Silva Gabreta	vol. 13 (2)	p. 121–148	Vimperk, 2007

Forest edges in the mixed-montane zone of the Bavarian Forest National Park – hot spots of biodiversity

Jörg Müller[1,*], Heinz Bußler[2], Martin Goßner[3], Axel Gruppe[4], Andrea Jarzabek-Müller[1], Manuel Preis[1] & Thomas Rettelbach[5]

[1]Bavarian Forest National Park, Freyunger Strasse 2, D-94481 Grafenau, Germany
[2]Bayerische Landesanstalt für Wald und Forstwirtschaft, Am Hochanger 13, D-85354 Freising, Germany
[3]Schussenstrasse 12, D-88273 Fronreute, Germany
[4]Department of Animal Ecology, Technical University Munich, Am Hochanger 13, D-85354 Freising, Germany
[5]Fritzenanger 9, D-83362 Surberg, Germany
**joerg.mueller@npv-bw.bayern.de*

Abstract
Using 60 flight interception traps we investigated twelve different forest edges in the National Park Bavarian Forest. Half of the forest edges studied were created by bark beetle attacks (interior edges), the others result from clearance for farming by humans. At each forest edge, five traps were installed as follows: one trap was placed in the open area 50–80 m distant from the forest edge, two traps at the edge (one at ground level, one in the canopy), and two traps in the forest interior 70–100 m away from the edge (one at ground level, one in the canopy). We caught and determined 10,966 specimens representing 421 insect species: 240 beetles, 96 true bugs, 65 Aculeata, and 20 lacewings. The highest number of species was found in the open spaces and at the edges. Bark beetle gaps are shown as hot spots of insect biodiversity.

Key words: interior forest edge, exterior forest edge, biodiversity, flight interception traps, bark beetles.

Introduction

Insects are the most species-rich group in forest ecosystems (Grove & Stork 2000). Most of them feed on parts of plants, such as leaves, pollen, cones, under the bark, or in wood varying in condition from dying to a state of advanced decomposition. Thus the diversity of insects depends on the diversity of plant species and structures. But it is not only for feeding that insects use plants. Many of them use flowers for mating as well as feeding (Bense 1995). Further, the life cycle of the majority of insects is strongly influenced by light and temperature. Considering this combination of facts, it is not surprising that open and sunny strata in forest ecosystems are important for many species (Oxbrough et al. 2006). Many entomologists have already investigated this "edge effect" on communities and species, for example using pitfall traps (Baker et al. 2007), or traps in the canopy (Flückinger & Duelli 1997). However, the majority of studies on edge effect has focused on exterior forest edges (Wermelinger et al. 2007) that occur next to agricultural land. In this case we are referring to the condition: forest – forest edge – open farmland. This frame of reference is inadequate. We also have to take into consideration the internal dynamics of forests, which can include many interior edges created by the death of groups of trees caused by windblow or insects, or

cleared by man. In most of the originally mixed forest of the montane zones of Germany we have today a domination of Norway spruce (*Picea abies*), caused by man's preference for this fast-growing, easily marketable tree species. One of the most significant species which attacks spruce is *Ips typographus* (Scolytidae). High levels of infestation lead to death of single trees or whole stands of spruce (Wermelinger 2004). In the following contribution we present data which answer the following two questions: How does the spatial distribution of Coleoptera, Heteroptera, Neuroptera and Hymenoptera Aculeata at a species level compare between two different types of forest edges: interior (caused by bark beetle) and exterior (next to agricultural land)? What is the relationship between species richness and the spatial distribution of the samples?

Study site and methods

Study site

The study was carried out in the Bavarian Forest National Park, a mountainous region (the Bohemian Forest, Böhmerwald) in south-eastern Germany. The Park was founded in 1970 and in the years thereafter forest management activities were stopped in its core area. Since 1983 the bark beetle *Ips typographus* has spread and killed Norway spruce (*Picea abies*) over a large area. This process is still going on. As a result of settlement history, there are some exclaves of human settlement within the park that are dominated by meadows and places of habitation. Additionally, we sampled some ancient pasture areas, which were used for grazing until some decades previously. We selected twelve sites for investigation of forest edges (Fig. 1, Table 1). Two types of edges were differentiated (Fig. 2): Exterior forest edges were next to pasture land and result from forest clearance (Fig. 3). Interior forest edges are the result of massive bark beetle attack on spruce trees, mainly caused by *Ips typographus* and *Pityogenes chalcographus* (Fig. 4).

Table 1. Characterisation of the 12 sampling sites.

Nr. /Abbr.	Site	Type	Altitude	X	Y
1 MSH	Mittelsteighütte	Pasture	885	13°15'16"	49°06'02"
2 RWS	Ruckowitzschachten	Pasture	1130	13°15'31"	49°06'18"
3 ABS	Albrechtschachten	Pasture	1115	13°18'24"	49°05'19"
4 GPP	Gfällparkplatz	Bark beetle gap	890	13°22'29"	49°57'27"
5 NEU	Neuhütte	Meadow	790	13°21'43"	49°55'48"
6 GOE	Guglöd	Meadow	840	13°26'09"	49°55'56"
7 LUS	Lusenparkplatz	Bark beetle gap	1110	13°29'42"	49°55'49"
8 BOS	Böhmstraße	Bark beetle gap	915	13°29'34"	49°54'35"
9 HES	Heilstein	Bark beetle gap	920	13°29'53"	49°54'39"
10 SLF	Schleif	Meadow	720	13°28'31"	49°53'56"
11 GHW	Glashüttenwald	Bark beetle gap	725	13°28'31"	49°53'38"
12 BAS	Basisstraße	Bark beetle gap	825	13°31'21"	49°52'53"

Methods

Insects were sampled during 2006 using flight interception traps placed at ground level and in the canopy (Grove 2000, Kaila et al. 1994, Martikainen et al. 2000). Traps consisted of

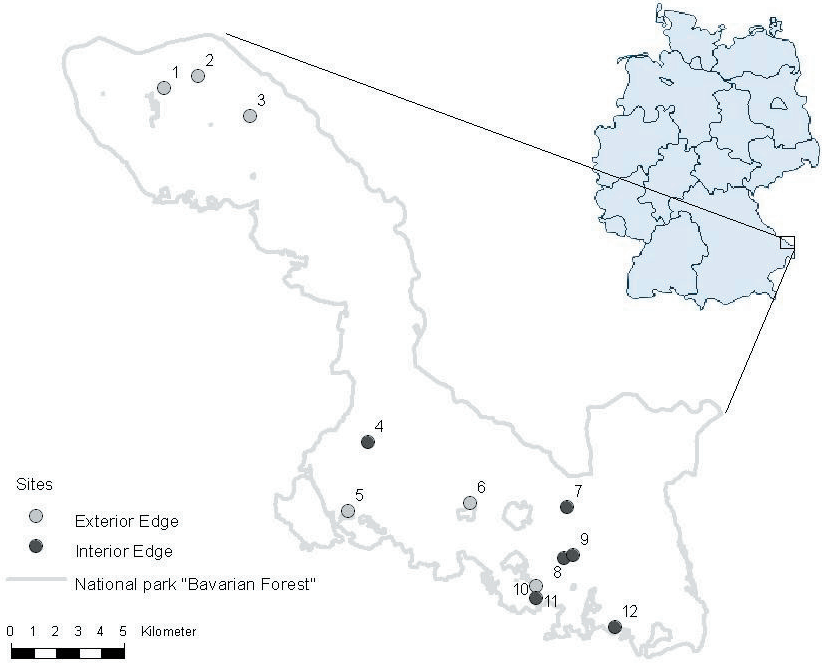

Fig. 1. Map of the 12 sampled forest edges.

a crossed pair of transparent plastic shields (40×60 cm with one yellow strip of tape) with a funnel of smooth plastic material attached to the bottom and a plastic roof at the top. At the end of the funnel a sampling jar was mounted, filled with killing and preserving agent (1.5% copper vitriol solution). The traps operated for five months and were emptied each month (May–September) by filtering the collecting fluid through a tea strainer and transferring the catch to 90% ethanol. Saproxylic beetles were identified by Heinz Bußler, Elateridae by Andrea Jarzabek-Müller, true bugs by Martin Goßner, lacewings by Axel Gruppe, bees and wasps by Thomas Rettelbach.

At each forest edge we installed 5 traps as follow: one in the open area at ground level, 50–70 m from the forest edge (defined as the position of the last mature trees); the next two at the forest edge (one at ground level and one in the tree crown at a height of 15–25 m depending on height of the tree); two in the closed forest, 80–100 m distant from the edge (one trap at ground level, the second in the canopy). To install the canopy traps we used a crossbow to shoot a line through the tree crown (Fig. 5).

Results and discussion

The data for all the species caught and determined are presented below (Appendix 1–4: number of species, individuals, and comments on threatened species in Bavaria). RL-Bay after the name of commented species mean the present ranking of the species in the Red list of Bavaria.

