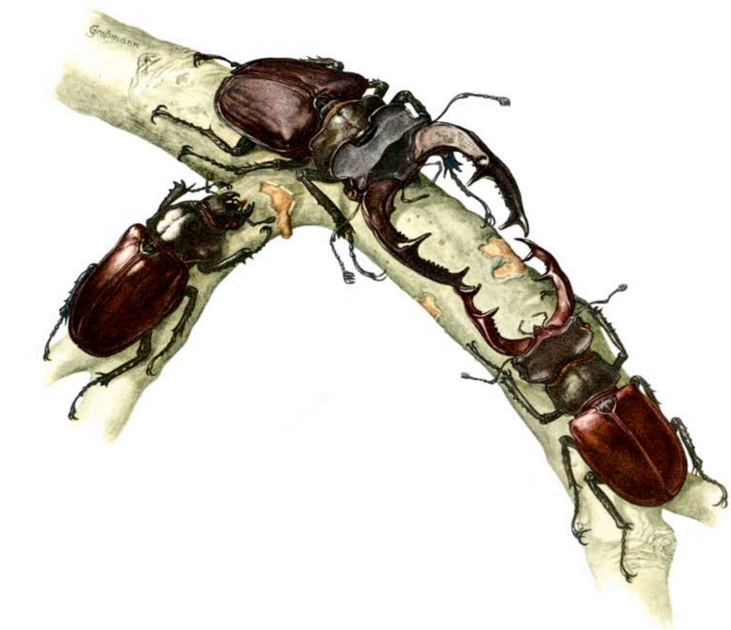
Part II

Studies of organismical biodiversity

3 Animal diversity and ecology of wood decay fungi



Contents

3.1 Methods of sampling arthropods in the canopy of the Leipzig floodplain forest

ERIK ARNDT[1], MARTIN UNTERSEHER & PETER J. HORCHLER

SHORT COMMUNICATION

Intensive entomological investigations have been carried out at the Leipzig crane site in the years 2001 to 2003, to evaluate the diversity and distribution of both flying and non-flying arthropods in its canopy region (see contributions in this volume). Besides hand collections from aerial inflorescenses of *Acer*, *Tilia*, *Fraxinus*, and *Quercus* trees (TAL, this volume) and tree fogging (FLOREN & SPRICK, this volume), several trap types were used to investigate the arthropod fauna in tree crowns. The forest floor was also investigated using pitfall traps (Carabidae; ARNDT & HIELSCHER, this volume).

Figure 1 – Window trap in a tree crown of the Leipzig crane site. The handrail of the orange coloured gondola is visible in the front.

[1]corresponding author

Window trap (Flight interception traps)

Composite flight-interception traps (BASSET *et al.* 1997, SCHUBERT 1998) were used to catch flying insects (e.g. wasps, gnats, aphids, beetles). The insect flight is interrupted when it hits the acrylic glass pane. Good and light flyers try to overcome the obstacle by flying upwards. They are conducted then into the container partly filled with diethylene glycol. Bad and heavy flyers plump down through the funnel into a second vessel (Fig. 1).

Branch eclectors

The full range of crawling arthropods can be recorded with this trap type. The tubular shaped trap is installed around a branch, fixed and closed on one side. Animals moving on the branch surface are conducted through the only opening and are trapped either in the upper or lower vessel (Fig. 2). Construction and use of branch eclectors followed SIMON (1995).

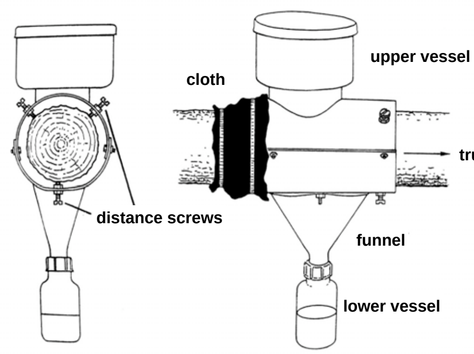


Figure 2 – Branch eclector fixed to a branch in the canopy (left); schenatic drawing (right; from SIMON, 1995).

Stem eclectors

Stem eclectors following the method of FUNKE (1971) and BEHRE (1989) were installed on one tree each of *Quercus robur*, *Tilia cordata*, and *Fraxinus excelsior*, to get an impression of the activity of climbing invertebrates in the years 2002 and 2003 (Fig. 3). Stem eclectors measure ground-canopy-interactions of the invertebrate fauna. They are installed using a steel ring under which the mounts carrying the white sampling tins are clamped. The black cloths are also clamped under a steel ring. The type of branch eclectors described here is a variant to sample the fauna that moves from ground to the tree top.

Figure 3 – Stem eclector fixed around a large *Tilia cordata* tree in about 3 m in height.

Sampling design

The arthropod fauna of the tree crowns at the crane site was examined using 50 window traps with two in each of 25 trees and 48 branch eclectors with four in each of 12 trees (Fig. 4, Appendix Table 1).

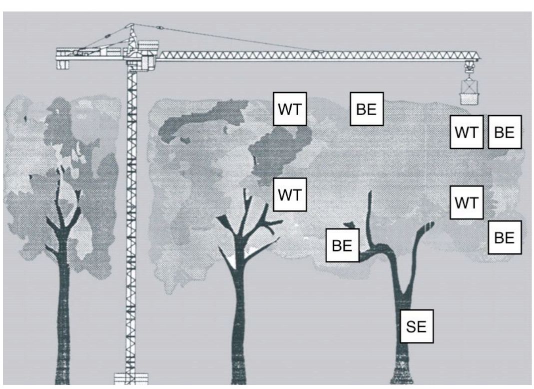


Figure 4 – Schematic view of the sampling design used for flight interception traps (WT) and branch eclectors (BE).

The window traps were fixed at two levels (26 m average [light crown] and 22 m average [shadow crown] respectively), and sampled at two weekly intervals from the beginning of May to the end of Oktober 2002 and from early April to late October 2003. The branch eclectors were sampled at four weekly intervals in the same periods. Fig. 5 shows the exact positions of the trees selected for installing the traps whereas Appendix Table 1 depicts the exact locations of every individual trap in metres above ground in the years 2002 and 2003. Six trees each of *Q. robur*, *T. cordata*, *F. excelsior*, four trees of *Acer pseudoplatanus*, two of *Q. rubra*, and one tree each of *F. pennsylvanica* and *Robinia pseudacacia* where prepared with window traps.

Twelve of these trees were also used for branch eclectors. In 2002: Four trees each of *Q. robur*, *T. cordata*, and *F. excelsior*, two per tree in the lower crown (ø 20 m in height) and two in the upper crown (ø 27 m). In 2003: Three trees each of *Q. robur*, *T. cordata*, and *F. excelsior*, two of *A. pseudoplatanus* and one *Q. rubra* tree (Appendix Table 1). This sample design made possible a statistical analysis of the main trees on side but also trends of species composition in neophytic trees on the other side.

Additionally, stem eclectors were installed on one tree individual of *Q. robur*, *T. cordata*, and *F. excelsior*, respectively, to get an impression of the activity of climbing invertebrates (compare Stenchly *et al.*, this volume).

This sample design made possible a statistical analysis of the main trees on side but also trends of species composition in neophytic trees on the other side. In contrast to most of the formerly used methods of studying temperate canopies (e.g. cutting of trees, cutting of branches, fogging with pyrethrum), the use of a crane and the mentioned trap types are little destructive and allowed continuous and comparable research of the tree crowns.

In contrast to most of the formerly used methods of studying temperate canopies (e.g. cutting of trees, cutting of branches, fogging with pyrethrum), the use of a crane and the mentioned trap types are little destructive and allowed continuous research of the tree crowns.

ACKNOWLEDGEMENTS

We are grateful to Dr. Manfred Verhaagh (Natural History Museum, Karlsruhe, Germany) and Dr. Ulrich Simon (Freising, Germany) for providing a majority of flight interception traps and branch eclectors. We thank Prof. Joachim Adis (Max Planck Institute of Limnology, Plön, Germany) for allocation of the trunk eclectors and Mr. H. Wolf (University Leipzig) for the construction of additional window traps and maintenance repairs during the sampling periods. Special thanks also go to many students engaged with installing and emptying the traps.

REFERENCES

ARNDT, E. & S. HIELSCHER (in press) Ameisen (Hymenoptera: Formicidae) im Kronenraum des Leipziger Auwaldes. *Veröffentlichungen Naturkundemuseum Leipzig.*

BASSET Y., SPRINGATE N.D., ABERLENE H.P. & DELVARE, G. (1997) A review of methods for sampling arthropods in tree canopies. In: Stork N.E., Adis J. & Didham R.K. (Eds.) Canopy arthropods, Chapman & Hall, London. 27-52.

BEHRE, G.F. (1989) Freilandökologische Methoden zur Erfassung der Entomofauna (Weiter- und Neuentwicklung von Geräten). *Jahresberichte des naturwissenschaftlichen Vereins Wuppertal* **42**: 1-6.

FUNKE, W. (1971): Food and energy turnover of leaf-eating insects and their influence on primary production. *Ecological Studies* **2**: 81-93.

SCHUBERT, H. (1998) Untersuchungen zur Arthropodenfauna in Baumkronen – Ein Vergleich von Natur- und Wirtschaftswäldern (Araneae, Coleoptera, Heteroptera, Neuropteroidea; Hienheimer Forst, Niederbayern). Wissenschaft und Technik Verlag Berlin.

SIMON, U. (1995) Untersuchung der Stratozönosen von Spinnen und Weberknechten (Arachn.: Araneae, Opilionida) an der Waldkiefer (Pinus sylvestris L.). - Wissenschaft und Technik Verlag, Berlin.

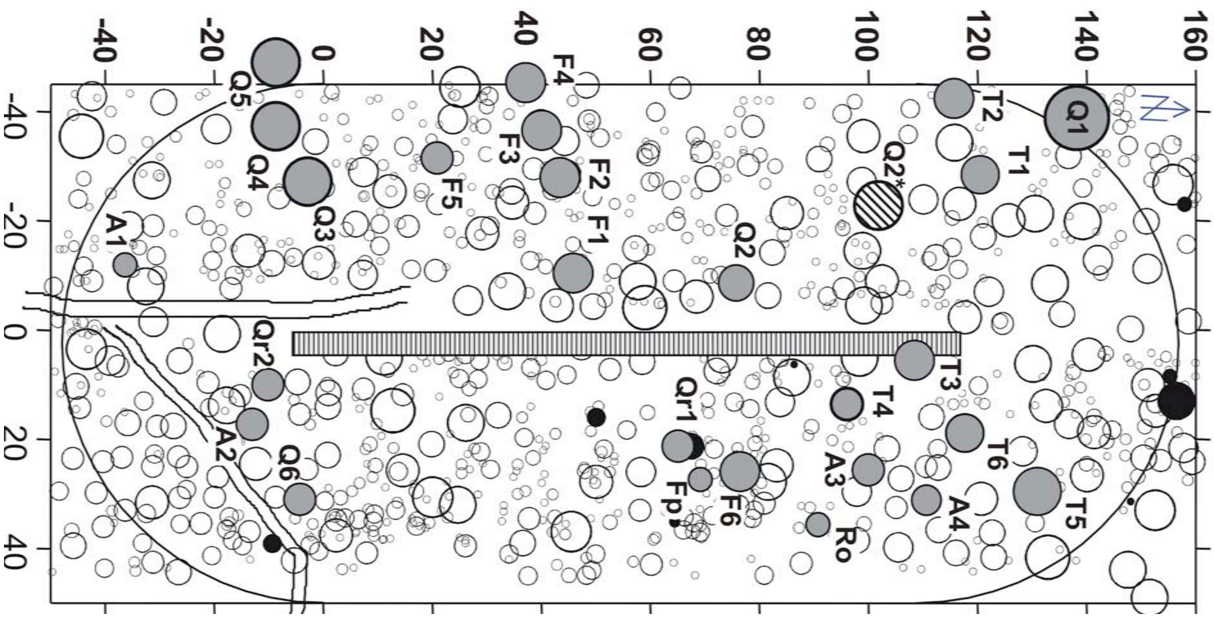


Figure 5 – Exact position of the trees selected for the different trap types in the investigation site (redrawn from ARNDT & HIELSCHER, 2006). A: Acer pseudoplatanus; F: Fraxinus excelsior; Fp: Fraxinus pennsylvanica; Q: Quercus robur; Qr: Quercus rubra; T: Tilia cordata.

Appendix Table 1 – Positions of window traps (WT) and branch eclectors (BE) in the tree crowns of the investigation site; N: northern part of the tree crown; W: western part; S: southern part; E: eastern part.

Tree	Trap	2002		2003	
		Height in m	Exposition	Height in m	Exposition
Quercus robur 1	WT 1	27.8	–	27.4	–
	WT 2	24.2	–	20.1	–
Quercus robur 2	WT 3	27.8	–	29	–
	WT 4	24	–	20.5	–
	BE 1	25.3	N	–	–
	BE 2	29.7	SW	–	–
	BE 3	20.3	N	–	–
	BE 4	24	NW	–	–
Quercus robur 3	WT 5	28.4	–	28.1	–
	WT 6	23	–	20	–
	BE 5	27.6	N	27.6	N
	BE 6	27.8	W	27.8	W
	BE 7	16.2	NE	16.2	NE
	BE 8	19	W	19	W
Quercus robur 4	WT 7	27.7	–	27.7	–
	WT 8	20.5	–	20.4	–
	BE 9	27.3	NW	27.3	NW
	BE 10	27.8	W	26.9	S
	BE 11	20	W	22.7	NW
	BE 12	21.5	S	21.5	S
Quercus robur 5	WT 9	25.4	–	26.5	–
	WT 10	18.1	–	20.1	–
Quercus robur 6	WT 11	23.7	–	27.1	–
	WT 12	19.3	–	18.4	–
	BE 13	22	E	22	E
	BE 14	15.6	E	15.6	E
	BE 15	22.5	S	15.6	E
	BE 16	13.7	E	18.6	N
Tilia cordata 1	WT 13	26.6	–	26.2	–
	WT 14	22.8	–	19.2	–
	BE 17	24.7	N	26	N
	BE 18	26.6	W	25.8	W
	BE 19	20	W	20	W
	BE 20	17.1	N	21.8	E
Tilia cordata 2	WT 15	26.3	–	25.8	–
	WT 16	22.5	–	19.3	–
Tilia cordata 3	WT 17	26.3	–	26.7	–
	WT 18	22	–	19.4	–
	BE 21	26.5	E	–	–
	BE 22	25.2	SE	–	–
	BE 23	18	NW	–	–
	BE 24	20.5	W	–	–

Appenidx Table 1 continued – Positions of window traps (WT) and branch eclectors (BE) in the tree crowns of the investigation site.

Tree	Trap	2002		2003	
		Height in m	Exposition	Height in m	Exposition
Tilia cordata 4	WT 19	28.2	–	27.4	–
	WT 20	24	–	19	–
	BE 25	26.3	N	27	NE
	BE 26	26.3	E	27.6	W
	BE 27	17.8	N	17.6	N
	BE 28	18.2	S	18.2	S
Tilia cordata 5	WT 21	28.5	–	27.8	–
	WT 22	24.3	–	21.1	–
	BE 29	27.5	E	26.7	N
	BE 30	27.2	S	25.9	W
	BE 31	20.9	E	19.4	E
	BE 32	20.9	S	19.5	W
Tilia cordata 6	WT 23	25	–	27.7	–
	WT 24	20.6	–	20.3	–
Fraxinus excelsior 1	WT 25	29.2	–	29	–
	WT 26	23.8	–	20.3	–
	BE 33	28.1	S	28.1	S
	BE 34	29.2	W	29.2	W
	BE 35	22.4	S	22.4	S
	BE 36	23.8	SW	22.5	W
Fraxinus excelsior 2	WT 27	26.7	–	26.8	–
	WT 28	21	–	19.8	–
	BE 37	27	N	27	E
	BE 38	27.5	N	27.5	N
	BE 39	22.4	NE	22.3	E
	BE 40	22.5	NE	22.5	NW
Fraxinus excelsior 3	WT 29	28.9	–	26.9	–
	WT 30	24.6	–	20.1	–
Fraxinus excelsior 4	WT 31	29.1	–	27.4	–
	WT 32	23.2	–	20.9	–
	BE 41	30.6	W	–	–
	BE 42	29.1	SE	–	–
	BE 43	24.7	N	–	–
	BE 44	21.4	S	–	–
Fraxinus excelsior 5	WT 33	26.6	–	26.5	–
	WT 34	23.8	–	20.8	–
Fraxinus excelsior 6	WT 35	28	–	27.1	–
	WT 36	24.9	–	20.1	–
	BE 45	28.6	SE	27	E
	BE 46	28	W	26.7	W
	BE 47	20.1	SE	19.3	E
	BE 48	18.1	SW	22.2	NW

Appenidx Table 1 continued – Positions of window traps (WT) and branch eclectors (BE) in the tree crowns of the investigation site.

Tree	Trap	2002		2003	
		Height in m	Exposition	Height in m	Exposition
Acer pseudoplatanus 1	WT 37	27.7	–	24.1	–
	WT 38	23.2	–	16.8	–
Acer pseudoplatanus 2	WT 39	24.2	–	25.1	–
	WT 40	21.1	–	17.8	–
	BE 49	–	–	21.4	SW
	BE 50	–	–	25.3	NW
	BE 51	–	–	17	SW
	BE 52	–	–	16.8	NW
Acer pseudoplatanus 3	WT 41	22.8	–	27.3	–
	WT 42	18.1	–	20.2	–
Acer pseudoplatanus 4	BE 53	–		27.7	NW
	BE 54	–	–	27	W
	BE 55	–	–	20.1	NE
	BE 56	–	–	22.5	N
Robinia pseudacacia	WT 43	24.8	–	27	–
	WT 44	20.4	–	19.9	–
Fraxinus pennsylvanica	WT 45	25.2	–	25.4	–
	WT 46	20.1	–	19.3	–
Quercus rubra 1	WT 47	24.4	–	25	–
	WT 48	18.7	–	17.9	–
Quercus rubra 2	WT 49	26.8	–	27.1	–
	WT 50	19.5	–	20.3	–
	BE 57	–	–	26	S
	BE 58	–	–	26.2	N
	BE 59	–	–	18.4	SW
	BE 60	–	–	19.1	NW

3.2 Arboricolous spiders (Arachnida, Araneae) of the Leipzig floodplain forest – first results

Kathrin Stenchly[1], Detlef Bernhard & Oliver-D. Finch

During 2002 and 2003 an extensive study of the arthropod fauna, including the spider fauna, was carried out within the research plot of the Leipzig Canopy Crane Project. Bark-inhabiting spiders were collected using five upwards-directed stem eclectors installed at three autochthonous and abundant tree species: *Fraxinus excelsior*, *Quercus robur*, and *Tilia cordata*. Branch traps were used to sample arboricolous spiders that dwell in the canopy. For each investigated tree, two branch traps were arranged at the lower and at the upper canopy areas, resulting in a total of 48 traps. Additionally, 50 flight-interception traps at two different heights were used to investigate the ballooning activity of spiders in the canopy. Using the combination of different trap types a comprehensive analysis of the diversity of spiders was realised. Thus, on the one hand, comparisons of the spider fauna between different tree species were possible. On the other hand, investigations of different elevations enabled us to compare two strata of the canopy. The presented results refer to samples of the year 2002. A total of 4 289 spiders belonging to 71 species (15 families) were recorded. Clubionidae were dominant in both strata (trunk zone and canopy). Amaurobiidae, Linyphiidae, and Theridiidae were abundant on the trunks, whereas Anyphaenidae, Philodromidae, and also Theridiidae were common groups in the canopy. The most active species were *Coelotes terrestris* (trunks) and *Anyphaena accentuata* (canopy). The spider fauna of the stems comprised 52% web-builders and 48% free living hunters, however, more hunters than web-builders occurred in the canopy. Trunks of *Quercus robur* showed the most abundant spider fauna with highest species richness compared to both other tree species. In the *Quercus* canopies spider species richness was also high, but activity was low. Preferences of certain spider species for single tree species were not detected. Further data from 2003 will strengthen these preliminary results.

