DIPLOMARBEIT

Carabid assemblages of various forest communities of the National Park Thayatal (northern part), Lower Austria

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Summary

The study took place in the Nationalpark “Thayatal-Podyjí” (northern Lower Austria) on seven sites from April to October 2005 and additionally on two different sites from April to October 2006. The carabid assemblages of this different sampling sites, which vary in their geology and forest type, were examined by using pitfall traps.

Carabids were suitable bioindicators for this study because they are easy to trap and their ecological preferences are well known. The carabid assemblages were characterised by composition of wing morphology types, body sizes and ecological valences and by three ecological parameters which were Shannon Index, Eveness, and Forest Affinity Index (FAI).

In total 17 different species were identified and the species number varied from 1 to 10 among the sites. *Aptinus bombarda* was the most abundant species but could only be found at two sites followed by *Abax parallelepipedus, Abax ovalis* and *Molops piceus. Abax paralellepipedus* was the most wide spread species and appeared at six sites. In total more than 80 % of all registrated species were brachypterous, 30 % were stenoecious and 70 % were body size category IV and V which means that large species were in the majority. The Shannon Index was highest with 2.01 at the very well structured oaktree mixed forest MXG3, and the FAI Index showed its highest value at the oaktree hornbeam forest ES and at the beechwood forest MXG2 with 0.98 each. To show similarity between the investigated sites a hierarchic cluster analysis was performed. The dendrogram showed two big clusters consisting of smaller ones. All three sites covered with beech forests are located together in one cluster, as the oaktree forest communities are all located together in the second cluster. Only oaktree-hornbeam forest communities occur in both big clusters.

This study shows that forest ecosystems are poor in carabid diversity and that brachypterous and large species dominate. The study also displays that there are differences in the carabid assemblages in different forest communities. But the grade of disturbance and structuring of the habitat as well as the climatic conditions might play the major role for the composition of carabid coenosis.

Keywords: **Carabids, ground beetles, pitfall traps, forest communities, bioindicators, biodiversity, National Park Thayatal-Podyjí.**

Contents

1. Introduction

The National Park Thayatal is the smallest National Park in Austria (1330 ha) and is located at the Czech border 15 km northern of the City Retz. It was founded in the year 2000 and is devided by the river Thaya from the much larger Czech National Park Podyí which encloses an area of more than 6600 ha. Forest is the dominating landscape type and covers 93 % of the National Park. Though these forests were managed and at some places even clearcut during World War II, today it has regained its nativeness. Management of the forest communities is only allowed for protection and recreation due to the status of IUCN category 2.

Caused by its location on the border between atlantic and pannonic climate and by its heterogenous terrain, many different habitat types like oak-, hornbeam- and beech forests as well as meadows, floodplain forests and grasslands can be found. This is the base for a high biodiversity of flora and fauna.

In the years 2005 and 2006 a study to document this biodiversity was conducted which investigated carabid beetle, terrestrial snails and the fauna of xylobiontic beetles. The following study displays the results of the carabid communities in the northern part of the Nationalpark Thayatal. Together with VIDIC (2007) who investigated carabid assemblages of forest communities in the western part of the Nationalpark, we tried to record all of the most frequent forest types according to a study of WRBKA (2006) about the forest associations. The goals of this study were to detect biodiversity and to create a list of species, and to make ecological statements and comparisons of the different habitat types, as well as to register endangered species and to underline the importance of the Nationalpark Thayatal to preserve Carabids as ecological important members of faunistic diversity.

Carabid beetles served in many ecological studies of the last decades as model organisms in various ecoloiocal surveys, because their morphological characteristics and their ecological demands are well documented (MARGGI 1992, HURKA 1996, FREUDE et al. 2004). Most of them are polyphageous and other species are the most important predators of phytophageous and detritophageous evertebrates within the epigaeic soil Arthropodes. Small and macropterous species can change their habitat quickly and are often pioneers of unstable habitats (ZULKA 1994) while large and brachypterous species typically are philopatric and inhabit ecosystems in a late stage of succession (DEN BOER 1971, STEINWEGER 2004.). Carabids are good indicators for the nativeness and for the ecological state of an ecosystem due to their ability of reacting much faster and much more sensible on disturbances than vegetation does (HOLSTE 1974, BUCK et al. 1992, TRAUTNER & ASSMANN 1998, GOULET 2003). MÜLLER-MOTZFELD (1989) describes them as important bioindicators for comparative synecological studies because their species richness, their high activity abundance and their easy handling assure good results. They occur in most terrestrial habitats and differentiate among a multitude of environmental gradients like soil humidity, disturbance intensity and spatial structure (LUFF et al 1989). Carabid beetles are easy to catch with pitfall traps (e.g. LUFF 1975; DESENDER & MAELFAIT 1986) and show according to THIELE (1977) by their occurance at certain habitats, coherences with environmental factors like soil and vegetation which makes them precious indicators for environmental changes.

2. Materials and Methods

2.1. Sampling sites

All investigated sites are located in the National Park Thayatal in Lower Austria at the the border to the Czech Republic in the surrounding of the little town Hardegg. The National Park is devided into two climate zones. The eastern parts are influenced by the dry and warm pannonian climate while the western parts are affected by the atlantic climate which is much more humid and cooler.
The botanical characterization of the sampling sites follows WRBKA (2006).

MXG1 – Maxplateau Eiche Hainbuche (Oaktree – Hornbeam forest)
(N 48°51‘ 29,3" ; E 15°50‘ 21,7")

Oak trees dominate the forest community of this sampling site mixed with some single Hornbeam trees. The ground is lightly shaded and sparsely covered with leaf litter. Deadwood biomass is very low. This area is rather dry and the soil is firm and partly overgrown with grass. The vegetation is specified as <u>Galio sylvatici-Carpinetum typicum</u>

MXG2 – Maxplateau Buchenwald (Beechwood forest)

(N 48°51‘ 23,5" ; E 15°50‘ 39,7")

This sampling site is situated in a slight depression with a rather dense population of common beeches. The ground is strongly shaded and completely covered with a thin layer of leaf litter. Grass or other ground vegetation is nearly absent. Also deadwood is rarely found. Caused by the lack of direct sunlight and wind the ground is humid. The vegetation is described as Galio odorati-Fagetum.

MXPR – Maxplateau Profil (Beechwood forest)

(N 48°51‘ 32,7" ; E 15°50‘ 22,6")

The investigated area is located close to the sampling site MXG1. While the terrain at MXG1 is flat, the compound of MXPR is situated on a very steep hillside with an inclination up to 60°. The exposition is north–east. Th e ground is strongly shaded at the top of the hillside and becomes a little bit lighter at the bottom. The main occurring trees are beeches but some Oaks and Hornbeams also can be found.
Ground vegetation is totally missing and the soil is hidden under a thick layer of leaf litter mixed with deadwood. Caused by its steepness this area is much more disturbed than the others mentioned before. The leaf litter layer is very instable and shows a tendency of slipping down the hillside. Also the appearance of wild boars has an impact on the habitat stability. The soil is humid and at some places even wet. The described vegetation community is a Galio odorati-Fagetum.

MXG3 – Maxplateau Gipfel (Oaktree mixed forest)

(N 48°51‘ 19,3" ; E 15°51‘ 09,3")

The oaktree mixed forest is located on the top of the "Max–Plateau". This site is dominated by the oaks and hornbeams while also beeches are present. The vegetation is much lighter than on the sampling sites mentioned before. This leads to much dryer, less shaded and warmer climate conditions. The ground is interspersed with large stones and partly covered with leaf litter and sporadically overgrown with grass. Also some blackberry bushes (*Rubus fructicosus*) can be found. The specified vegetation community is Sorbo torminalis-Quercetum

HS – Hohe Sulz (Beechwood forest)

(N 48°50‘ 14" ; E 15°50‘ 14“)

The sampling site is located on a hillside with an inclination of 20° to 30° and a northern exposition. The forest is light with an open character. This makes it rather dry. Though the soil is not much covered with leaf litter, ground vegetation is sparsely present. This may be caused by the frequent wild boar activity with makes this habitat rather instable. <u>Galio odorati-Fagetum</u> ist the described vegetation.

ES – Einsiedler (Oaktree – Hornbeam forest)

(N 48°51‘ 12,3" ; E 15°52‘ 30,2")

On this investigated site hornbeams were the most common trees. The area has an inclination of 10° and a north–western exposition. The forest is more dense than at HS and the soil is overgrown by grass and partly covered with leaf litter. The vegetation community is described as <u>Galio sylvatici-Carpinetum typicum.</u>

KW1 – Kirchenwald 1 (Oak forest)

(N 48°48‘ 55,6" ; E 15°56‘ 56,4")

The following three sampling sites are located at a more eastern region of the National Park, where tourism doesn’t take place. At this area the forest mainly consists of oaks mixed with pine. The ground is only lightly shaded and covered with pine needles and leaves. Dead wood is much more present than on the other examined sites. The specified vegetation type is a <u>Luzulo-Quercetum typicum</u>.

KW2 – Kirchenwald 2 (Oak forest)

(N 48°48‘ 58,6" ; E 15°57‘ 06,6")

This sampling site is similar to KW1 simply because they are situated close together. Vegetation communities and climate conditions are the same.

KWB – Kirchenwald Blockfelsen

(N 48°49‘ 15,3" ; E 15°56‘ 53,1")

Rocks, stones and the lack of forest makes this sampling site completely different to all the others. It is located on the very top of a steep slope that leads down to the river Thaya. The inclination is up to 60° and expositi on is north. Only rocks stapled on top of each other form this area. Soil and leaf litter can only be found in small crevices between the stones. The only occurring plants are tresses. Nevertheless the sampling site is surrounded by some oaks. Due to the lack of wood and the position on the very top of the slope, wind is very strong and forms a rougher climate than at the other areas.

2.2. Sampling methods and design

Pitfall traps were used to collect carabid beetles. These traps consisted of a plastic cup with a diameter of 6.5 cm and a depth of 9.5 cm and a lid approximately 2 cm above to protect the trap from rain and leaf litter. The traps were filled to two third with a 50 % ethylene glycol water mixture. A drop of detergent was added to abolish the surface tension. On some sampling sites iron rods were placed around the traps to protect them from wild boar activity. Three traps per site were used (DESENDER, VANDEN BUSSCHE 1998) and placed in an equilateral triangle with a sidelength of approximately five meters. The method of pitfall trapping only acquires activity abundances because the collected number of individuals also depends on their different amount of activity and does not reflect the true frequency or population density of species (MÜLLER 1984). The traps were installed in April 2005 and emptied every 10 days in spring and autumn and every two weeks in summer till the end of October 2005.