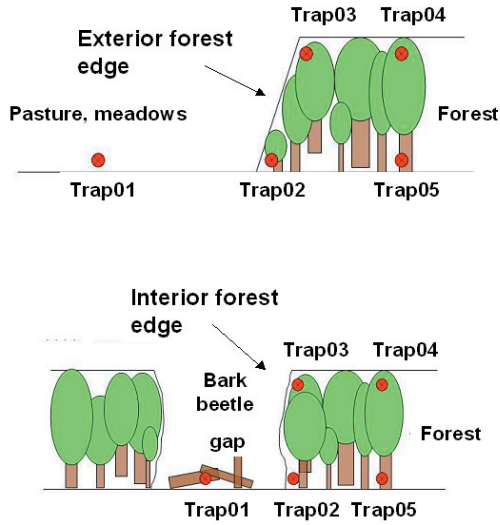

Fig. 2. Sampling design at interior and exterior forest edges.

Beetles / Coleoptera

A total of 240 beetle species was identified (saproxylic species and all Elateridae), represented by 6592 specimens. The species richness was highest in traps situated in gaps in the forest interior (Fig. 6), followed by the ground level traps of both forest edge types. Canopy traps at the edge caught more species than traps in the canopy of the closed stands. Twenty two of the species were new records for the Bavarian Forest as a whole, 12 species were new for the Bavarian Forest National Park (see Apfelbacher & Geiss 2006, Köhler 1997). See Table 1 for details of sampling sites.

Atrecus longiceps (Fauv., 1872) RL-Bay 2
Only one specimen was collected at the edge of GFP.

Danosoma fasciatus (L., 1758) RL-Bay 2
The most spectacular beetle record was the rediscovery in the Bavarian Forest of *D. fasciata* after an interval of 101 years (see Hennevogel 1905). Horion (1948) wrote of this species (translated from German): "We need new records to confirm the species in the Bohemian and Bavarian Forest". We found the specimen in an old gap caused by *Ips typographus* attack south of the GFP. Several recent records are known even from the Czech side of the Bohemian Forest (L. Dvořák, J. Boháč, unpubl. data)

Denticollis rubens Pill. Mitt., 1783 RL-Bay 2
The species is associated with large logs, which are present at the former pastures ABS and RWS and the gaps HES and GFP, which are rich in dead wood.

Diacanthous undulatus (DeGeer, 1774) RL-Bay R
D. undulatus was found only once in a trap in the canopy of an interior edge. This species was however also found in 2006 in the National Park on dead wood of alder and beech as described by Horion (1953).

Fig. 3. Forest edge next to a meadow, typical for cleared enclaves in the mountain zone of the Bavarian Forest.

Fig. 4. Forest edge at an old gap evolved after a severe bark beetle attack.

Fig. 5. Installation of flight interception traps in tree crowns with aid of a crossbow.

Hylis procerulus (Mannh., 1823) RL-Bay 1
H. procerulus, a very rare Eucnemidae, was found in the gap GHW caused by bark beetles, together with *H. foveicollis*.

Ipidia binotata Rtt., 1875 RL-Bay 4
I. binotata seems to be a typical "winner" which has benefitted from the large dead wood areas. This formerly rare species (Apfelbacher & Geiss 2006) was collected in three traps. In 2006 it was also found in dead wood of spruce, but sometimes in fir and beech, at several sites.

Rhizophagus cribratus Gyll., 1827 RL-Bay G
R. cribratus was found once in a canopy trap at the edge of RWS.

Phloeostichus denticollis Redt., 1842 RL-Bay 2
As expected the species was found in a trap at RWS. Further records are from Rachel, and ABS in the National Park. The species lives in the bark of living maple trees.

Atomaria bella Rtt., 1875 RL-Bay 2
Only one specimen was trapped in the gap of GFP.

Leptophloeus alternans (Er., 1846) RL-Bay G
L. alternans was found at a meadow (SLF) and in the ground level trap in the closed forest (GPP, BAS).

Mycetophagus populi F., 1798 RL-Bay 2
This fungi feeder was found at ground level of the edge in the gap BOE. Additional records were made in MSH in 2006 (J. Müller, unpubl. data).

Arpidiphorus orbiculatus (Gyll., 1808) RL-Bay G
This species is probably more widely distributed than estimated, but the short time of appearance of adults, feeding on slime mould, makes recording difficult. We trapped it in GHW at the edge at ground level.

Cis quadridens Mell., 1848 RL-Bay 2
This montane fungus feeder on *Fomitopsis pinicola* was found only in the closed forest at the edge LUS.

Hadreule elongatulum (Gyll., 1827) RL-Bay G
Köhler (1995) published his records from the National Park as the first for Germany. Since then new records from the mountains of Sächsische Schweiz have been made. We found this rare Ciidae in a gap produced by bark beetles (GHW). One more record was obtained in 2007 from a Window trap at 35 m height in the canopy in the Hans-Watzlik-Hain (J. Müller, unpubl. data).

Dorcatoma punctulata Muls. Rey, 1864 RL-Bay 2
This species is a new record for the Bavarian Forest.

Anaspis ruficollis (F., 1792) RL-Bay 2
We could find the species only in bark beetle gaps, both at ground level and in the tree crowns.

Xylita livida (Sahlb., 1834) RL-Bay 2
This "primaeval-forest relict" species was found in the ground level edge trap of Basisstraße, in a gap caused by bark beetles.

Corymbia scutellata (F., 1781) RL-Bay 2
This species is a typical species of forests with large dying deciduous trees. It was found in Mittelsteighütte and Ruckowitzschachten, both with old beech and maple trees.

Judolia sexmaculata (L., 1758) RL-Bay 2
All four records were from gaps and interior edges caused by bark beetles, where sun exposed spruce dead wood occurs in combination with flowers.

Rhyncolus sculpturatus Waltl, 1839 RL-Bay 2
This "primaeval-forest relict" species was found in the old forest MSH. It was trapped in 2006 additionally on beech and fir trees (J. Müller, unpubl. data).

Hexarthrum duplicatum Folw., 1966 RL-Bay 1
H. duplicatum is a rare species, restricted in its distribution to the Bavarian Forest and one locality in the Bavarian Alps. In the area of Mittelsteighütte with very large fir trees it is a common species in snags (standing, dead trunks) and logs.

Scolytus rugulosus (P. W. Müller, 1818)
S. rugulosus, typically attached to arborescent Rosaceae, was found at the RWS (1130m). This was surprising, but may be explained by the use of *Sorbus aucuparia* by this species.

True bugs / Heteroptera

We caught 96 species represented by 2301 individuals of Heteroptera. 15% of these species (14) are listed in the Red List of Endangered Species of Bavaria (Achtziger et al. 2003). Species richness was highest in the open, meadow areas, but also high in bark beetle gaps in the interior of forests. Numbers sampled in traps at ground level and in the canopy at the forest edge were similar. Closed forest was poor in species, both at ground level and in the canopy.

The more remarkable species are discussed below in detail. See Table 1 for details of sampling sites. Additionally, *Psallus montanus* (Josifov 1973) is worthy of comment. Once considered to be a subspecies of *P. betuleti*, it was raised to species rank by Rieger & Rabitsch (2006). Four specimens of *P. montanus* were captured in the gap in the forest interior at site BOS. In this gap single trees of *Betula*, *Sorbus* and *Fagus* grow. *P. montanus* probably lives on *Betula*.

Scoloposcelis pulchella (Zetterstedt, 1838)
Only four previous records of *S. pulchella* (Anthocoridae) are known from Bavaria (Péricart 1972 and personal communication from T. Kothe: Dachau, 3 specimens; Mariabrunn, 1 specimen, leg. Wichmann, all in the collection of Zoologische Staatssammlung München). The female found in June 2006 in a ground level trap at an interior forest edge (BOS) is the first record for the Bavarian Forest. During most of their life span nymphs and adults of this species live hidden in the galleries of bark beetles where they pierce and feed on the eggs, larvae and pupae of bark beetles (Wachmann et al. 2006). Because of its cryptic way of life *S. pulchella* is probably more widely distributed than might be supposed from the few previous records. Studies on captures of non-target insects in pheromone baited bark beetle traps showed that some bark beetle pheromones are attractive for this species (Sellenschlo 1986, Wachmann et al. 2006). Catches from pheromone traps therefore should be checked for *S. pulchella* in future.

Aradus obtectus Vásárhelyi, 1988 RL-By R
A. obtectus has been rarely recorded, but Seidenstücker has already found it in the Bavarian Forest National Park, on the Falkenstein (see Vásárhelyi 1988, Schuster 1993). In the present study three individuals (2 males, 1 female) of this species were caught in a bark beetle induced gap (GHW) in June 2006. On April 30, 2006, a further two males, one female and one juvenile of *A. obtectus* (leg. det. coll. M. Goßner) were observed under the bark of dead spruce trees colonised by *Fomitopsis pinicola* in Schachtenau. Jonsell et al. (2005) also demonstrated the dependency of *A. obtectus* on the occurrence of *F. pinicola* on dead standing spruce trees (snags) in Sweden. According to Seidenstücker (cited in Schuster 2001), *A. obtectus* occurs primarily on spruce snags. Hence, bark beetle induced gaps with spruce snags colonised by *F. pinicola* might be a key structure for the occurrence of this species in the Bavarian Forest.