INTRODUCTION

Concerning the tree canopies of tropical forests, it is known that they hold an extremely high animal diversity (e.g. Erwin 1988; Lowman & Nadkarni 1995; Stork, Adis & Didham 1997; Adis 2001; Floren & Linsenmair 2001; Basset 2001; Adis & Junk 2002). It has not yet been clarified whether a comparably high biodiversity can be found in the canopy of temperate forests, since only a small number of investigations exist so far (e.g. Barnard, Brooks & Stork 1986; Barbosa & Wagner 1989; Reynolds & Crossley 1997; Stork & Hammond 1997; Stork *et al.* 2001; Thunes, Skarveit & Gjerde 2003). Due to the small number of projects, which mostly have been started recently, knowledge about the canopy-specific fauna, including that of central Europe, is still limited (e.g. Klomp & Teerink 1973; Ammer & Schubert 1999; Floren & Schmidl 1999). Species adaptations, e.g. to certain heights within the canopies or to different tree species, have been the subject of little research so far.

Spiders from the canopy region of central European tree species have been studied to varying degrees (e.g. Hesse 1939; Engelhardt 1958; Simon 1995; Gutberlet 1997; Schubert 1998), yet overall the canopy stratum is among the least commonly investigated habitats of forests for this animal group. Detailed knowledge concerning the requirements of the species, together with for example the abundance and ecological function of spiders in tree canopies, is almost completely lacking.

So far, investigations of the fauna of central European tree canopies have mostly been carried out using highly destructive methods that make a continuous investigation impossible (including tree felling, e.g. Engelhardt 1958; Hesse 1939; sawing off branches, e.g. Klomp & Teerink 1973), or the entire fauna was removed at a time by fogging (e.g. Floren & Schmidl 1999; Floren & Otto 2002). As part of the Leipzig Canopy Crane Project in the

[1]corresponding author

Burgaue nature reserve a non-destructive trap system was set up in the tree canopies with the aid of a crane, enabling almost unlimited access to all tree regions. It was therefore possible to provide continuous analysis throughout the vegetation period. Analyses of bark-inhabiting and canopy-active arthropod fauna, in which spiders were also condsidered, took place in 2002 and 2003. In the present article, results concerning spiders caught during the year 2002 are presented, while an evaluation of the results from 2003 remains to be done. The following questions are in focus: **(1)** What is the community structure of spiders in the canopies or, respectively, on trunks and how large is their species richness? **(2)** Do spiders living on trunks or in the canopies show a preference for certain tree species and are there differences between different tree species? **(3)** Are certain canopy regions preferred by spiders? **(4)** What is the phenology of spiders in the canopy area?

MATERIALS AND METHODS

Open, upwards-directed stem-eclectors (tree photoeclectors; e.g. Funke & Sammer 1980; Simon 1995), branch traps and flight-interception traps (e.g. Winter *et al.* 1999) were used to analyse the spider fauna. (Arndt & Unterseher, this volume). In total, stem-eclectors were installed at five living trees, of which two stood at respectively in a gap. Thus the intention was to search for potential differences in the range of species as a result of altered parameters such as light intensity and temperature in the trunk region. In the closed forest stand, an oak (*Quercus robur*), ash (*Fraxinus excelsior*), and lime (*Tilia cordata*) were each equipped with a stem-eclector, in the vicinity of the gap, one ash and one lime tree.

Of the branch traps, two in each case were installed in the upper canopy regions (27.0 m ± 2.0 m) and in the lower canopy regions (20.0 m ± 2.8 m). In total, 12 trees were equipped with branch traps ($\sum = 48$). The three tree species *Q. robur*, *F. excelsior* and *T. cordata* were likewise taken into account and four trees in each case equipped with four branch traps.

The free-hanging flight-interception traps were attached at an average height of 27.0 m (± 1.8 m) and 22.0 m (± 2.2 m). Of the three main tree species mentioned above, six trees in each case were fitted with one trap in the upper, and one trap in the lower canopy region ($\sum = 36$). The tree species *Acer pseudoplatanus* (6 traps), *Robina pseudoacacia* (2 traps), *Fraxinus pennsylvanica* (2 traps) and *Quercus rubra* (4 traps), also equipped with fligth-interception traps, had a lower number of traps. The killing-preserving agent was H_2O dest. diluted diethylenglycol (ratio 1 : 1). After emptying, the animals were transferred to 70% ethanol. The investigation period under consideration in this article was 22/4/-21/10/2002 for both eclector types and for the flight-interception traps 9/5/-21/10/2002.

RESULTS

Species numbers and numbers of individuals

During the first year of the investigation, 2002, a total of 4 289 spider individuals were caught with all the traps used. So far 71 species belonging to 15 families were recorded (Table 1). *Pachygnatha*-, *Pholcus*-, *Scotophaeus*- and *Zelotes*-species were caught only as juveniles. More than 80% of the species were characteristic for dry or humid mixed deciduous forests. 40 species were classified as arboricolous spiders, of which 11 were stenotopic bark-inhabiting spiders.

Diaea livens (on *Q. robur* and *T. cordata*), *Philodromus albidus* (on *F. excelsior*, *Q. robur*, and *T. cordata* as well as in flight-interception traps) and *P. praedatus* (on *F. excelsior* and *Q. robur* as well as in flight-interception traps) were recorded for the first time in Saxony (Tolke & Hiebsch 1995). *P. buxi* (on *T. cordata* and in flight-interception traps) has only rarely been found in Germany so far. There is only one record of this species for the federal state of Saxony (Martin 1973 in Tolke & Hiebsch 1995). The rare Theridiidae *Theridion blackwalli* (in flight-interception traps) was likewise only recorded once in Saxony (Heimer 1982). *Entelecara congenera* is classified in Saxony's Red List in the "highly endangered" risk category; *Gibbaranea gibbosa*, *Lathys humilis* and *Micaria subopaca* are deemed "at risk" (Hiebsch & Tolke 1996).

Stem-eclectors

In total, only 234 individuals were recorded in the stem region using the five trunk eclectors. 200 of them were identified down to the species, genus or family level, respectively. The 111 adult spiders belonged to 23 species (Table 2).

With a total of 62 individuals (31%, Fig. 1) the Clubionidae were the dominant family. Further abundant families were the Amaurobiidae (16%) together with the Theridiidae and the Linyphiidae, each with a proportion of around 15% of the total catch. The Salticidae represented 11% of the bark-inhabiting spiders. Both the Agelenidae and Gnaphosidae appeared subdominantly, each at 5%. The families Anyphaenidae, Dictynidae, Philodromidae and Thomisidae were present with less than four individuals. Web-builders represented 52% of the total catch, of which 18% were funnel-web-builders. The remaining 48% were free living hunters. Of these 37% were nocturnal hunters (e.g. Clubionidae), the remaining 11% were day-active (e.g. Salticidae).

Table 1 – List of spider species that were recorded with different trap types during 2002 (*: new to Saxony, trap types: A: branch trap, F: flight-interception trap, S: stem-eclector).

	A	**F**	**S**		**A**	**F**	**S**
Agelenidae				**Metidae**			
Tegenaria ferruginea			S	*Metellina segmentata*	A	F	
Tegenaria silvestris	A			**Philodromidae**			
Amaurobiidae				*Philodromus albidus**	A	F	
Coelotes terrestris	A		S	*Philodromus aureolus*	A		
Anyphaenidae				*Philodromus buxi*	A	F	
Anyphaena accentuata	A	F	S	*Philodromus praedatus**	A	F	
Araneidae				*Philodromus rufus*	A	F	
Araneus diadematus	A			**Pholcidae**			
Araneus sturmi		F		*Pholcus* spec. juv.	A		
Araneus triguttatus		F		**Salticidae**			
Araniella cucurbitina		F		*Ballus chalybeius*	A	F	
Cyclosa conica		F		*Salticus zebraneus*	A	F	S
Gibbaranea gibbosa	A			**Tetragnathidae**			
Larinioides patagiatus	A	F		*Pachygnatha* spec. juv.		F	
Nuctenea umbratica	A	F		*Tetragnatha montana*	A		
Clubionidae				*Tetragnatha obtusa*	A	F	
Clubiona brevipes	A	F	S	**Theridiidae**			
Clubiona corticalis	A	F	S	*Achaearanea lunata*	A	F	
Clubiona pallidula	A	F		*Achaearanea simulans*		F	
Clubiona reclusa	A			*Anelosimus vittatus*	A	F	
Dictynidae				*Dipoena melanogaster*	A		
Dictyna pusilla	A	F		*Enoplognatha ovata*	A	F	S
Lathys humilis	A	F		*Paidiscura pallens*		F	
Nigma flavescens		F		*Theridion blackwalli*		F	
Gnaphosidae				*Theridion melanurum*	A	F	
Scotophaeus spec. juv.	A			*Theridion mystaceum*	A	F	S
Micaria subopaca	A	F	S	*Theridion pictum*	A		
Zelotes spec. juv.			S	*Theridion pinastri*	A	F	
Linyphiidae				*Theridion tinctum*	A	F	S
Araeoncus humilis		F		*Theridion varians*		F	
Bathyphantes nigrinus		F		**Thomisidae**			
Ceratinella brevis		F		*Diaea dorsata*	A		S
Diplocephalus latifrons		F		*Diaea livens**	A		
Diplocephalus picinus		F		*Xysticus lanio*	A	F	S
Drapetisca socialis			S				
Entelecara acuminata	A	F					
Entelecara congenera			S				
Entelecara erythropus			S				
Entelecara flavipes		F					
Erigone atra		F					
Erigone dentipalpis		F					
Lepthyphantes minutus	A		S				
Lepthyphantes tenuis		F	S				
Linyphia triangularis	A		S				
Maso sundevalli			S				
Meioneta rurestris		F	S				
Moebelia penicilata	A		S				
Neriene montana	A		S				
Oedothorax apicatus		F	S				
Trematocephalus cristatus		F					

Table 2 – Abundance of spiders at tree trunks (only adult specimen).

Species	Family	Individuals
Coelotes terrestris	Amaurobiidae	21
Salticus zebraneus	Salticidae	16
Enoplognatha ovata	Theridiidae	16
Drapetisca socialis	Linyphiidae	8
Clubiona corticalis	Clubionidae	8
Tegenaria ferruginea	Agelenidae	7
Theridion mystaceum	Theridiidae	7
Leptyphantes minutus	Linyphiidae	5
Entelecara congenera	Linyphiidae	3
Theridion tinctum	Theridiidae	3
Anyphaena accentuata	Anyphaenidae	2
Clubiona brevipes	Clubionidae	2
Entelcara erythropus	Linyphiidae	2
Moebelia penicillata	Linyphiidae	2
Micaria subopaca	Gnaphosidae	1
Leptyphantes tenuis	Linyphiidae	1
Linyphia triangularis	Linyphiidae	1
Maso sundevalli	Linyphiidae	1
Meioneta rurestris	Linyphiidae	1
Neriene montana	Linyphiidae	1
Oedothorax apicatus	Linyphiidae	1
Diaea dorsata	Thomisidae	1
Xysticus lanio	Thomisidae	1
total		111

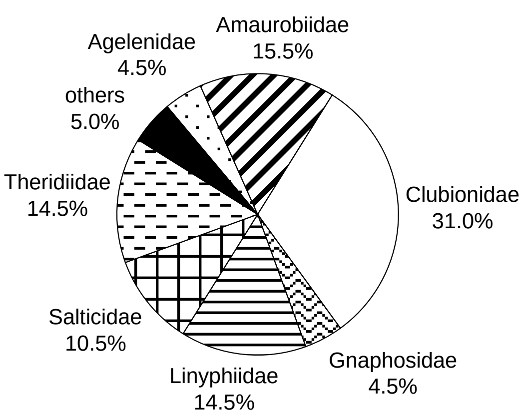


Figure 1 – Proportion of single spider families in the total catch of the stem-eclectors (n = 200 ind.; without unidentified immature spiders).

The Linyphiidae (11 species) were the most species-rich family. The Theridiidae were represented with three species characteristic for the lower trunk zone. Among the trunk inhabiting Clubionidae were the typical bark spiders *Clubiona corticalis* and *C. brevipes*. *Coelotes terrestris* (Amaurobiidae) was predominantly recorded on trunks of *Q. robur*. *Tegenaria ferruginea* (Agelenidae) was identified as a further common species in the trunk area, likewise preferring stems of *Q. robur*. From the Salticidae only *Salticus zebraneus* was recorded. It was present with a higher number of individuals (n = 15) on the free-standing stem of *F. excelsior*. Of the Gnaphosidae and Dictynidae predominantly juvenile and sub-adult individuals were caught.

Taking into account the overall small total catch in the stem eclectors, the trunk area of *Q. robur* produced the highest diversity of species and families (Table 3). The highest numbers of individuals were also recorded on this tree species. The high proportion of epigeic spiders (mainly Agelenidae and Amaurobiidae) was striking. Theridiidae, Linyphiidae and Clubionidae were also common. The catches on *T. cordata* and *F. excelsior* in the closed forest stand produced similar results to those on *Q. robur*. *F. excelsior* in the forest gap, by contrast, showed a different family range due to the appearance of Salticidae and Gnaphosidae. The trunk of the free-standing lime tree showed the lowest diversity. Only three species of three families were recorded. Here, too, the Clubionidae dominated.

Table 3 – Number of spider families, species and individuals collected with stem-eclectors at the five tree trunks.

Tree	Families	Species	Individuals
Fraxinus excelsior (forest stand)	5	12	24
Fraxinus excelsior (gap)	7	15	44
Quercus robur (forest stand)	9	22	67
Tilia cordata (forest stand)	8	17	57
Tilia cordata (gap)	3	3	8

Branch traps

In 2002 a total of 2 436 individuals were recorded in the branch traps. 977 juveniles were determined only to a higher taxonomic level; the 1 316 adults belonged to 42 species.

As in the trunk area, the Clubionidae family was also dominant in the tree canopies (33%, Fig. 2). The Theridiidae too, with approx. 16%, showed similarly high proportions in the total catch as in the trunk region. The Anyphaenidae were encountered considerably more often in the canopies (21%). Further, considerably higher catch numbers of the Philodromidae (13%) were registered in the canopy area. The most abundant guild within the canopy-active spider community recorded with branch traps were the hunters (76%). Spaceweaving species made up to 17% and orbweavers 5%.

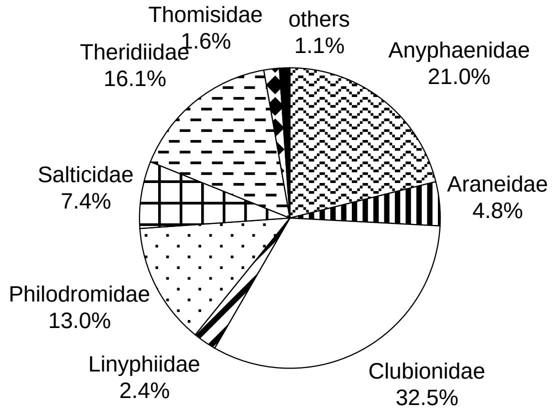


Figure 2 – Proportion of single spider families in the total catch of the branch traps (n = 2 436 ind.).

Among the 1 316 adult spiders, *Anyphaena accentuata* (Anyphaenidae) was eudominant at 34%. *Clubionia brevipes* (19%) and *Theridion tinctum* (11%) were dominant, *Salticus zebraneus* (8%), *Clubiona pallens* (6%), *Clubiona corticalis* (5%), and *Nuctenea umbratica* (3%) subdominant species. Thus the proportion of main species in the total catch was 86%.

An analysis of the preference behaviour of the individual families with respect to height revealed that the Salticidae and Clubionidae were concentrated in the upper canopy region (27.0 m±2.0 m) (Table 4); by contrast, Linyphiids were recorded in the lower canopy region (20.0 m±2.8 m).

Table 4 – Most dominant spider families in the lower and the upper canopy.

Family	Lower canopy	Upper canopy
Anyphaenidae	53%	47%
Philodromidae	49%	51%
Theridiidae	54%	46%
Clubionidae	39%	61%
Salticidae	20%	80%
Linyphiidae	75%	25%

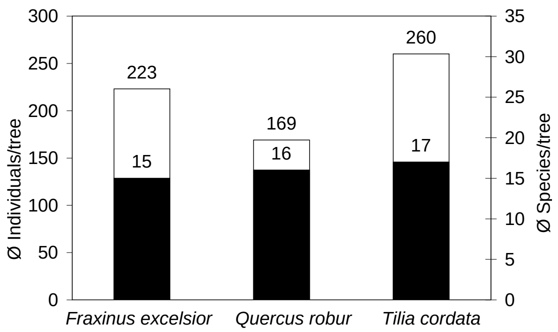


Figure 3 – Mean total catch of individuals and species per investigated tree species.

Table 5 – Mean number of individuals (SD: standard deviation) of dominant spider families in the canopies of the investigated tree species.

Family	*Fraxinus excelsior*		*Quercus robur*		*Tilia cordata*	
	Ø ind./tree	SD	Ø ind./tree	SD	Ø ind./tree	SD
Anyphaenidae	41	±10	36	±15	52	±5
Clubionidae	81	±17	49	±11	69	±24
Philodromidae	20	±2	24	±17	37	±31
Salticidae	14	±3	14	±9	18	±18
Araneidae	9	±4	9	±5	12	±6
Theridiidae	33	±6	25	±12	42	± 20

Table 6 – Most dominant spider species in the lower and the upper canopy.

Species	Lower canopy	Species	Upper canopy
Anypaena accentuata	45.8%	*A. accentuata*	25.6%
Clubiona brevipes	11.3%	*C. brevipes*	23.2%
Theridion tinctum	10.0%	*T. tinctum*	10.9%
Clubiona corticals	6.5%	*S. zebraneus*	9.7%
Clubiona pallidula	4.9%	*C. pallidula*	7.4%
Salticus zebraneus	4.9%	*Gibbaranea gibbosa*	4.5%
Nuctenea umbratica	3.8%	*Theridion pinastri*	4.1%
Moebelia penicillata	3.3%	*Clubiona corticals*	3.4%

No clear pattern for either of the two canopy regions could be observed for any of the remaining families.

