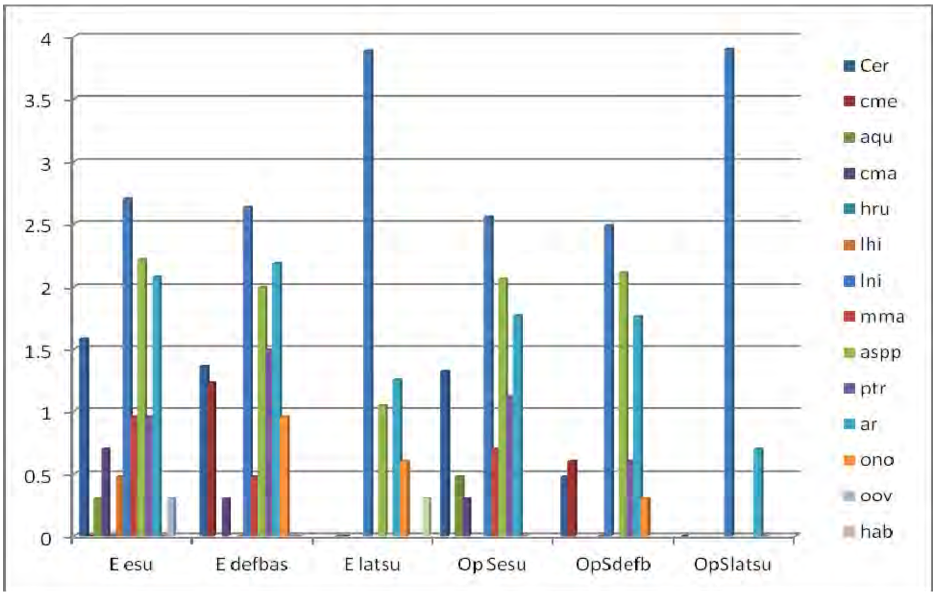

Fig. 2 15 Invertebrate species caught in 6 ecological vegetation types (patches) (number of specimens was transformed in Log10).

The soil macroinvertebrate assemblage at the study sites is dominated by arthropods and the dominant group in number under all the successional gradient is Formicidae (*Lasius niger*), mostly on patches of Elatsu and Oslatsu, where evidently its colonies have at the same time more space and less competence for carrying off and store great amounts of food.

After of ants, Leafhopper *Aphrodes spp.* (Cicadellidae) and soil spider (Araneae) were the macroinvertebrates more abundant on all microhabitats monitored. This possibly due the decomposition process is driven by litter quality, physicochemical environment and composition of the decomposer community and this last process as a result of carbon and nitrogen utilization by heterotrophic microbial and animal populations (Hättenschwiler et al., 2005; Berg and Staff, 1981; Berg et al., 1984; McClaugherty et al., 1982).

Carabids more abundant represented by *Calathus erratus* are actives as predators, moving on *Empetrum* patches and open sand early succession habitats. The others species of this family are more restricted for a habitat in particular so *Calathus melanocephalus* have preference only by *Empetrum* deflation basin and *Cymindis macularis* moves inside *Empetrum* early succession patches; *Amara quenseli* and *Harpalus rufipes* are not common for the study area.

Other carabid species no included here and collected on *Empetrum* patches by us on late summer (mid-September 2006) in the study area were: *Bembidion nigricorne*, *Pterostichus niger* and *Carabus hortensis*. Snout beetles (Curculionidae) *Otiorhynchus ovatus* and *Hylobius abietis* (This species is regarded as the most important pest of conifer seedlings) are occasional on the primary vegetation in the coastal area of the bay, although periods of high populations of this last specie could be regarding with *Pinus* seedlings died growing on *Empetrum* patches, as we have observed in other years. On the same, relative importance of positive and negative interactions between plant species and their epigeus arthropods associated with them may change along disturbance and resource gradients, so positive interactions are suggested to prevail in low resource, low productivity (high stress) conditions and negative interactions in high resource availability. Mountain crowberry (*Empetrum nigrum* ssp. *hermaphroditum)* is known to have allelopathic impacts on both Scots pine (*Pinus sylvestris*) and its ectomycorrhizal symbionts. On primary succession gradients in the dune shore of Bothnian Bay, however, Scots pine seedlings are founded to occur more abundantly in *Empetrum* patches in early and mid succession stages, whereas patches without *Empetrum* are preferred in late succession, however, as it is seem to, this is not reflected on the number of seedlings or natural regeneration at all these places, which could be due too to high pine seed depredation by carabids and what before has been widely documented (Ovenistrand and Granstroem, 2000), but none of carabid species reported and cited above are not Pine seed consumers (Lindroth, 1985, 1986; Nystrand and Granström, 2000).

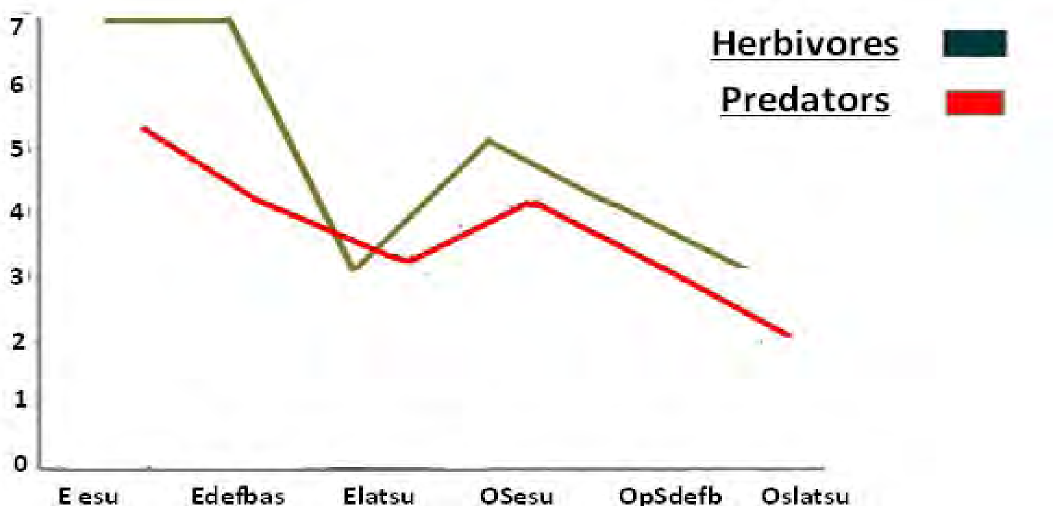

Fig. 3 Specific richness of Herbivores and predators in the 6 successional gradients.