Physatocheila harwoodi China, 1936 RL-By 3
P. harwoodi has rarely been recorded in Bavaria (Schuster 2001, 2005, Bräu & Schwibinger 2004), from Swabia, Lower Franconia and Upper Bavaria. The male found in the tree crown of *Acer pseudoplatanus* at the exterior forest edge RWS in July is therefore the first record for Lower Bavaria and also for the Bavarian Forest. *A. pseudoplatanus* seems to be the main habitat tree (Wachmann et al. 2006).

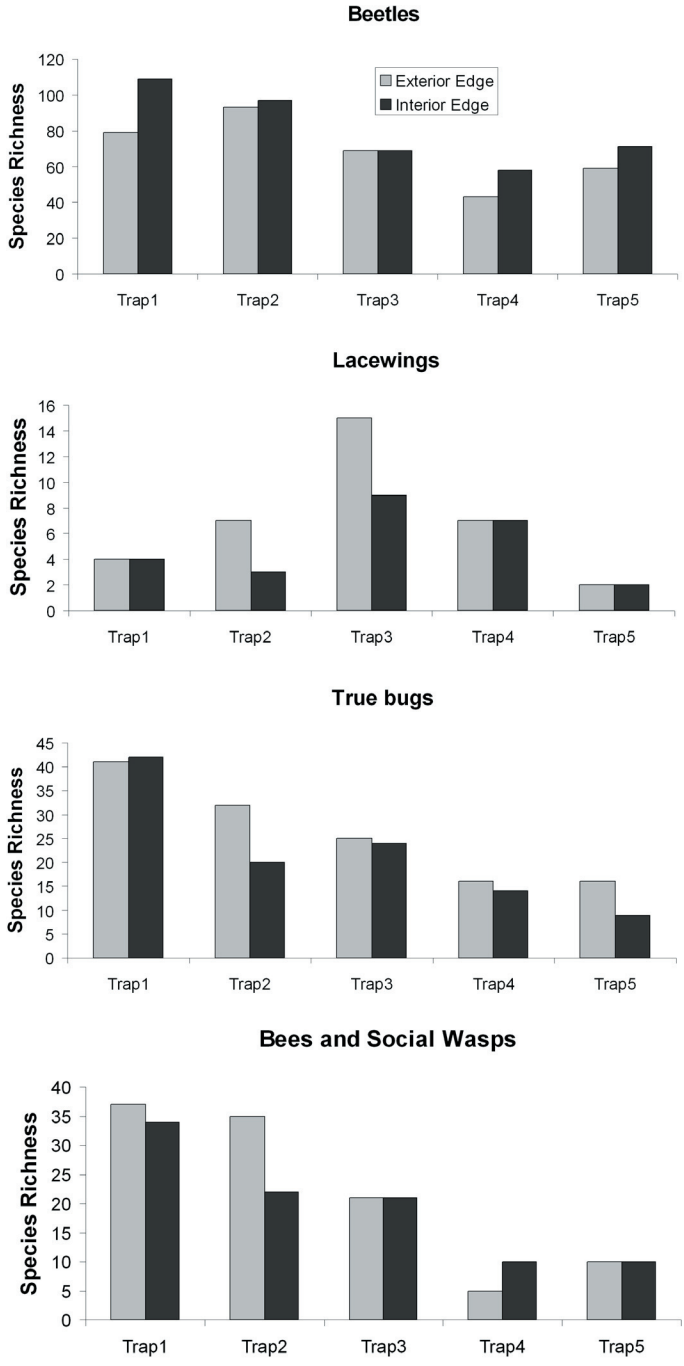

Fig. 6. Species richness of beetles, true bugs, lacewings, and bees and wasps in 60 traps at 5 different positions, with 6 replicates for each type of forest edge.

Scolopostethus decoratus (Hahn, 1833) RL-By 3
S. decoratus occurs primarily in *Calluna* heathlands on sandy as well as peaty sites, but is recorded with a low level of constancy in Bavaria (Bräu & Schwibinger 2004). The female found at the exterior edge at site GOE in June is the first record for the Bavarian Forest.

Elasmucha ferrugata (Fabricius, 1787) RL-By R
E. ferrugata lives primarily on *Vaccinium* in less dense pine stands. In the present study one male was found in the forest interior near ground level (BAS) in May. *E. ferrugata* is known from several sites scattered throughout Bavaria, but its distribution seems to be patchy (Bräu & Schwibinger 2004). Only a few recent records have been published, most of them from Middle Franconia (Bräu & Schwibinger 2004, Gossner, unpubl. data). In the Bavarian Forest it was found by Necker in August 1975 near Richnach (Bräu & Schwibinger 2004). Our record is the first for the National Park.

Derephysia foliacea (Fallén, 1807) RL-By 3
Little is known on the biology of this species, probably because of its cryptic way of life (Wachmann et al. 2006). The place of development of the nymphs is still unknown. *D. foliacea* is found in open habitats as well as dry and warm, less dense forest habitats. According to Bräu & Schwibinger (2004) most records are from neglected grasslands on limy or sandy soils. In the present study it was found in a forest clearing with spruce stumps, *Sorbus* and natural regeneration of *Picea* and *Abies* (1 male in August at GHW). Another recent record of *D. foliacea* in a forest habitat was made by Gossner (unpubl. data): 1 female in the crown of an old oak in the Forest Nature Reserve Eichhall in the High Spessart, August 2003. The record resulting from the present study is the first for the Bavarian Forest.

Stenodema virens (Linnaeus, 1767) RL-By 3
According to Wachmann et al. (2004) *S. virens* is widely distributed in Germany and not rare. However, this species seems to have declined in abundance during the last decades: only a few records from Bavaria exist (Knoerzer 1941, Eckerlein 1962, Schuster 1979, 1981, 1988, Bräu, pers. comm.). The habitat of *S. virens* is semi-moist to dry open grass formations as well as Poaceae in less dense woodland stands. Imagines overwinter on conifers and therefore this species is often found close to coniferous trees (Wachmann et al. 2004). In the present study one female was found on a meadow, at a distance to the forest edge of about 50 meters, in May. This is the first known record for the Bavarian Forest.

Adomerus biguttatus (Linnaeus, 1758) RL-By G
This species may be often overlooked because of its digging way of life. It colonises various open to semi-shaded sites. In Bavaria it is mostly found in dwarf-shrub heathlands of degraded raised bogs and on river alluvium, but also at forest sites (Schuster 1979, 1981, 1986, 1987, 1990, 1993, 1998, 2005, Bräu & Schwibinger 2004, Schmolke et al. 2006). In the Bavarian Forest it was already recorded by Wachnitz near Grafenau in 1954 (see Bräu & Schwibinger 2004). It lives mainly under *Melampyrum*, seldom under other Scrophulariaceae such as *Rhinanthus*. In the present study one male was found near ground level in a *Picea* and *Abies* stand with understory of *Fagus sylvatica,* in September (GHW).

Ceratocombus coleoptratus (Zetterstedt, 1819) RL-By G
This species is probably widely distributed in Germany and might even be locally abundant, but because of its cryptic way of life and its small body size it is certainly often overlooked. According to Wachmann et al. (2006) *C. coleoptratus* inhabits the litter of moist to very dry

sites on open land as well as in forests. In Bavaria, for example, Schuster (1979, 1987, 1990, 2005) found it primarily in mosses (mainly *Sphagnum*) in Swabia und Upper Bavaria, Gossner (unpubl. data) captured it frequently with pitfall traps on newly developed grassland sites in the Nature Reserve Rosenau near Dingolfing (Lower Bavaria). In the present study three males were collected at a distance of about 50 meters from an interior forest edge at site MSH in August. This is the first known record for the Bavarian Forest.

Actinonotus pulcher (Herrich-Schaeffer, 1835) RL-By R
While rarely found so far, *A. pulcher* was recorded abundantly in the present study. In total 87 individuals (54 males, 33 females) were captured. Our results demonstrate that forest edges are an important habitat for this species during years of relatively high population densities. In general, *Abies alba* seems to be the most important host tree for this species (for details see Gossner et al. 2007). Future studies should aim to reveal the decisive factors for the occurrence of *A. pulcher*. This species might exhibit high population densities only in years of optimal microclimatic conditions for larval development. Further, climate change might have a positive effect on the occurrence of *A. pulcher*. It is supposed that the main focus of its geographical distribution is South-East Europe (Wachmann et al. 2004).

Capsodes gothicus (Linnaeus, 1758) RL-By V
C. gothicus has mainly been recorded in neglected grasslands, but occurs also at forest edges (Schuster 1979, 1989, 2001, Bornholdt 1991, Bräu, pers. comm.). Several plant species in different families are supposed to be host plants of *C. gothicus* (Wachmann et al. 2004). In the present study one specimen was found in July on an ancient meadow resulting from forest clearance, with single mature *Picea abies* and *Acer pseudoplatanus,* approximately 50 meters distant from the forest edge at site ABS. In Bavaria it has been previously recorded in Swabia, Upper Bavaria, Middle Franconia and the Upper Palatinate (Schuster 1971, 1979, 1981, 1989, 2001, Schmolke et al. 2006). In the Bavarian Forest, *C. gothicus* was previously recorded by sweep-netting on pasture land at Adamsberg near Riedelsbach (leg. Achtziger 1995, Bräu, pers. comm.).