Sites KW, KW1 and KW2 were examined a bit different because of their locations which were hard to reach. For these sites larger cups (diameter 8.5, depth 12 cm) were used and 4 % formaldehyde was added to the ethylene glycol water mixture for a better conservation of the beetles. KW was investigated from April to the end of October 2005 and emptied monthly. KW1 and KW 2 were investigated from Mai 2006 until the end of October 2006 and also emptied monthly. To get an overview of the microclimatic conditions of the sampling sites, measurements of the temperature were carried out. Therefore minumum and maximum thermometers were placed on a shady place on the ground in the center of most examined sites.

Carabid beetles were identified to species level according to HURKA (1996) and MÜLLER -MOTZFELD (2004).

2.3. Data Analysis

In ecology, description of beetle communities can be done in two ways. Either some biological characteristics of the occurring species can be investigated to describe the attributes of communities, or some statistic measurements of various investigated parameters can be done to acquire structure and attributes of communities and ecosystems. Conclusions of the maturity of a community can be drawn by the allocation of individuals on the various species (MAGURRAN 1988).

Distribution of carabid species among the sampling sites is documented in a species list. In addition a Box Whisker plot, to show the allocation of species numbers on the different forest types was drawn with SPSS v.15.0 program. Vegetation community of site MXG3 was not exactly the same as those of ES and MXG1.but due to their similar character, in this analysis all three were put together in one group.

Wing morphology and body size

These parameters and are known as good indicators to determine the stability of the examined area (HEYDEMANN 1964, DEN BOER et al. 1980, BLAKE et al. 1994, LÖVEI & SUNDERLAND 1996).

Wing morphology varies from macropterous (wings are completely developed), brachypterous (no wings are developed or at least shortened) to dimorph (all variations between macropterous and brachypterous occur) species. Determination of wing morphology and body size follows HURKA (1996) whose classification was simplified for this study. Classification of bodysize categories follows HEYDEMANN (1953).

Ecological valence

Carabid beetles can be classified whether they are more specialists (stenoecious) or generalists (euryecious). Especially undisturbed and in a late succession stage processed forests, are habitat to silvicole and stenoecious carabid beetles. The ratio of stenoecious to euryecious species can be a good gauge for the ecological quality of a forest (KÖHLER 1996, WAITZBAUER 2001).
Determination follows and MARGGI (1992) and HURKA (1996).

Forest affinity index (FAI)

Another way to define the quality of the sampling sites is to calculate the forest affinity index which was used by ALLEGRO & SCIAKY (2002), TÓTHMÉRÉSZ & MAGURA (2003) and VIDIC (2007). For calculation of this index the species have to be divided according to their habitat preference into forest - generalist species and species of open habitats. These different habitat preferences are put into five different ranks:
+1…….obligate forest species
+0,5…...partial forest species
0………whether forest nor open habitat preference
-0,5……partial open habitat species
-1……..obligate open habitat species

The alghorithm for the FAI is:

$$FAI = \sum_{(i=1,\, n)} (p_i F_i)$$

p_i……sum of species frequencies
F_i……the value of the forest specialization of the species

The more forest species occur at a site, the higher is the value of the forest affinity index.
Characterization for forest specialization was done according to MARGGI (1992), HURKA (1996), FREUDE et al. (2004) and a study of VIDIC (2007).

Diversity

As indicator for diversity the Shannon Index (H_S) was used. This index puts the number of species in connection with the dispersion of the individuals on the single species. The higher the value of H_S is, the higher the diversity.

Additionally the Eveness (E) was calculated as another index to describe how evenly the individuals are spread on the single species. The closer the Eveness value is to 1, the more equal the individuals are dispersed on the single species.
The Eveness is calculated according to MÜHLENBERG (1993):

Rarefaction curve

The rarefaction curve shows the assessment status of carabid beetles in the investigated areas and can be ascertained by the program Past version 1.7.
The rarefaction curve is calculated after the rarefaction – algorithm (KREBS 1998).

Similarity

To show how much different sampling sites resemble each other, a hierarchic cluster analysis was performed with the program SPSS v.15.0.

3. RESULTS

3.1. Overview and structure:

In total 17 different carabid species with 305 individuals were found over all investigated sites (Table 1). *Aptinus bombarda* contains the largest individual number with 159 though this species was only registrated at two sampling sites. At ES 158 individuals were found. *Abax parallelepipedus* was recorded on all sites except KW1, KW2 and KWB which are all located close to each other. It was the most widespread species. MX G3 comprised the highest species richness with 10 species, on the other side only one species could be registrated. at KWB.

Table 1. Recorded carabid beetles, their habitat preference and their forest specialisation value (F_i). Species represented by less than 3 individuals: *Abax parallelus* F, 1 ; *Bembidion lampros* G, -1 ; *Carabus coreaceus* G, 0,5 ; *Notiophilus biguttatus* G, 0,5

Abbreviations: F…forest species, O…open habitat species, G…generalist species

	Habitat pref	F_i	ES	MXG1	MXG2	MXG3	MXPR	HS	KWB	KW1	KW2
Abax ovalis	F	1	12		8		1				
Abax parallelepipedus	F	1	7	4	7	6	14	6			
Amara ovata	G	0		1		6					
Aptinus bombarda	F	1	158					1			
Carabus hortensis	F	1		1		1		1			1
Carabus intricatus	F	1				1	1		3	1	2
Carabus nemoralis	G	-1		1		1				1	1
Carabus scheidleri	F	1	5								
Molops elatus	G	1	2	1	1	1	5				
Molops piceus	F	1	2		8	6		1			
Notiophilus rufipes	O	-1				5	1			3	4
Pogonophorus rufomarginatus	F	1		1		2					
Pterostichus burmeisteri	F	1	1				3	1			
Total number of individuals			187	9	24	29	25	10	3	5	8
Total number of species			7	6	4	9	6	5	1	3	4

As shown in Figure 1 the investigated Carabid fauna consits of 10 forest species (~59 %), 6 generalist species (~35 %) and 1 open habitat species (~6 %). Considering the individual numbers, nearly 90 % of all individuals are forest types and only 10 % consist of generalist and open habitat types.

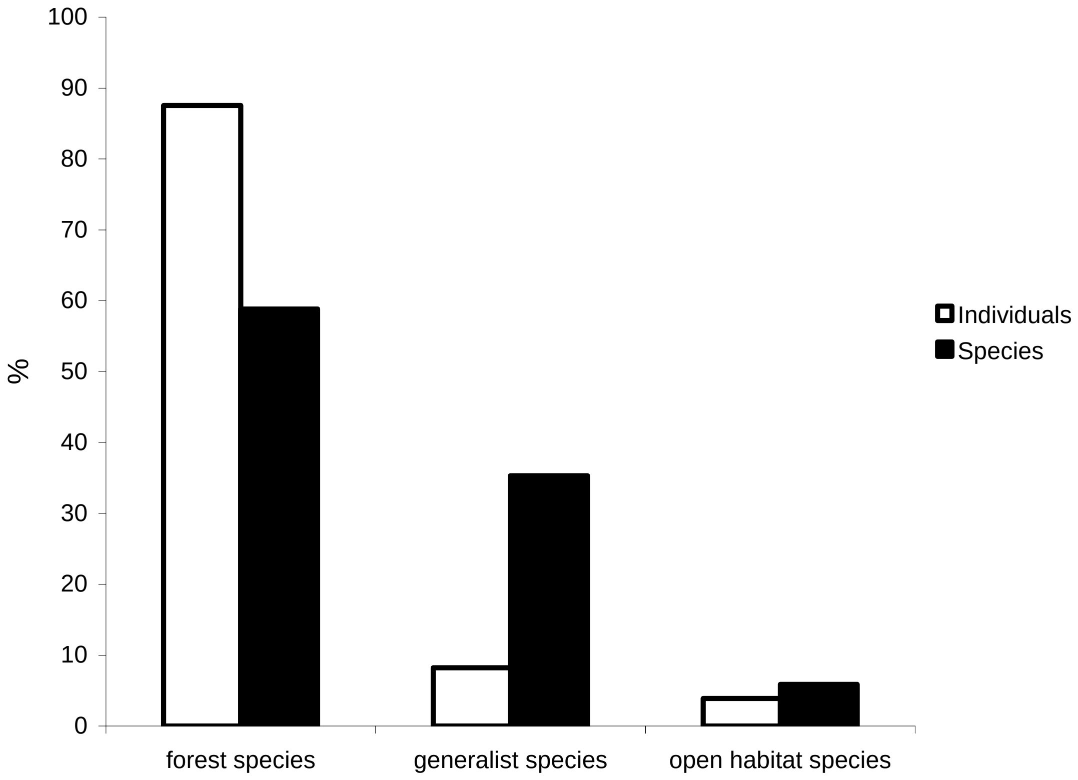

Figure 1. Habitat preference of all recorded carabid species.

Regarding habitat preference for single sampling sites, it is conspicuous that forest species as well as generalist species are present at every examined site (Figure 2). Nevertheless forest species play the biggest part on most sampling sites and especially on ES and HS they dominate. Generalist species display a huge contingent on MX G3, MX G1 and MX PR. Open habitat species were found at four sites. KW1 is the only area were all habitat preference sites are represented equally.