In general, the average species richness was statistically significant when it was compared versus abundance for 6 successional gradients, as it is mentioned forward.

Table 1 Numbers and percentages share of epigeus invertebrates and individuals occurring in a bay forest under a successional gradient with 6 vegetation patches types at Hailotu Island (Bothnia Bay), 2007.

						UNIQUE				GENERAL			
E esu	E defbas	E latsu	Op Sesu	OpSdefb	OpSlatsu	Especies	%	Individuals	%	Especies	%	individuals	%
*						1	6,66	1	0,01155135	13	86,66	856	4,49721551
	*					2	13,33	2	0,02310269	12	80	771	4,05064621
		*				1	6,66	2	0,02310269	7	46,66	7745	40,6903436
			*			3	20	10	0,11551346	9	60	576	3,02616371
				*		3	20	68	0,78549151	8	53,33	506	2,65840076
					*	5	33,33	8574	99,0412383	5	33,33	8580	45,0772302

3.2 Number of soil arthropods caught during the study period

Below we present graphically the variation in the number of specimens caught for different species of soil invertebrates during the different dates at the study period.

The detritivores group appears more frequently on late summer.

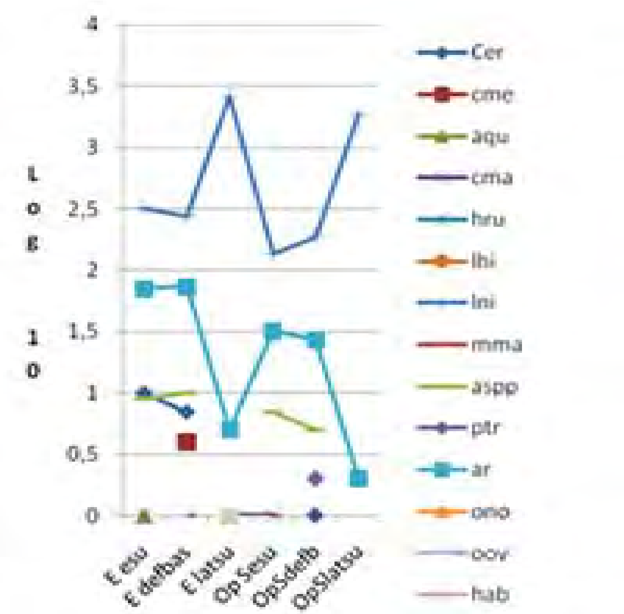

Fig. 4 Number of invertebrates caught during first sampling period (June 28-July 4/2007).

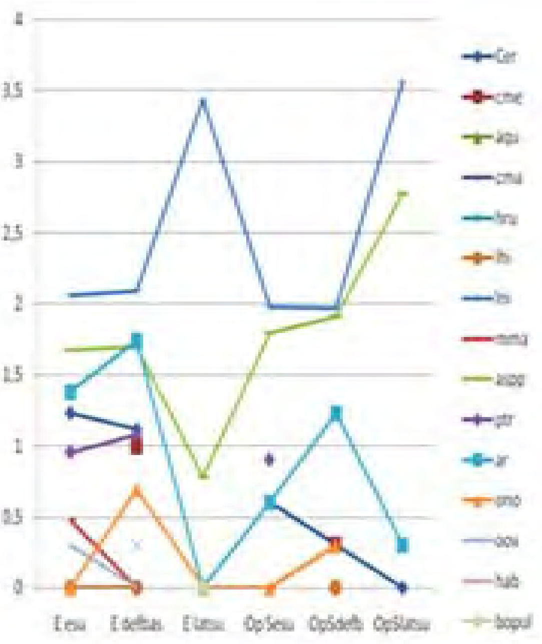

Fig. 5 Number of invertebrates caught during second sampling period (July 4-August 7/2007).

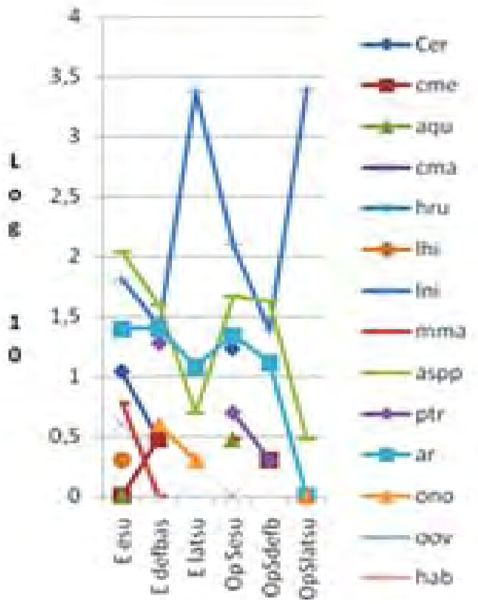

Fig. 6 Number of invertebrates caught during third sampling period (August 7- August 22/2007).

3.3 Soil arthropods assemblages: abundance, diversity and species richness

As it was mentioned, *Empetrum* vegetation patches are more important ecological niches supporting the most soil invertebrate assemblages in early successional stages as can see in results obtained.

The invertebrates species were grouped at two levels: summing all them and obtaining by vegetation type their abundance, richness, diversity and evenness (Table 2); Afterword, They were separate by 3 tropic groups: herbivores, predators and detritivores and too calculated their four diversity measures (Table 3).

In general in both cases, the average species richness was highest in Eesu and with a decreasing trend in other successional gradients, but was not statistically significant after to realize the two–way ANOVA (1) showed below and even more after MRPP (2) (Multi-Response Permutation Procedure). As it is seen, much highest species abundance in Elatsu and OpSlatsu are determined by the number specimens of ants (*Lasius niger*) caught, places where richness was lowest.

Table 2 General diversity of epigeus macroinvertebrates by successional gradients.

	Eesu	**Edefbas**	**Elatsu**	**OpSesu**	**OpSdefb**	**OpSlatsu**
Abundance	28.53	25,70	258,16	19,20	16,86	286,00
Richness	13	12	7	9	8	5
Diversity	0,223	0,25	0,009	2,58	0,177	0,003
Evenness	0,50	0,524	0,019	5,41	0,371	0,005

Table 3 Specific diversity of epigeus macroinvertebrates by trophic groups in 6 ecological succesional gradients.