Dictyla convergens (Herrich-Schaeffer, 1835) RL-By V
According to Bräu & Schwibinger (2004) *D. convergens* lives mainly on *Myosotis palustris* in wet, peaty meadows. Several localities are known in Bavaria (Schuster 1971, 1979, 1981, 1986, 1990, 1993, 2001, 2005, Scholze 1990, Bräu & Schwibinger 2004). However, *D. convergens* was found only at a few sites where the supposed host plant occurs (Bräu & Schwibinger 2004). Two previous records are known from the Bavarian Forest, one from a moor near Achslach and one from Siebenellen near Grafenau (Bräu & Schwibinger 2004). In the present study *D. convergens* was observed in forest gaps at HES (June: 3 males 1 female, July: 1 male, 1 female) and GPP (July: 1 female).

Zicrona caerulea (Linnaeus, 1758) RL-By V
This species is widely distributed in Bavaria, but only found at low levels of abundance (Schuster 1993, 1998, 2001, Bräu & Schwibinger 2004). Because of a decline of suitable habitats (moor sites, dry neglected grasslands), this species is included in the Red List of Endangered Species of Bavaria (Bräu & Schwibinger 2004, Achtziger et al. 2003). In the present study one male occurred in a bark beetle induced gap at site LUS in May. Other localities in the Bavarian Forest are Achslach, Rusel, Haunstein, Elsenthal and Grafenau (see Bräu & Schwibinger 2004, Schmolke et al. 2006).

Rubiconia intermedia (Wolff, 1811) RL-By V
R. intermedia is widely distributed in Bavaria, but not very frequent (Singer 1952, Schneid 1954, Fischer 1970, Schuster 1979, 1981, 2001, Bräu & Schwibinger 2004). It occurs primarily in neglected grasslands on limy soils and feeds by piercing fruits of a variety of different plant species. It is already known to occur in Lower Bavaria, but the capture of one female in a bark beetle induced gap (GHW, June) is the first record for the Bavarian Forest.

Lacewings / Neuroptera

185 specimens were captured, representing a total of 20 species: Raphidioptera (3 species) Chrysopidae (6 species), Hemerobiidae (9 species), and Coniopterygidae (2 species). The species richness was highest in the canopy of exterior forest edges, followed by the canopy of interior forest edges. Number of species in the meadows and the canopy of closed forest were nevertheless still high. The greater richness in the canopy, and especially in sun exposed tree crowns, has already been described by Gruppe & Schubert (2001) in closed mixed forests. Six of the species sampled are included in the Red List of Endangered Species in Bavaria (Pröse & Gruppe 2003). With respect to the Bavarian Forest, four of them were listed in category 3, one species in category D, and one species was not listed for that region. Most species were represented by only one or two captured specimens, indicating the rare occurrence of these taxa. However, the euryoecious *Hemorobius micans* occurred in nearly all traps except those in the meadows, with the highest numbers in the canopy of closed forests and from the edges. Its preference for the higher strata within closed forests was also shown by Gruppe & Müller (2007) in southern Germany and by Duelli et al. (2002) in Switzerland in beech forests. Due to the small number of specimens it is impossible to analyse the preferences of the other species for any particular stratum.

Bees and Wasps / Aculeata

We captured 1888 specimens representing 65 species. The highest number of species was found in the gaps and meadows, and at their edges. A closed forest was poor in species. More species were found at ground level than in tree crowns. Although this high level of species richness in openings in the forest was found during other investigations in the National Park (Kuhlmann 1999, 2001), these studies omitted the trapping in closed stands which enables a comparison. Three of the species captured are listed in the Red List of Endangered Species in Bavaria (Mandery et al. 2003): *Andrena semilaevis* (RL Bavaria G) was found only once at ground level of an exterior forest edge (Schleif). *Hylaeus annulatus* (RL Bavaria R) was found at two interior edges (Gfällparkplatz, Heilstein). Thirty three specimens of *Lasioglossum subfulvicorne* (RL Bavaria G) were found in all types of open area and at the edges. Only one specimen was found in the closed forest.

Conclusion

The total of 421 determined insect species represented by 10 966 specimens shows the high importance of forest edges for biodiversity in the montane zone, as has previously been demonstrated for lower altitudes (Flückinger & Duelli 1997, Wermelinger et al. 2007). The structural mosaic, with interior forest edges produced for example by bark beetle attacks, is important for the maintenance of biodiversity in our forests. The combined occurrence of small scale structures such as dead wood with sunny habitats seems very important for many forest species. Tree crowns are of greatest importance for most of the lacewing species, some true bugs, and only a few of the beetle species.

Zusammenfassung

Mit Hilfe von 60 Flugfensterfallen wurden 12 verschiedene Waldränder im Nationalpark Bayerischer Wald untersucht. Die Hälfte der Waldränder ist durch Borkenkäferfraß entstanden, die anderen sind Ergebnis menschlicher Rodungstätigkeit. An jedem Waldrand wurden 5 Fallen installiert: Eine im offenen Bereich, 50–80 m vom Waldrand entfernt, je zwei unten und oben am Waldrand, und im geschlossenen Wald, in einer Entfernung von 70–100 m vom Waldrand. Insgesamt wurden 10 966 Individuen in 421 Arten gefangen und bestimmt: 240 Käferarten, 96 Wanzen, 65 Bienen und Wespen sowie 20 Netzflügler. Die höchsten Artenzahlen wurden auf den Lücken, Wiesen und Waldrändern gefangen. Borkenkäferlücken erwiesen sich als Hotspots für Biologische Vielfalt.

References

Achtziger R., Bräu M. & Schuster G., 2003: Rote Liste der Landwanzen (Heteroptera: Geocorisae) Bayerns. *Schriftenreihe des Landesamt für Umweltschutz*, 166: 82–91.

Apfelbacher F. & Geiss G., 2006: Liste der Käfer des östlichen Bayerischen Waldes. *Der Bayerische Wald*, 20: 3–43.

Baker S.C., Barmuta L.A., McQuillan P.B. & Richardson A.M.M., 2007: Estimating edge effects on ground dwelling beetles at clearfelled non-riparian stand edges in Tasmanian wet eucalyptus forest. *Forest Ecology and Management*, 129: 92–101.

Bense U., 1995: *Longhorn Beetles. Illustrated key to the Cerambycidae and Vesperidae of Europe*. Markgraf Verlag, Weikersheim, 512 pp.

Bornholdt G., 1991: Auswirkungen der Pflegmaßnahmen Mahd, Mulchen, Beweidung und Gehölzrückschnitt auf die Insektenordungen Orthoptera, Heteroptera, Auchenorrhyncha und Coleoptera der Halbtrockenrasen im Raum Schlüchtern. *Marburger Entomologische Publikationen*, 2(6): 1–330.

Bräu M. & Schwibinger M., 2004: Beitrag zur Wanzen-Faunistik in Bayern mit Kommentaren zur Neufassung der Roten Liste (Insecta: Heteroptera, Geocorisae). *Beiträge zur bayerischen Entomofaunistik*, 6: 95–216.

Eckerlein H., 1962: Das Wanzenvorkommen im Gebiet des Börstigs bei Bamberg. *Berichte der Naturforschenden Gesellschaft Bamberg*, 38: 79–89.

Fischer H., 1970: Die Tierwelt Schwabens. Die Schildwanzen mit Verbreitungsatlas. *Berichte der Naturforschenden Gesellschaft Augsburg*, 19: 1–166.

Flückinger P.F. & Duelli P., 1997: Waldränder – Zentren der Biodiversität. *Mitteilungen der Deutschen Gesellschaft für Angewandte Entomologie*, 11: 119–123.

Gossner M., Preis M. & Altmann I., 2007: Neue Funde von *Actinonotus pulcher* (Herrich-Schaeffer, 1835) aus dem Bayerischen Wald (Heteroptera: Miridae). *Nachrichtenblatt der bayerischen Entomologen*, 56: 30–42.

Grove S. & Stork N.E., 2000: An inordinate fondness for beetles. *Invertebrate taxonomy*, 14: 733–739.

Hennevogel F., 1905: *Zur Käferfauna des Böhmerwaldes*. Verlag der Gesellschaft für Physiokratie in Böhmen, Prag, 17 pp.

Horion A., 1953: *Faunistik der mitteleuropäischen Käfer, Bd. III, Malacodermata, Sternoxia (Elateridae – Throscidae)*. Eigenverlag Museum Frey, München, 340 pp.

Knoerzer A., 1941: Beitrag zur Kenntnis der Hemipterenfauna des südlichen Frankenjuras. *Mitteilungen der Münchner Entomologischen Gesellschaft*, 30: 580–589.

Köhler F., 1997: Bestandserfassung xylobionter Käfer im Nationalpark Bayerischer Wald (Insecta: Coleoptera). *Beiträge zur bayerischen Entomofaunistik*, 2: 73–118.

Kuhlmann M., 1999: Besiedlung von Windwürfen und abgestorbenen Waldflächen im Nationalpark Bayerischer Wald durch Wildbienen und aculeate Wespen (Hymenoptera Aculeata). *Bericht der Naturforschenden Gesellschaft Bamberg*, 73: 65–94.