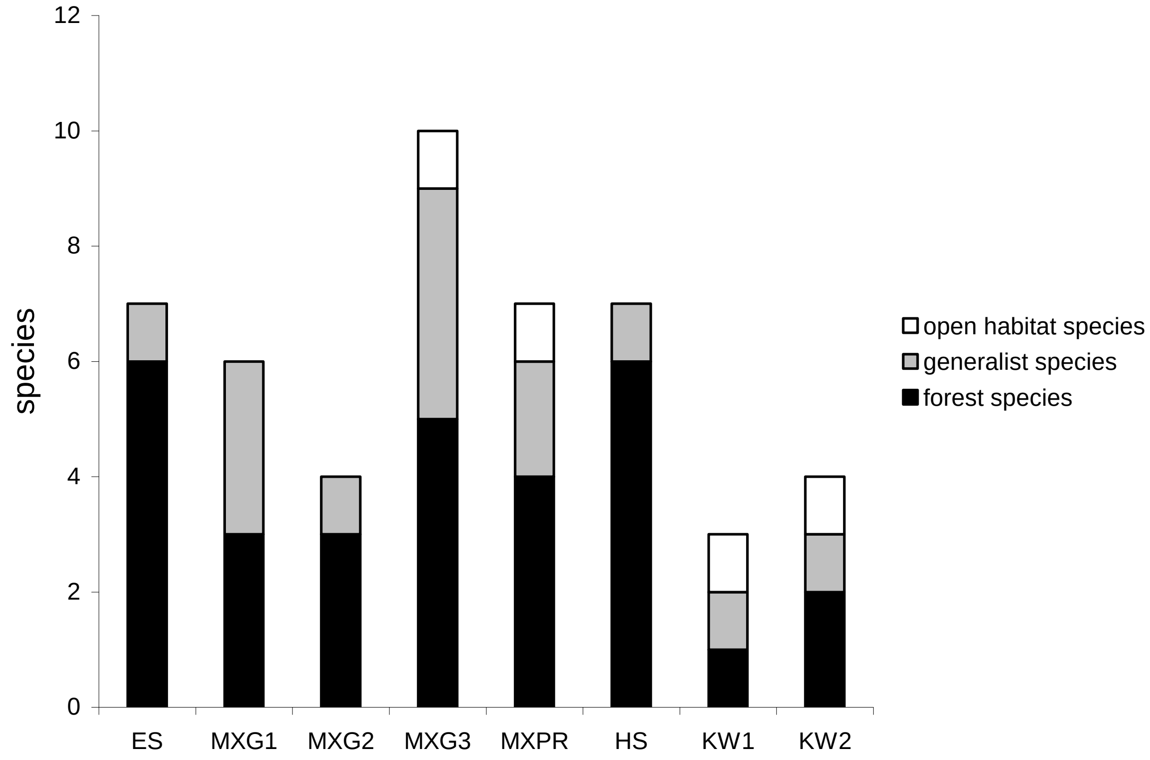

Figure 2. Habitat preference of carabid species at different sampling sites. Only sites with three or more species were analysed.

The Box Whisker Plot (Figure 3) shows that Oaktree - Hornbeam forest were richest in species numbers while Oaktree forests inhabited only few species. Oaktree–Hornbeam forests also show a huge range between minimum and maximum recorded species number. Though OAHB contains the most rich in species sampling sites the median is the same like in Beechwood forests.

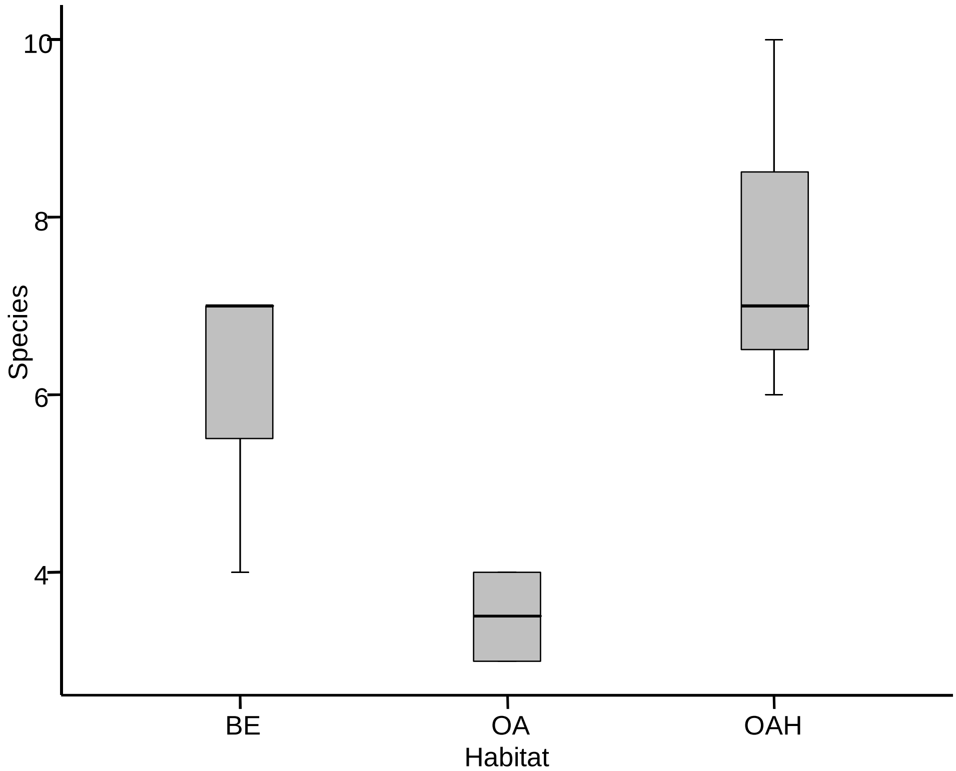

Figure 3. Box Whisker Plot of species dispersion on three different kind of forest types. Only sampling sites with three or more species were analysed.

Abbreviations: BE…beech forest (contains sites MXG2, MXPR, HS), OA…oak forest (contains sites KW1, KW2), OAHB…oaktree–hornbeam forest (contains sites ES, MXG1, MXG3)

3.2. Wing morphology

Figure 4 shows that the proportion of brachypterous species was more than 80 % on the examined areas. The only macropterous species were *Amara ovata* and *Notiophilus rufipes* whereas only one dimorph species (*Notiophilus biguttatus*) could be proved. Therefore it seems that macropterous and dimorph species play a minor role in the overall carabid compound.

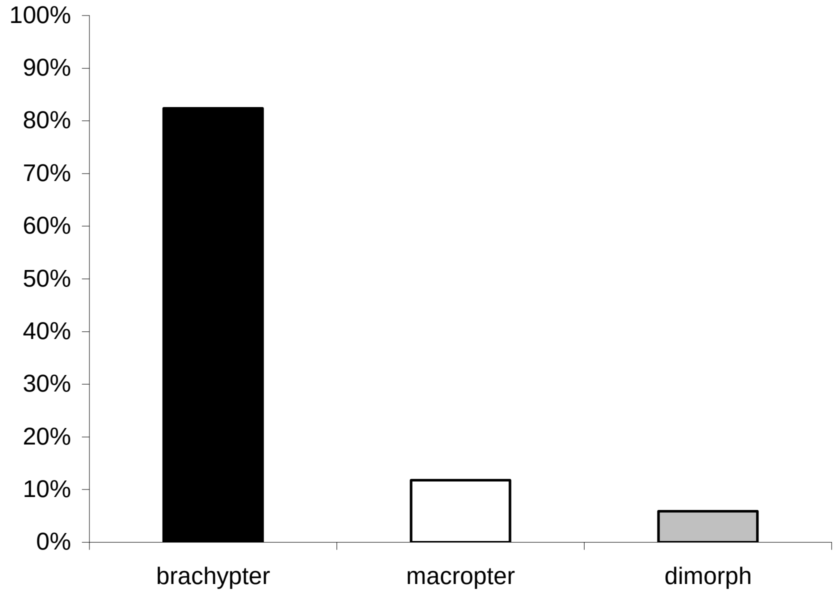

Figure 4. Distribution of wing morphology types across all sampling sites.

Wing morphology composition for every single sampling site is shown in Figure 5. Brachypterous species dominate on every site. Three areas (ES, MX G2, HS) consisted only of brachypterous species. While especially on MX G3, KW1 and KW2 approximately 30 % of the species were macropterous or dimorph.

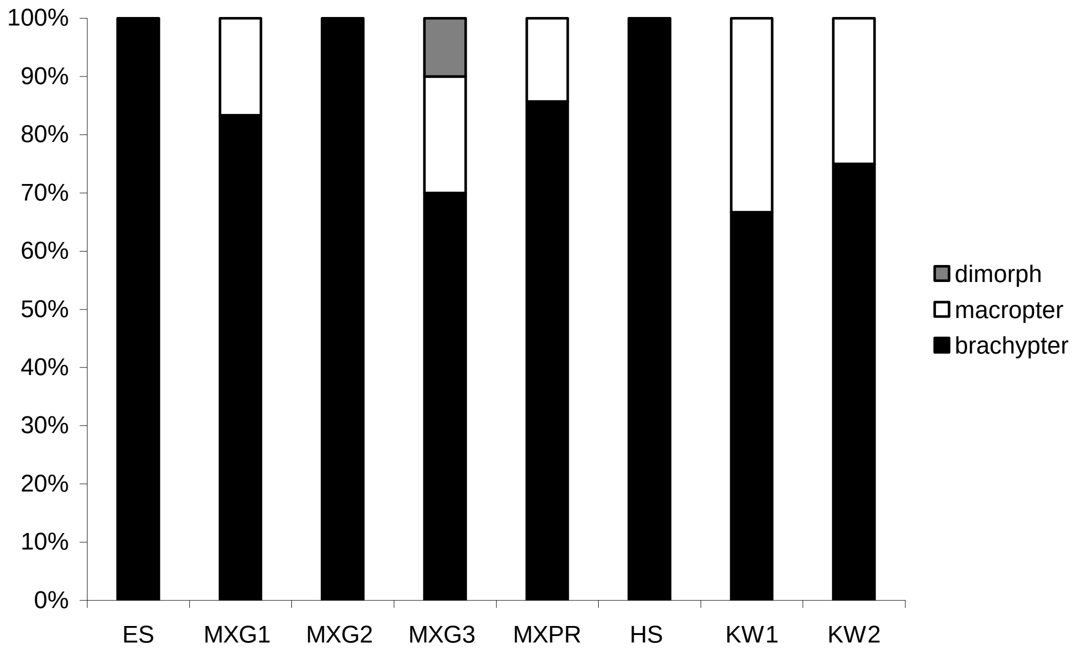

Figure 5. Distribution of wing morphology types at different sampling sites. Only sampling sites with three or more species were analysed.

3.3. Body size

The composition of body size categories is very heterogeneous. All five body size categories were found but large species of category IV and V occured more frequent and equally distributed (Figure 6). Regarding individual numbers body size category IV clearly dominates.