Herbivorous	**Eesu**	**Edefbas**	**Elatsu**	**OpSesu**	**OpSdefb**	**OpSlatsu**
Abundance	22,9	19,13	257,43	16,4	14,7	285,8
Richness	7	7	3	5	4	3
Diversity	0,314	0,343	0,006	0,315	0,295	0,11
Evenness	0,371	0,405	0,014	0,451	0,49	0,23
Predators	**Eesu**	**Edefbas**	**Elatsu**	**OpSesu**	**OpSdefb**	**OpSlatsu**
Abundance	5,53	0,53	0,66	2,8	2,13	0,2
Richness	5	4	3	4	3	2
Diversity	0,33	0,303	0,171	0,351	0,21	0,195
Evenness	0,472	0,503	0,358	0,583	0,44	0,647
Detritivoros	**Eesu**	**Edefbas**	**Elatsu**	**OpSesu**	**OpSdefb**	**OpSlatsu**
Abundance	0,1	0,03	0,06	0	0,03	0
Richness	1	1	1	0	1	0

In general, the more high values of species richness, diversity and evenness are observed in Eesu, Edefbas and OpSesu, and lower of them are for Elatsu and OpSlatsu.

The herbivores abundance in OpSlatsu is regarding the ant colonies, *Lassius niger*. For that, the community of epigeus invertebrates living on *Empetrum* patches plays an important factor for the stability of those forest ecosystems. In the case of detritivores, the values corresponding to diversity and evenness of the specific diversity were zero for 6 habitats, due to lower number of species belongs to these consumers group.

ANOVA test results coincide with the MRPP analysis, although this last analysis give seen significance between the general diversity between factors (abundance, richness, diversity and evenness obtained between the invertebrate species caught at the 6 environmental types as shown in the Tables 4 and 5.

Table 4. ANOVA(two-way) test, comparing abundance of soil invertebrate consumers and 6 different habitats

(ANOVA TEST) ----------
--1)**MINITAB 15 for windows:**

Source	DF	SS	MS	F	P
C2	3	47255	1575.6	3.7	0.036
C3	5	19729	3945.7	0.93	0.491
Error	15	63827	4255.1		
Total	23	130810			

S = 65.23 R-Sq = 51.21% R-Sq(adj) = 25.18%

Reason for variance calculations:15751.6/4255.1=3.70; critical value of F=3.29 , So Ho is rejected; **there is a significant difference between blocks**

```
      Individual 95% CIs For Mean Based on
      Pooled StDev
C2  Mean  --------+--------+--------+--------+
1  105.742          (--------*-------)
2    9.000 (--------*------
-)
3    0.540 (-------*-------
-)
4    1.133 (-------*-------
-)
          --------+--------+--------+------
+
           0      60     120     180
```

C2(=blocks)= *Herbivoros, Detritivoros Predators*
C3(=treatments)= Environmental types:

Eesu	Edefbas	Elatsu	OSesu	OpSdefb	Oslatsu

Cm_b/Cm_e, F= k-1/(n-1)(k-1)------degrees of freedom

For C3: Rv= 3945.7/4255.1=0.927 , what is a minor value than 3.9(F), So Ho is not rejected; ie **there is not a significant difference between treatments**

Similarly when all factors were compared under MRPP test, have the successional gradient (vegetation types), presence of herbivores, predators and detritivores under general and specific diversity as response variables are not significant. Otherwise, general diversity between factors represented by abundance, richness, diversity and evenness have differences and this is particularly clear for the case of abundance versus richness.

Table 5 MRPP analysis: comparing grouping variable(s) between response variables.

Grouping variable(s)	**Response variables**	**Number of observations**	**Number of groups**	**Significance(-)**
Successional Gradient	**General diversity**	12	6	**NS**
Herbivores	**Specific diversity**	12	6	**NS**
Predators	-----------	12	6	**NS**
Detritivores	------------	12	6	**NS**
Abundance Richness Diversity Evenness	**General diversity between factors**	12	4	**
Abundance vs Richness	-----------	6	2	*
Abundance vs Diversity	-----------	6	2	**NS**
Abundance vs Evenness	-----------	6	2	**NS**
Richness vs Diversity	-----------	6	2	**NS**
Richness vs Evenness	------------	6	2	**NS**
Diversity vs Evenness	-------------	6	2	**NS**

(-)NS, not significance; *, P<0.05, **, P<0.01

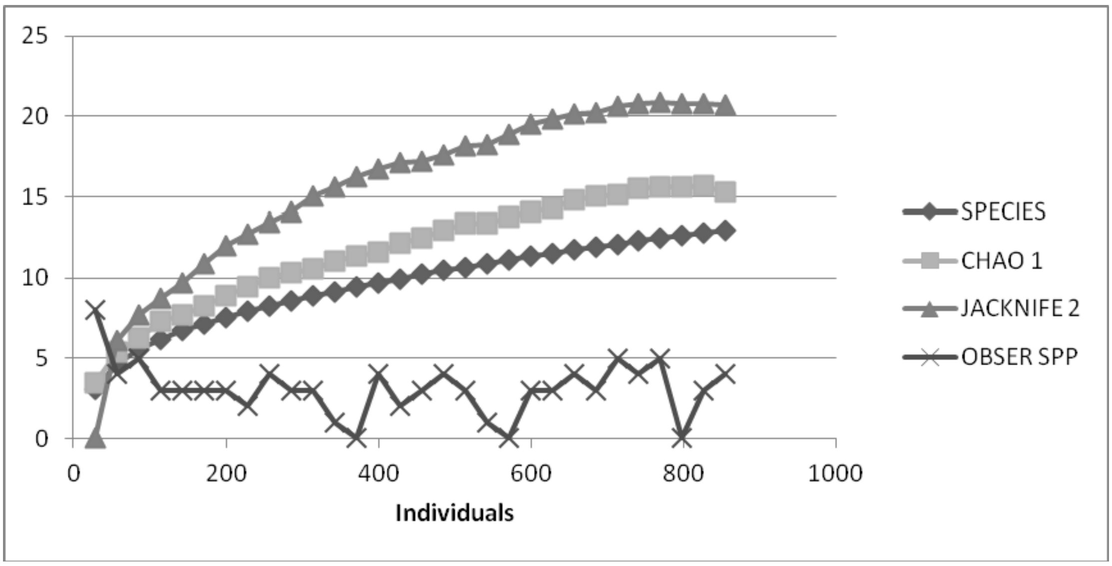

Fig. 7 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: Eesu (all samples pooled) dataset. Curves are generated from 100 randomizations.