Kuhlmann M., 2001: Zur Besiedlung unterschiedlicher Waldstandorte durch Wildbienen und Wespen (Hymenoptera Aculeata) im Nationalpark Bayerischer Wald. *Bericht der Naturforschenden Gesellschaft Bamberg*, 75:55–69.

Mandery K., Voith J., Kraus M., Weber K. & Wickl K.-H., 2003: Rote Liste gefährdeter Bienen (Hymenoptera: Apidae) Bayerns. *Schriftenreihe des Bayerischen Landesamt für Umweltschutz*, 166:198–207.

Oxbrough A.G., Gittings T., O'Halloran J., Giller P.S. & Kelly T.C., 2006: The influence of open space on ground-dwelling spider assemblages within plantation forests. *Forest Ecology and Management*, 237: 404–417.

Péricart J., 1972: Hémiptères Anthocoridae, Cimicidae et Microphysidae de l'Ouest Paléarctique. *Faune de*

Europe et du Bassin Méditerranéen, vol. 7, Paris, 402 pp.
Pröse H. & Gruppe A., 2003: Rote Liste gefährdeter Netzflügler (Neuropteroidea) Bayerns. *Schriftenreihe des Bayerischen Landesamt für Umweltschutz*, 166: 95–98.
Rieger C. & Rabitsch, W., 2006: Taxonomy and distribution of *Psallus betuleti* (Fallén) and *P. montanus* Josifov stat. nov. (Heteroptera, Miridae). *Tijdschrift voor Entomologie*, 149: 161–166.
Schmolke F., Bräu M. & Schönitzer K., 2006: Interessante Wanzenfunde aus Bayern mit besonderer Berücksichtigung der Coreoidea (Insecta: Heteroptera, Geocorisae). *Beiträge zur bayerischen Entomofaunistik*, 8: 131–181.
Schneid T., 1954: Die Wanzen (Hemiptera-Heteroptera) der Umgebung von Bamberg. *Berichte der Naturforschenden Gesellschaft Bamberg*, 34: 47–107.
Scholze W., 1990: Ökofaunistische Untersuchungen an der Wanzenfauna Oberfränkischer Distelhabitate. *Berichte der Naturwissenschaftlichen Gesellschaft Bayreuth*, 21: 113–148.
Schuster G., 1971: Die Hemipterenfauna des Landkreises Schwabmünchen. *Berichte der Naturforschenden Gesellschaft Augsburg*, 26: 37–120.
Schuster G., 1979: Wanzen aus Südbayern (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 34: 1–55.
Schuster G., 1981: Wanzenfunde aus Bayern, Baden-Württeberg und Nordtirol (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 36: 5–50.
Schuster G., 1987: Wanzenfunde aus Oberbayern und Nordtirol (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 44: 1–40.
Schuster G., 1988: Zur Wanzenfauna Mittelfrankens (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 36: 5–50.
Schuster G., 1989: Die Wanzenfauna des Windsberges bei Freinhausen, Oberbayern (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 49: 4–29.
Schuster G., 1989: Die Wanzenfauna Schwabens und der Schwäbischen Alb (Hemiptera, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 47: 1–32.
Schuster G., 1990: Beitrag zur Wanzenfauna Schwabens (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 50: 5–35.
Schuster G., 1993: Wanzen aus Bayern (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 54: 1–49.
Schuster G., 1998: Wanzen aus Bayern II (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 57: 1–64.
Schuster G., 2001: Wanzen aus Bayern III (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 60: 1–78.
Schuster G., 2005: Wanzen aus Bayern IV (Insecta, Heteroptera). *Berichte der Naturforschenden Gesellschaft Augsburg*, 62: 63–124.
Sellenschlo U., 1986: Beifänge in Borkenkäfer-Pheromonfallen in Norddeutschland. *Journal of Pest Science*, 59(8): 1612–4758.
Singer K., 1952: Die Wanzen (Hemiptera-Heteroptera) des unteren Maingebietes von Hanau bis Würzburg mit Einschluß des Spessarts. *Mitteilungen des naturwissenschaftlichen Museums Aschaffenburg*, 5: 1–127.
Vásárhelyi T., 1988: New palaearctic *Aradus* species in the betulae-group (Heteroptera, Aradidae). *Annales Historico-Naturales Musei Nationalis Hungarici*, 80: 57–63.
Wachmann E., Melber A. & Deckert J., 2004: Wanzen Band 2. *Die Tierwelt Deutschlands 75*. Goecke & Evers, Keltern, 288 pp.
Wachmann E., Melber A. & Deckert J, 2006: Wanzen Band 1. *Die Tierwelt Deutschlands 77*. Goecke & Evers, Keltern, 263 pp.
Wermelinger B., 2004: Ecology and management of the spruce bark beetle *Ips typographus* – a review of recent research. *Forest Ecology and Management*, 202: 67–82.
Wermelinger B., Flückinger P.F., Obrist M.K. & Duelli P., 2007: Horizontal and vertical distribution of saproxylic beetles (Co., Buprestidae, Cerambycidae, Scolytidae) across sections of forest edges. *Journal of Applied Entomology*, 131:104–114.

Received: 10 April 2007
Accepted: 26 June 2007

Appendix 1. Frequency and number (number of traps/specimens) of beetles (saproxylic species and all Elateridae) from forest edges (specimens/traps). Exterior Forest Edges are next to pasture land and are the result of ancient human clearings. Interior Forest Edges are the result of massive bark beetle attacks on spruce trees. Numbers indicate position of traps: 1 – open area, ground level; 2 – forest edge, ground level, 3 – forest edge, canopy; 4 – forest canopy; 5 – forest, ground level. M/F – males/females, * – new for National Park, ** – new for Bavarian Forest.

		Exterior Forest Edge					Interior Forest Edge				
Species	M/F	Trap1	Trap2	Trap3	Trap4	Trap5	Trap1	Trap2	Trap3	Trap4	Trap5
HISTERIDAE											
Plegaderus vulneratus	1/1		1/1								
LEIODIDAE											
Anisotoma humeralis	1/1						1/1				
SCYDMAENIDAE											
Neuraphes coecus	1/1							1/1			
STAPHYLINIDAE											
Scaphidium quadrimaculatum	1/1						1/1				
Scaphisoma agaricinum	3/4	2/2					1/2				
Phyllodrepa linearis	1/1									1/1	
Nudobius lentus	4/7		1/1				3/6				
Atrecus affinis	2/2						1/1	1/1			
Atrecus longiceps	1/1							1/1			
Gabrius splendidulus	3/5	1/3		1/1					1/1		
Quedius mesomelinus	2/2										2/2
Quedius xanthopus	1/2									1/2	
Quedius plagiatus	2/2										2/2
Gyrophaena joyioides	1/2						1/2				
*Placusa complanata***	3/3								1/1	1/1	1/1
Leptusa pulchella	3/3						2/2	1/1		/	
Leptusa fumida	2/2			1/1						1/1	
Bolitochara obliqua	1/1						1/1				
Bolitochara mulsanti	1/1							1/1			
Dinaraea aequata	1/1										1/1
Phloeopora corticalis	1/1			1/1							
*Phloeopora bernhaueri***	1/1	1/1									
*Ischnoglossa prolixa***	1/1						1/1				
PSELAPHIDAE											
Bibloporus bicolor	7/8		1/1				1/1	2/3			3/3
Plectophloeus fischeri	3/5							2/4	1/1		
Tyrus mucronatus	1/1						1/1				
LYCIDAE											
Dictyopterus aurora	3/3					1/1		1/1			1/1
Pyropterus nigroruber	1/1		1/1								

Appendix 1. Continued.

CANTHARIDAE											
Malthinus punctatus	2/2			2/2							
Malthodes fuscus	2/3		1/1					1/2			
Malthodes mysticus	12/24				1/1	1/2	1/3	1/3	1/4	4/7	3/4
Malthodes hexacanthus	10/20					1/3	3/7	3/7	2/2		1/1
Malthodes pumilus	3/5	1/1	1/2				1/2				
*Malthodes brevicollis***	5/5							1/1	1/1	2/2	1/1
MELYRIDAE											
Aplocnemus nigricornis	4/6			1/1					3/5		
Aplocnemus tarsalis	6/12			1/2				2/6	3/4		
Dasytes niger	3/8	1/1					2/7				
Dasytes obscurus	16/76	1/1		2/3			6/32	2/14	4/25		1/1
*Dasytes cyaneus**	19/30	2/2	1/1	3/7	3/4	2/4	1/1	3/3	3/7	1/1	/
Dasytes plumbeus	23/93	4/26	4/33	3/6		3/3	5/14	2/5	1/5		1/1
CLERIDAE											
Tillus elongatus	3/13		1/2	2/11							
Thanasimus formicarius	4/4						1/1	1/1		1/1	1/1
Thanasimus pectoralis	2/3										2/3
*Korynetes caeruleus**	1/1	1/1									/
TROGOSSITIDAE											
Nemosoma elongatum	6/9		1/1				1/2	1/1	2/2		1/3
PELTIDAE											
Ostoma ferruginea	2/4						1/3	1/1			/
LYMEXYLONIDAE											
Hylecoetus dermestoides	9/47	1/1	1/4			2/33	2/2	1/1			2/6
ELATERIDAE											
Ampedus erythrogonus	19/49	1/1	1/2	2/3	2/3	2/2	3/4	3/5	4/27	1/2	/
Ampedus balteatus	6/13	1/1					2/5	2/6			1/1
Ampedus aethiops	5/40		1/1				2/10		2/29		
Ampedus sanguineus	1/2						/		1/2		
Ampedus pomorum	3/10	1/7		1/2			1/1				
*Ampedus nigroflavus***	1/4			1/4			/				
Ampedus nigrinus	27/494	1/1	2/5	3/12	1/8	1/1	6/155	5/19	5/290	1/1	2/2
Sericus brunneus	7/24			1/1	/	/	4/20	1/1	1/2	/	/
Dalopius marginatus	43/296	4/23	6/69	4/11	2/4	3/15	4/47	6/70	3/23	6/11	5/23
Agriotes pilosellus	1/1	1/1									
Adrastus pallens	1/3		1/3								
Melanotus rufipes	1/1										
Melanotus castanipes	34/96	1/1	3/9	2/3	1/1	4/10	4/14	5/21	4/11	4/10	6/16
Danosoma fasciatus	1/1						1/1				
Agrypnus murina	10/212	3/203	2/2	2/3			2/3	1/1			

Appendix 1. Continued.