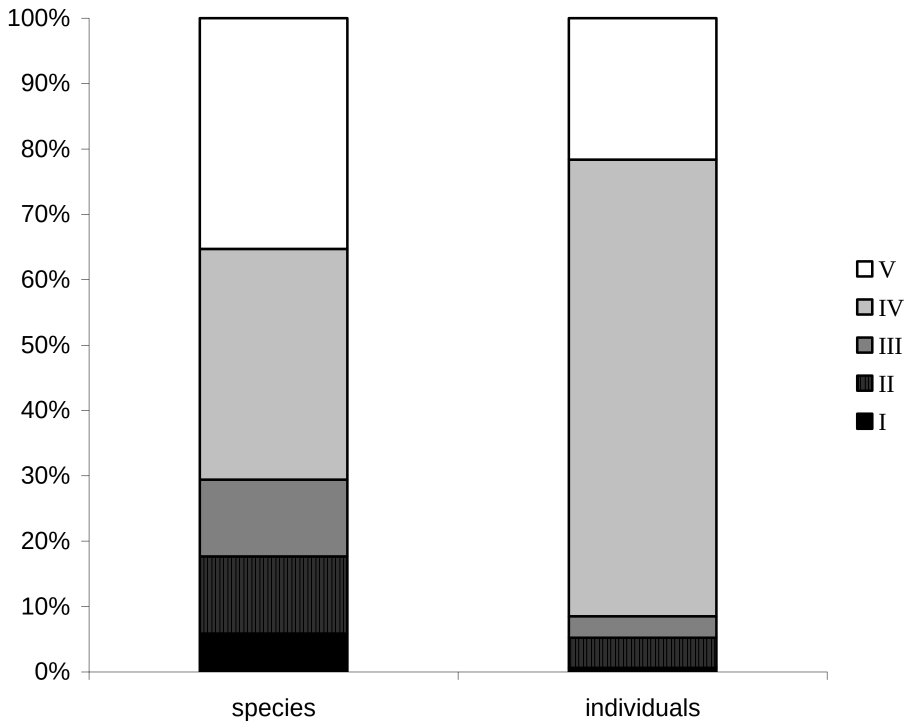

Figure 6. Distribution of body size categories across all sampling sites.

Species of category V were found at every sampling site in great numbers and species of category IV were only missing at two areas (Figure 7). In general large species dominate on every sampling site. In body size category I the only recorded species was *Bembidion lampros* and only occurred at HS. Though carabids of size II and III were found each with two species, the smaller ones (category II) were wider spread and could be detected at four sampling sites. The most heterogeneous area was MXG3 where four different body size categories were registrated.

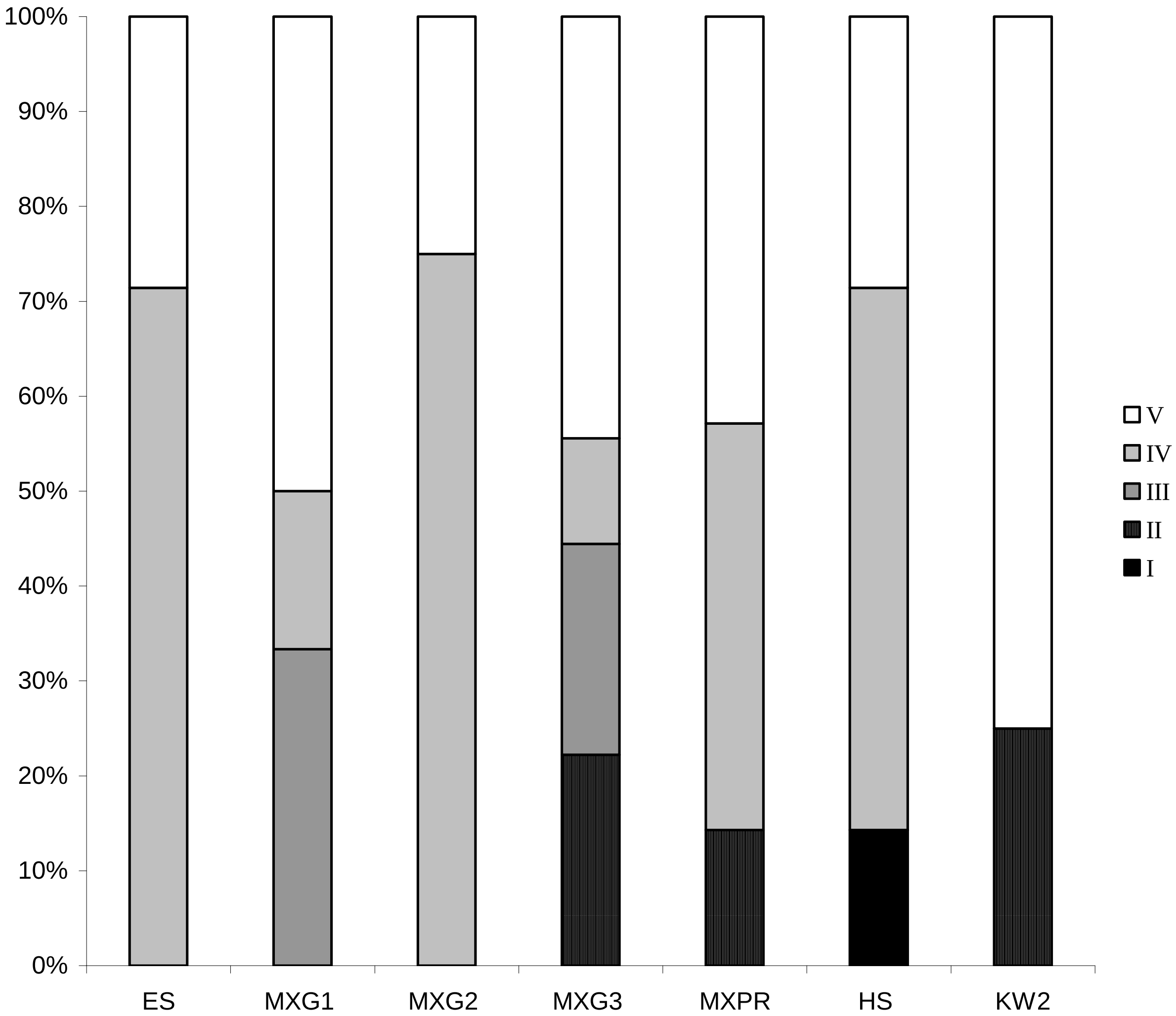

Figure 7. Distribution of body size categories at different sampling sites.
Only sampling sites with three or more species were analysed.

3.4. Ecological Valence

Figure 8 shows that 70 % of all species were euryoecious. This situation is inverted as individual numbers are regarded. In total 12 out of 17 carabid species were euryoecious and only five stenoecious. *Abax parallelepipedus* was the most abundant euryoecious species with 44 recorded individuals and even the most widespread one. On the other hand *Aptinus bombarda* clearly was the most abundant stenoecious species with 159 recorded individuals but occurred only at the two sampling sites HS and ES.

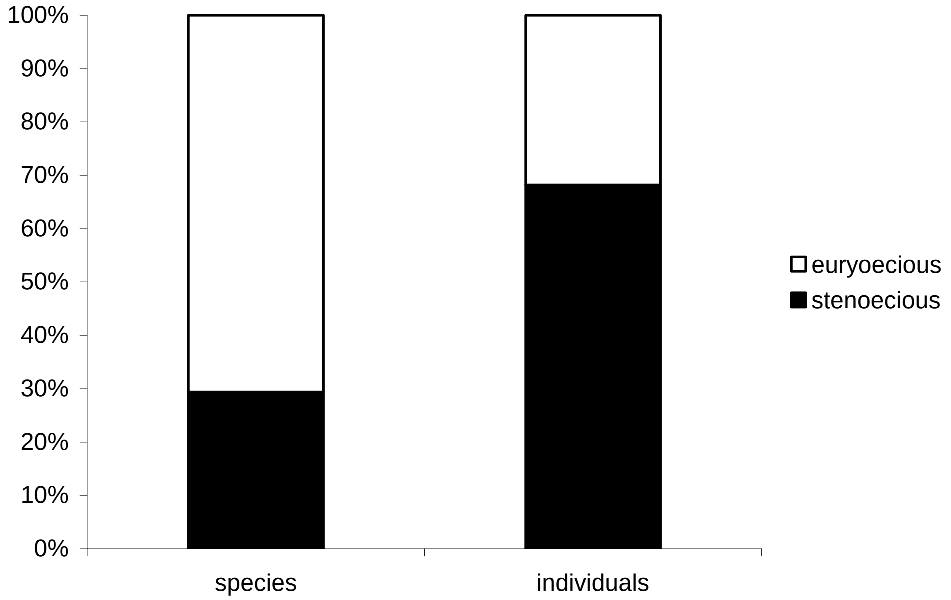

Figure 8. Distribution of ecological valence types across all sampling sites.

On most sampling sites euryoecious species dominated the carabid species structure (Figure 9). Only at ES and MXG2 stenoecious species were in superiour numbers. The two areas KW1 and KW2 showed no stenoecious species at all.

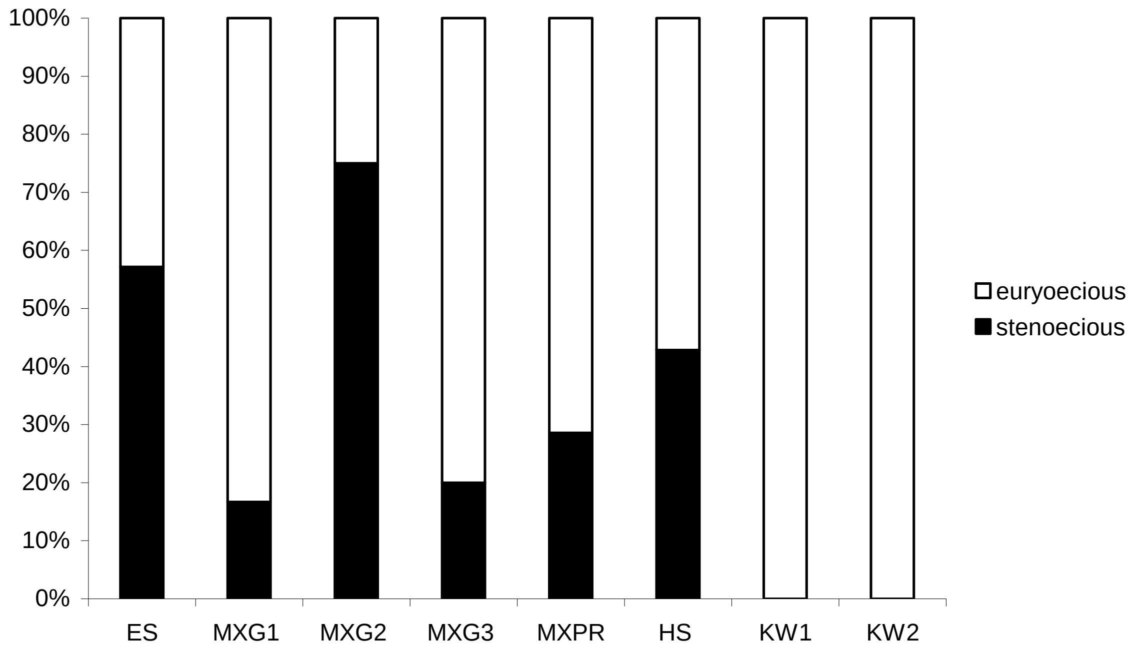

Figure 9. Distribution of ecological valence types at different sampling sites. Only sites with three or more species were analysed.