On the other hand, at all sites the amount of soil macroinvertebrates collected was incomplete, since the observed total species richness was lower than the estimates obtained by Chao 1 and Jacknife 2. The species accumulation curves indicated as expected-an asymptotic tendency (Figs 7-12) and too as it is possible appreciate on them, in general there is no an noticeable difference of the model for 6 vegetation types monitored.

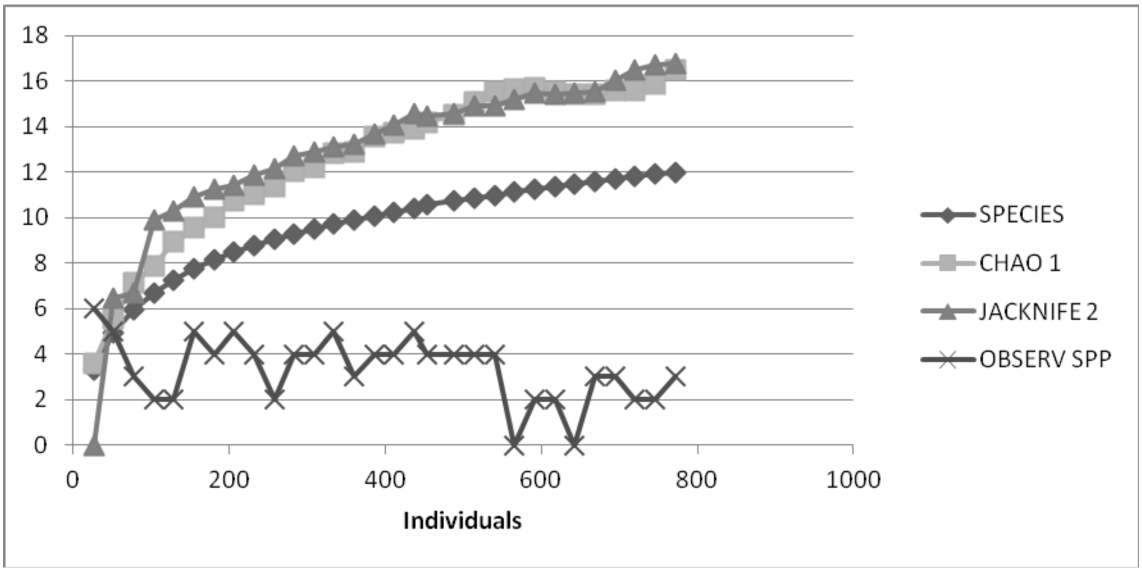

Fig. 8 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: Edefbas (all samples pooled) dataset. Curves are generated from 100 randomizations.

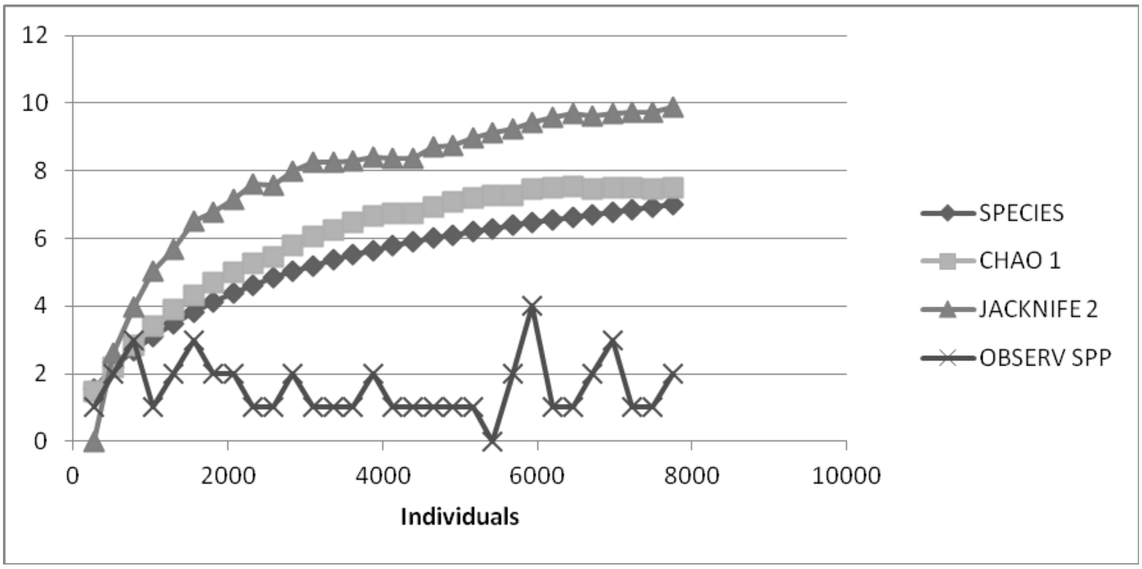

Fig. 9 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: Elatsu (all samples pooled) dataset. Curves are generated from 100 randomizations.

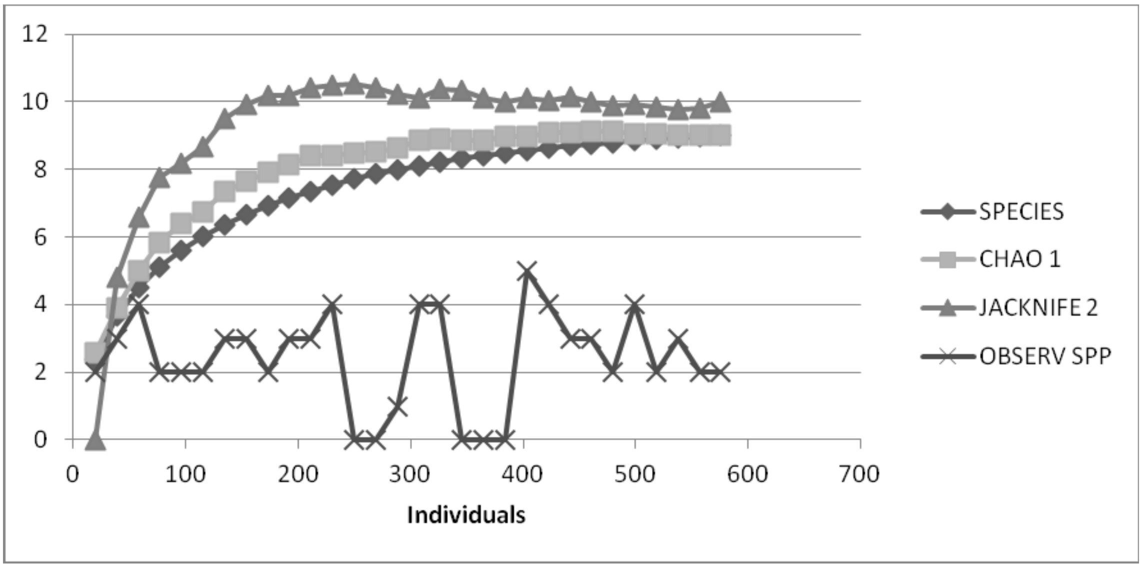

Fig. 10 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: OSesu (all samples pooled) dataset. Curves are generated from 100 randomizations.