Comparisons of the three tree species investigated using the results from the branch traps in respect of their inventory of individuals or species showed that the highest numbers of individuals and species appeared on *T. cordata* (Fig. 3). 16 spider species on average were recorded on *Q. robur*, even though the fewest individuals were caught on this tree species. On average, the second-highest number of individuals per tree was recorded on *F. excelsior* (15 species). There was no recognisable preference for any of the three investigated tree species (*F. excelsior*, *Q. robur* and *T. cordata*) for any spider family so far. A consideration of individual species so far has also not revealed any clear preference for a particular tree species (Table 5). Slight differences became evident between the upper and lower canopy area (Table 6). For example, *Anyphaena accentuata* was eudominant in the lower canopy area, while the proportion of this species was smaller in the spider community in the upper canopy area. There, proportions of *Clubiona brevipes* increased.

The highest activity of adult spiders appeared during the early summer (Fig. 4), the activity phenology of sexually mature spiders differing considerably from that of the juvenile animals. Thus, the adult spiders were most active at the beginning of June. At this time, the recorded number of males was more than double that of females. During the vegetation period the number of recorded adults declined continuously, while the number of juveniles increased steadily until the end of October.

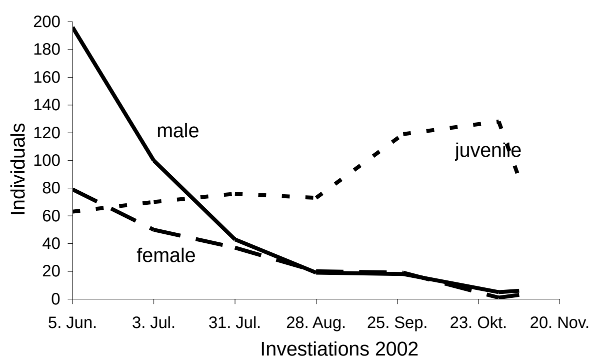


Figure 4 – Activity phenology of adult and immature spiders during 2002.

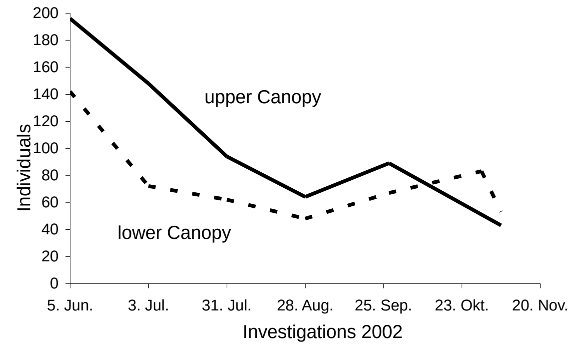


Figure 5 – Activity phenology of spiders in branch traps of the lower and the upper canopy during the year 2002.

The peak of the juveniles' activity came at the end of October, at the close of the investigations. While upper and lower canopy area differed in respect of their spider communities (see above), only slight differences could be seen in the spiders' activity phenology (Fig. 5). Of the two activity peaks observed, the second peak was only achieved in the lower canopy region about one month later than in the upper.

Flight-interception traps

A total of 1 618 individual spiders were recorded in the flight-interception traps. These were predominantly juvenile. The proportion of adult animals was only 27% (n = 434 ind.), and they belonged to 47 species and 12 families. Theridiidae, Clubionidae, Philodromidae and Anyphaenidae were predominantly recorded (Fig. 6).

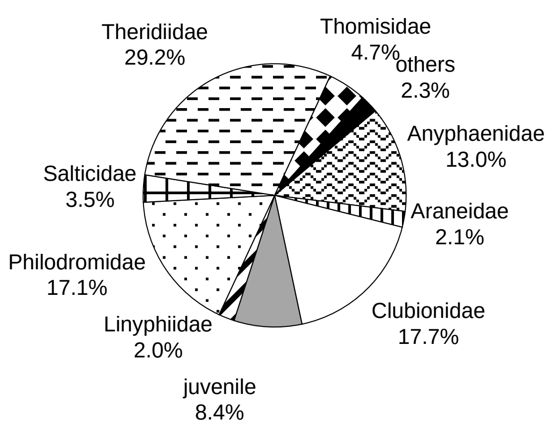


Figure 6 – Proportion of single spider families in the total catch of the flight-interception traps (n = 1 618 ind.).

The Theridiidae were the most abundant family (29%). The Clubionidae and Philodromidae were similarly abundant (18% resp. 17%), followed by the Anyphaenidae, which achieved a proportion of 13%.

Clubionia brevipes (18%), *Anyphaena accentuata* (14%) and *Theridion tinctum* (14%) were common. *Salticus zebraneus* (9%), *Philodromus albidus* 6%, *Theridion blackwalli* 4% and *T. pinastri* 4% were subdominant. The proportion of main species was 70%. With reference to their hunting behaviour, 61% of the individuals were hunters, and 36% were web-building spiders.

The highest numbers of adults appeared from mid-May to mid-June (Fig. 7); thereafter their number declined considerably, while the number of juveniles increased sharply and reached its maximum at the end of September.

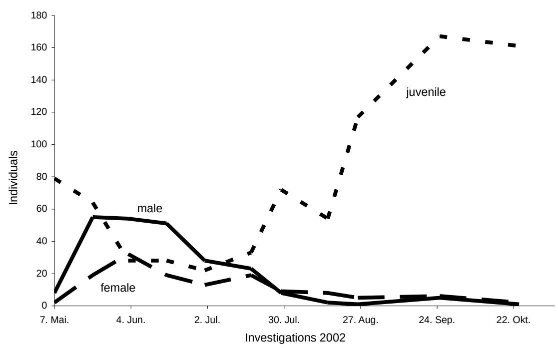


Figure 7 – Activity phenology of adult and immature spiders in flight-interception traps during 2002.

So far, a number of species have been recorded exclusively in flight-interception traps. Among these many Linyphiids, such as *Diplocephalus picinus*, *D. latifrons*, *Ceratinella brevis* and *Trematocephalus cristatus*. A number of other species, such as *Theridion blackwalli* (Theridiidae) and *Cyclosa conica*, *Araneus sturmi* and *A. triguttatus* (Araneidae), so far have likewise only been recorded using this method.

DISCUSSION

Bark and canopy spiders

Although several central-European spider species were described as stenotopic bark-inhabiting spiders (e.g. Wunderlich 1982), they are mostly only present in the trunk area during certain phases of their life cycle. Many spiders hibernate, for example, in the litter layer of the forest floor and then dwell to higher strata during the vegetation period. They may remain in the trunk area or simply migrate through it in order to reach the canopy (e.g. Funke & Sammer 1980, Simon 2002). Therefore, on trees, two groups of spiders can be distinguished with reference to their preferred habitat: on the one hand, species which reproduce in the canopy and on the other, species which are associated with tree trunks and in particular with bark (Kubcová & Schlaghamersky 2002). So, although *Anyphaena accentuata* (Anyphaenidae), belongs to the first group, it appeared occasionally on the trunks particularly at the start of our investigations. This species was principally recorded in the tree canopies and counts among the dominant spiders there. The trunk is used by this species predominantly as a transitional area, since according to our data mainly juveniles migrate to the canopy. Furthermore, *Clubionia brevipes*, *Theridion tinctum* and *Salticus zebraneus* count among the characteristic elements of the spider fauna active in the canopy of the Leipzig floodplain forest. *Drapetisca socialis*, by contrast, was in our investigations only recorded in the trunk area, but not in the canopy. This is confirmed by the results of Simon (2002), who, in contrast to Ellenberg *et al.* (1986), classifies this species as being stenotopic on trunks, but not as an inhabitant of high tree canopies.

In the Leipzig floodplain forest, among the spiders defined as characteristic for tree barks according to Wunderlich (1982) are *Clubiona corticalis*, *Drapetisca socialis*, *Micaria subopaca*, *Moebelia penicillata* and *Theridion mystaceum*. However, species of the field layer (e.g. *Enoplognatha ovata*), as well as epigeic species, were also recorded (see also Braun 1992). The former include for example *Coelotes terrestris*, which occurred during other investigations also with a high abundance in stem eclectors (e.g. Finch 2001). This species evidently leaves the forest floor from time to time, for example on its search for a mate.

The influence of various parameters on the spider cenosis

Evidence as to the influence of bark structure arise from the comparative investigations of the three tree species with varying bark structures using stem eclectors. According to this, the bark of *Q. robur* represents a particularly suitable habitat for spiders. Its deep and wide bark furrowing appears to provide a well structured habitat for web-building as well as good opportunities for hiding. Web-building spider families (Linyphiidae, Theridiidae) therefore were well established at the oak stem. For the Theridiidae in particular, bark structure may be the limiting factor for web-building, since they were recorded on *Q. robur* with a high abundance in comparison with the catches on *F. excelsior* and *T. cordata*. In general, highest numbers of spider species can be found on trunk areas of tree species with a particularly richly-structured bark (e.g. Nicolai 1994). Overall, it can be assumed that tree species with a similar bark texture are also inhabited by similar spider coenoses and that there are no tree species-specific communities (cf. Curtis & Morton 1973, Wunderlich 1982). In addition to bark texture, microclimatic conditions may also considerably influence the qualitative and quantitative composition of spider communities. If the dominance structure of the spider community of *F. excelsior*, situated in the gap, is considered in comparison with the trunks of this tree species situated in the forest stand, it becomes evident that *Salticus zebraneus* preferred the trunk area which received plenty of sun light. Representatives of the Gnaphosidae, too, appeared exclusively on this free-standing trunk.

While there seems to be a preference for particular bark structures by some species, the data assessed so far delivers no clues as to a preference of spiders for the canopy area of certain tree species. It is possible that the spider communities in the canopy area are predominantly determined by microclimatic conditions. Thus, a preference for the upper canopy strata by Salticidae and Clubionidae would be explainable by the exposure to sun light and the associated increased temperatures. Work on the material from 2003, which remains to be done, will provide the results obtained so far with a broader database.

ACKNOWLEDGEMENTS

We thank Carsten Schmidt, Patrick Gerhardt and Claudia Jesche for their assistance during serving the traps and carrying out sorting tasks within the scope of the arthropod investigations. Our thanks also go to Prof. Dr. W. Morawetz and P. Horchler, who enabled and co-ordinated the investigations. We would like to thank Prof. Dr. M. Schlegel for his financial support for the arthropod subproject. Dr. U. Simon provided the branch eclectors for the investigation, Dr. M. Verhaagh some of the window traps and Prof. Dr. J. Adis three trunk eclectors. Furthermore we thank Theo Blick for checking individual spider species.

REFERENCES

Adis, J. (2001) Amazonian arthopods (terrestrial). In: Levin, S.A. (Ed.) Encyclopedia of biodiversity. Academic Press, San Diego, pp. 249-260.

Adis, J. & Junk, W.J. (2002) Terrestrial invertebrates inhabiting lowland river floodplains of Central Amazonia and Central Europe: a review. *Freshwater Biology* **47**: 711-731.

Ammer, U. & Schubert, H. (1999) Arten-, Prozeß- und Ressourcenschutz vor dem Hintergrund faunistischer Untersuchungen im Kronenraum. *Forstwissenschaftliches Centralblatt* **118**: 70-87.

Barbosa, P. & Wagner, M.R. (1989) (Eds.) Introduction to forest and shade tree insects. Academic Press, San Diego.

Barnard, P.C., Brooks, S.J. & Stork, N.E. (1986) The seasonality and distribution of Neuroptera, Raphidioptera and Mecoptera on oaks in Richmond Park, Surrey, as revealed by insecticide knock-down sampling. *Journal of Natural History* **20**: 1321-1331.

Basset, Y. (2001) Invertebrates in the canopy of tropical rain forests: how much do we really know? *Plant Ecology* **153**: 87-107.

Braun, D. (1992) Aspekte der Vertikalverteilung von Spinnen (Araneae) an Kiefernstämmen. *Arachnologische Mitteilungen* **4**: 1-20.

Curtis, D.J. & Morton, E. (1973) Notes on spiders from tree trunks of different bark texture – with indices of diversity and overlap. *Bulletin of the British Arachnological Society* **3**: 1-5.

Ellenberg, H., Mayer, R. & Schauermann, J. (Eds.) (1986): Ökosystemforschung – Ergebnisse des Sollingprojekts 1966-1986. E. Ulmer, Stuttgart.

Engelhardt, W. (1958) Untersuchungen über Spinnen aus Fichtenwipfeln. *Opuscula Zoologica* **17**: 1-9.

Erwin, T.L. (1988) The tropical forest canopy: The heart of biotic diversity. In: Wilson, E.O. (Ed.) Biodiversity. National Academy Press, Washington: 123-129.

Finch, O.-D. (2001) Webspinnen (Araneae) aus zwei Naturwäldern des Staatlichen Forstamtes Sellhorn (Lüneburger Heide). *NNA-Berichte* **14**: 106-118.

Floren, A. & Schmidl, J. (1999) Faunistisch-ökologische Ergebnisse eines Baumkronen-Benebelungsprojektes in einem Eichenhochwald des Steigerwaldes (Col.: Xylobionta, Phytobionta). *Beiträge zur bayerischen Entomofaunistik* **3**: 179-196.

Floren, A. & Linsenmair, K.E. (2001) The influence of anthropogenic disturbances on the structure of arboreal arthropod communities. *Plant Ecology* **153**: 153-167.

Floren, A. & S. Otto (2002) Beeinflusst die Anwesenheit der Waldameise *Formica polyctena* Foerster die Artenzusammensetzung und Struktur von Spinnengemeinschaften auf Eichen? *Arachnologische Mitteilungen* **24**: 1-18.

Funke, W. & Sammer, G. (1980): Stammauflauf und Stammanflug von Gliederfüßern in Laubwäldern (Arthropoda). *Entomologia Generalis* **6**: 159-168.

Gutberlet, V. (1997) Untersuchungen zur Spinnenzönose (Araneae) der Stamm- und Kronenregion von Eichen unterschiedlich genutzter Waldstandorte unter Verwendung des Ökotypensystems nach PLATEN. *Arachnologische Mitteilungen* **14**: 16-27.

Heimer, S. (1982) Interessante Theridiidae aus dem Elbtal bei Dresden (Arachnida, Araneae). *Faunistische Abhandlungen Staatliches Museum für Tierkunde Dresden* **10**: 179.

Hesse, E. (1939) Untersuchungen an einer Kollektion Wipfelspinnen. *Sitzungsberichte der Gesellschaft Naturforsch. Freunde Berlin* **193**: 350-363.

Hiebsch, H. & Tolke, D. (1996) Rote Liste Weberknechte und Webspinnen. *Materialien zu Naturschutz und Landschaftspflege (Radebeul)*: 1-12.

Klomp, H. & Teerink, B.J. (1973) The density of the invertebrate summer fauna on the crowns of pine tree, *Pinus sylvestris*, in the central parts of the Netherlands. *Beiträge zur Entomologie* **23**: 325-340.

Kubcová, L. & Schlaghamersky, J. (2002) Zur Spinnenfauna der Stammregion stehenden Totholzes in südmärischen Auwäldern. *Arachnologische Mitteilungen* **24**: 35-61.

Lowman, M. & Nadkarni, N.M.(1995) (Eds.) Forest canopies. Academic Press, San Diego.

Nicolai, V. (1994) Ökologische Bedeutungen der Borke von Bäumen für Tierbesiedlungen und Regenerationsprozesse in Waldökosystemen. *Zoologische Beiträge N. F.* **35**: 79-102.

Reynolds, B.C. & Crossley, D.A. (1997) Spatial variation in herbivory by forest canopy arthropods along an elevational gradient. *Environmental Entomology* **26**: 1232-1239.

Schubert, H. (1998) Untersuchungen zur Arthropodenfauna in Baumkronen - ein Vergleich von Natur- und Wirtschaftswäldern (Araneae, Coleoptera, Heteroptera, Neuropteroidea; Hienheimer Forst. Niederbayern). Wissenschaft und Technik Verlag, Berlin.

Simon, U. (1995) Untersuchung der Stratozönosen von Spinnen und Weberknechten (Arachn.: Araneae, Opilionida) an der Waldkiefer (*Pinus sylvestris* L.). Wissenschaft & Technik Verlag, Berlin.

Simon, U. (2002) Stratum change of *Drapetisca socialis* reexamined (Araneae, Linyphiidae). *Arachnologische Mitteilungen* **23**: 22-32.

Stork, N.E., Adis, J. & Didham, R.K. (1997) (Eds.) Canopy arthropods. Chapman & Hall, London.

Stork, N.E. & Hammond, P.M. (1997) Sampling arthropods from tree-crowns by fogging with knockdown insecticides: lessons from studies of oak tree beetle assemblages in Richmond Park (UK). In: Stork, N.E., Adis, J. & Didham, R.K. (Eds.) Canopy arthropods. Chapman & Hall, London, pp 3-26.

Stork, N.E., Hammond, P.M., Russel, B.L. & Hadwen, W.L. (2001) The spatial distribution of beetles within canopies of oak trees in Richmond Park, U.K. *Ecological Entomology* **26**: 302-311.

Tolke, D. & Hiebsch, H. (1995) Kommentiertes Verzeichnis der Webspinnen und Weberknechte des Freistaates Sachsen. *Mitteilungen Sächsischer Entomologen* **32**: 3-44.

Thunes, K.H., Skarveit, J. & Gjerde, I. (2003) The canopy arthropods of old and mature *Pinus sylvestris* in Norway. *Ecography* **26**: 490-502.

Winter, K., Bogenschütz, H., Dorda, D., Flechtner, W.H.O., Graefe, U., Köhler, F., Menke, N., Schauermann, J., Schubert, H, Schultz, U. & Tauchert, J. (1999) Programm zur Untersuchung der Fauna in Naturwäldern. IHW-Verlag, Eching.

Wunderlich, J. (1982) Mitteleuropäische Spinnen (Araneae) der Baumrinde. *Zeitschrift angewandte Entomologie* **94**: 9-21.

3.3 Species diversity and tree association of Heteroptera (Insecta) in the canopy of a Quercus-Fraxinus-Tilia floodplain forest

Erik Arndt[1], Detlef Bernhard, Claudia Jesche, Sven Kupillas & Winfried Voigt

The canopy bug fauna (Heteroptera) was examined in the mesophilic floodplain forest area "Burgaue" north of Leipzig in the scope of the LAK project. All arthropods were collected by window traps and branch eclectors in the canopy of 25 trees (*Quercus robur, Tilia cordata, Fraxinus excelsior*, and some neophytic trees) using a mobile tower crane during two seasons. A total of 67 species with 7 315 adult bugs (7 065 in window traps, 250 in branch eclectors) was collected. *Deraeocoris lutescens* was the most common species representing 30.5% of the entire sample. Further dominant species were *Rhabdomiris striatellus, Campyloneura virgula, Dryophilocoris flavoquadrimaculatus, Harpocera thoracica, Orius* cf. *minutes*, and *Pentatoma rufipes*, therefore only one phytophagous bug (*H. thoracica*) reached high abundances. We could not detect differences in the species numbers on different trees. However, significant differences between different trees appeared with regard to the individual numbers of phytophagous and omnivorous Heteroptera, while the species richness of carnivorous bugs did not show significant differences on various tree species. Most of the phytophagous bugs live on *Quercus* (*Q. robur* as well as the neophytic *Q. rubra*). The lowest species numbers appear on *Tilia cordata*. Similar results were found for omnivorous species . A total of 14 bug species show a preference for a certain tree species or *Quercus* as genus (including *Q. rubra*). Only two phytophagous Heteroptera occur among these specialists. These results indicate a stronger preference for specific tree species by carnivorous than by phytophagous Heteroptera.