3.5. Diversity and forest affinity

The <u>Shannon Indices</u> showed on almost all sampling sites rather low values below 2. Only MX G3 was richer in diversity and the Hs value reached 2,01 (Table 2). The values of <u>Eveness</u> were relatively similar at all examined sites and around 0.8 except ES were Eveness reached only 0.34 (Table 2) caused by *Aptinus bombarda* which occurred with 158 individuals on this site. The <u>Forest affinity index</u> displays much more heterogeneous values than the other two indices. At ES and MXG2 the values were highest and reached 0.98 (Table 2). These two sites consist only of forest species and one generalist species each. The sampling sites KW1 (FAI = -0.2) and KW2 (FAI =0.06) showed the lowest FAI values. Low species richness and the presence of open habitat and generalist species are the reasons for these values.

Table 2. Values of the Shannon Index (H_s), Eveness (E) and the forest affinity index (FAI). Indices were only calculated for sampling sites with three or more species.

	ES	MXG1	MXG2	MXG3	MXPR	HS	KW1	KW2
Hs	0,66	1,58	1,22	2,01	1,40	1,63	0,95	1,21
E	0,34	0,88	0,88	0,87	0,72	0,84	0,86	0,88
FAI	0,98	0,61	0,98	0,43	0,83	0,69	-0,2	0,06

3.6. Similarity

The <u>hierachic cluster analysis</u> shows a dendrogram which devides the sites into two big clusters consisting of smaller ones (Figure 9). The first of these two big clusters contains the sampling sites KW1, KW2, MXG1 and MXG3. Within this cluster KW1 and KW2 build their own cluster as well as MXG1 and MXG3.

The second big cluster includes the carabid assemblages of ES, MXG2, MXPR, and HS. Within this cluster the green marked sites build their own cluster while HS is more separated.

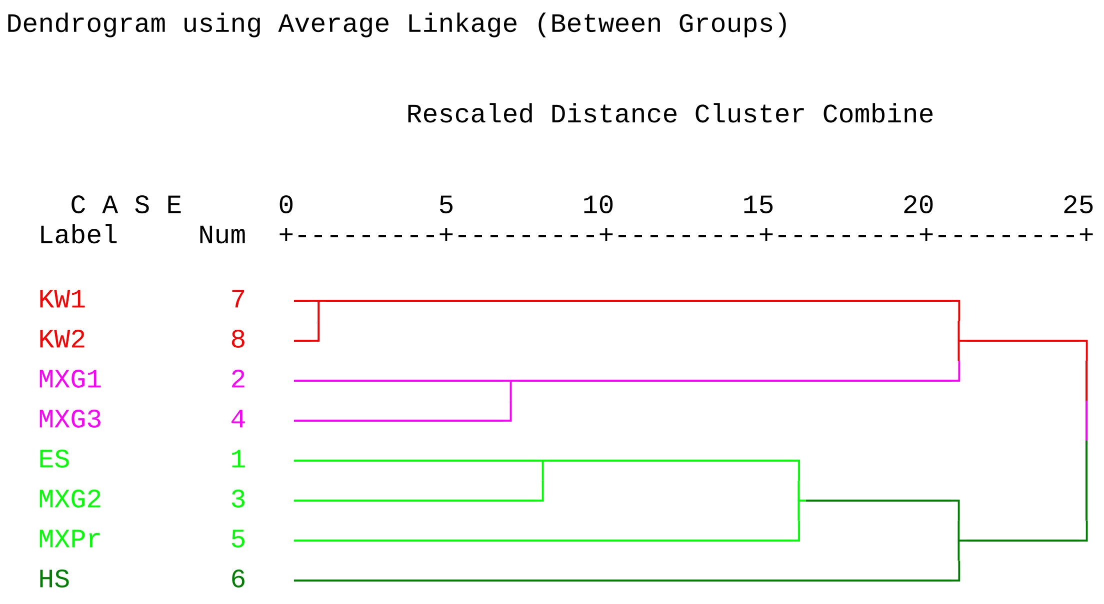

Figure 9. Dendrogram showing similarity between different sampling sites. Only sampling sites with three or more species were analysed.

3.7. Rarefaction

- The rarefaction curve (Figure 10) shows a steep gradient which flattens to the end. This implies that gathering of carabid beetles in this study was quite good and only few more silvicole species can be expected. This good detection rate was achieved though the sampling method of pitfall trapping is not indisputable and has already been discussed in other studies (MÜLLER 1984, SOUTHWOOD 1978). Not all in the Nationalpark Thayatal occuring habitat types were examined in this study. Especially the water meadows and floodplain forests of the National Park show high carabid beetle diversity (VIDIC 2007).

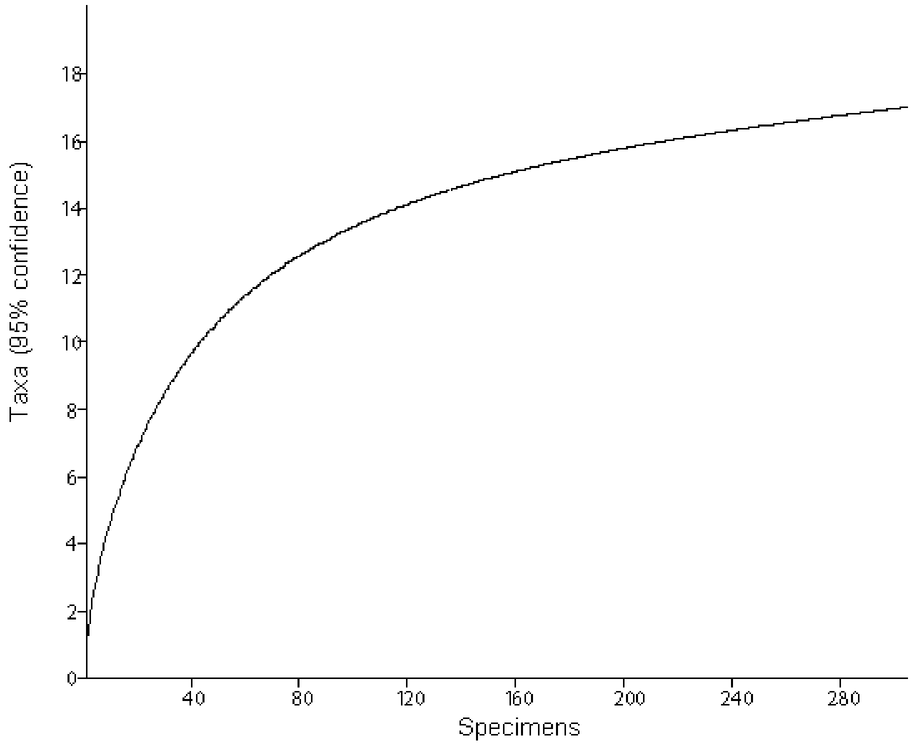

Figure 10. Rarefaction curve across all sampling sites.

3.8. Characterization of carabid assemblages

MXG1 – Maxplateau Eiche Hainbuche (Oaktree – Hornbeam forest)

Six species inhabited this sampling site but only nine individuals were found. The euryoecious and wide spread species *Abax parallelepipedus* was the most frequent found species here. *Amara ovata*, *Pogonophorus rufomarginatus* and *Molops elatus* as well as *Carabus nemoralis* and *C. hortensis* could be proved at this site. While *Pogonophorus rufomarginatus* is a typical silvicole species, with a rather low requirement of humidity, the species *Carabus nemoralis* and *Molops elatus* prefer a more open and humid habitat. Despite the large amount of euryoecious species, the carabid assemblage and the data from wing morphology and body size analysis describe this sampling site as a stable and undisturbed forest type.

MXG2 – Maxplateau Buchenwald (Beechwood forest)

Carabid diversity is low at this site with only four detected species. The carabid fauna only contains brachypterous and large species. Surprisingly *Molops piceus* was found in large numbers in this beechwood but inhabits typically hornbeam forests. The occuring species are mostly obligate forest species and especially the presence of *Abax ovalis* characterizes this site as a typical habitat for forest specialists and as an undisturbed forest community in a late stage of succession.

MXPR – Maxplateau Profil (Beechwood forest)

This sampling site shows a similar climate situation as MXG2 and therefore a similar species compound where also large and brachypterous species prevail. The genus *Carabus* is represented by *Carabus coreaceus* and *Carabus intricatus*. This is the only sampling site where *Carabus coreaceus* was recorded. It is a euryoecious species that normally prefers more dry places and does not really fit in that moist habitat. With *Notiophilus rufipes* and *Pterostichus burmeisteri*, two typical inhabitants of beechwood forests, occured at that site. *Abax paralellepipedus* was the most frequent species at that area and reached eudominant status while *Abax ovalis* was only recorded with one individual, this may be caused by the steep inclination.