Ctenicera pectinicornis	7/9	2/3	1/2	1/1		1/1	2/2					
Ctenicera cuprea	9/101	2/88	2/2	2/2			2/8	1/1				
Liotrichus affinis	8/49						4/41	2/5	1/1		1/2	
Actenicerus sjaelandicus	3/9	2/7	1/2									
Prosternon tessellatum	5/9	2/6	2/2				/	1/1				
Anostirus purpureus	6/6	1/1	1/1				2/2		2/2			
Anostirus castaneus	1/1						1/1					
Selatosomus aeneus	5/6		2/3	1/1			1/1	1/1				
*Calambus bipustulatus**	1/1								1/1			
Denticollis rubens	7/8	1/1	1/2		1/1	2/2	1/1	1/1				
Denticollis linearis	5/9		1/4			1/2	1/1	1/1			1/1	
Nothodes parvulus	2/2		2/2					/				
Limonius aeneoniger	7/57						4/42	2/9	1/6			
Diacanthous undulatus	1/1								1/1			
Hemicrepidius niger	4/9	2/7	2/2									
Hemicrepidius hirtus	3/3	2/2		1/1								
Athous vittatus	15/31	2/2	5/14	1/6	1/1	1/2		1/1		3/3	1/2	
Athous subfuscus	58/1388	4/31	6/230	6/69	6/150	6/152	6/195	6/213	6/115	6/123	6/110	
Athous zebei	36/216	3/9	5/40		2/4	5/46	4/23	5/39	3/4	3/6	6/45	
Zorochros minimus	1/1		1/1									
Quasimus minutissimus	1/1						1/1					
Cardiophorus ruficollis	3/4						1/1	1/1	1/2			
EUCNEMIDAE												
Hylis foveicollis	3/3						1/1				2/2	
Hylis procerulus	1/2						1/2					
BUPRESTIDAE												
Anthaxia quadripunctata	6/6	3/3	1/1	1/1			1/1					
*Chrysobothris affinis***	1/1		1/1									
Agrilus viridis	1/1								1/1			
DERMESTIDAE												
Megatoma undata	3/3			2/2		1/1						
CERYLONIDAE												
Cerylon histeroides	1/1	1/1										
Cerylon ferrugineum	4/4					2/2	1/1		1/1			
NITIDULIDAE												
Epuraea neglecta	1/1					1/1						
Epuraea marseuli	2/2					1/1				1/1		
Epuraea pygmaea	1/1				1/1							
Epuraea binotata	1/1						1/1					
Epuraea variegata	1/1				1/1							
*Epuraea rufomarginata***	2/2					1/1		1/1				

Appendix 1. Continued.

Ipidia binotata	4/5	1/1				1/2	1/1	1/1			
Cychramus variegatus	14/32	1/1	2/3		1/1	2/5	2/6	3/11			3/5
Cychramus luteus	3/17	1/3	1/13				1/1				
Pityophagus ferrugineus	1/2		/					1/2			
Rhizophagus depressus	3/3	1/1	1/1								1/1
Rhizophagus nitidulus	5/5		2/2			1/1		2/2			
Rhizophagus cribratus	1/1			1/1							
PHLOESTICHIDAE											
Phloeostichus denticollis	1/2			1/2							
EROTYLIDAE											
Tritoma bipustulata	4/13	2/10	1/2						1/1		
Triplax aenea	1/1	1/1									
Triplax russica	4/10		2/3	1/5		1/2					
CRYPTOPHAGIDAE											
Pteryngium crenatum	10/18			1/1		1/1	2/6	4/7			2/3
*Cryptophagus cylindrus***	2/2	1/1									1/1
Cryptophagus lapponicus	2/2								1/1	1/1	
Cryptophagus scanicus	1/1			1/1							
Cryptophagus scutellatus	1/1		1/1								
Micrambe abietis	30/149	2/5	3/14	4/46	2/9	2/2	2/11	5/9	4/31	3/14	3/8
Atomaria lewisi	1/1							1/1			
Atomaria turgida	3/4		1/2								2/2
Atomaria diluta	1/1		1/1								
Atomaria alpina	1/1							1/1			
Atomaria ihsseni	2/2						2/2				
Atomaria bella	1/1						1/1				
LAEMOPHLOEIDAE											
*Leptophloeus alternans***	3/3	1/1									2/2
LATHRIDIIDAE											
Enicmus fungicola	3/3	1/1				1/1	1/1				
Enicmus transversus	2/2						1/1				1/1
Cartodere constricta	1/1								1/1		
Stephostethus alternans	2/2						1/1		/		1/1
Stephostethus rugicollis	6/9			1/1			1/1		1/1		3/6
Corticaria abietorum	11/20			2/2		1/1	1/2	2/3	1/1		4/11
Corticaria linearis	1/1						1/1				
Corticaria elongata	1/1				1/1						
MYCETOPHAGIDAE											
*Mycetophagus multipunctatus***	1/1		1/1								
*Mycetophagus populi***	1/1							1/1			

Appendix 1. Continued.

ENDOMYCHIDAE											
Endomychus coccineus	2/2		1/1				1/1				
SPHINDIDAE											
Arpidiphorus orbiculatus	1/1							1/1			
CIIDAE											
Cis nitidus	1/1							1/1			
Cis glabratus	3/3		1/1					1/1			1/1
Cis hispidus	1/1							1/1			
Cis boleti	2/2		1/1					1/1			
Cis quadridens	1/1										1/1
Cis punctulatus	1/1						1/1				
Cis castaneus	4/4			1/1			1/1	2/2			
Cis dentatus	1/1										1/1
Orthocis alni	2/2							1/1		1/1	
Hadreule elongatulum	1/2						1/2				
ANOBIIDAE											
Hedobia imperialis	19/36		1/1	1/1	2/4	4/6	1/1	1/1	1/1	3/12	5/9
Dryophilus pusillus	8/11		1/1	2/3			1/1		2/4	1/1	1/1
*Xestobium plumbeum***	2/2									1/1	1/1
*Ernobius abietinus***	5/11			1/6					3/3	1/2	
Ernobius abietis	10/41		1/1	2/25	2/2	1/1		2/2	2/10		
*Ernobius mollis**	1/1			1/1							
Anobium costatum	12/27		1/1	2/2	3/17	2/2			1/1	1/1	2/3
Anobium emarginatum	7/20	1/1		1/5		1/1			1/1	2/11	1/1
Anobium pertinax	4/10		1/1				2/8				1/1
Ptilinus pectinicornis	9/13		1/1	1/1	1/3	4/6				2/2	
*Dorcatoma punctulata***	1/5						1/5				
PTINIDAE											
Ptinus dubius	1/1								1/1		
OEDEMERIDAE											
Calopus serraticornis	1/1						1/1				
*Ischnomera caerulea**	3/6		1/1	2/5							
SALPINGIDAE											
*Rabocerus foveolatus***	3/3				1/1				1/1	1/1	
*Sphaeriestes castaneus**	1/1				1/1						
Salpingus planirostris	3/3		1/1		1/1					1/1	
Salpingus ruficollis	21/47	1/2	2/4	4/4	3/3	2/8	2/4	2/3	1/1	1/3	3/15
SCRAPTIIDAE											
Anaspis frontalis	5/9		1/1	1/1				1/2		2/5	
*Anaspis thoracica**	7/30			1/1			1/1	1/1	3/25	1/2	
*Anaspis ruficollis***	4/4							2/2	1/1	1/1	

Appendix 1. Continued.