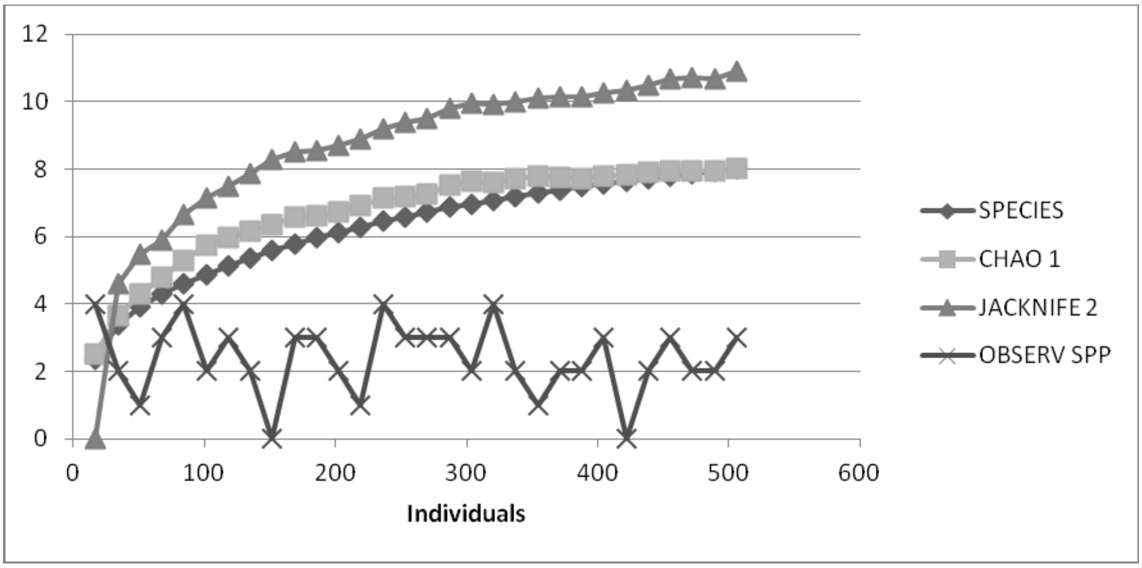

Fig. 11 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: OpSdefb (all samples pooled) dataset. Curves are generated from 100 randomizations.

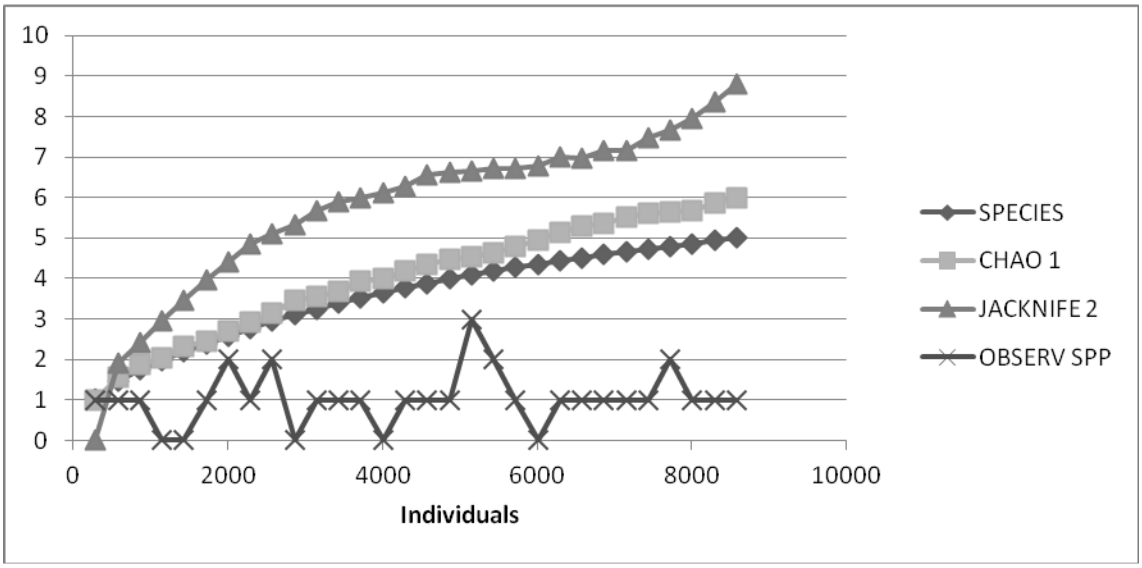

Fig. 12 Species-accumulation curve and estimation curves Chao 1 and Jackknife 2 in ecological subgroup: Oslatsu (all samples pooled) dataset. Curves are generated from 100 randomizations.

3.4 Correspondence analysis (CA)

For the canonical analysis (CA) options were taken the next steps: it was given a common species weighting and data transformation chosen with square root and calculated the similarity/correlations matrices using cyclic Jacobi.