MXG3 – Maxplateau Gipfel (Oaktree mixed forest)

The carabid coenosis of this sampling site was the most diverse of all examined sites with 10 recorded species. Due to the dry and open character of this site the xero-thermophile species *Amara ovata* was recorded with six individuals and also *Pogonophorus rufomarginatus* was found which also prefers a rather dry habitat. This site is the only place where *Notiophilus biguttatus*, an euryecious species, was registered. The three recorded mesophile *Carabus* species (*C. intricatus*, *C. hortensis* and *C. nemoralis*) underline the warm character of this area. The rather low forest affinity index of 0.43 is caused by the appearance of species that prefer open habitats or bright woods like *Notiophilus rufipes*

The high diversity and the carabid assemblage characterize this site as a warm, well structured and a more instable habitat like it is typical for the edge of the wood near clearings.

HS – Hohe Sulz (Beechwood forest)

Abax paralellepipedus again reached eudominant status at that site though the carabid composition is different to the other sites which is shown in the dendrogram (Figure 9). This is the only site where *Bembidion lampros* and *Abax paralellus* were found. While *Bembidion lampros* is euryoecious and does not even have a humidity preference, *Abax paralellus* is a stenoecious forest species and prefers dry habitats. This sampling site is also one of two sites where *Aptinus bombarda* was found. *Aptinus bombarda* which normally occurs in great individual numbers was only found with one individual and can therefore be neglected. Though the forest ecosystem at that site shows a lack of macropterous carabids, the assemblage structure demonstrates that there are many generalist and euryoecious species and also the forest affinity index is not as high as on the other investigated beech forests.

ES – Einsiedler (Oaktree – Hornbeam forest)

This is the second sampling site where the stenoecious forest species *Aptinus bombarda* was found eudominant with 158 individuals. Another typical silvicole species was recorded with *Abax ovalis* which was more common on that site than *Abax parallelepipedus.* The only representative of the genus *Carabus* was the robust *Carabus scheidleri* which was found only at that site. All of the seven found species were brachypterous and they all were body size category IV and V. According to that a similarity to the area MXG2 can be seen which is underlined by the dendrogramm in Figure 9.

KW1 – Kirchenwald 1 (Oak forest)

Here only few species were found and all in few individual numbers that makes characterization of that site hardly possible. The three species *Carabus nemoralis*, *Carabus intricatus* and *Notiophilus rufipes* were registered. Though *Carabus intricatus* prefers beechwood forests it also occures in pine woods, that were mixed with the dominating oak forest on that site.

KW2 – Kirchenwald 2 (Oak forest)

The carabid assemblage is nearly the same like at KW1 but additionally *Carabus hortensis* was found.

KWB – Kirchenwald Blockfelsen

On this site only one species, *Carabus intricatus* was registered which typically prefers rather dry and light habitats

3.9. Endangered and remarkable species

The red list of Bavaria (LORENZ 2000) was used due to the lack of an actual red list for carabid beetles for Austria. In total five endangered species were found and listed in Table 3.

Table 3. Status of endangerment of recorded carabid species listed in the red list of Bavaria (LORENZ 2005).

Grade of endangerment	species
Grade 2, strongly endangered	*Aptinus bombarda*
Grade 3, endangered	*Carabus intricatus*
Pre-warn list	*Carabus scheidleri, Notiophilus rufipes*
Insufficient data	*Molops piceus austriacus*

4. Discussion

Together with VIDIC (2007) these studies were the first to create a carabid species list of the National Park Thayatal. At first sight carabid diversity with 17 different species seems to be rather low. But it has to be noticed that forest communities mostly are much poorer in carabid beetle diversity than other habitats like grasslands (NIELMÄ & HALME 1992, MAGURA et al. 2001). Especially the carabid fauna of natural forests in Europe is well documented WAITZBAUER (2001) and species numbers around 20 are quite normal.

The method of pitfall trapping as used in this study is not indisputable and was discussed by THIELE (1977), SOUTHWOOD (1978), BAARS (1979), MADER & MÜHLENBERG (1981), MÜLLER (1984), and much more. Especially species which show low activity and occure in low densities might not have been assessed. Also the requested number of traps per site to get usefull ecological statements has often been discussed. Three traps per site as used in this study are, according to RÜHMER & MÜHLENBERG (1988) and HÄNGGI (1989) enough to get good results while other authors like STEIN (1965), HANDKE (1996) and ZULKA (1996) recommend five traps per site as the best compromise between minimized amount of work and a complete coverage of the carabid population. The use of ethylen-glycol as conservation fluid which is a lower attractant as formalin has also been discussed several times, like in studies of HOLOPAINEN (1990), and BUCHSBERGER & GERSTMEIER (1993).

Due to the heterogeneity of the National Park and its richness in different forest habitat types not all microhabitats were investigated. According to VIDIC (2007) this manifoldness of various habitat types in the National Park Thayatal leads to habitat fragmentation effects. The reasons for habitat fragmentation are factors like urbanisation, road construction, agriculture, forest management, tourist trails and many more (KOIVULA & VERMEULEN 2005, SADLER et al. 2006, NIELMÄ et al. 2006).

The effects of habitat fragmentation and its influence on carabid and arthropod diversity in general is very controversial. According to HAILA (2002) habitat fragmentation has a negative effect on biodiversity. Many other authors even say that habitat fragmentation is one of the most important causes of species declines and extinctions across the world (SAUNDERS et al. 1991, HAILA et al. 1994, DIDHAM et al. 1996, DIDHAM 1997a, DAVIES et al. 2000). On the other hand studies of TSCHARNTKE et al. (2002) and YAACOBI et al. (2007) show that species richness is not affected by habitat fragmentation. In this study the sampling sites MXG1 and MXG3 showed light habitat fragmentation but no negative effects on carabid diversity were registered. The rarefaction curve (Figure 10) displays that the assessment of carabid cummunities of the forest habitats in the National Park Thayatal was good. As seen in Figure 1 the great contingent of forest species is an indication of the high orientation by nature of the investigated area. The calculated forest affinity index (Table 2) is a good tool to put the quality and the orientation by nature of a habitat in numbers (MAGURA et al. 2006). For calculation of the FAI, species have to be classified in five ranks. This comprises a subjective factor when assessing the F_i coefficient due to deviant information on the habitat preference of species in different literature and to the behaviour of the species personally observed (ALLEGRO & SCIAKY, 2002). Three sampling sites (ES, MXG2 and MXPR) showed high values of the FAI which indicates that these areas are stable and undisturbed habitats in a late stage of succesion. The most diverse sampling site MXG3 (Hs = 2.01) showed a much lower FAI with only 0.43. According to VIDIC (2007) this instance can be caused by a high niche richness which serves as a habitat for various carabid species with different ecological needs. This assumption is based on the "Intermediate Disturbance Hypothesis" HORN (1975), CONELL (1978). In general more heterogeneous and more disturbed habitats like floodplains or forest edges show higher diversity which can bee seen in studies from WAITZBAUER (2001), DRAPELA (2004), VIDIC (2007) and.

The mobility of carabids plays an important role for their survival, especially at habitats with frequent changing environmental conditions (DEN BOER 1968, 1971; RODE & DÜLGE 1994). The dispersibility and the mobility of carabid beetles depends on their development of hindwings (LÖVEI & SUNDERLAND 1996) but it has to be noticed that not all macropterous species are able to fly. According to DEN BOER et al. (1980) and DESENDER (2000) some carabides have well developed hindwings but no functionable flight muscles. Nevertheless wing morphology was often examined like in studies of LINDTROTH (1945), DEN BOER (1977) or MARGGI 1992). Macropterous beetles can cover a longer distance and can switch their habitat much faster and much more efficient when environmental conditions alter. Temporary habitats which are subjected to a frequent change of natural and anthropogenic factors host more macropterous types (LEHMANN, 1965). On the other hand brachyperous beetles are in need of stable systems which are not often subjected to environmental changes (STEINWEGER 2004). The contingent of brachyperous beetles often rises with increasing stage of maturity of a forest (DEN BOER 1971, WAITZBAUER 2001). So the composition of wing morphology types is a good indicator for the grade of disturbance and for the stage of succession of a habitat (VIDIC 2007). An overall contingent of more than 80 % of brachypterous species, suggests an undisturbed and stable habitat in a late stage of succession. The sites ES, MXG2 and HS even consisted of 100 % brachypterous carabid beetles (Figure 5). In general there were not much disturbing factors at the examined sites. Wild boar activity was the main distracting influence on some sites. Especially at MXG1, MXG3 and MXPR tracks of wild boar activity often were found. This instance probably will be a reason for the occurance of macropterous and dimorph species. The comparatively high contingent of macropterous species at KW1 and KW2 may also have been caused by wild boar activity though no traces were found, but due to the low number of recorded species and individuals at these two sites, an interpretation of the mentioned results can hardly be made. The contribution of wing morphology types with a high contingent of brachypterous species as found in this study, is typical for stable forests in Central Europe. In a study of WAITZBAUER (2001) undisturbed and natural old forests showed similar results.

Besides wing morphology, also body size can be used to characterize a habitat according to its ecological conditions. Authors like HEYDEMANN (1964), GEILER & BELLMANN (1974), POSPISCHIL & THIELE (1979) and BLAKE et al. (1994) showed in their studies that there are coherences between body size and habitat conditions. Exposed, dynamic and frequently disturbed forests host a higher number of small carabid beetles while stable and undisturbed forest habitats mainly consist of larger species. These coherences can be explained by the model of r- and K-strategists (VOIGHT 1998), (DRAPELA 2004). K-strategists inhabit stable ecosystems where they establish balanced and stable populations. Therefore, they raise their competitive advantage compared to other species by increasing their body size. Normally larvae of large species need more time to develop and therefore need more stable habitats and react sensitive on environmental changes (BLAKE et al 1994).

On the other hand r-strategists, mostly small species which only need few time to develop, are more oppertunists and can form large populations quite fast. Due to their body size they have only little competitiveness and therefore often are pioneer species which inhabit disturbed and dynamic ecosystems.

The results of this study confirm the theory that large species occur in undisturbed or late succession stage habitats and the disposition of body size classes concurs to the results of wing morphology. On ES and MXG2 only large carabides of category IV and V occurred (Figure 7) and also on HS and MXPR they clearly dominated the carbid fauna. As seen in the dendrogram in Figure 9 these four sites with the greatest part of large species are forming a cluster and are seperated from the other cluster consisting of sites which contain more smaller species. Again MXG3 presents itself as a less stable habitat with a considerable part of cateory II and III carabides. All sites together large species (category IV and V) state 70 % of all recorded species and regarding individual numbers more than 90 % belong to these two categories. The only species belonging to the smallest category I was *Bembidion lampros,* which was only found at HS with two individuals only and can therefore be neglected. In general the investigated forests of the National Park Thayatal can therefore, also based on body size data, be characterized as forests in a late stage of succession and as stable and undisturbed habitats.