INTRODUCTION

Considering species diversity, habitat requirements and feeding type bugs (Heteroptera) are quite an ecologically heterogeneous group. Members of terrestrial families, however, are predominantly associated with vegetation structures, to a considerable extent living on bushes or trees. So far in middle Europe, only a small number of examinations concerning the ecology of woodland-dwelling Heteroptera have been carried out, and refer predominantly to forest edges or comparisons of natural with cultivated forests (Achtziger 1991; 1995; Schubert 1998; Gossner 2002). One focus of these studies is the distribution of bug species on individual tree species or in various strata.

Our project contributes to and proceeds with the objectives and results of the studies mentioned above. We analysed the vertical and horizontal distribution of Heteroptera in the canopy stratum of a dried-out oak-ash-winter lime tree floodplain forest. The aim of the project was to (a) check whether there are differences between individual tree species with respect to bug fauna and to (b) detect if there are bug species associated with certain tree species. To this end the Heteroptera were recorded during two vegetation periods in a sample of all major tree species of the floodplain forest and then assessed both specifically and grouped according to several "feeding types". In particular by analysing ecological types we expected new insights into species composition of the community as well as into structural aspects of the canopy-dwelling fauna. We used this approach to test the two following hypotheses: (a) species diversity between individual types of woodland varies significantly, (i.e. oak as an autochthonous species has the highest, neophytic woodland introduced by forestry, in contrast, the lowest species diversity); (b) there is a close association of phytophagous species with certain types of woodland but no association of zoophagous species generally to a particular tree species.

MATERIALS AND METHODS

Data were gathered during a two-year examination of the canopy area of the Burgaue nature reserve in the Leipzig floodplain forest (vegetation periods 2002 and 2003) by using a 40 m high mobile tower crane in

[1]corresponding author

conjunction with window traps and branch eclectors. Details of sampling design are described earlier in this volume.

The sampling design we used enables us **(1)** to test our hypotheses for the principal tree species and **(2)** it also reveals trends in species composition on the neophytes introduced by forestry (*Quercus rubra, Fraxinus pennsylvanica*). Multivariate analyses (PCA; calculated using CANOCO, Ter Braak & Šmilauer 2002, Lepš & Šmilauer 2003), together with the Species Indicator Analysis according to Dufrêne & Legendre (1997) by means of PC-Ord 4 (McCune & Mefford 1999) were used for the statistical evaluation. The Species Indicator Analysis was originally developed by Dufrene and Legendre in order to ascertain the indicator value of certain animal species for a habitat type or (in the case of nature conservation purposes) a certain usage or preservation status. This method is therefore suitable for testing the preference of species in relation to a certain locality (here: tree species).

Differences in species and individual numbers in the colonisation of individual trees or tree species, respectively, were tested using ANOVA.

Identification of species

All bugs recorded during the examination were identified to species level. Some species (e.g. among Anthocoridae) were unable to be identified beyond doubt; their names are therefore prefixed with 'cf.'. Voucher specimens of all species are available for inspection in the institutional collections of the Anhalt University (Bernburg) and the Friedrich Schiller University (Jena), Institute of Ecology. The nomenclature follows Hoffmann & Melber (2003).

In the genera *Orthotylus* Fieber and *Psallus* Fieber (Miridae) only males can be identified absolutely certainly with the aid of their genital appendage. However, since the majority of specimens collected in both genera were females, these genera can only be included into the analysis summarily as *Orthotylus* sp, respectively, *Psallus* sp. In the genus *Orthotylus* males of the following species were detected: *O. nassatus* (Fabricius), *O. tenellus* (Fallén), *O. viridinervis* (Kirschbaum) (in the ratio 7 : 4 : 1).

In the genus *Psallus*, seven species were identified based on their male genitals: *P. variabilis* (Fallén), *P. lepidus* Fieber, *P. perrisi* (Mulsant & Rey), *P. albicinctus* (Kirschbaum), *P. mollis* (Mulsant) *P.* cf. *assimilis* Stichel, *P. varians* (Herrich-Schaeffer) (in the ratio 9 : 9 : 6 : 3 : 2 : 2 : 1). A problem in the allocation of feeding types results from the grouping of *Psallus* species into one complex: *P. perrisi* is classified as zoophagous (Wagner 1955), while all other species are regarded as polyphagous (= omnivorous). We therefore listed this genus in both feeding groups while doing numerical analyses.

Abbreviations used: (Ac) - Sycamore, *Acer pseudoplatanus*; (ET) - Feeding type; (F) - Common ash, *Fraxinus excelsior*; (Fp) - Red ash, *Fraxinus pennsylvanica*; (OV) - omnivorous, polyphagous; (PCA) - Principal Component Analysis (see Lepš & Šmilauer 2003); (PP) - phytophagous; (Q) - Common oak, *Quercus robur*; (Qr) - Red oak, *Quercus rubra*; (T) - Winter lime tree, *Tilia cordata*; (ZP) - zoophagous.

RESULTS

With the aid of the crane, a total of 7 315 adult individuals of Heteroptera in 67 species were recorded in the canopy area of the Leipzig floodplain forest. The majority of individuals (7 065) were caught in the window traps (WT; Appendix Table 1) but only 250 specimens in the branch eclectors (BE; Appendix Table 2). The results of both examination years differ considerably, 4 458 bugs were collected in 2002, only 2 857 in 2003. These differences are probably due to weather differences (temperature progression, precipitation totals) between the two years.

Of the total of 67 species, at least 30 species (excluding *Psallus* sp. and *Orthotylus* sp.) were only detected in the window traps (while flying through the canopy area) and not by branch eclectors (while crawling on branches). At least 18 species were caught in 2002 alone, 12 species only in 2003. The dominant species in the canopy area (abundances > 3.2% of the total collection) were, in decreasing frequency, *Deraeocoris lutescens* (Schilling) (ZP), *Harpocera thoracica* (Fallén) (PP), *Pentatoma rufipes* (Linné) (OV), *Orius* cf. *minutus* (Linné) (ZP), *Campyloneura virgula* (Herrich-Schaeffer) (ZP), *Rhabdomiris striatellus* (Fabricius) (OV), and *Dryophilocoris flavoquadrimaculatus* DeGeer (OV). 30.5% of the entire catch fell to *Deraeocoris lutescens* alone.

Differences between the tree species with regard to the structure of their bug fauna

In order to analyse differences between the tree species, the recorded bugs were allocated to three ecological groups (Fig. 1): phytophagous, polyphagous (= omnivorous) or zoophagous feeding type (see Appendix Table 1 for classification). Species distribution across the three groups is in the same order of magnitude. In 2002 the PP : OV : ZP ratio was 14 : 14 : 19, in the following year 16 : 11 : 14, while both *Psallus* sp. and *Orthotylus* sp. are included as a summary species. Ratios of individuals from the three feeding types also level out in the window trap catches of examination year 2003. By contrast, the zoophagous bugs, with 2 736 specimens (incl. *Psallus* sp.), exceed the total of the other two gropus in 2002 (OV 1 040 and PP 774 individuals). All three groups and both years were analysed separately using, however, only data obtained from window trap catches for statistical reasons. There were no detectable differences between feeding types or years regarding the species numbers in relation to individual trees.

The analysis of individuals (not differentiated according to species, but lumped across feeding types, see Table 1) delivered more differentiated results (Fig. 2). The distribution of individuals varies significantly on individual tree species, even highly significantly in 2003 for phytophagous and omnivorous species, while no differences are detectable in the zoophagous species. By far most phytophagous bugs live on *Quercus* species (both on common oak as well as on the neophytic red oak), the fewest live on *Tilia cordata*. A similar result was found for omnivorous bugs, but the differences between the individual trees are not so marked there.

Table 1 – Results of the distribution of Heteroptera individuals in the main trees of the flood plain forest of Leipzig (*Quercus robur, Tilia cordata, Fraxinus excelsior*; sampled with window trap samples in the years 2002, 2003). Samples of both years were listed in the ecological groups "zoophagous (carnivorous)", "phytophagous", and "omnivorous (polyphagous)" as a first step, and the differences between trees were tested using an ANOVA in a second step. Except for omnivorous individuals of 2002, the significance increases if neophytic trees are included.

	2002					**2003**				
	D.f.	**SS**	**MS**	**F**	**p**	**D.f.**	**SS**	**MS**	**F**	**p**
Zoophage	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Phytophage	2	1411.4	705.7	4.84	0.023	2	10981.4	5490.7	7.022	0.007
Omnivore	2	2357.4	1178.7	4.12	0.037	2	9439	4719.5	13.4	0.0004

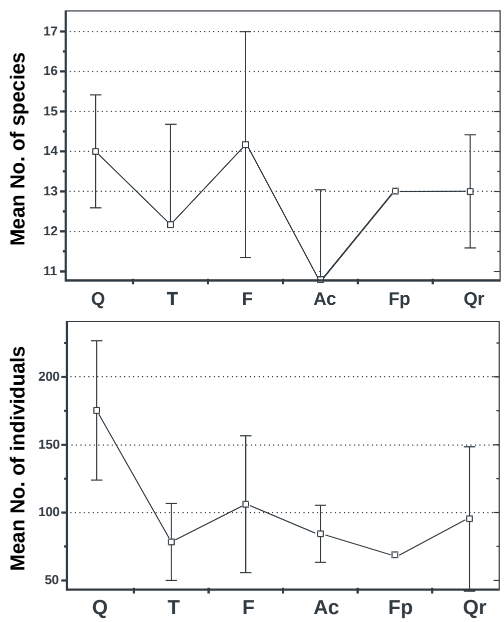


Figure 1 – Average numbers and standard deviation of species and individuals of Heteroptera sampled in window traps on the examined trees in 2003.

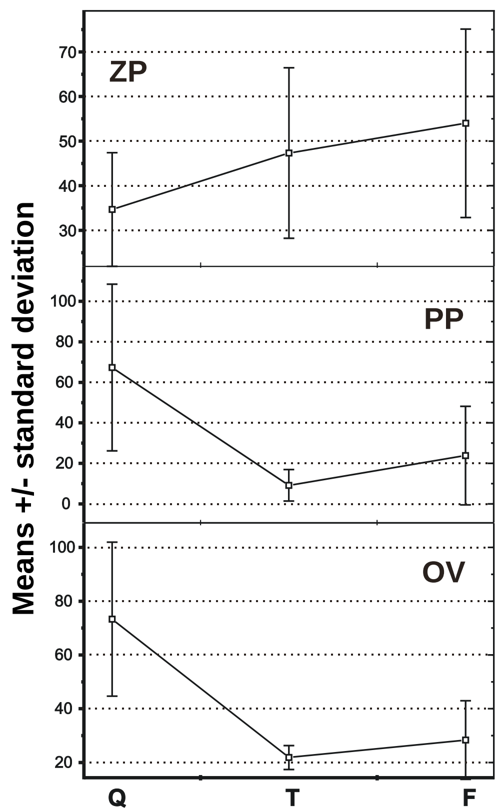


Figure 2 – Average numbers and standard deviation of Heteroptera individuals sampled in window traps on the main trees in 2003 – according to their feeding types. OV: omnivorous; PP: phytophygous; ZP: zoophagous.

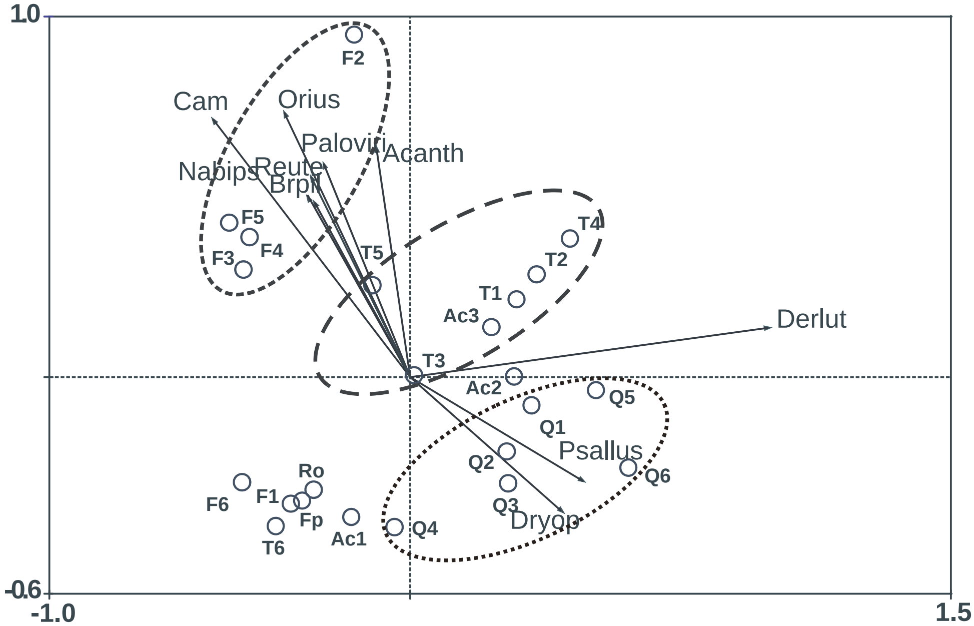


Figure 3 – Non-standardised PCA of Heteroptera sampled in window traps in 2002 (axis 1 vs. axis 2; eigenvalues axis 1: 0.6561, axis 2: 0.1348) . Except for *Quercus rubra* (which was excluded from the analysis because of its unduly influence on axis 1 caused by the dominating huge abundance of *Harpocera thoracica*) all trees and species with species fits ≥ 30% are shown. The figured species may be suitable indicators or tree specialists. The three main tree species are well separated on both the first and the second axis.

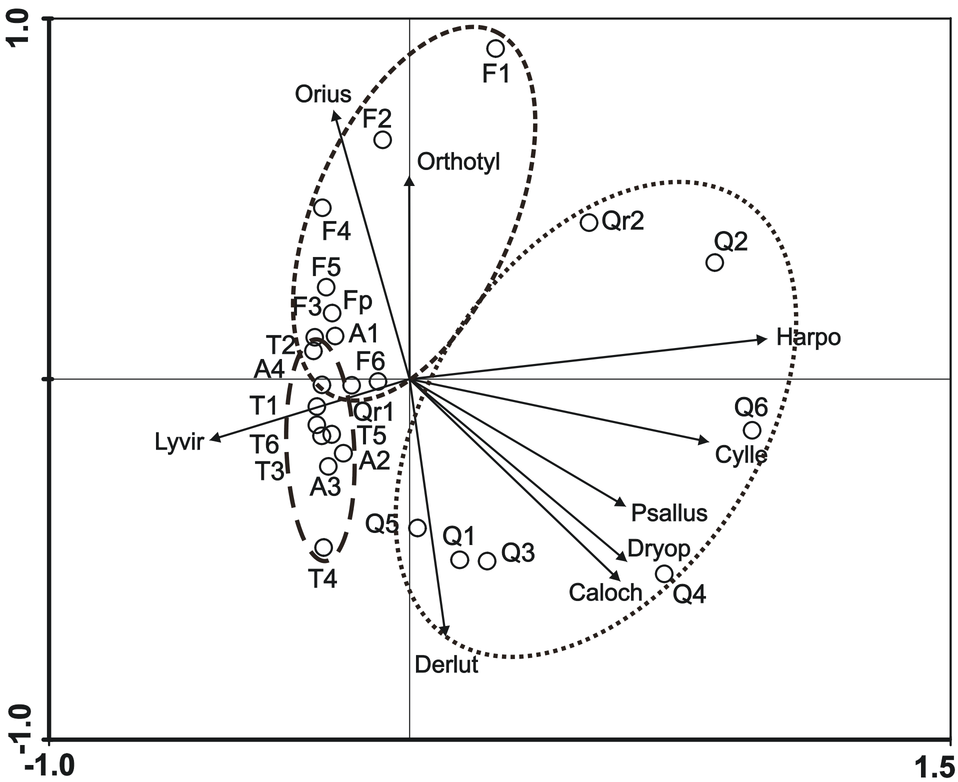


Figure 4 – Non-standardised PCA of Heteroptera sampled in window traps in 2003 (axis 1 vs. axis 2, eigenvalues: axis 1: 0.6364, axis 2: 0.1565). All trees and Heteroptera species with species fits ≥ 30% are shown. The figured species may be suitable indicators or tree specialists. The main tree species are surrounded by circles.

Preferences of canopy-dwelling bug species with reference to certain tree species

In order to ascertain bug species preferences in terms of tree species, a “Species Indicator Analysis” was first carried out (Appendix Table 1).

Seven species turned out to be significant specialists for one tree species or one tree genus in both years: **(1)** *Quercus robur*: *Psallus* sp., *Cyllecoris histrionicus* (Linné) **(2)** *Quercus* spp: *Dryophilocoris flavoquadrimaculatus* DeGeer, *Harpocera thoracica* (Fallén) **(3)** *Tilia cordata*: *Phytocoris tiliae* (Fabricius) **(4)** *Fraxinus excelsior*: *Temnostethus reduvinus* (Herrich-Schaeffer), *Orius* cf. *minutus* (Linné).

Seven other species only achieve significance in one of the two years and must therefore be classified as indicators of little value in respect of tree species preference. *Phylus* cf. *melanocephalus* (Linné) (on *Q. robur*) could only be detected in 2002, this species shows a low abundance, but high tree specificity.

Six species were caught in both years; but their tree specificity is only significant in one of the two years: **(1)** *Rhabdomiris striatellus* (Fabricius) has the highest number of individuals on *Quercus robur* in both years, but only in 2003 this specificity of host plant is significant, since in 2002, 39 individuals were also caught on *Acer pseudoplatanus.* **(2)** *Brachyocoleus pilicornis* (Panzer) and *Campyloneura virgula* (Herrich-Schaeffer) show by the far the highest abundance in both years on *Fraxinus excelsior.* However, *B. pilicornis* was not caught in 2003 in sufficient number of individuals to achieve significance. *C. virgula* also achieves a high abundance on lime tree in 2003 in contrast to the previous year. **(3)** *Lygus viridis* (Fallén) has, in both years, the highest abundance on *Tilia cordata*, but only achieves significant results in 2003, since in 2002, 21 individuals were also caught on an *Acer pseudoplatanus. Pinalitus cervinus* (Herrich-Schaeffer) and *Orthotylus* cf. *nassatus* (Fabricius) achieve significance in 2002 on *Tilia cordata*, but were detected in the second year in one or two specimens only.