The results of similarity matrix and eigenvalues are detailed as follows:

Similarity matrix

	Eesu	Edefbas	Elatsu	OpSesu	OpSdefbas	OpSlatsu
Eesu	0,095					
Edefbas	0,019	0,095				
Elatsu	-0,062	-0,054	0,096			
OpSesu	0,029	0,021	-0,051	0,064		
OpSdefbas	0,006	0,030	-0,036	0,008	0,029	
OpSlatsu	-0,049	-0,066	0,053	-0,037	-0,016	0,070
	Eesu	Edefbas	Elatsu	OpSesu	OpSdefbas	OpSlatsu

Eigenvalues

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6
Eigenvalues	0,275	0,084	0,048	0,038	0,005	0,000
Percentage	61,130	18,786	10,706	8,358	1,020	0,000
Cum. Percentage	61,130	79,916	90,622	98,980	100,000	100,000

CA variable scores

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6
A-Eesu	1,092	-1,702	-1,332	-0,184	0,003	1,000
B-Edefbas	1,164	1,766	-0,582	0,199	-1,020	1,000
C-Elatsu	-1,133	0,277	-0,671	1,019	0,750	1,000
D-OpSesu	0,935	-0,588	2,066	1,478	0,138	1,000
E-OpSdefbas	0,587	0,711	0,573	-1,771	2,209	1,000
F-OpSlatsu	-0,872	-0,275	0,503	-0,850	-0,944	1,000

CA case scores

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6
A-cer	1,945	-0,694	-0,143	1,054	-0,354	1,000
B-cme	1,861	4,894	-0,934	-2,293	0,514	1,000
C-aqu	1,784	-2,026	9,421	7,627	2,035	1,000
D-cma	2,084	-5,858	-6,073	-0,948	0,048	1,000
E-lhi	2,084	-5,858	-6,073	-0,948	0,048	1,000
F-ln	-0,750	-0,005	-0,120	0,212	0,095	1,000
G-mma	2,021	-1,661	-0,251	2,295	-3,071	1,000
H-aspp	0,453	-0,395	0,993	-1,565	-0,837	1,000
I-ptr	1,925	0,979	0,437	0,854	-0,786	1,000
J-ar	1,323	0,362	-0,352	0,088	2,026	1,000
K-ono	0,467	4,030	-2,817	2,721	-4,607	1,000

The complete matrix was displayed in a scatter plot (joint plot), creating CA graph with the main purpose to visualize more clearly the affinities between different soil invertebrates species and their relation with the vegetation patches or habitats.

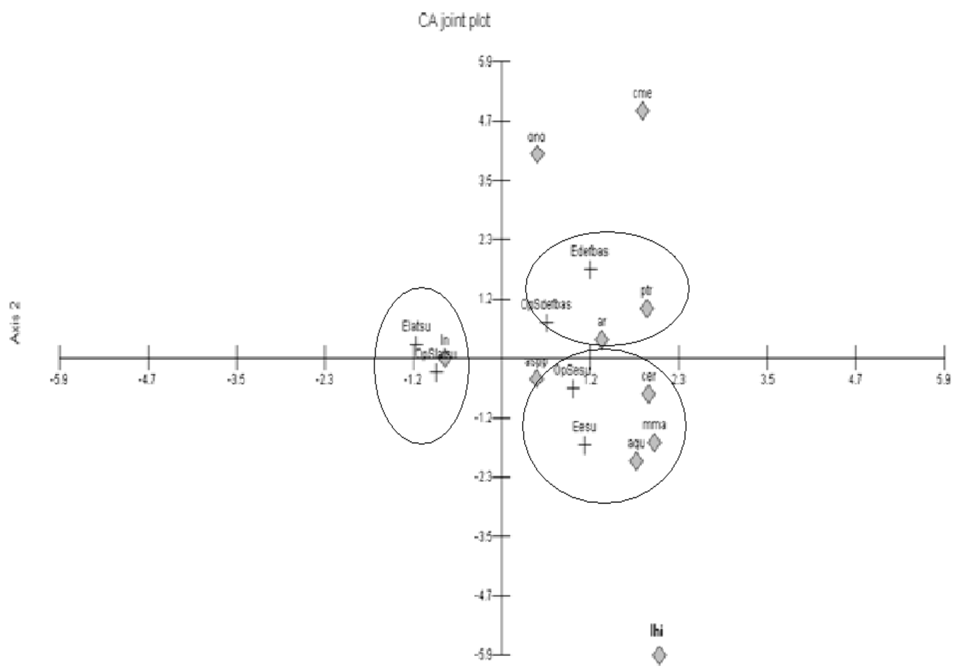

Fig. 13 Correspondence Analysis (CA) for 11 epigeus invertebrates at 6 microhabitats in Hailotu Island (Summer 2007).

In correspondence analysis(CA) and obtained in this case only for 11 macroinvertebrates species (analysis were removed from those species collected in numbers 1), can be differentiated 3 invertebrate groups relevant to their respective microhabitats and are preferably for ant *ln* more open space and less competition between species, and greater availability of pasture and moving mostly on microhabitats as OpSlatsu, Elatsu; the next group is composed by soil spiders *ar* and leafhoppers *ptr* occupying microhabitats of intermediate or transition: Edefbas and OpSdebas and finally, as the leafhopper species *aspp* preferably in OpSesu and carabids *cer* and *aqu* together here along with the more abundant grasshopper *mma* caught in the microhabitat-Eesu. Other species such as carabid *cme* and weevil *ono* showed no preference for a specific microhabitat (axis 1, North, Fig. 13), and a detritivores , the long-jointed beetle *lhi* (axis 1, South, Fig. 13) although this may be explained in large part because abundant species and incidental catch.

Moreover, to visualize the relationship of epigeus macroinvertebrate groups was analyzed by a dendrogram(UPGMA) with eucledian distance; Then, we can appreciate the near relationship between carabid *cer* and leafhopper *ptr,* followed closely by a larger and more compact species group very closed to each other and divided: carabid *cme* and weevil *ono* and, here, carabid *cma* and long-jointed beetle *lhi* , carabid *aqu* and grasshopper *mma*; Other distant group consisting composed by sand spiders *ar* and leafhooper *aspp* and finally, the ant *Lassius niger* (*ln*), interrelated with the above groups but forming a specific group independent.