The distribution of ecological valence types (Figure 8, 9) also supports the conclusions of the other discussed parameters. Figure 8 displays that 30 % of all recorded species are stenoecious ones which is quite a high quota and typical for stable forest ecosystems in Central Europe. Stenoecious individuals actually reached a quota of 70 % that can be explained by *Aptinus bombarda* which occurred in large individual numbers at one site. Stenoecious species are good bioindicators for the stability and for the stage of succession of a habitat because they show a small ecological optimum and only little tolerance to environmental changes (THIELE 1967, WAITZBAUER 2001, VIDIC 2007). The grade of nativeness of old forest ecosystems is often characterized by special stenoecious indicator species that are well adapted to the microclimatic and structural attributes of the habitat as well as their feeding is linked to their habitat (WAITZBAUER 2001). The sampling sites ES, MXG2 and HS showed the highest percentage of stenoecious species, while KW1 and KW2 inhabited only euryoecious species (Figure 9). These data again confirm the results from wing morphology, body size and FAI and show that especially these three sites (ES, MXG2 and HS) are late succession stage habitats where specialists like *Abax parallelus, Abax ovalis*, *Aptinus bombarda, Molops piceus* and *Molops elatus* find a stable livelihood.

The dispersion of species numbers on different forest types in Figure 3 displays that oaktree–hornbeam forests and beech forests were richer in species than oak forests. Forest type my play a role at habitat choice of carabid beetles but much more important are according to THIELE (1964, 1977); PAARMANN (1966) and NEUDECKER (1974) factors like temperature, humidity and brightness, as well as the pH-value of the soil (PAJE & MOSSAKOWSKI 1985).

From 17 recorded species, five are mentioned on the red list (Table 3). This turns the National Park into an important and worthy hideaway for endangered carabid species. The study illustrates that the forests of the Nationlal Park Thayatal seem to have recovered from managing and economic intrusions in the middle of the 20th century. Though many typical silvicole forest species were found and especially *Abax ovalis* is mentioned at MARGGI (1992) and AßMANN (1994) as a typical indicator species for historical forest ecosystems, some other indicator species for ancient forests like *Cychrus caraboideus, Carabus auronitens, C.irregularis* and *C. violaceus*

(TERRELL-NIELD 1990, WAITZBAUER 2001) were missing within the scope of own examinations but exist in the woods of the National Park (WAITZBAUER, verbal announcement).

5. References

ALLEGRO, G., SCIAKY, R. 2002: Assessing the potential role of ground beetles (Coleoptera, Carabidae) as bioindicators in poplar stands, with a newly proposed ecological index (FAI). Forest ecol. and management 175 (2003), 275-284

AßMANN, T. 1994: Epigäische Coleopteren als Indikatoren für historisch alte Wälder der Nordwestdeutschen Tiefebene. NNA-Berichte (Münster) 3, 142-151

BAARS, M. A. 1979: Catches in pifall traps in relation to mean densities of carabid beetles. Oecologia 41, 25-66.

BLAKE, S., FOSTER, G.N., EYRE, M. & LUFF, M. 1994: Effects of habitat type and grassland management practices on the body size distribution of carabid beetles. Pedobiologia 38: 502-512

BUCHSBERGER, P., GERSTMEIER R. 1993: Vergleich von Formol und Ethylenglykol als Fangflüssigkeit in Barberfallen, unter besonderer Berücksichtigung der Carabidae. Ber. Naturf. Ges. Augsburg 54: 77-93

Buck H., Konzelmann, E. & Alf, A. 1992: Käfer als Bioindikatoren zur Habitatcharakterisierung und –entwicklung. Hohenheimer Umwelttagung 24: 142-192.

CONNELL, J. H. 1978: Diversity in tropical rain forests and coral reefs. Science 199: 1302-1310.

DAVIES, K. E., MARGULES, C.R. & LAWRENCE, J.E. 2000: Which traits of species predict population declines in experimental forest fragments? – Ecology 81: 1450-1461.

DEN BOER, P. J. 1968: Spreeding of risk an stabilization of animal numbers.- Acta biotheoretica 18, 165 – 194.

DEN BOER, P. J. 1971: On the dispersal power of carabides and its possible significance.- Miscell. Papers L.H. Wageningen 8, 105-110.

DEN BOER, P. J. 1977: Dispersal power and survival. Miscell. Papers 14. Veenmann & Zonen, Wageningen

DEN BOER, P. J., VAN HUIZEN, T. H. P., DEN BOER-DANNJE, W., AUKEMA, B., DEN BIEMANN, C. F. M. 1980: Wing poloymorphism and dimorphism in ground beetles as stages in an evolutionary process (Coleoptera: Carabidae). Ent. Gen. 6, 107-134

DESENDER, K., MAELFAIT: J. P. 1986: Pifall trapping within enclosures: A method for estimating the relationship between the abundances of coexisting carabid species (Coleoptera: Carabidae). Hol. Ecol. 9, 245-250

DESENDER, K., VANDEN BUSSCHE, C. 1998: Ecological diversity, assemblage structure and life cycles of ground beetles (Col., Carabidae) in the forest of Ename (Eastern Flanders, Belgium). Bull. Inst. Royal Scie. Nat. Belgique, Entomologie, 68: 37-52

DESENDER K. 2000: Flight muscle development and dispersal in the life cycle of carabid beetles: patterns and processes. Entomologie 70: 13-31

DINDHAM, R. K. 1997a: An overview of invertebrate responses to forest fragmentation. – In WATT, A.D., STORK, N.E. & HUNTER, M.D. (eds.): Forests and insects. Chapman & Hall, London, 304-319.

DINDHAM, R. K., GHAZOUL, J., STORK, N. E. & DAVIES, A. J. 1996: Insects in fragmentated forests: a functional approach. – Trends Ecol. Evol. 11: 255-260.

DRAPELA, T. 2004: Laufkäfer (Coleoptera, Carabidae) als Indikatoren für die Naturnähe der Auwälder Beugenau (Donau, Niederösterreich) und Müllerboden (Leitha, Burgenland), Diplomarbeit Universität Wien

FREUDE, H., HARDE, K. W., Lohse G. A. 2004: Die Käfer Mitteleuropas. Band 2: Adephaga 1, Carabidae (Laufkäfer). G. Müller-Motzfeld (ed.). Vol. 1. Spektrum Verlag.

GEILLER, H., BELLMANN, C. 1974: Zur Aktivität und Dispersion der Carabiden in Fichtenforsten des Tharandter Waldes (Coleoptera, Carabidae). Faun. Abh. Staatl. Mus. Tierkde. Dresden 5, 1-71.

GOULET, H. 2003: Biodiversity of ground beetles (Coleoptera: Carabidae) in Canadian agricultural soils. – Can. J. Soil Sci., 83 (3): 259-264 Sp.

HAILA, Y., HANSKI, I. K., NIEMELÄ, J., PUNTTILA, P., RAIVIO, S. & TUKIA, H. 1994: Forestry and the boreal fauna: matching management with natural forest dynamics. – Ann. Zool. Fenn. 31: 187-202.

HAILA, Y. 2002: A conceptual genealogy of fragmentation research: from island biogeographie to landscape ecology. Ecol. Appl. 12, 321 – 334.

HANDKE, K. 1996: die Laufkäferfauna des Naturschutzgebietes „Lampertheimer Altrhein“ in der südhessischen Oberrheinebene (Kreis Bergstraße). Decheniana 149: 139-160

HÄNGGI, A. 1989: Erfolgskontrollen in Naturschutzgebieten. Gedanken zur Notwendigkeit der Erfolgskontrolle und Vorschlag einer Methode der Erfolgskontrolle anhand der Spinnenfauna. Natur u. Landschaft 64: 143-146

HEYDEMANN, B. 1953: Agrarökologische Problematik, dargetan an Untersuchungen über die Tierwelt der Bodenoberfläche der Kulturfelder. Diss. Univ. Kiel.

HEYDEMANN, B. 1964: Die Carabiden der Kulturbiotope von Binnenland und Nordseeküste – ein ökologischer Vergleich (Coleopt.; Carabidae). Zool. Anz. 172, 49-86

HOLOPAINEN, J. K. 1990: Influence of ethylen glycol on the numbers of carabids and other soil arthropods caught in pitfall traps. The role of ground beetles in ecological and environmental studies. N. E. STORK ed. Intercept, Andover, England. 339–341.

HOLSTE, U. 1974: Faunistisch-ökologische Untersuchungen der Carabiden- und Chrysomelidenfauna (Coleoptera, Insecta) xerothermer Standorte im Weserbergland. – Abh. Landesmus. Naturkd. Münster 36, 28-53.

HORN, H. S. 1975: Markovian properties of forest succession.. 196–211 in M. L. CODY & J.M. DIAMOND (eds.) Ecology and evolution of communities. Belknap Press, Cambridge, Massachusetts.

HURKA, K. 1996: Carabidae of the Czech and Slovak Republics. Kabourek, Zlin.

KÖHLER, F. 1996: Käferfauna in Naturwaldzellen und Wirtschaftswald. LÖBF-Schriftenreihe 6-

KOIVULA, M., VERMEULEN, H. J. W. 2005: Highways and forest fragmentation – effects on carabid beetles (Coleoptera, Carabidae) Landscape Ecol. 20: 911-926

KREBS, C.J. 1998: Ecological Methodology. Addison Wesley Longmann, Menlo Park

LEHMANN, H. 1965: Ökologische Untersuchungen über die Carabidenfauna des Rheinufers in der Umgebung von Köln.- Z. Morph. Ökol. Tiere 55: 597-630.

LINDTROTH, C. H. 1945: Die Fennoskandischen Carabidae. I. Spezieller Teil. Elanders Boktryckeri Aktieverlag, Göteborg.

LORENZ, W. 2000: Rote Liste gefährdeter Lauf- und Sandlaufkäfer Bayerns (nach ICZN 1999). In: Fachtag. Bayr. Umweltminist. 2003.

LÖVEI, G. L. and SUNDERLAND, K. D. 1996: Ecology and Behavior of Ground Beetles (Coleoptera: Carabidae). Ann. Rev. Entomol. 41: 231-256.