We produced a comparable result performing a multivariate analysis (PCA, Figs. 3, 4). If only bug species with a PCA-declared variance of ± 30% are taken into consideration, *Quercus robur* is associated with the same six species in 2003 as in the Species Indicator Analysis (see above). For the winter lime tree, this is *Lygus viridis*, and for the oak, *Orius* cf. *minutus* (Fig. 4). For 2002, in contrast to the Species Indicator Analysis, the PCA graphic (Fig. 3) shows seven species as characteristic for *Fraxinus excelsior.* Only *Phytocoris tiliae* and *Temnostethus reduvinus* show significance associations in the Species Indicator Analysis in both years, with a relatively low fraction of shared variance as explained by the PCA.

The surprise during analysis of these indicators is that among the species which were significant for both years, there is one phytophagous species to three omnivores (including *Psallus* sp.) or three zoophagous species, respectively. Within the seven indicator species with a low indication weight we find an equally low proportion of phytophagous species: one phytophagous species to five omnivores and one zoophagous species.

This result means that predatory or partially predatory species show a much larger tree specificity than is the case with phytophagous bugs.

DISCUSSION

As an exceedingly species-rich order of insects, bugs colonise the widest variety of aquatic and terrestrial habitats and are characterised by different adaptations in respect of their micro-habitats (in the canopy area for example, to living under bark) and feeding type (phytophagous, zoophagous, polyphagous).

The examination evaluated here in the canopies of various tree species covers only a small part of the bug fauna to be expected in floodplains. The use of standardised trapping technology, however, enables a targeted analysis of ecological questions and statements concerning the colonisation of individual tree species to be made which so far have not been possible from the ground.

So far, robust middle-European comparisons of the bug fauna of various tree species have been available concerning common oak vs. red beech or, respectively, common oak + red beech vs. spruce or larch (Schubert 1998) as well as common oak vs. red oak+red beech (Gossner 2002). Schubert (1998) arrives at the conclusion that numbers of species and individuals differ significantly between the examined tree species. According to his analyses, bug species numbers are “ranked” *Quercus* > *Larix* > *Picea* > *Fagus* and numbers of individuals *Quercus* >> *Larix* > *Fagus* > *Picea.* Gossner (2002) sees significant differences in the number of species between common oak and the other tree species, and there was an identical trend among the numbers of individuals. On the basis of these findings from southern German low mountain range forests, it was an aim of our examinations to check whether the results can also be confirmed in a floodplain in a completely different natural area. Against the background of the studies cited above, the result of our examinations is no doubt surprising: no differences in the colonisation of tree species in respect of species numbers of Heteroptera, but significant differences in phytophagous and omnivorous individuals. The significances are lost in one of the two years if the species of all feeding types are considered summarily. Therefore, hypothesis (a), which was expressed at the start, must be rejected; neither the species diversity is significantly varied among the individual tree species, nor does the neophytic *Quercus rubra* show the lowest species diversity. In respect of numbers of individuals, the two *Quercus* species dominate for the phytophagous species, while the fewest phytophagous bugs live on *Tilia* and *Acer*.

Omnivorous species are the most common on *Quercus robur*, and the least numerous on *Tilia* or *Fraxinus*. By contrast, *Tilia* and *Fraxinus* show the highest numbers of zoophagous Heteroptera, but the differences for this feeding type are not significant.

A second aim of our work was to investigate tree preferences while taking account of the various feeding types. For plant suckers, which are adapted to certain plant constituents, a closer association to tree species or genera should be detectable than is the case for zoophagous species, which feed for example on butterfly caterpillars or leaf lice and can potentially find suitable food on any one of the autochthonous deciduous trees (hypothesis b).

In order to test tree species specificity, the Species Indicator Analysis (Dufrêne & Legendre 1997) was used. The results obtained were tested by means of a PCA. When the examined bug species were roughly evenly distributed among the three feeding types, we could not detect a particularly close association of phytophagous species to one tree species or genus: two significant specialists among the phytophagous bugs for 8, respectively 4 of the other two feeding types. This means that hypothesis (b) must also be rejected.

With reference to tree species / genera, we were able to detect two specialists for *Quercus* sp. as a genus as well as four specialists each for *Quercus robur*, *Tilia cordata* and *Fraxinus excelsior* in the canopy area of the floodplain forest. Among these specialists are 12 taxa of the Miridae, which are all named by Wagner (1955) for the same tree genus, together with two Anthocoridae, which Wagner (1967) classifies as ubiquitous.

In middle European woodland flora, the common oak is regarded as particularly species-rich in Heteroptera, which has also been confirmed in various studies concerning bugs (Kennedy & Southwood 1984, Dorow 2002, Gossner 2002). So far, 51 species are known to dwell in common oaks; 15 of these are specialists for *Quercus robur* (Dorow 2002). At the genus level, our results confirm a higher number of oak specialists compared with *Fraxinus* or *Tilia*, particularly since eight different *Psallus* species were recorded by us, all of which Wagner (1952), with the exception of *P. lepidus* (on *Fraxinus*), identifies as *Quercus* dwellers. A higher number of bugs dwelling on oaks is, however, not surprising, since *Quercus* is a widespread genus in Europe and, compared with *Tilia* or *Fraxinus*, it is also species-rich with endemites in the Mediterranean biodiversity centres and glacial refuge areas.

Two of the specialists detected by us on *Quercus robur* (*Psallus* sp.; *Cyllecoris histrionicus*) are also indicated by Gossner (2002), who conducted the same indicator analysis during his examinations on common oak, red oak and red beech. For two other species, however, the preferences calculated by us differ from the results that Gossner (2002) obtained. Thus, *Harpocera thoracica* in Gossner (l.c.) significantly prefers the common oak, while this species in our examination is a specialist for *Quercus* overall. On average, this species was more commonly caught on red oak (114 individuals in window traps per individual tree) than on common oak (44 individuals per individual tree). *Orthotylus tenellus* is likewise indicated as significantly associated with common oak by Gossner (2002). In our examination, the *Orthotylus* group (*O. nassatus*, *O. tenellus* and *O. viridinervis*; only significant in one year) prefers *Tilia cordata*. However, this tree species was not investigated by Gossner (2002). Existing differences between the two studies in respect of indicator species cannot, however, really be estimated using the Species Indicator Analysis. The calculated indicator values are a combination of the information concerning the relative abundance of bug species on various tree species (specificity) and their presence (fidelity) on all individual trees of one and the same species. They therefore only refer to the variation in the data included in the calculation and cannot be compared among different studies straight away.

The results concerning bug fauna obtained on the crane show that there are species-rich guilds in the canopy area of floodplain forests and many flight-active species can be recorded using window traps. Furthermore, dominance structures (numbers of individuals) of individual tree species differ clearly from one another and there are differences in respect of ecological types - we investigated feeding types - among the tree species. A number of interesting questions could not be clarified with the aid of the present evaluation. For example, there are still no answers as to whether interactions or niche separation occur among individual species. There are different findings from the same examination area concerning other animal groups in this respect (e.g. Schmidt *et al.* in this volume and Arndt *et al.* in press). Microclimatic dependencies and vertical zonation have not yet been analysed. The guild of bark dwellers (Aradidae, Aneuridae) could also not be reached using flight traps and branch eclectors. These gaps of knowledge should form the subject of future studies on canopy-dwelling Heteroptera.

ACKNOWLEDGEMENTS

We thank Prof. W. Morawetz and Dr. P. Horchler for co-ordinating the LAK-Project, as well as Prof. M. Schlegel (Leipzig University) for financially supporting our studies. Furthermore, we would like to thank Prof. J. Adis (Plön) for his support during preparation for the project. Some of the traps used were kindly made available by U. Simon (Freising; branch eclectors) and M. Verhaagh (Karlsruhe; window traps). We would also like to thank numerous students from Leipzig University and Anhalt University (Bernburg) for their assistance while measuring the crane plot and sorting the traps.

REFERENCES

Achtziger, R. (1991) Zur Wanzen- und Zikadenfauna von Saumbiotopen. *Berichte der ANL* **15**: 37–68.

Achtziger, R. (1995) Die Struktur von Insektengemeinschaften an Gehölzen: Die Hemipterenfauna als Beispiel für die Biodiversität von Hecken und Waldrandökosystemen. *Bayreuther Forum Ökologie (BfÖ)* **20**: 1–216.

Arndt, E. & Hielscher, S. (in press) Ameisen (Hymenoptera: Formicidae) im Kronenraum des Leipziger Auwaldes. *Veröffentlichungen Naturkundemuseum Leipzig.*

Dorow, W. H. O. (2002) Heteroptera (Wanzen). In: Dorow, W.H.O., Flechtner, G. & Kopelke, J.-P. (Eds.)Naturwaldreservate in Hessen: Schönbuche. Zoologische Untersuchungen. Frankfurt am Main, Forschungsinstitut Senckenberg & Hessisches Ministerium für Umwelt, Landwirtschaft und Forsten. No **6/2.1**: 157–254.

Dufrêne, M. & Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* **67**: 345–366.

Gossner, M. (2002) Arthropoden auf Neophyten. In: Ammer, U. & Schmidt, O. (Eds.) Vergleichende waldökologische Untersuchungen in Naturwaldreservaten (ungenutzten Wäldern) und Wirtschaftswäldern unterschiedlicher Naturnähe (unter Einbeziehung der Douglasie) in Mittelschwaben. Forschungsvorhaben des BMBF (0339735A). 216 pp.

Hoffmann, H.-J. & Melber, A. (2003) Verzeichnis der Wanzen (Heteroptera) Deutschlands. In: Klausnitzer, B. (Eds.) Entomofauna Germanica 6. *Entomologische Nachrichten und Berichte, Dresden* **8**: 209–272.

Kennedy, C. E. J. & Southwood, T. R. E. (1984) The number of species of insects associated with british trees: a reanalysis. *Journal of Animal Ecology* **53**: 455–478.

Lepš, J. & Šmilauer, P. (2003) Multivariate Analysis of Ecological Data using CANOCO. Cambridge University Press.

McCune, B. & Mefford, M. J. (1999) PC-ORD. Multivariate Analysis of Ecological Data. Version 4.0. MjM Software, Gleneden Beach, Oregon, USA.

Schubert, H. (1998) Untersuchungen zur Arthropodenfauna in Baumkronen - Ein Vergleich von Natur- und Wirtschaftswäldern (Coleoptera, Araneae, Heteroptera, Neuropteroidea; Hienheimer Forst, Niederbayern). Wissenschaft und Technik Verlag Berlin, 154 pp.

Ter Braak, C. J. F. & Šmilauer, P. (2002) CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, NY. 500 p.

Wagner, E. (1952) Blindwanzen oder Miriden. In *Die Tierwelt Deutschlands und der angrenzenden Meeresteile.* **41**. Fischer, Jena. 211 pp.

Wagner, E. (1967) Wanzen oder Heteropteren. II. Cimicomorpha. In *Die Tierwelt Deutschlands und der angrenzenden Meeresteile.* **55**. Fischer, Jena. 179 pp.

Appendix Table 1 – Heteroptera of the LAK-project sampled with window traps in 2002 and 2003. Feeding type (ET), average numbers of individuals per individual tree, significant values of the species-indicator-analysis (species-IVS; genera-IVG), as well as average numbers of bug species per tree species (last row) are given. Species of the genera *Psallus* and *Orthotylus* are combined.

WT 2002	**ET**	**Q**	**T**	**F**	**Ac**	**Ro**	**Fp**	**Qr**	**IVS**	**IVG**
Acanthosoma haemorrhoidale (Linné)	pp	0.33	0.5	1.33	0.33	0	2	0	-	-
Aelia acuminata (Linné)	pp	0.17	0.17	0	0	0	0	1	-	-
Alloeotomus germanicus Wagner	pp	0	0.33	0.17	0	1	0	0	-	-
Anthocoris amplicollis Horvath	zp	0.17	0	0	0.33	0	0	0	66.7	66.7
Anthocoris cf. *visci* Douglas	zp	0.17	0	0	0	0	0	0	-	-
Anthocoris minki Dohrn	zp	0	0	0.17	0	0	0	0	-	-
Anthocoris nemorum (Linné)	zp	0	0	0	0.33	0	0	0	-	-
Blepharidopterus cf. *angulatus* (Fallén)	zp	0	0.17	0.17	0	0	0	0	-	-
Brachyocoleus pilicornis (Panzer)	pp	0.33	2.67	4.5	0.33	2	1	0.5	50.9	54.2
Campyloneura virgula (Herrich-Schaeffer)	zp	1.5	5.83	39.83	0.67	2	3	0	81.2	81.9
Chilacis typhae (Perris)	pp	0.17	0	0	0	0	0	0	-	-
Cyllecoris histrionicus (Linné)	ov	1.17	0	0	0	0	0	0	50	-
Deraeocoris lutescens Schilling	zp	109.3	89.3	35.17	83.33	41	37	25.5	-	-
Dryophilocoris flavoquadrimaculatus DeGeer	ov	6.33	0.5	1	0	0	7	20	-	80.5
Elasmostethus interstinctus (Linné)	pp	0.5	0	0.33	0.33	1	0	1	-	-
Elasmucha grisea (Linné)	pp	0.17	0	0	0	0	0	0	-	-
Harpocera thoracica (Fallén)	pp	23.5	0.33	11.33	1.67	1	3	186.5	-	84.1
Himacerus apterus (Fabricius)	zp	0.17	1.5	1.33	0.67	2	1	1	-	-
Isometopus intrusus (Herrich-Schaeffer)	zp	0.17	0.17	0.17	0	0	0	0	-	-
Kleidocerys resedae (Panzer)	pp	1.5	1	2.33	0	0	3	1	-	-
Loricola cf. *elegantula* (Baerensprung)	zp	0.17	0	0.33	0	0	0	0	-	-
Lygus pratensis (Linné)	ov	0.33	0.33	0.5	0.67	0	1	0.5	-	-
Lygus viridis (Fallén)	ov	0.83	11.5	1.33	10.67	4	1	1	-	-
Miris striatus Linné	zp	0	0.33	0.17	0.33	0	0	0	-	-
Nabis pseudoferus Remane	zp	0.33	1.33	1.67	0	0	1	1	-	-
Orius cf. *minutus* (Linné)	zp	4.5	15.8	21.67	8	3	1	5	51.8	-
Orthotylus sp.	ov	1.67	9.5	1.67	0.67	0	0	0.5	57.6	61
Palomena prasina (Linné)	pp	0.5	1.83	0.5	1.67	0	1	2.5	-	-
Palomena viridissima (Poda)	pp	0	0	3.5	0	1	1	0.5	-	-
Pantilius tunicatus (Fabricius)	pp	0	0.17	0	0	0	0	0	-	-
Pentatoma rufipes (Linné)	ov	8.5	11	15.5	12.33	16	23	8	-	-
Phylus cf. *melanocephalus* (Linné)	ov	1	0	0	0	0	0	0	66.7	50
Phytocoris dimidiatus Kirschbaum	ov	0.33	0.83	0.5	0	1	0	0.5	-	-
Phytocoris longipennis Flor	ov	0	0.83	0.17	0	0	0	0	-	-
Phytocoris populi (Linné)	ov	0	0.83	0.5	0.33	0	0	0	-	-
Phytocoris tiliae (Fabricius)	zp	0	2.33	0.33	1	0	0	0	50.7	51.7
Pilophorus clavatus (Linné)	zp	0	0.5	0	0	0	0	0	-	-
Pinalitus cervinus (Herrich-Schaeffer)	ov	0	5	1.17	0	0	2	0	75	79.5
Psallus sp.	zp/ov	28	2.17	7	3.33	1	0	2	67.1	57
Reuteria marqueti Puton	ov	0	0	0.33	0	0	0	0	-	-
Rhabdomiris striatellus (Fabricius)	ov	9.5	0.17	0.17	13	1	0	6.5	-	-
Rhopalus parumpunctatus (Schilling)	pp	0	0	0	0.33	0	0	0	-	-
Stenodema laevigata (Linné)	pp	0.33	0.33	0.33	0.33	0	0	0.5	-	-
Temnostethus reduvinus (Herrich-Schaeffer)	zp	1	1.17	3.17	0	0	1	0	56.7	59.9
Tingis crispata Herrich-Schaeffer	zp	0.17	0	0	0	0	0	0	-	-
Troilus luridus (Fabricius)	zp	0	0.17	0	0	0	0	0	-	-
Sum of individuals		1217	1012	951	436	77	89	530		
Species per tree		16.5	18.5	19.17	13	14	17	14.5		

Appendix Table 1 – continued.

WT 2003	ET	Q	T	F	A	Fp	Qr	IVS	IVG
Acanthosoma haemorrhoidale (Linné)	pp	0.5	0.5	1	0	1	0.5	-	-
Aelia acuminata (Linné)	pp	0	0	0.17	0	0	0.5	-	-
Alloeotomus germanicus Wagner	pp	1.17	2.83	1.33	3	0	0	-	-
Brachycarenus tigrinus (Schilling)	pp	0.17	0	0	0	0	0	-	-
Brachyocoleus pilicornis (Panzer)	pp	0.33	0.33	1.83	0.5	0	1.5	-	-
Campyloneura virgula (Herrich-Schaeffer)	zp	1.83	4	6.33	0.25	1	0.5	-	-
Chilacis typhae (Perris)	pp	0	0	0	0.25	0	0	-	-
Cyllecoris histrionicus (Linné)	ov	1.33	0	0	0	0	0	50	-
Deraeocoris lutescens Schilling	zp	24.33	23.3	7	22.75	3	5	-	-
Deraeocoris olivaceus (Fabricius)	zp	0	0	0.17	0	0	0	-	-
Deraeocoris trifasciatus (Linné)	zp	0.33	0	0	0	0	0	-	-
Dryophilocoris flavoquadrimaculatus DeGeer	ov	23.17	0.83	0.5	0	2	2	87.4	92
Eurydema oleracea (Linné)	ov	0.17	0.17	0	0	0	0.5	-	-
Gastrodes grossipes (DeGeer)	zp	0	0	0.17	0	0	0	-	-
Harpocera thoracica (Fallén)	pp	63.67	1	16.67	3.5	4	42	55.8	75.1
Himacerus apterus (Fabricius)	zp	0.17	0.83	0.5	1.5	1	0	-	-
Isometopus intrusus (Herrich-Schaeffer)	zp	0	0.17	0	0	0	0	-	-
Kleidocerys resedae (Panzer)	pp	0.67	0.33	0.83	0.25	0	1.5	-	-
Lygus rugulipennis Poppius	ov	0	0.17	0	0	0	0	-	-
Lygus viridis (Fallén)	ov	1.17	8.83	2.67	4.5	2	3	44.5	50.4
Megacoelum infusum (Herrich-Schaeffer)	zp	0	0	0.17	0.25	0	0	-	-
Megalonotus chiragra (Fabricius)	pp	0.17	0	0	0	0	0	-	-
Miris striatus Linné	zp	0.33	0.17	0.33	0	0	0	-	-
Nabis pseudoferus Remane	zp	0.67	1.33	0.83	0.5	0	0.5	-	-
Nysius thymi (Wolff)	pp	0	0	0.17	0	0	0	-	-
Orius cf. *minutus* (Linné)	zp	5.17	13.33	32.8	10	11	11.5	45.2	49.7
Orthotylus sp	ov	0	0	0.33	0	0	0	-	-
Palomena prasina (Linné)	pp	0.5	3.83	1.67	1.75	5	2	-	-
Pentatoma rufipes (Linné)	ov	15.17	10.83	21.5	28.25	34	17	-	-
Phytocoris populi (Linné)	ov	0.17	0	0	0	0	0	-	-
Phytocoris tiliae Fabricius	zp	1.5	3.83	4.17	1.75	0	0.5	36	-
Pinalitus cervinus (Herrich-Schaeffer)	ov	0.17	0	0	0	0	0	-	-
Psallus sp.	zp/ov	8	0.67	2.5	2.25	2	1	54.2	-
Rhabdomiris striatellus (Fabricius)	ov	24	0.33	0.83	1.25	0	5.5	79.8	89.4
Rhopalus parumpunctatus (Schilling)	pp	0	0.17	0	0	0	0	-	-
Scoloposthetus affinis (Schilling)	pp	0.17	0	0	0	0	0	-	-
Stenodema laevigata (Linné)	pp	0	0	0	0	1	0.5	-	-
Stictopleurus abutilon (Rossi)	pp	0	0	0.17	0	0	0	-	-
Temnostethus reduvinus (Herrich-Schaeffer)	zp	0.33	0.33	1.5	0.25	2	0	-	56
Tritomegas sexmaculatus (Rambur)	pp	0	0	0	0.25	0	0	-	-
Sum of individuals		1052	470	637	332	69	191		
Species per tree		14.17	13	15.17	11	14	13		

Appendix Table 2 – Heteroptera of the LAK-project sampled with branch eclectors in 2002 and 2003. The table shows feeding type (ET) and numbers of collected specimens of the different trees.