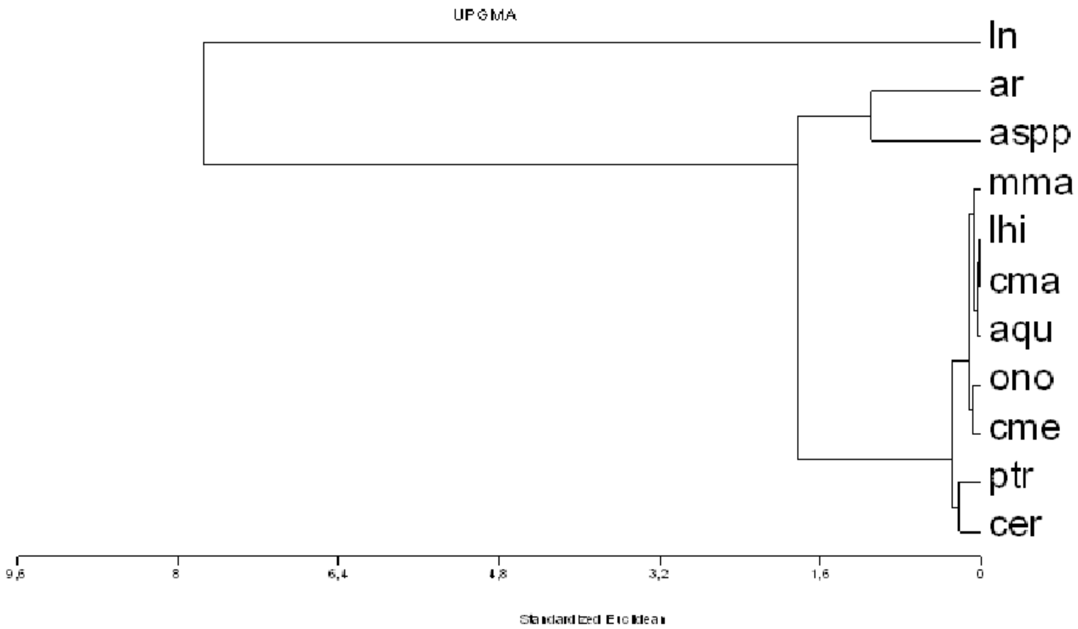

Fig. 14 Cluster analysis: dendrogram representative for 11 soil macroinvertebrates.

All previous information on the structure, richness and diversity of soil arthropods in a succession in the coastal area of the island of Hailuoto is of significant importance for protection, conservation and restoration of natural ecosystems (Kremen et al., 1993; Niemelä, 1999; Pearce and Venier, 2006; Petersen et al. 2003; Wilson, 1987; Wiggings et al., 1991; Uotila et al., 2001, 2002), such as where the study was conducted.

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References

Basset Y. 1991. The taxonomic composition of the arthropod fauna associated with an Australian rainforest tree. Australian Journal of Zoology, 39: 171-190

Bell JR, Wheater CP, Cullen WR. 2001. The implications of grassland and heathland management for the conservation of spider communities: a review. Journal of Zoology, 255: 377-387

Berg C, Christensen J, Ressel P. 1984. Harmonic Analysis on Semigroups: Theory of Positive Definite and Related Functions. Springer, Netherlands

Berg B, Staaf H. 1981. Leaching, accumulation and release of nitrogen in decomposing forest floor litter. In: Terrestrial Nitrogen Cycles (Clark FE, Rosswall T, eds). Ecological Bulletin, 33: 163-178

Blossom w2008.04.02. Blossom Statistical Software

Borges PAV, Brown VK. 2004. Arthropod community structure in pastures of an island archipelago (Azores): looking for local–regional species richness patterns at fine scales. Bulletin of Entomological Research, 94: 111-121

Brooks AJ, et al. 2005. Hydraulic microhabitats and the distribution of macroinvertebrates assemblages in riffles. Fresh Water Biology, 50: 331-344

Chiarucci A, Enright NJ, Perry GLW, et al. 2003. Performance of nonparametric species richness estimators in a high diversity plant community. Diversity and Distributions, 9: 283-295

Chiarucci A, Enright NJ, Perry GLW, et al. 2003. Performance of nonparametric species richness estimators in a high diversity plant community. Diversity and Distributions, 9: 283-295

Coddington JA, Grisworld CE, Dávila DS, et al. 1991. Designing and testing sampling protocols to estimate biodiversity in tropical ecosystems. In: Proceedings of the Fourth International Congress of Systematic and Evolutionary Biology. Dioscorides Press, Portland, USA

Colwell RK. 2000. EstimateS-Statistical Estimation of Species Richness and Shared Species from Samples. University of Connecticut, Connecticut, USA

Colwell RK. 2006. EstimateS: statistical estimation of species richness and shared species from samples. Version 8.0. User's Guide and Application.

Doblas E. 2007. Ecology of soil macroinvertebrates in a Mediterranean arid ecosystem. PhD thesis. Univerity of Granada, Spain

Doblas-Miranda E, Wardle DA, Peltzer DA, et al. 2008. Changes in the community structure and diversity of soil invertebrates across the Franz Josef Glacier chronosequence. Soil Biology and Biochemistry, 40: 1069-1081

Doblas-Miranda E, Sánchez-Piñero F, González-Megías A. 2009a. Different structuring factors but connected dynamics shape litter and belowground soil macrofaunal food webs. Soil Biology and Biochemistry, 41: 2543-2550

Doblas-Miranda E, Sánchez-Piñero F, González-Megías A. 2009b. Different microhabitats affect soil macroinvertebrate assemblages in a Mediterranean arid ecosystem. Applied Soil Ecology, 41: 329-335

Doblas-Miranda E, Sánchez-Piñero F, González-Megías A. 2009c. Vertical distribution of soil macrofauna in an arid ecosystem: are litter and belowground compartmentalized habitats? Pedobiologia, 52: 361-373

Entling W, Schmidt MH, Bacher S, et al. 2007. Niche properties of Central European spiders: shading, moisture and the evolution of the habitat niche. Global Ecology and Biogeography, 16: 440-448

Finch OD, Krummen H, Plaisier F, et al. 2007. Zonation of spiders (Araneae) and carabid beetles (Coleoptera: Carabidae) in island salt marshes at the North Sea coast. Wetlands Ecology and Management, 15: 207-228

Finch OD, Blick T, Schuldt A. 2008. patterns of spider richness across Europe. Biodiversity and Conservation, 17: 2849-2868

Hatley CL, MacMahon JA. 1980. Spider community organization: seasonal variation and the role of vegetation architecture. Environmental Entomology, 9: 632-639

Hättenschwiler S, Tiunov A,Scheu S. 2005. Biodiversity and litter decomposition in terrestrial ecosystems ; Annual Review of Ecology, Evolution and Systematics, 36: 191-218

Heimer S, Nentwig W. 1991. Spinnen mitteleuropas. Paul Parey, Berlin, Hamburg, Germany

Hendrickx F, Maeilfait JP, Wingerden WV, et al. 2007. How landscape structure, land–use intensity and habitat diversity affect components of total arthropod diversity in agricultural landscapes. Journal of Applied Ecology, 44: 340-351