Anaspis rufilabris	45/136	2/4	5/26	5/13	3/7	5/10	6/10	5/19	6/17	3/11	5/19
ADERIDAE											
Anidorus nigrinus	1/1						/	1/1			
MORDELLIDAE											
Tomoxia bucephala	8/15	1/3	3/3	3/7			1/2				
Mordella holomelaena	4/5	2/3					2/2				
Curtimorda maculosa	3/3	2/2					1/1				
Mordellochroa abdominalis	2/2			1/1			1/1				
MELANDRYIDAE											
Orchesia micans	1/1			1/1							
*Orchesia luteipalpis**	2/2					1/1				1/1	
Orchesia minor	2/2				1/1	1/1					
Abdera flexuosa	1/1							1/1			
Xylita livida	1/1							1/1			
Serropalpus barbatus	4/5	1/1				2/3			1/1		
*Conopalpus testaceus**	2/6			1/4	1/2						
TETRATOMIDAE											
Tetratoma ancora	1/2									1/2	
TENEBRIONIDAE											
Bolitophagus reticulatus	2/2		1/1				1/1				
*Corticeus linearis**	4/4		1/1				1/1	1/1			1/1
SCARABAEIDAE											
Melolontha melolontha	8/18	2/11	1/1	1/1	1/1		1/2			1/1	1/1
*Gnorimus nobilis**	1/1				1/1						/
LUCANIDAE											
Platycerus caprea	18/33	1/1	3/10		1/3	4/6	2/4	3/5		1/1	3/3
Sinodendron cylindricum	2/3	1/1	1/2								
CERAMBYCIDAE											
Arhopalus rusticus	1/1	1/1									
Tetropium castaneum	2/2	1/1									1/1
Rhagium bifasciatum	17/35	2/3	1/1			1/2	3/8	4/8	3/9	1/1	2/3
Rhagium mordax	13/29	2/5	1/10		1/1	1/3	4/4	1/1	1/1		2/4
Rhagium inquisitor	4/4	1/1						1/1	2/2		/
Oxymirus cursor	14/21			2/2	1/1	3/4	3/4	3/4	1/5		1/1
Evodinus clathratus	14/27	1/2	2/2	1/2	1/1	2/2	/	2/9	1/1		4/8
Gaurotes virginea	12/15	4/4	1/3				4/5	1/1	2/2		
Pidonia lurida	2/4		1/2					1/2			
Alosterna tabacicolor	3/6		2/5					1/1			
Leptura maculata	2/2	1/1	1/1								
Corymbia maculicornis	12/37	2/12	1/2	2/3	1/2		2/6	1/1	2/9	1/2	
Corymbia rubra	5/28	2/5					2/22	1/1			

Appendix 1. Continued.

Corymbia scutellata	4/4	1/1		2/2	1/1		/	/			
Anastrangalia dubia	4/4	2/2					1/1	1/1			
Lepturobosca virens	3/18						3/18	/			
Judolia sexmaculata	5/12						4/10	1/2			
Pachytodes cerambyciformis	6/14	1/1					3/10	2/3			
Stenurella melanura	18/201	4/9	3/4			1/1	6/181	3/5			1/1
Obrium brunneum	1/1		1/1								
Molorchus minor	12/16		2/3	1/2	1/1	1/1	1/1	1/2	1/2	4/4	
Clytus lama	3/3	1/1							1/1	1/1	
Anaglyptus mysticus	3/3			1/1				1/1	1/1		
Leiopus nebulosus	6/6		1/1							2/2	3/3
CHRYSOMELIDAE											
Donacia versicolorea	1/1	1/1									
SCOLYTIDAE											
*Scolytus rugulosus***	1/1		1/1								
*Hylastes opacus***	1/1	1/1									
Hylastes cunicularius	24/91	1/1	3/15			5/20	3/7	3/6	2/4	1/2	6/36
*Hylastes attenuatus***	1/1		1/1								
Hylurgops palliatus	5/7		1/1				1/1		1/1		2/4
Polygraphus poligraphus	27/104	1/3	1/2	4/15	3/4	1/3	1/1	2/2	6/43	3/14	5/17
Leperisinus fraxini	6/6	2/2		2/2	1/1						1/1
Xylechinus pilosus	4/4				1/1					1/1	2/2
Crypturgus cinereus	9/9		1/1			1/1	3/3	1/1		2/2	1/1
Crypturgus hispidulus	9/13			1/1	1/1	1/1	3/5	1/2	1/1	1/2	
Dryocoetes autographus	13/50		1/3			1/1	3/14	3/4	1/1	1/2	3/25
*Cryphalus piceae***	3/5		1/1	1/2						1/2	
Cryphalus abietis	3/4	1/2		/						2/2	
Ernoporicus fagi	32/173	1/1	2/5	4/13	5/17	3/9	2/4	3/30	4/42	4/23	4/29
*Pityophthorus exsculptus***	1/2									1/2	
Pityophthorus pityographus	34/77	2/3	4/7	2/3		1/1	5/19	5/10	5/15	4/9	6/10
Taphrorychus bicolor	8/8		2/2		2/2			1/1		1/1	2/2
Pityogenes chalcographus	43/725	3/13	4/59	3/15	1/1	3/16	6/398	6/100	6/64	5/7	6/52
Orthotomicus laricis	1/1							1/1			
Ips typographus	38/223	2/5	3/8	2/9		3/6	6/44	6/33	6/85	4/12	6/21
*Ips amitinus***	1/1						1/1				
Xyleborus dispar	1/1			1/1							
Xyloterus domesticus	10/37	1/1	2/2			3/5	1/3				3/26
Xyloterus lineatus	20/54	1/1	1/5			2/3	4/6	3/6	2/2	2/3	5/28
CIMBERIDAE											
Cimberis attelaboides	1/1				1/1						

Appendix 1. Continued.

CURCULIONIDAE											
Rhyncolus sculpturatus	1/1	1/1									
Rhyncolus ater	2/2					1/1	1/1				
Hexarthrum duplicatum	1/1		1/1								
Magdalis nitida	4/5							1/1	2/3	1/1	
Hylobius abietis	1/1			1/1							

Appendix 2. True bugs (Heteroptera) from forest edges. For further explanations see Appendix 1.

Species	M/F	Exterior Forest Edge					Interior Forest Edge				
		Trap 1	Trap 2	Trap 3	Trap 4	Trap 5	Trap 1	Trap 2	Trap 3	Trap 4	Trap 5
Acanthosoma haemorrhoidale	2/2			1/1			1/1				
Acompocoris alpinus	4/6			1/3	1/1				2/2		
Actinonotus pulcher	13/87	1/2	4/23	2/18	2/3	1/1	1/1		2/39		
Adelphocoris quadripunctatus	1/1		1/1								
Adelphocoris seticornis	1/1	1/1									
Adomerus biguttatus	1/1										1/1
Anthocoris confusus	6/7	1/1	1/1		1/2		1/1	1/1		1/1	
Anthocoris nemorum	5/7	1/3	2/2				2/2				
Aquarius paludum	1/1									1/1	
Aradus obtectus	1/3						1/3				
Atractotomus magnicornis	14/24	1/1		3/9	1/2	1/1	1/1	1/1	4/6	1/2	1/1
Blepharidopterus angulatus	3/3					1/1		1/1	1/1		
Calocoris affinis	4/5		2/3					1/1	1/1		
Capsodes gothicus	1/1	1/1									
Capsus ater	8/11	2/3	1/2				3/4	1/1	1/1		
Carpocoris fuscispinus	2/2						1/1	1/1			
Carpocoris purpureipennis	4/13	2/10					2/3				
Ceratocombus coleoptratus	1/3	1/3									
Charagochilus gyllenhalii	1/1	1/1									
Closterotomus biclavatus	5/8	2/3	1/3	1/1			1/1				
Coreus marginatus	1/1						1/1				
Cremnocephalus alpestris	32/1017	4/12	4/18	6/248	2/240	1/1	2/2	2/3	6/471	5/22	
Cymus claviculus	1/1						1/1				
Deraeocoris lutescens	3/4				1/1		1/2				1/1
Deraeocoris olivaceus	1/1		1/1								
Deraeocoris ruber	2/4	1/3					1/1				
Derephysia foliacea	1/1						1/1				
Dichrooscytus intermedius	4/9			2/6					2/3		
Dictyla convergens	2/7						2/7				
Dolycoris baccarum	17/121	4/30	2/2				6/56	3/29	2/4		
Drymus sylvaticus	2/2	1/1	1/1								
Dufouriellus ater	1/1	1/1									
Elasmucha ferrugata	1/1										1/1
Eurygaster testudinaria	1/2	1/2									
Gastrodes abietum	1/1				1/1						
Gastrodes grossipes	1/1								1/1		
Globiceps flavomaculatus	1/1		1/1								
Halticus apterus	1/1						1/1				

Appendix 2. Continued.