BE2002

	ET	Q3	Q4	Q6	T1	T3	T4	T5	F1	F2	F4	F6
Acanthosoma haemorrhoidale (Linné)	pp	0	0	0	1	0	0	0	1	1	1	3
Anthocoris minki Dohrn	zp	0	0	0	0	0	0	0	1	0	0	0
Brachyocoleus pilicornis Panzer	pp	1	0	0	0	0	0	0	0	0	0	1
Campyloneura virgula Herrich-Schaeffer	zp	0	0	0	1	0	1	0	1	0	0	1
Deraeocoris lutescens Schilling	zp	0	1	0	2	0	0	0	0	0	0	0
Dryophilocoris flavoquadrimaculatus DeGeer	ov	0	0	0	0	0	0	0	0	0	0	1
Elasmostethus interstinctus (Linné)	pp	0	0	0	0	0	0	0	1	0	0	0
Harpocera thoracica (Fallén)	pp	0	1	2	0	0	0	0	0	0	0	0
Himacerus apterus (Fabricius)	zp	4	1	1	6	3	7	15	2	7	3	4
Isometopus intrusus (Herrich-Schaeffer)	zp	0	0	0	0	0	0	0	1	0	0	0
Lygus viridis (Fallén)	ov	0	0	1	1	0	0	0	0	0	1	0
Nabis pseudoferus Remane	zp	0	0	0	0	0	0	0	0	0	1	0
Orius cf. *minutus* (Linné)	zp	0	0	0	2	2	0	5	1	0	6	1
Orthotylus sp.	ov	0	0	0	0	5	0	0	0	0	0	0
Palomena prasina (Linné)	pp	0	0	0	1	0	0	1	0	0	0	0
Pentatoma rufipes (Linné)	ov	0	2	1	1	1	1	3	5	7	1	2
*Phytocoris dimidiatus*Kirschbaum	ov	1	0	0	0	0	0	0	0	0	0	2
Phytocoris longipennis Flor	ov	0	0	0	0	0	0	0	0	1	0	0
Phytocoris populi (Linné)	ov	0	0	0	0	0	0	0	0	1	0	0
Phytocoris tiliae (Fabricius)	zp	1	0	0	2	0	0	1	0	1	0	0
Pinalitus cervinus (Herrich-Schaeffer)	ov	0	0	1	0	0	0	1	0	0	0	0
Psallus sp.	ov	0	0	0	1	0	0	0	0	0	0	0
Stenodema laevigata (Linné)	pp	0	0	0	0	0	0	0	1	0	0	0
Temnostethus reduvinus (Herrich-Schaeffer)	zp	0	0	0	0	0	0	0	0	0	2	0
Individuals		7	5	6	18	11	9	26	14	18	15	15
Species		4	4	5	10	4	4	5	9	6	7	8

BE2003

	ET	Q3	Q4	Q6	T1	T4	T5	F1	F2	F6	A2	A4	Qr2
Acanthosoma haemorrhoidale (Linné)	pp	0	0	0	0	0	0	0	1	0	0	0	0
Alloeotomus germanicus Wagner	pp	0	1	0	0	0	0	0	0	0	0	0	0
Brachycarenus tigrinus (Schilling)	pp	0	0	0	0	0	0	0	1	1	0	0	0
Cyllecoris histrionicus (Linné)	ov	0	0	1	0	0	0	0	0	0	0	0	0
Deraeocoris lutescens Schilling	zp	0	0	0	1	0	0	0	0	0	0	0	1
Dryophilocoris flavoquadrimaculatus DeGeer	ov	0	0	0	0	0	1	0	0	0	0	0	1
Harpocera thoracica (Fallén)	pp	0	0	0	0	0	0	1	0	0	0	0	0
Himacerus apterus (Fabricius)	zp	0	1	1	0	4	7	2	0	0	4	1	1
Isometopus intrusus (Herrich-Schaeffer)	zp	0	0	0	1	0	0	0	1	0	0	0	0
Nabis pseudoferus Remane	zp	0	0	2	1	0	2	0	0	0	0	0	0
Orius cf. *minutus* (Linné)	zp	0	0	0	1	0	0	8	2	0	0	0	0
Palomena prasina (Linné)	pp	1	0	0	0	0	0	0	1	0	0	0	0
Pentatoma rufipes (Linné)	ov	2	3	1	4	1	2	4	8	2	1	1	1
Phytocoris tiliae (Fabricius)	zp	0	0	0	4	0	1	0	1	1	3	0	0
Pilophorus clavatus (Linné)	zp	0	0	0	1	0	0	0	0	0	0	0	0
Psallus sp.	zp	0	2	2	0	0	0	0	3	0	1	0	0
Rhabdomiris striatellus (Fabricius)	ov	0	1	3	0	0	0	0	0	0	0	0	0
Temnostethus reduvinus (Herrich-Schaeffer)	zp	0	0	1	1	0	0	0	0	0	0	0	0
Individuals		3	8	11	14	5	13	15	18	4	9	2	4
Species		2	5	7	8	2	5	5	8	3	4	2	4

3.4 Spatial distribution of Neuropterida in the LAK stand: significance of host tree specificity

Axel Gruppe

The insect material caught in flight interception and branch traps which were exposed in tree crowns of the LAK plot contained 306 adult Neuropterida of 24 species (3 Raphidioptera; 21 Neuroptera) in the year 2002. The number of specimens and species caught on the three main tree species *Fraxinus excelsior* (ash), *Quercus robur* (oak), and *Tilia cordata* (lime) differed between 80 (ash) and 96 (lime) specimens and 11 (ash) and 17 (oak) species. Although, the differences are not statistically significant, a DCA revealed a separation of the neuropterid communities on the three tree species. These numbers of species are low compared to the results of other studies on the same tree species in Central Europe. The occurrence and distribution of some species was unexpected compared to literature. Requirements of larvae and adults of the neuropterid species for specific nutritional qualities are more likely the reason for the host tree preference than the tree species itself.

INTRODUCTION

The Neuropterida are one of the poorly studied insect taxa in faunistical studies. This applies also to studies of arthropod assemblages in tree crowns but there are some publications already recently dealing with lacewings in this stratum (Czechowska 1994, 1997, 2002; Gruppe & Schubert 2001; Gruppe, Gossner & Simon 2004; Gossner, Gruppe & Simon 2005). Eventhough the autecology and ecological demands of most of the Central European species of Neuropterida are assumed to be known (New 1998), these informations are derived from samplings in strata close to the ground level and from light trapping (Aspöck *et al.* 1980; Gepp 1999; Saure & Gruppe 1999). Therefore, conspicious differences might appear between the assemblages close to the ground level and in the tree crowns of closed forest stands. 'Rare species' might be very abundand in the crown stratum.

The abundance and spatial distribution of species in a diverse environment like the canopy of forests is determined by the demands of each particular species, like food, mating and oviposition sites, and structures which match the particular camouflage behavour etc. The natural food ressource of many species, particularly of Coniopterygidae, is unknown, but Raphidioptera, Hemerobiidae and Coniopterygidae are assumed to be zoophagous in all developmental stages. In green lacewings (Chrysopidae) the food ressource of larvae and adults may be different, because adults of many species feed on nectar or pollen whereas larvae are zoophagous (Canard 2001). This makes it difficult to analyse host tree specificity from sampling by flight interception traps in which mostly adults are caught.

In this paper I discuss the spatial distribution patterns of adult lacewings which were caught with flight interception traps and branch traps in tree crowns of different tree species in the flood plain forest of Leipzig.

MATERIALS AND METHODS

In the year 2002, the flight interception traps (window traps; WT) (Winter *et al.* 1999) and branch traps (branch eclector; BE) (Simon 1995) provided by the LAK research facility were used to investigate neuropterid species (for a detailed description of sampling design refer to Arndt & Unterseher, this volume). Dominant tree species in the plot were *Quercus robur* (oak), *Tilia cordata* (lime) and *Fraxinus excelsior* (ash) with six individual trees each and *Acer pseudoplatanus* with three trees. In addition, two trees of the neophytic tree species *Quercus rubra*, and one tree of *Robinia pseudoacacia* and *Fraxinus pennsilvanica* were sampled. The traps were purged in regular intervals of 2–4 weeks. The captured arthropods were sorted down to the order level and all adult Neuropterida (orders Raphidioptera, Neuroptera) were further determined to the species level. Females of the genus *Coniopteryx* (Neuroptera, Coniopterygidae) were determined to the genus level only since species determintion is uncertain even after mazeration of the internal genitalia. At least three species of the genus *Chrysoperla* occure in Germany (Tröger 2000; Gruppe 2002) but since morphologica characters are highly variable (Henry *et al.* 2002) several specimens were determined to the genus level only. Some specimens could not be determined to the species level due to damages and/or discoloration.

Abundance and host tree preference were analysed using data from flight interception traps of *Quercus robur*, *Tilia cordata* and *Fraxinus excelsior* only. These tree species were sampled in similar numbers. Statistical tests were done by SPSS 12 (SPSS Inc. 2003) and PC-ORD 4.10 for Windows (McCune & Mefford 1999).

RESULTS AND DISCUSSION

A total number of 306 specimens of 21 species of Neuroptera and 3 species of Raphidioptera was caught in the year 2002 (Appendix Tab. 1).

All species were reported to occur in Saxonia by Kleinsteuber (1994) except of *Chrysoperla pallida*. This species was separated from the *C. carnea* group and described as a valid species by Henry *et al.* (2002). It has been found all over Germany in arboreal habitats in the meantime (Tröger 2000; Gruppe 2002). This suggests that the species is also present in older collections from the region but this was not yet verified. The Raphidioptera *Subilla confinis* was known to occur in Saxonia from the literature earlier than 1956 only. Its high abundance characterizes it as a typical species of the tree crown fauna as it was also shown by Gruppe & Schubert (2001) and Gruppe, Gossner & Simon (2004) in different forest stands in southern Bavaria especially for oak.

Statistical analysis of the abundance of neuropterid species was done using data of flight interception traps of the three dominant tree species. Similar numbers of specimens were caught on lime (83 specimens) and oak (82) but less on ash (52) with this trap type. The same appeared for the numbers of species (lime 15 species, oak 15, ash 9). However, differences between average number of specimens as well as species were not statistically significant (specimens: K-W-test $p = 0.053$; species: K-W-test $p = 0.220$) (Fig. 1).

A correspondence analysis revealed a large variability between the communities of single trees either along axis 1 (oak) or along axis 2 (oak, lime, ash), respectively. However, there was a separation of neuropterid communities in tree crowns along the first two axes. A high β-diversity particular in oak is indicated by the high range along axis 1 and 2. Although no distinct borderlines were found between the assemblages of respective data points communities of Neuroptera can be separated in regard to all three abundant tree species. In ash and oak a high variability between neuropterid assemblages are obvious. Lime trees seem to be peculiar due to their low variability along along axis 1 (Fig. 2).

The captured neuropterid community in the Leipzig flood plain forest comprised 24 species, a relatively low number compared to the assemblages in other forest types in Central Europe (Table 1).

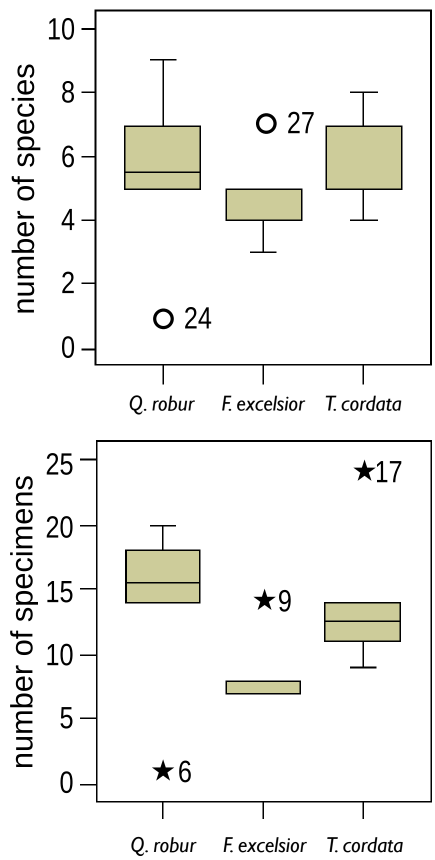


Figure 1 – Average number of Neuropterida (species top, specimens bottom) caught on different tree species at the LAK plot.

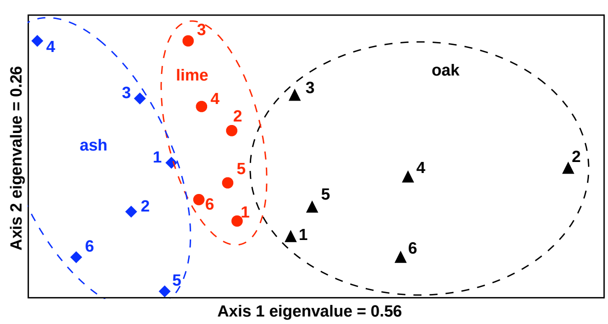


Figure 2 – DCA ordination of the neuropterid communities in the tree corwon of oak, ash, and lime at the LAK plot.

Table 1 – Number of neuropterid species in tree crowns in different Central European forest stands caught with several trap types. *yellow pan traps, **total number of species in the studied stand. [1]Gruppe, Gossner & Simon 2004; [2]Gruppe & Schubert 2001; [3]Czechowska 1997; [4]Gossner 2004. Raph: Raphidioptera, Chrys: Chrysopidae, Hem: Hemerobiidae, Coni: Conioterygidae.

		No. traps	No. years	Raph	Chrys	Hem	Coni	sum	total**
Quercus petrea/robur									
D-Krumbach[1]	Luzulo-Fagetum	6	2	0	9	7	5	21	31
D-Freising[1]	Luzulo-Fagetum	6	2	5	12	4	3	20	30
D-Hienheim[2]	Asperulo-Fagetum	9	3	5	11	9	8	33	44
D-Leipzig	Querco-Ulmetum minoris	12	1	3	5	5	4	17	24
D-Berlin[4]	Pino-Quercetum	6	2	0	3	2	3	8	10
Poland[3]	Tilio-Carpinetum	3*	2	1	8	4	3	16	28
Poland[3]	Pot.albae-Quercetum	3*	2	2	9	3	2	16	26
Poland[3]	Qu.roboris-Pinetum	3*	2	3	8	5	4	20	31
Tilia cordata									
D-Leipzig	Querco-Ulmetum minoris	12	1	2	8	3	2	15	24
Poland[3]	Tilio-Carpinetum	3*	2	2	8	5	3	18	28
Poland[3]	Pot.albae-Quercetum	3*	2	2	8	5	2	17	26

One reason for this discrepancy is probably the different type and numbers of traps in these studies. However, these data are the first systematic study of flood plain forests in that region. All others were done in stands of more diversity, i.e. in mixed forest stands with both, decidous and conifer tree species (Czechowska 1994, 1997, 2002; Gruppe & Schubert 2001; Gruppe, Gossner & Simon 2004). According to Engelmann's system (Engelmann 1978) we could find eight 'Hauptarten' defined as species the percentage of which is more than 3.2% of all caught specimens. These are discussed more detailed as follows.

About 75% of all *Subilla confinis* and *Coniopteryx borealis* were caught on oak. This suggests that they belong to the neuropterid community typically for oak crowns. Both species occurred also on lime but *C. borealis* was missing on ash. *S. confinis* seems to be a real oak specialist. It was captured in oak crowns, rarely but exclusively, in studies in southern Bavaria and, more important, it was reared in high numbers from dead wood from oak crowns (Gruppe & Schubert 2001; Gruppe *et al.* 2004). In contrast, *C. borealis* is more euryoecious and was reported by the same authors for huge number of host tree species, broad leaved trees and conifers as well. The second group of species was represented by two thirds of their specimens on ash: *Hypochrysa elegans*, *Chrysopidia ciliata* and *Sympherobius elegans*. These species show very different ecological requirements which might be responsible for their occurrence on ash. Adults of *H. elegans* are specialized pollen feeders (Canard 2001) but they seem to be strongly associated with *Fagus sylvatica* in almost all forest types (Szentkiralyi 2001). More than 60% of all specimens occurred in the sample derived at Mai 21st, when ash was still blooming but oak trees had just started to bloom. This suggests that the availability of pollen seems to be responsible for the high abundance of adult *H. elegans* in particular tree species. *S. elegans* is aphidophagous during adult and larval stage with the larvae specialized for galling aphids (Szentkiralyi 2001). Many Pemphigidae species (Homoptera) live on ash and most of these Homopterans are gall forming species which may serve as food ressource for *S. elegans* larvae. Galling Homoptera are missing on lime and oak although free living species are common on the leaves. No particular specialisation is known for *Chrysopidia ciliata* neither for adults nor for larvae. It is one of the most abundant chrysopid species in decidous forests with dense undergrowth in Central Europe (Aspöck *et al.* 1980). The reason for its high abundance on ash however is not yet clear.

Three neuropterid species were found with about 50% of their specimens on lime but also frequently on the other tree species. These were the euryoecious species *Phaeostigma notata, Chrysoperla carnea* and *C. pallida.* It seems that the distribution of the food resource, aphids and honeydew, might be responsible for the occurrence on lime.

Most lacewing species are assumed to have a more or less intense host tree preference, and therefore, it should be possible to define characteristic lacewing assemblages for several tree species (Szentkiralyi 2001), a context which is probably questionable at least for some species. The results from the LAK show that *Hypochrysa elegans* which might be strongly associated with *Fagus sylvatica* (Montserrat & Marin 1994; Szentkiralyi 2001), occurs in the flood plain forest predominantly on ash. Thus, not only the tree species seems to be the clue for host tree preference but also the tree composition of any particular forest stand.