Hengeveld R. 1985. Dynamics of Dutch ground beetle species during the twentieth century (Col; Carabidae).Journal of Biogeography, 12: 389-411

Kouki A, Hyvärinen E, Lappalainen H, et al. 2012. Landscape context affects the success of habitat restoration: large-scale colonization patterns of saproxylic and fire-associated species in boreal forests. Diversity and Distributions, 18(4): 348-355

Koricheva J, Mulder CPH, Schmid B, et al. 2000. Numerical responses of different trophic groups of invertebrates to manipulations of plant diversity in grasslands. Oecologia, 125: 271-282

Kouki J, Löfman S, Martikainen P, et al. 2001. Forest fragmentation in Fennoscandia: linking habitat requirements of wood-associated threatened species to landscape and habitat changes. Scandinavian Journal of Forest Research, Suppl. 3: 27-37

Kovach WL. 1999. MVSP - A Multivariate Statistical Package for Windows (Ver.3.1). Kovach Computing Services, Pentraeth, Wales, UK

Kremen C, Colwell RK, Erwin TL, et al. 1993. Terrestrial arthropod assemblages: their use in conservation planning. Conservation Biology, 7(4): 796-808

Lindroth CH. 1985. The Carabid (Coleoptera) of fennoscandia and Denmark; Fauna entomologica scandinavica (Vol.15, part 1). E. J. Brill/Scandinavian Science Press, Denmark

Lindroth CH. 1986. The Carabid(Coleoptera) of fennoscandia and Denmark; Fauna entomologica scandinavica, vol.15, part 2. E. J. Brill/Scandinavian Science Press, Denmark

Magurran AE. 1988. Ecological Diversity and Its Measurement. University Press, Cambridge, UK

McClaugherty CA, Aber JD, Melillo JM. 1982. The role of fine roots in the organic matter and nitrogen budgets of two forested ecosystems. Ecology, 63: 1481-1490

Marshall SA, Anderson RS, Roughley RE, et al. 1994. Terrestrial arthropod biodiversity: planning a study and recommended sampling techniques. Bulletin of the Entomological Society of Canada 26(1): 33

Martikainen P, Siitonen J, Punttila P, et al. 2000. Species richness of Coleoptera in mature managed and old-growth boreal forests in southern Finland. Biological Conservation, 94: 199-209

Minitab@15 software. www.minitab.com

Moreno CE. 2001. Métodos para Medir la Biodiversidad. Volumen I. Manuales y Tesis. Sociedad Entomológica Aragonesa. Zaragoza, España

Niemelä J. 1997. Invertebrates and boreal forest management. Conservation Biology, 11: 601-610

Niemelä J. 1999. Management in relation to disturbance in the boreal forest. Forest Ecology and Management, 115: 127-134

Nystrand O, Granström A. 2000. Predation on Pinus sylvestris seeds and juvenile seedlings in Swedish boreal forest in relation to stand disturbance by logging. Journal of Applied Ecology, 37(3): 449-463

Oxbrough AG, Gittings T, O‘Halloran J, et al. 2005. Structural indicators of spider communities across the forest plantation cycle. Forest Ecology and Management, 212: 171-183

Pearce JL, Venier LA. 2006. The use of ground beetles (Coleoptera: Carabidae) and spiders (Araneae) as bioindicators of sustainable forest management: A review. Ecological Indicators, 6(4): 780-793

Petersen WJ, Lurton H. 1982. A comparative analysis of soil fauna populations and their role in decomposition processes. Oikos, 39: 288-388

Petersen GD, Cumming GS, Carpenter SR. 2003. Scenario Planning: a Tool for Conservation in an Uncertain World. Conservation Biology, 17(2): 358-366

Rautio P, Markkola A. 2006. Competition or facilities: effects on *Empetrum nigrum* mycorrhizal colonization on seedlings of *Pinus sylvestris* in a successional gradient (Manuscript unpublished)

Scharff N, Coddington JA, Griswold CE, et al. 2003. When to quit? Estimating spider species richness in a northern European deciduous forest. Journal of Arachnology, 31: 246-273

Schmidt MH, Roschewitz I, Thies C, et al. 2005. Differential effects of landscape and management on diversity and density of ground–dwelling farmland spiders. Journal of Applied Ecology, 42: 281-287

Similä M. 2002. Patterns of Beetle Species Diversity in Fennoscandian Boreal Forests: Effects of Forest Age, Naturalness and Fertility, and Co-variation with Other Forest-dwelling Taxa Volumen 141 de Tiedonantoja / Joensuun yliopisto, metsätieteellinen tiedekunta. University of Joensuu, Finland

Similä M, Kouki J, Mönkkönen M. 2002. Ecography: Pattern and diversity in ecology. Diversity and Distributions, 25(1): 42-52

Slansky F, Rodriguez JG. 1987. Nutritional Ecology of Insects, Mites, Spiders, and Related Invertebrates. Wiley, USA

Sorensen LL, Coddington JA, et al. 2002 .Inventorying and estimating subcanopy spiders diversity using semiquantitative sampling methods in anafromontane forest. Environmental Entomology, 31: 319-330

Uotila A, Maltamo M, Uuttera J, et al. 2001. Stand structure in seminatural and managed forests in eastern Finland and Russian Karelia. Ecological Bulletins, 49: 149-158

Uotila A, Kouki J, Kontkanen H, et al. 2002. Assessing the naturalness of eastern Fennoscandian boreal forests. Forest Ecology and Management, 161: 257-277

Wiggins GB, Marshall SA, Downes JA. 1991. The importance of research collections of terrestrial arthropods. A brief prepared by the Biological Survey of Canada (Terrestrial Arthropods). Bulletin of the Entomological Society of Canada, 23(2): 16

Wilson EO. 1987. The little things that run the world (the importance and conservation of invertebrates). Conservation Biology, 1: 344-346

Wise DH. 1993. Spiders in Ecological Webs. Cambridge University Press, Cambridge, UK

Zhang WJ. 2011a. Constructing ecological interaction networks by correlation analysis: hints from community sampling. Network Biology, 1(2): 81-98

Zhang WJ. 2011b. Simulation of arthropod abundance from plant composition. Computational Ecology and Software, 1(1): 37-48

Zhang WJ, Zhong XQ, Liu GH. 2008. Recognizing spatial distribution patterns of grassland insects: neural network approaches. Stochastic Environmental Research and Risk Assessment, 22(2): 207-216