Kleidocerys resedae	2/2			1/1		1/1					
Leptopterna dolobrata	4/4	2/2	2/2								
Liocoris tripustulatus	1/1		1/1								
Loricula elegantula	1/1			1/1							
Lygocoris viridis	1/1			1/1							
Lygus gemellatus	4/4	2/2	1/1				1/1				
Lygus pratensis	1/2	1/2									
Lygus rugulipennis	1/1								1/1		
Mecomma ambulans	2/2	1/1						1/1			
Megaloceroea recticornis	2/5	1/4	1/1								
Megalonotus chiragra	2/2	2/2									
Miris striatus	4/6	1/2		1/1					2/3		
Monalocoris filicis	1/1		1/1								
Myrmedobia exilis	1/1						1/1				
Nabis pseudoferus	12/14	2/4	1/1	1/1		2/2	2/2	1/1	3/3		
Orius minutus/vicinus	9/14	2/7		2/2	2/2	1/1		1/1		1/1	
Orthocephalus coriaceus	1/1	1/1									
Orthops kalmii	4/4	3/3						1/1			
Orthotylus marginalis	1/1		1/1								
Palomena prasina	11/35	1/1					5/29	2/2	3/3		
Parapsallus vitellinus	14/41	1/1	1/1	3/17	1/7	1/1	1/2	2/4	2/3	1/2	1/3
Pentatoma rufipes	36/184	2/2	5/11	5/85	4/13	1/4	3/5	3/4	5/48	5/8	3/4
Peribalus vernalis	1/1						1/1				
Phoenicocoris modestus	2/2		1/1	1/1							
Physatocheila harwoodi	1/1			1/1							
Phytocoris dimidiatus	10/22			1/2	2/7	2/3			2/5	3/5	
Phytocoris intricatus	7/9		1/1		2/2	1/2	1/2			1/1	1/1
Phytocoris longipennis	11/15		1/1		2/4	1/3	3/3	2/2	1/1	1/1	
Phytocoris pini	2/5			1/4						1/1	
Phytocoris tiliae	5/7		1/1						3/5	1/1	
Piesma maculatum	1/1			1/1							
Piezodorus lituratus	1/1						1/1				
Pinalitus rubricatus	2/5						1/4		1/1		
Plagiognathus arbustorum	3/8	2/7	1/1								
Psallus ambiguus	7/21		1/1	1/1	1/6	1/6		1/1	1/3	1/3	
Psallus montanus	1/4						1/4				
Psallus perrisi	2/2						1/1		1/1		
Psallus pseudoplatani	1/1			1/1							
Psallus salicis	1/1						1/1				
Psallus varians	39/441	2/4	3/5	4/89	4/51	5/31	4/12	4/15	5/190	4/37	4/7

Appendix 2. Continued.

Rhopalus parumpunctatus	1/1	1/1																		
Rhyparochromus pini	2/2	2/2																		
Rubiconia intermedia	1/1												1/1							
Saldula orthochila	3/3	2/2											1/1							
Saldula saltatoria	5/7	1/3			1/1				1/1				1/1							1/1
Scoloposcelis pulchella	1/1													1/1						
Scolopostethus decoratus	1/1		1/1																	
Stenodema calcarata	1/2	1/2																		
Stenodema holsata	1/1		1/1																	
Stenodema virens	1/1	1/1																		
Stygnocoris fuligineus	1/1												1/1							
Temnostethus gracilis	1/1				1/1															
Tingis pilosa	4/4	2/2	1/1											1/1						
Trapezonotus arenarius	1/1												1/1							
Troilus luridus	3/3	1/1											1/1			1/1				
Xylocoris cursitans	1/1												1/1							
Xylocoris galactinus	3/6		1/4				1/1		1/1											
Zicrona caerulea	1/1												1/1							

Appendix 3. Lacewings from forest edges. For more explanations see Appendix 1.

		Exterior Edge					Interior Edge				
Species	M/F	Trap1	Trap2	Trap3	Trap4	Trap5	Trap1	Trap2	Trap3	Trap4	Trap5
Chrysoperla carnea	9/10	3/4	1/1	1/1					2/2	2/2	
Chrysoperla lucasina	3/3	1/1		1/1			1/1				
Coniopteryx pygmaea	2/2			1/1	1/1						
Cunctochrysa albolineata	1/1			1/1							
Hemerobius humulinus	7/8		3/2	2/3		1/1	1/1		1/1		
Hemerobius lutescens	3/4		1/1	1/1			1/2				
Hemerobius marginatus	3/3	1/1							1/1	1/1	
Hemerobius micans	23/101		2/2	2/11	4/38	1/1	3/7	3/7	3/12	3/20	2/3
Hemerobius pini	9/13		1/1	1/2	1/2				2/3	2/3	2/2
Inocellia crassicornis	1/1							1/1			
Micromus lanosus	2/2			2/2							
Nineta pallida	1/1				1/1						
Nineta vittata	1/1			1/1							
Parasemidalis fuscipennis	1/1								1/1		
Peyerimhoffina gracilis	6/8		1/1	1/1	2/2				1/1	1/3	
Phaeostigma notata	7/10	1/1	1/1	2/3	1/1				2/4		
Sympherobius pellucidus	2/2							1/1	1/1		
Wesmaelius nervosus	3/3			1/1	1/1					1/1	
Wesmaelius quadrifasciatus	2/2			1/1						1/1	
Xanthostigma xanthostigma	1/2			1/2							

Appendix 4. Bees and wasps from Forest edges. For further explanations see Appendix 1.

		Exterior Edge					Interior Edge				
Species	M/F	Trap1	Trap2	Trap3	Trap4	Trap5	Trap1	Trap2	Trap3	Trap4	Trap5
Ancistrocerus nigricornis	1/1	1/1									
Ancistrocerus parietinus	1/1						1/1				
Ancistrocerus trifasciatus	1/1							1/1			
Andrena cineraria	2/2	1/1		1/1							
Andrena clarkella	2/2		1/1				1/1				
Andrena fucata	4/5		2/2				1/2	1/1			
Andrena fulvago	1/1		1/1								
Andrena gravida	1/1		1/1								
Andrena haemorrhoa	8/19	2/10	2/5	1/1			2/2				1/1
Andrena helvola	11/23	4/9	3/10	1/1		1/1	1/1				1/1
Andrena lapponica	33/180	1/5	3/10	5/15	2/6	3/3	6/74	4/22	5/38	2/4	2/3
Andrena ovatula	1/1	1/1									
Andrena scotica	1/1	1/1									
Andrena semilaevis	1/1		1/1								
Andrena subopaca	4/9		1/5				2/3	1/1			
Andrena varians	4/5		1/1	1/2					2/2		
Apis mellifera	36/536	5/44	4/8	1/1	1/1	1/1	6/386	6/47	4/24	3/13	5/11
Bombus barbutellus	1/1						1/1				
Bombus bohemicus	23/166	5/45	5/14	1/3			6/88	2/4	2/3	2/9	
Bombus hortorum	5/7	1/2					4/5				
Bombus humilis	1/1						1/1				
Bombus hypnorum	3/3	2/2							1/1		
Bombus jonellus	14/34	2/3	2/2	1/5			5/11	1/2	3/11		
Bombus lapidarius	7/11	1/2	1/1	1/2			1/1	1/1	2/4		
Bombus lucorum	35/281	5/99	6/28	6/15		2/2	6/108	4/10	5/15	1/4	
Bombus norvegicus	4/4		2/2								2/2
Bombus pascuorum	27/142	5/52	5/16	2/2		1/1	6/42	4/20	2/3	1/5	1/1
Bombus pratorum	27/76	4/7	4/6	2/3	1/1	1/1	5/30	2/4	4/9	1/11	3/4
Bombus rupestris	2/2						1/1	1/1			
Bombus sylvestris	22/54	4/8	3/3	2/2	1/1	1/1	5/29	4/6	1/2	1/2	
Bombus terrestris	1/1	1/1									
Bombus wurflenii	5/6	1/2	1/1				1/1		2/2		
Dolichovespula adulterina	3/5		1/2			1/1			1/2		
Dolichovespula norwegica	9/15	3/5	2/2	2/6							2/2
Dolichovespula saxonica	1/1								1/1		
Dolichovespula sylvestris	2/3	1/2				1/1					
Halictus rubicundus	3/3	1/1					1/1	1/1			
Halictus tumulorum	1/1	1/1									

Appendix 4. Continued.

Hylaeus annulatus	2/2						2/2				
Hylaeus communis	2/2		1/1				1/1				
Hylaeus confusus	16/59	2/3	2/3				5/33	1/6	4/8	1/5	
Hylaeus sinuatus	1/1		1/1								
Lasioglossum albipes	1/1	1/1									
Lasioglossum fulvicorne	1/1	1/1									
Lasioglossum lativentre	16/29	4/6	2/3	2/3			5/10	1/2	2/5		
Lasioglossum leucozonium	1/1		1/1								
Lasioglossum rufitarse	8/28			1/2			4/13	1/11	2/2		
Lasioglossum subfulvicorne	14/34	1/1	3/3	1/1			4/14	3/13	1/1		1/1
Megachile lapponica	1/1						1/1				
Megachile nigriventris	1/1	1/1									
Nomada alboguttata	1/1		1/1								
Nomada flava	1/1		1/1								
Nomada marshamella	1/1		1/1								
Osmia bicornis	2/2	1/1	1/1								
Osmia truncorum	1/1	1/1									
Polistes dominulus	1/1						1/1				
Polistes nimpha	1/1	1/1									
Sphecodes crassus	2/2							1/1	1/1		
Sphecodes ephippius	3/4		1/2	1/1			1/1				
Sphecodes geoffrellus	1/1							1/1			
Sphecodes hyalinatus	2/2	1/1					1/1				
Sphecodes reticulatus	1/1	1/1									
Vespula germanica	24/70	3/16	3/13	5/9	1/4		4/12	2/3	4/11	1/1	1/1
Vespula rufa	5/10	2/6					2/2		1/2		
Vespula vulgaris	17/24	3/3	5/11	4/5		2/2	1/1	1/1		1/1	