One important factor regarding host tree preference is the nutritional requirement of a particular species. Neuropterida like other holometabolic insects often use different food ressources as larvae and adult insects. In discussion about host tree preference temporal food availability and prey community has to be considered. All terrestrial larvae of Neuropterida in Central Europe are zoophagous but due to their behaviour and morphology of the mouthparts some species are restricted to more or less motionless arthropods like Coccidae, Aleyrodidae, mites, insect eggs or galling aphids. The nutritional ecology of adult insects is more diverse. Species can roughly be subdivided to be zoophagous, glycophagous or palynophagous, but for many species, even in Central Europe, the natural food is not well known. Notably palynophagous species need a close coincidence to blooming plant species and, thus, might show a high seasonality in host plant preference.

The neuropterid community in a Central European flood plain forest which typically consists of broad leafed trees seems to have a low degree of tree species specialisation. The differences in the number of specimens indicate that oak offers the most suitable habitat to Neuropterida whereas ash does less. However, some species prefer even ash when the occurrence of adult insects coincides with food. This suggests that the association of Neuropterida with particular host tree species is more likely to be influenced by the tree as a resource-carrying structure than as an individual of a particular species.

REFERENCES

Aspöck, H., Aspöck, U. & Hölzel, H. (1980) Die Neuropteren Europas. Vol. **1–2**, Göecke & Evers, Krefeld.

Canard, M. (2001) Natural food and feeding habits of lacewings. In: McEwen, P., New, T.R. & Whittington, A.E. (Eds.) Lacewings in the crop environment. Cambridge University Press, pp. 116–129.

Czechowska, W. (1994) Neuropterans (Neuropteroidea: Raphidioptera, Planipennia) of the canopy layer in pine forests. *Fragmenta Faunistica* **36**: 459–467.

Czechowska, W. (1997) A comparative analysis of the structure of Neuropteroidea communities of tree canopies in linden-oak-hornbeam forests, light oak forests, mixed coniferous forests and pine forests. *Fragmenta Faunistica* **40**: 127–168.

Czechowska, W. (2002) Raphidioptera and Neuroptera (Neuropterida) of the canopy in montane, upland and lowland fir forests of *Abies alba* Mill. in Poland. *Fragmenta Faunistica* **45**: 31–56.

Engelmann, H.D. (1978) Zur Dominanzklassifizierung von Bodenarthropoden. *Pidobiologia* **18**: 31–56.

Gepp, J. (1999) Neuropteren als Indikator der Naturraumbewertung – Eignung als Modellgruppe, Methodenwahl, Fallbeispiele sowie Diskussion möglicher Fragestellungen (Neuropterida). In: Aspöck, H. (Ed.) Kamelhälse Schlammfliegen Ameisenlöwen. *Stapfia* **60**: 116–129.

Gossner, M. (2004) Diversität und Struktur arborikoler Arthropodenzönosen fremdländischer und einheimischer Baumarten. Ein Beitrag zur Bewertung des Anbaus von Douglasie (*Pseudotsuga menzenii* (Mirb.) Franco) und Roteiche (*Quercus rubra* L.). *Neobiota* **5**.

Gossner, M., Gruppe, A. & Simon, U. (2005) Aphidophagous insect communities in tree crowns of the neophyte Douglas-fir (*Pseudotzuga menziesii* (Mirb.) Franco) and Norway spruce (*Picea abies* L.). *Journal of Applied Entomology* **129**: 81–88.

Gruppe, A. & Schubert, H. (2001) The distribution and biodiversity of Neuropterida in different strata of forest sites (Insecta, Neuropterida). *Beiträge zur Entomologie* **51**: 519-530.

Gruppe, A. (2002) Zur Verbreitung von *Chrysoperla carnea* s. lat. in Südbayern. *Galathea (Nürnberg)* Suppl. **13**: 15–19.

Gruppe, A., Gossner, M. & Simon, U. (2004) Neuropteren in Wäldern Schwabens und Oberbayerns. *Beiträge zur bayerischen Entomofaunistik* **6**: 115–126.

Henry, C.S., Brooks, S.J., Duelli, P. & Johnson, J.B. (2002) Discovering the true *Chrysoperla carnea* (Insecta: Neuroptera: Chrysopidae) using song analysis, morphology, and ecology. *Annals of the Entomological Society of America* **95**: 172–191.

Kleinsteuber, E. (1994) Vorläufiges Verzeichnis der Schlammfliegen (Megaloptera), Kamelhalsfliegen (Raphidioptera), Netzflügler (Planipennia) und Schnabelfliegen (Mecoptera) des Freistaates Sachsen. *Mitteilungen Sächsischer Entomologen* **27**: 17–19.

McCune, B. & Mefford, M.-J. (1999) Multivariate analysis of ecological data. Version 4.20- MjM Software Gleneden Beach, Oregon, USA.

Montserrat, V. & Marin, F. (1994) Plant substrate specificity of Iberian Chrysopidae (Insecta: Neuroptera). *Acta Oecologica* **15**: 119–131.

New, T.R. (1998) Are Neuroptera an informative focal group for conservation assessment? In: Panelius, S. (Ed.) Neuropterology 1997. *Acta Zoologica Fennica* **209**: 167–174.

Saure, C. & Gruppe, A. (1999) Netzflügler, Schlamm- und Kamelhalsfliegen. *Handbuch landschaftsökologischer Leistungen.* Band **1**: 210–215. VUBD Nürnberg.

Simon, U. (1995) Untersuchung der Stratozönosen von Spinnen und Weberknechten (Arachneae: Araneae, Opilionida) an der Waldkiefer (*Pinus sylvestris*). W & T Verlag.

SPSS (2003) SPSS für Windows, Version 12.- SPSS Inc.

Szentkiralyi, F. (2001) Lacewings in vegetables, forests, and other crops. In: McEwen, P., New, T.R. & Whittington, A.E. (Eds.) Lacewings in the crop environment. Cambridge University Press, pp. 239–291.

Tröger, E.J. (2000) *Chrysoperla lucasina* (Lacroix 1912) – Schwesterart der Gemeinen Florfliege *Crysoperla carnea* (Stephens 1836) – in Süddeutschland (Neuroptera: Chrysopidae). *Mitteilungen des Baden-würtembergischen Landesverband für Naturkunde und Naturschutz* **17**: 679–682.

Winter K., Bogeschütz H., Dorda, D., Dorow, W.H.O., Flechtner, G., Graefe, U., Köhler, F., Menke, N., Schauermann, J., Schubert, H., Schulz, U. & Tauchert, J. (1999) Programm zur Untersuchung der Fauna in Naturwäldern. IHW-Verlag.

Appendix Table 1 – Total number af Neuropterida caught in the crowns of different tree species at the LAK plot (Sum of all trap types). *specimens collected by hand from various tree species.

	Quercus robur	*Fraxinus excelsior*	*Tilia cordata*	*Acer pseudoplatanus*	*Quercus rubra*	*Robinia pseudacacia*	*Fraxinus pennsilvanica*	**Unknown***	**no. of specimens**
no. of WT	6	6	6	3	2	1	1	–	–
no. of BE	16	16	16	–	–	–	–	–	–
Raphidioptera									
Phaeostigma notata	4	1	6	–	–	–	–	18	29
Subilla confinis	12	2	2	–	–	–	–	5	21
Xanthostigma xanthostigma	1	–	–	–	–	–	–	2	3
Neuroptera, Chrysopidae									
Hypochrysa elegans	–	13	8	3	–	–	–	–	24
Nineta flava	–	6	3	–	–	–	–	–	9
Chrysopa viridana	–	–	1	–	–	–	–	–	1
Chrysopa sp.	1	1	–	–	–	–	–	–	2
Dichochrysa abdominalis	–	1	1	–	–	–	–	–	2
Dichochrysa prasina	1	–	–	–	–	–	–	–	1
Cunctochrysa albolineata	–	1	1	–	–	–	1	–	3
Chrysopidia ciliata	2	7	2	–	1	1	1	–	14
Chrysoperla carnea	19	19	37	6	3	–	–	–	84
Chrysoperla pallida	3	6	10	–	–	–	–	–	19
Chrysoperla sp.		7	4	1	–	–	–	–	12
Neuroptera, Hemerobiidae									
Drepanepteryx phalaenoides	1	–	–	–	–	–	–	–	1
Hemerobius humulinus	4	–	3	–	1	–	–	–	8
Hemerobius stigma	–	–	–	1	–	–	–	–	1
Hemerobius micans	–	–	–	1	–	–	–	–	1
Hemerobius lutescens	–	–	2	–	–	–	–	–	2
Hemerobius marginatus	1	–	–	–	–	–	–	–	1
Wesmaelius nervosus	–	–	–	–	1	–	–	–	1
Wesmaelius sp.	1	–	–	–	–	–	–	–	1
Sympherobius elegans	1	14	6	2	–	–	–	–	23
Neuroptera, Coniopterygidae									
Coniopteryx borealis	13	–	4	–	–	–	–	–	17
Coniopteryx haematica	6	–	2	–	–	–	–	–	8
Coniopteryx tineiformis	2	–	–	–	–	–	–	–	2
Coniopteryx sp.	9	2	4	–	–	–	–	–	15
Parasemidalis fuscipennis	1	–	–	–	–	–	–	–	–
Total no.of specimens	82	80	96	14	6	1	2	25	306
no.of species	17	11	15	5	4	1	2	3	24

3.5 Ecological examinations concerning xylobiontic Coleoptera in the canopy of a Quercus-Fraxinus forest

Carsten Schmidt, Detlef Bernhard & Erik Arndt[1]

Xylobiontic Coleoptera were sampled using window traps and branch eclectors in the canopy of a *Quercus–Fraxinus–Tilia* forest in the "Burgaue" nature conservation area northwest of Leipzig. This study was part of the interdisciplinary LAK crane project. We examined the three autochthonous main tree species (*Quercus robur, Fraxinus excelsior, Tilia cordata*) as well as introduced ones (*Acer pseudoplatanus, Robinia pseudoacacia, Fraxinus pennsylvanica*, and *Quercus rubra*) over six months from April 24–October 24, 2002. The horizontal distribution patterns of xylobiontic Coleoptera are presented based on a total catch of 4 130 individuals and 175 species. Numbers of species and individuals are significantly different between the main trees. The fauna of xylobiontic beetles was poorer on neophytic trees compared to their autochthonous relatives of the same genera (*Quercus, Fraxinus*). Comparably high numbers of species and individuals were found on *Acer pseudoplatanus*. Significant differences in numbers of species and individuals were only found in the ecological guild of mycetophagous beetles on different tree species. Regarding microhabitat guilds, differences between tree species occurred concerning the individual but not the species numbers in the guilds of inhabitants of rotten wood, inhabitants of recently dead wood and fungi. The quantitative largest guild (coloniser of decayed wood) did not show differences between tree species. Only four xylobiontic species were subdominant to dominant, comprising two *Dasytes* species. Even though both *Dasytes* species are regarded as generalists, *Dasytes aeratus* preferred *Quercus robur*, while *Dasytes plumbeus* favoured *Tilia cordata*. We propose a partial niche separation of these two *Dasytes* species. Using a species indicator analysis, 22 species of Coleoptera were identified as significantly preferring a certain tree species or genus: *Quercus robur* (preferred by 1 xylobiontic species), *Q. rubra* (1), *Quercus* spp. (1), *Tilia cordata* (3), *Fraxinus excelsior* (3), *Fraxinus* spp. (1), and *Acer pseudoplatanus* (12). The surprisingly high number of xylobiontic species occurring predominantly on *Acer pseudoplatanus* is due to generalistic species, which significantly prefer *Acer* in the area under investigation.

INTRODUCTION

All species of the order Coleoptera, which by definition are associated with the wood habitat, count as wood-inhabiting, or xylobiontic, beetles (Palm 1959, Bense unpubl.). Xylobiontic Coleoptera are therefore an "ecological group", which, in central Europe, includes representatives from 72 families (Köhler 2000). This extremely species-rich and diverse group can be divided into guilds of defined microhabitat inhabitants (Bense 1998) or feeding preferences (Köhler 2000). A differentiated reflection on guilds of these types allows statements to be made about the naturalness of a location regarding the nature conservational assessment of forests. The investigation of wood-inhabiting beetles was one of the main projects within the Leipzig Canopy Crane Project because the results from earlier investigations (Bense 1998, Jansen & Kirmse 2002) revealed that the Burgaue nature reserve can be considered as a refuge for xylobiontic relict primeval forest species.

The aim of this project was to analyse the horizontal distribution of various species and species groups in the canopy space of this oak-ash-winter lime tree forest. Comparative examinations between several animal groups were undertaken in order that general statements could be projected concerning the canopy fauna of a "natural" forest. The study presented here is an initial ecological assessment of xylobiontic beetles. The following questions were the focus of our investigations: **(1)** are there differences in the fauna of the xylobiontic Coleoptera of various deciduous trees and **(2)** is it possible to detect beetle species preferences for certain species of trees?

MATERIALS AND METHODS

The analysis of xylobiontic Coleoptera was effected using the sampling design described in this volume.

[1] corresponding author

The capture efficiency of the window traps and branch eclectors used is kept restricted to a narrow range. This makes it possible to record the spatial distribution of xylobiontic Coleoptera in the immediate surroundings which are only mobile to a limited extent, due to their swarming behaviour (Simon & Linsenmair 2001; Bussler *et al.* 2004). The two trap types used reflect various activity patterns (flight or crawling activity). As the investigation shows, considerably fewer animals were caught in the branch eclectors than in the window traps. Since, predominantly, species with just one or two individuals were caught in the branch eclectors, only data from the window traps are considered in the further assessment.

The examination period was during six months between 24/04/ and 24/10/2002. From the total catch of Coleoptera, 48 are included in the assessment, while a few families – for example, Carabidae (ground beetles) and Chrysomelidae (leaf beetles) – were ignored, as they are not xylobiontic beetles in the strict sense. Determination took place on the basis of Freude, Harde & Lohse, volumes 3–11 (1964–83), as well as the supplementary volumes by Lohse & Lucht (1989–93) and Lucht & Klausnitzer (1998). Further, Grüne (1979) was used to determine the Scolytidae. Determination was followed down to the species for all animals; where necessary, the animals (e.g. *aedeagus*) were dissected for this purpose as appropriate. Difficult species or families, were determined or checked by experts (see Acknowledgements). The Coleoptera assessed, together with samples from 2003, which remain to be processed, are kept correspondingly prepared or conserved at the Institute of Biology II at the University of Leipzig.

In order to enable a differentiated assessment, the species were divided according to their determination into ecological guilds in respect of their microhabitats and feeding preferences. The following guilds of microhabitat inhabitants (according to Bense unpubl.) were assessed: **(1)** colonisers of recently dead and diseased wood (hkf); **(2)** colonisers of highly decomposed wood (ht); **(3)** wood fungus colonisers (hp); **(4)** rotten wood colonisers (m). Likewise with regard to feeding preferences (according to Köhler 2000) four guilds were distinguished: **(1)** mycetophagous; **(2)** necro- and saprophagous; **(3)** xylophagous; **(4)** zoophagous.

There were problems with the assessment due to the varyingly large sample number. For example, oak Q2 (1.5 m trunk diameter) fell during a storm on 05/06/2002 and could no longer be used for the canopy investigation. Two window traps and four branch eclectors were lost with Q2. Furthermore, only three representatives of *Acer pseudoplatanus* and one or two representatives each of the various neophytic species. Nevertheless, six representations each of the main tree species were sampled. The reason for the differing sample numbers was a compromise between the request to include neophytes in the investigations and the capacities available for this purpose.

An ANOVA was applied in order to test if differences in numbers of species and individuals were significant.

In order to illustrate the commonalities or differences in the species communities of the investigated tree species, the Euclidean Index was calculated and on the basis of this index a cluster diagram (UPGMA process) was compiled. Using this procedure, a multi-dimensional data set can be depicted as two-dimensional sub-groups resembling one another (clusters) (Lozán & Kausch 1998). The Indicator Species Analysis was used in order to test species preference with regard to a particular locality (here: tree species) (Dufrêne & Legendre 1997).

RESULTS

A total of 4 130 xylobiontic beetles, belonging to 175 species, were caught during the recording period 2002. Of these, 4 057 individuals (175 species) were found in the window traps and just 73 individuals (34 species) in the branch eclectors. Only the catches from the window traps are included in the following assessment.

Differences between individual tree species

Seven different tree species were investigated in 2002. Average numbers of species and individuals of xylobiontic beetles on the tree species are shown in Fig. 1. Species numbers of the main tree species (*Quercus robur*, *Tilia cordata*, and *Fraxinus excelsior*) differ significantly from one another ($p = 0.026$). If these are compared to the other two tree groups (*Acer pseudoplatanus* and neophytes with *Robina pseudoaccacia*, *Fraxinus pennsylvanica*, and *Quercus rubra*), there is only a significant difference in the neophytes. ($p = 0.011$). In the case of number of individuals, significant differences are limited to the three main tree species ($p = 0.016$).

In many respects, *Acer pseudoplatanus* assumes a special ecological position among the analysed trees (see below). The species number is significantly different from the main tree species, but considering species ranges and numbers of individuals it is closer to the *Quercus* species than to the other tree species (Fig. 2). If the xylobiontic Coleoptera are examined differentially according to their feeding preference, then only the mycetophagous species support the differences between tree species described above regarding their species numbers ($p = 0.008$) and numbers of individuals ($p = 0.007$).

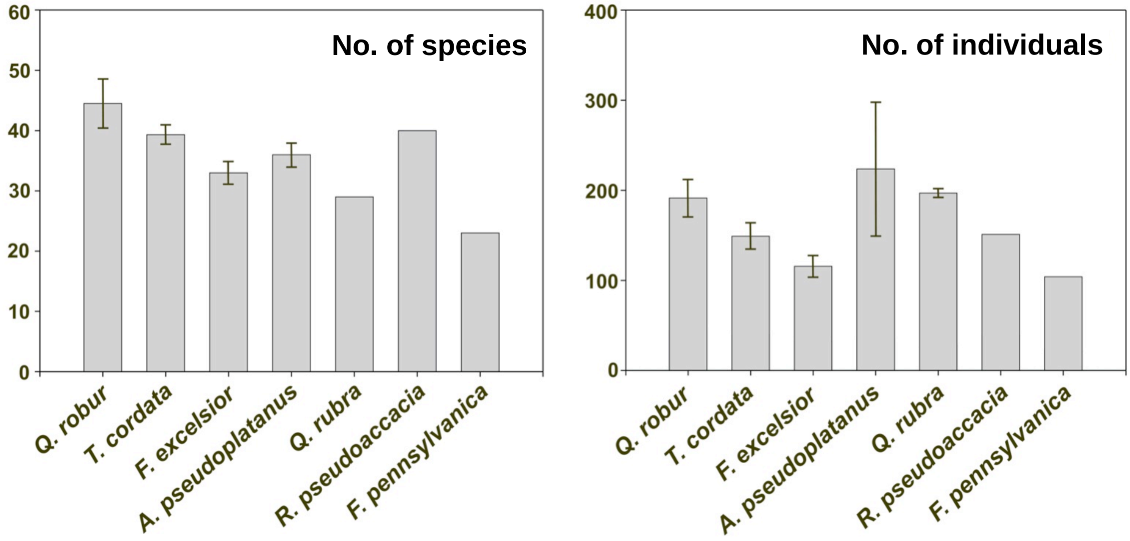


Figure 1 – Average numbers of species and individuals of xylobiontic Coleoptera in window traps of all examined tree species with standard errors.