LUFF, M. L. 1975: Some features influencing the efficiency of pitfall traps. Oecologia 19: 345-357

LUFF M. L., EYRE M. D. & RUSHTON S. P. 1989: Classification and ordination of habitats of ground beetles (Coleoptera: Carabidae) in north-east England. J. Biogeogr. 16: 121-130

MADER, H. J., MÜHLENBERG, M. 1981: Artenzusammensetzung und Ressourcenangebot einer kleinflächigen Habitatinsel, untersucht am Beispiel der Carabidenfauna. Pedobiol. 21, 46-59.

MAGURA, T., TÓTHMÉRÉSZ, B., MOLNAR, T. 2001: Forest edge and diversity: carabids along forest-grassland transects. Biodiversity and Cons. 10: 287-300.

MAGGURAN, A. 1988: Ecological diversity and its Measurement. Croom Helm, London Sydney.

MARGGI, W. A. 1992: Faunistik der Sandlaufkäfer und Laufkäfer der Schweiz (Cicindelidae und Carabidae) Coleoptera, Teil 1. Doc. Faunist. Helvetiae 13, 1-477.

MÜHLENBERG, M. 1993: Freilandökologie. Quelle & Meyer, Heidelberg

MÜLLER, J. K. 1984: Die Bedeutung der Fallenfang-Methode für die Lösung ökologischer Fragestellungen. Zool. Jb. Syst. 11: 218-305

MÜLLER-MOTZFELD, G.1989: Laufkäfer (Coleoptera: Carabidae) als pedobiologische Indikatoren. Pedobiologia 33: 145-153

NEUDECKER, C. 1974: Das Präferenzverhalten von Agonum assimile Payk. (Carab., Coleopt.) in Temperatur-, Feuchtigkeits- und Helligkeitsgradienten.- Zool. Jb. Syst. 101, 609-627

NIEMELÄ, J., KOIVULA, M., KOTZE. D., J. 2006: The effects of forestry on carabid beetles (Coleoptera: Carabidae) in boreal forests. Beetle conservation, J Insect Cons. 11: 5-18

NIEMELÄ, J. & HALME, E. 1992: Habitat associations of carabid beetles in fields and forests on the Åland Islands, SW finland. – Ecography 15: 3-11.

PAARMANN, W. 1966: Vergleichende Untersuchungen über die Bindung zweier Carabidenarten (*P. angustatus* DFT. und *P. oblongopunctatus* F.) an ihre verschiedenen Lebensräume. Z. Wiss. Zool. 174, 83-176

PAJE, F. & MOSSAKOWSKI, D. 1985: ph-Preferences and Habitat Selection in Carabid beetles. Oecologia 64, 41-46

POSPISCHIL, R., THIELE, H. U. 1979: Bodenbewohnende Käfer als Bioindikatoren für menschliche Eingriffe in den Wasserhaushalt eines Waldes. Verh. Ges. Ökol. 7, 453-463.

RODE, M. & DÜLGE, R. 1994: Flügelausbildung bei *Pterostrichus strenuus* Panzer und *Pterostichus diligens* Sturm (Coleoptera, Carabidae) in Abhängigkeit vom Habitat. Zool. Jb. Syst. 121, 159-170.

RÜHMER H., MÜHLENBERG, M. 1988: Kritische Überprüfung von „Minimalprogrammen“ zur zoologischen Bestandserfassung. Schr.-R. Bayer. Landesamt für Umweltschutz 83: 151-157

SADLER, J. P., SMALL, E. C., FISZPAN, H., TELFER, M. G., NIEMELÄ, J. 2006: Investigating environmental variation and landscape characteristics of an urban-rural gradient using woodland carabid assemblages. J. Biogeogr. 33, 1126-1138

SAUNDERS, D. A., HOBBS, R. J. & MARGULES, C. R. 1991: Biological consequences of ecosystem fragmentation: a review. Cons. Biol. 5, 18-32.

SOUTHWOOD, T. R. E. 1978: Ecological methods with particular reference to the study of insect populations. 2nd ed.. Chapman & Hall, London.

STEIN, W. 1965: Die Zusammensetzung der Carabidenfauna einer Wiese mit stark wechselnden Feuchtigkeitsverhältnissen. Z. Morph. Ökol. Tiere 55: 83-99

STEINWEGER, A. 2004: Auswirkungen waldbaulicher Maßnahmen auf die Laufkäfer (Col., Carabidae) und die Wolfspinnen (Aran., Lycosidae) im Fichten- und Buchenwald (Süderbergland). Dissertation Universität Bonn

TERRELL-NIELD, C., 1990: Is it possible to age the woodlands on the basis of their carabid beetle diversity? The Entomologist 109, 136-145

THIELE, H. U. 1964: Experimentelle Untersuchungen über die Ursachen der Biotopbindung bei Carabiden.- Z.. Morph. Ökol. Tiere 53: 387-452.

THIELE, H. U. 1967: Ein Beitrag zur experimentellen Analyse von Euryökie und Stenökie bei Carabiden. Z. Morph. Ökol. Tiere 58, 355-372

THIELE, H. U. 1977: Carabid beetles in their environments.- Zoophys. and Ecol. 10, Berlin, Heidelberg, New York, 369 S.

TÓTHMÉRÉSZ, B., MAGURA, T. 2003: Affinity indices for environmental assessment using carabids. European Carabidiology 2003. Proc. 11th Europ. Carabidologist Meeting

TRAUTNER, J. & ASSMANN, T. 1998: Bioindikation durch Laufkäfer – Beispiele und Möglichkeiten. Laufener Seminarbeitr. 8/98: 169-182.

TSCHARNTKE, T., STEFFAN-DEWENTER, I., KRUESS, A. & THEIS, C. 2002: Contribution of small habitat fragments to conservation of insect communities of grassland-cropland landscapes. Ecol. Appl. 12, 354-363.

VIDIC, A. 2007: Carabid assemblages of various forest communities in the National Park Thayatal (western part), Lower Austria. Diplomarbeit Universität Wien.

VOIGT U. 1998: Charakterisierung und Bewertung der Fauna strukturreicher Landschaftselemente in einem intensiv genutzten Agrarraum anhand ausgewählter Käfergruppen (Insecta: Coleoptera), Diplomarbeit Universität Hannover

WAITZBAUER, W. 2001: Bodenlebende Arthropoden (Laufkäfer, Carabidae) als Indikatoren für die Biodiversität naturnaher Waldgesellschaften. Unveröffentl. Projekt-Bericht „Beitrag von Naturwäldern zur Bewahrung der Biodiversität. Schwerpunkt Bodenökologie“. BM. Land- und Forstwirtschaft, Wien: 1-85.

WRBKA, T. 2006: Die Vegetationsgesellschaften des Nationalparks Thayatal. Unveröff. Endbericht.

YAACOBI, G., ZIV, Y. & ROSENZWEIG, M. L. 2007: Habitat fragmentation may not matter to species diversity. Proc. Royal Soc. (2007) 274: 1409-2412.

ZULKA, K.P. 1996: Methodisches Design für die Erfassung und Bewertung von Arthropodenbeständen und Arthropodenlebensräumen am Beispiel der Laufkäferfauna (Coleoptera, Carabidae). Wiss. Mitt. Niederöst. Landesmus. 9: 311-363

6. Deutsche Zusammenfassung

Die Untersuchungen für diese Diplomarbeit wurden im Nationalpark Thayatal im Norden Niederösterreichs an insgesamt sieben Untersuchungsflächen von April bis Oktober 2005 und an zwei zusätzlichen Flächen von April bis Oktober 2006 durchgeführt. Es wurde die Zusammensetzung der Laufkäfergesellschaften an den einzelnen Standorten die sich hinsichtlich Vegetationstyp, Geologie und Mikroklima voneinander unterscheiden betrachtet. Die Beprobung erfolgte durch Barberfallen. Da die ökologischen Ansprüche, wie auch die Morphologie von Laufkäfern sehr gut dokumentiert sind, und auch nicht zuletzt da sie sehr einfach zu sammeln sind, wurden sie für diese Untersuchung als Bioindikatoren herangezogen. Zur Beschreibung der Laufkäfergemeinschaften wurden Eigenschaften wie flügelmorphologische Typen, Körpergrößenklassen und ökologische Valenz sowie die Parameter. Shannon Index, Eveness und Forest Affinity Index (FAI) betrachtet.

Insgesamt wurden 17 verschiedene Arten gefunden wobei ihre Verteilung an den einzelnen Standorten zwischen einer und 10 Arten schwankte. Obwohl *Aptinus bombarda* nur an zwei Flächen gefunden wurde, war er mit 159 Individuen gefolgt von *Abax parallelepipedus, Abax ovalis* und *Molops piceus* die häufigste Art.

Abax parallelepipedus war die am weitesten verbreitete Art und wurde an insgesamt sechs Untersuchungsflächen nachgewiesen.

Mehr als 80% aller gefundenen Arten waren brachypter, 30% stenök und 70% gehörten zu großen Arten der Kategorie IV und V.

Der Shannon Index erreichte seinen höchsten Wert mit 2,01 im Eichenmischwald am Standort MXG3. Der Forest Affinity Index war mit jeweils 0,98 im Eichen Hainbuchenwald ES und im Buchenwald MXG2 am höchsten.

Um die Ähnlichkeit zwischen den einzelnen Standorten zu zeigen wurde eine hierachische Clusteranalyse durchgeführt. Im Dendrogramm erkennt man zwei große Cluster. Alle drei Standorte mit Buchenwald sind zusammen in einem Cluster und auch die Eichenwald Standorte sind gemeinsam im anderen Cluster zu fnden. Die Untersuchungsflächen auf denen Eichen- Hainbuchenwald vorherrscht sind in beiden Clustern vertreten.

Allgemein kann gesagt werden, dass Waldökosysteme arm an Laufkäferdiversität sind und dass große und brachyptere Arten dominieren. Es zeigen sich zwar klare Unterschiede in der Artenzusammensetzung der Laufkäfer in den verschiedenen Waldgesellschaften, aber klimatische Bedingungen, die Strukturierung des

Lebensraumes, sowie der Grad der Störung eines Habitats, scheinen die wichtigeren Einflussfaktoren für die Zusammensetzung der Laufkäferfauna zu sein.

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8. Lebenslauf

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