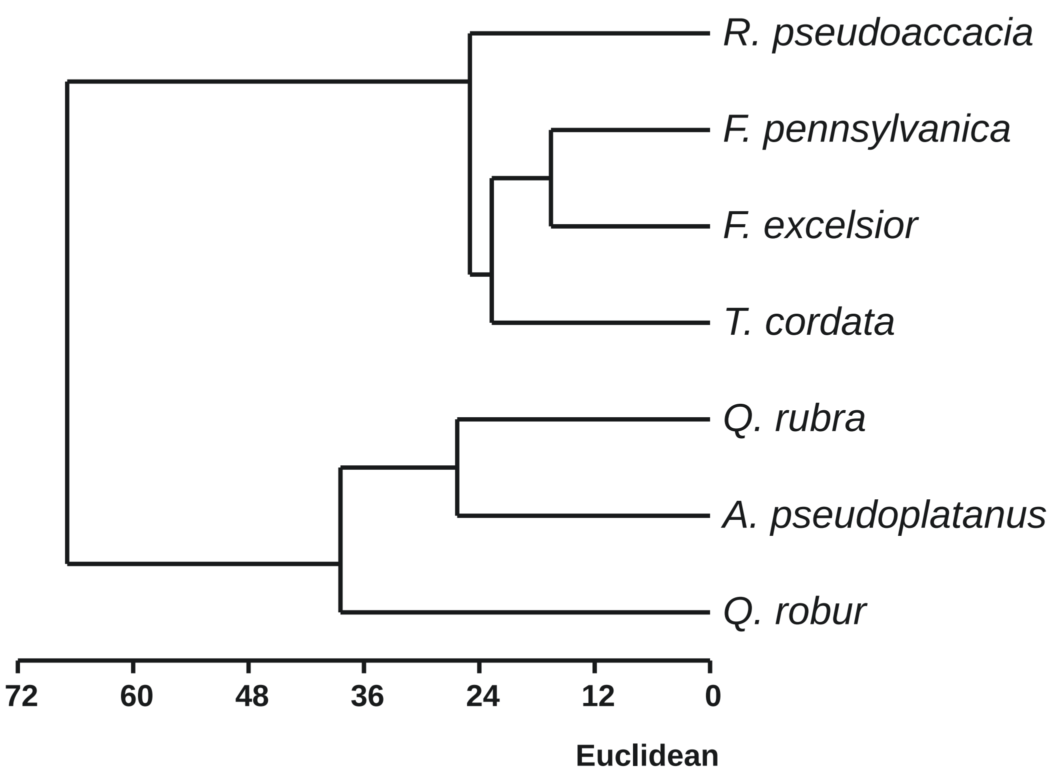


Figure 2 – Cluster analysis of Euclidean index of the tree species based on average data (UPGMA, xylobiontic species only represented by singletons and doubletons are excluded).

Table 1 – Xylobiontic generalists, sampled with window traps in all examined tree species.

Species	Ecology	Microhabitat
Alosterna tabacicolor (DeGeer)	lignicolous	ht
Anaglyptus mysticus Linné	lignicolous	ht
Anaspis rufilabris (Gyllenhal)	lignicolous	ht
Cerylon ferrugineum Stephens	mulm	ht
Cryptarcha undata (Olivier)	succicolous	hkf
Dacne bipustulata (Thunberg)	fungiocolous	hp
Dasytes aeratus Stephens	corticolous	ht
Dasytes plumbeus (Müller)	corticolous	ht
Denticollis linearis (Linné)	mulm	ht
Ennearthron cornutum (Gyllenhal)	fungicolous	ht
Ernoporicus caucasius Lindemann	corticolous	hkf
Ernoporus tiliae Panzer	corticolous	hkf
Glischrochilus quadriguttatus (Fabricius)	corticolous	hkf
Glischrochilus quadripunctatus (Linné)	corticolous	hkf
Hedobia imperalis (Linné)	lignicolous	ht
Hylesinus oleiperda Fabricius	corticolous	hkf
Ischnomera caerulea (Linné)	lignicolous	ht
Leperisinus fraxini (Panzer)	corticolous	hkf
Litargus connexus Geoffroy	corticolous	ht
Mordellistena neuwaldeggiana (Panzer)	lignicolous	ht
Nemosoma elongatum (Linné)	corticolous	hkf
Phloeopora spec	corticolous	ht
Plectophloeus erichsoni (Aubé)	mulm	ht
Rhinosimus planirostris (Fabricius)	corticolous	ht
Rhizophagus bipustulatus Fabricius	corticolous	hkf
Stenostola dubia (Laicharting)	lignicolous	ht

Examined differentially according to individual microhabitats, there are no significant differences at the species level. The number of individuals of single tree species, on the other hand, vary within the guild of wood fungus colonisers ($p = 0.002$) and rotten wood colonisers ($p = 0.022$), and within the three main tree species among the colonisers of recently dead and diseased wood ($p = 0.003$). The largest group (colonisers of already highly decomposed woods; ht according to Bense unpubl.) shows no differences between individual tree species either in numbers of species or individuals.

Generalists

Of the 175 species detected, only four species appeared to be dominant or subdominant, and all others to be recedent to sporadic. Only 10 species were caught on all tree species (referred to in the following as "generalists"; these species are listed in Table 1). In order to investigate whether these generalists are generally evenly distributed or appear on certain tree species more frequently than on others, the two species of the genus *Dasytes* present themselves in particular. On the one hand, *Dasytes* species were found on all tree species, and on the other hand belong to the dominant or subdominant species. Close examination shows that *Dasytes aeratus* Stephens prefers *Quercus robur*, while *Dasytes plumbeus* (Müller) favours *Tilia cordata* (Fig. 3). Both frequent *Acer pseudoplatanus* to an equal extent, but also *Quercus rubra* (the extreme standard error in the case of *Dasytes aeratus* is due to an 'en-masse' occurrence on 25/4/2005 in only one tree), where *Dasytes plumbeus* can be encountered on average in a significantly larger number of individuals.

Fraxinus excelsior is apparently avoided by both. The results lead us to conclude a partial niche differentiation between the two *Dasytes* species.

A preference for certain tree species is revealed for other "generalists" too: *Leperisinus fraxini* (Panzer)[2] (Scolytidae) principally occurs on *Fraxinus* species (Fig. 4), *Anaspis rufilabris* Gyllenhal (Scraptiidae) on *Acer pseudoplatanus*, *Cerylon ferrugineum* Stephens (Cerylonidae) on *Quercus robur* and *Tilia cordata.*

Specialists

In order to detect xylobiontic beetle preferences for certain species of trees a species indicator analysis was carried out. Significant preferences for certain tree species or genera were identified for 22 beetle species (Table 2). Among the specialists for individual tree species, only one species was significant for *Quercus*

[2] The term "generalist" only applies partially to *Leperisinus fraxini* (see below), but in addition to *Fraxinus* at least 10 other wood species are known to be host trees (Grüne 1979).

robur, but at 44.0%, however, it has a very low preference value. Four species preferred *Tilia cordata*, two *Fraxinus excelsior* and one species, the neophytic *Quercus rubra*. Nine different species showed significant preferences for the non-autochthonous *Acer pseudoplatanus*. A second species indicator analysis at the genus level revealed significant results for five more xylobiontic species (Table 3), among them three more on sycamore. *Ennearthron cornutum* (Gyllenhal) (Cisidae) significantly prefers both of the investigated *Quercus* species and the bark beetle *Leperisinus fraxini*, as in Fig. 4, the *Fraxinus* species. However, at the genus level, all five specialist only have low indicator values at 47–54%.

In addition to the xylobiontic species, which showed significant preferences for certain tree species or tree genera in the species indicator analysis, numerous beetle species, which are categorised in the literature as being tree-specific, were caught; however in our investigations, they attained no significance in the Monte Carlo test due to their very low abundance.

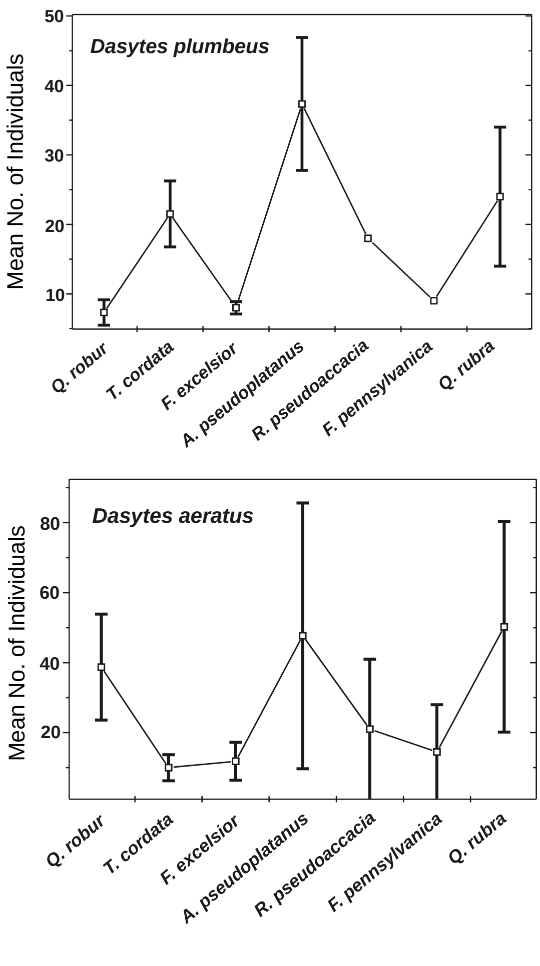


Figure 3 – Average individual numbers of *Dasytes plumbeus* (Müller) and *D. aeratus* Stephens in window traps of all examined tree species with standard errors.

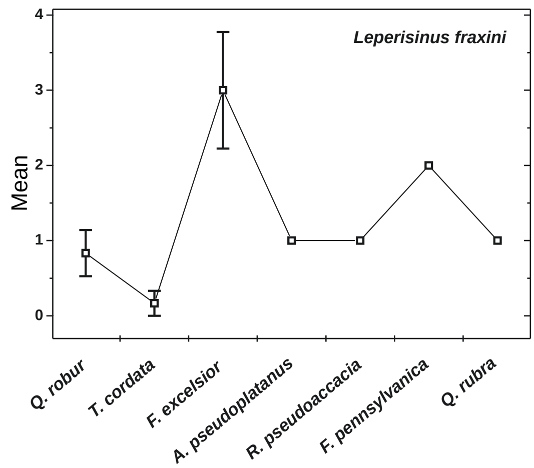


Figure 4 – Average individual numbers of *Leperisinus fraxini* (Panzer) in window traps of all examined tree species with standard error.

Table 4 provides an overview of these species with high tree specificity, but low abundance. Ten of these species are referred to by Köhler (2000) as specialists for *Quercus robur*, five for *Tilia cordata*, one for *Fraxinus excelsior* and two for *Acer pseudoplatanus*.

DISCUSSION

Xylobiontic beetles, as microhabitat specialists, have different claims on their host plant, its location, wood quality and deadwood structure. Because of these specialisations it is possible for individual species to make use of the widest variety of niches within the ecosystem (Köhler 2000). However, the specialisation of individual species simultaneously provides us with the opportunity to examine the ecology of this large insect group occupying the canopy space. Since the area of investigation is a mixture of autochthonous oaks, ash trees and winter lime trees, as well as various planted woods, it was possible to compare the species and individual patterns on native with introduced tree species.

In the literature referring to similar comparisons *Quercus robur* is considered the most species-rich tree (Palm 1959, Bense & Geiss 1998). Therefore, it is not surprising that in the Leipzig floodplain forest, too, most wood-inhabiting beetles inhabiting domestic tree species were found on *Q. robur* (Fig. 1). The other two main tree species, *Tilia cordata* and *Fraxinus excelsior*, show considerably lower species numbers and numbers of individuals. One possible reason for this is the diversity of structure provided by tree species (see e.g. Horchler, this volume). On the one hand, ash trees have fewer microhabitat structures (dead wood, rotten wood, bark structure, fungi etc.) than lime trees or oaks (see also Unterseher Tal, this volume, on the other, they fail by far to reach the age of the old oaks in the stand (more than 250 years; SEELE and PAROLIN *et al.*, this volume).

In addition to microhabitats and deadwood structures, historic and macro-ecological reasons are conceivably responsible for a higher xylobiontic species diversity on *Quercus*. In Europe, in contrast to *Fraxinus* or *Tilia*, *Quercus* is a genus species rich trees with numerous representatives in the Mediterranean region and Pleistocene refuge areas, from where a particularly high number of species may have migrated to central Europe post-glacially and established themselves on *Q. robur*.

Table 2 – Xylobiontic Coleoptera preferring specific tree species based on a species indicator analysis (acc. to DUFRÊNE & LEGENDRE 1997) of window trap samples. Only species with significant values are shown. I-Value: Indicator value, p*: significance.

Species	I-Value	p*	Tree species	Microhabitat
Alosterna tabacicolor (DeGeer)	53.3	0.044	*Acer pseudoplatanus*	ht
Anaglyptus mysticus Linné	53.3	0.046	*Acer pseudoplatanus*	ht
Anaspis rufilabris (Gyll.)	44.8	0.027	*Acer pseudoplatanus*	ht
Cryptarcha undata (Olivier)	63.8	0.025	*Acer pseudoplatanus*	ht
Denticolis linearis (Linné)	57.1	0.034	*Acer pseudoplatanus*	hfk
Ernoporicus caucasius Lindemann	83.3	0.004	*Tilia cordata*	hfk
Ernoporus tiliae Panzer	96.9	0.000	*Tilia cordata*	hfk
Glischrochilus quadriguttatus (Fabricius)	63.6	0.020	*Acer pseudoplatanus*	ht
Glischrochilus quadripunctatus (Linné)	66.7	0.015	*Acer pseudoplatanus*	ht
Hylesinus oleiperda Fabricius	82.4	0.000	*Fraxinus excelsior*	hkf
Ischnomera caerulea (Linné)	56.7	0.004	*Fraxinus excelsior*	hp
Mordellistena neuwaldeggiana (Panzer)	60.6	0.031	*Acer pseudoplatanus*	ht
Nemosoma elongatum (Linné)	76.9	0.000	*Tilia cordata*	hkf
Plectophloeus erichsoni (Aubé)	66.7	0.033	*Quercus rubra*	ht
Rhinosimus planirostris (Fabricius)	62.5	0.023	*Acer pseudoplatanus*	ht
Stenostola dubia (Laicharting)	66.7	0.024	*Tilia cordata*	hfk
Symbiotes gibberosus (Lucas)	44	0.024	*Quercus robur*	hfk

Table 3 – Xylobiontic Coleoptera preferring specific tree genera based on a species indicator analysis (acc. to DUFRÊNE & LEGENDRE 1997) of window trap samples. Only species with significant values are shown. I-Value: Indicator value, p*: significance.

Species	I-Value	p*	Tree	Microhabitat
Alosterna tabacicolor (DeGeer)	56.1	0.013	*Acer*	ht
Anaglyptus mysticus Linné	54.9	0.027	*Acer*	ht
Anaspis rufilabris (Gyllenhal)	51.8	0.011	*Acer*	ht
Cryptarcha undata (Ol.)	77.1	0.003	*Acer*	ht
Dasytes plumbeus (Müller)	47.6	0.01	*Acer*	ht
Denticolis linearis (Linné)	52.6	0.02	*Acer*	hkf
Ennearthron cornutum (Gyllenhal)	50	0.014	*Quercus*	ht
Ernoporicus caucasius Lindemann	83.3	0.002	*Tilia*	hkf
Ernoporus tiliae Panzer	97.3	0	*Tilia*	hkf
Glischrochilus quadriguttatus (Fabricius)	77.5	0.002	*Acer*	ht
Glischrochilus quadripunctatus (Linné)	66.7	0.012	*Acer*	ht
Grammoptera ruficornis (Fabricius)	47.5	0.044	*Acer*	hp
Hylesinus oleiperda Fabricius	89.4	0	*Fraxinus*	hkf
Ischnomera caerulea (Linné)	62.5	0.002	*Fraxinus*	hp
Leperisinus fraxini (Panzer)	50	0.029	*Fraxinus*	hp
Mordellistena neuwaldeggiana (Panzer)	62	0.01	*Acer*	ht
Nemosoma elongatum (Linné)	79.8	0	*Tilia*	hkf
Rhinosimus planirostris (Fabricius)	62.2	0.012	*Acer*	ht
Rhizophagus bipustulatus Fabricius	53.8	0.025	*Acer*	hkf
Stenostola dubia (Laicharting)	66.7	0.004	*Tilia*	hkf

Table 4 – Specialised xylobiontic Coleoptera with 80% or more individuals in window traps occurring on a single tree species, but failing significance in the species indicator analysis (species only represented by singletons and doubletons are excluded). The lacking significance of these species may be connected with too low abundances in our examination.

Tree species	> than 90% of individuals	> than 80% of individuals
Quercus robur	*Allecula morio* (Fabricius)	*Ampedus cardinalis* (Schrödte)
	Dendrophilus punctatus (Herbst)	*Anaspis melanostoma* Costa
	Dorcatoma dresdensis Herbst	*Cryptolestes duplicatus* (Waltl.)
	Conopalpus brevicollis Kraatz	*Tetratoma desmaresti* Latreille
	Euglenes oculatus (Paykull)	*Haploglossa marginalis* (Gravenhorst)
Tilia cordata	*Ernoporus tiliae* Panzer	
	Anobium fulvicorne Sturm	
	Exocentrus lusitanus (Linné)	
	Stenostola dubia (Laicharting)	
	Ernoporicus caucasius Lindemann	
Faxinus excelsior	*Agrilus olivicolor* Kiesewetter	
Acer pseudoplatanus	*Glischrochilus quadripunctatus* (Linné)	*Mordellistena neuwaldeggiana*

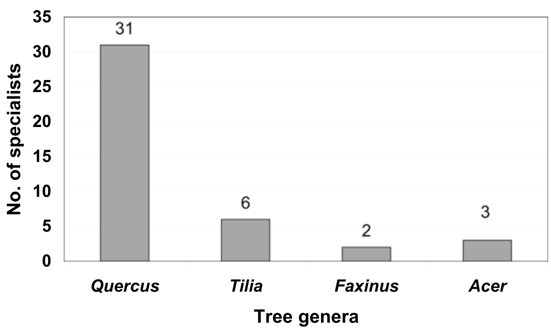


Figure 5 – Xylobiontic Coleoptera specialized on the tree genera *Quercus, Tilia*, and *Fraxinus* acc. to Köhler (2000).

The comparison of species numbers alone does not permit conclusions concerning the species composition of xylobiontic beetles on individual tree species. It is known from the literature that numerous species have specialised in one wood type or tree species (Fig. 5; Köhler 2000). In contradiction to these findings, two species were separated by the species indicator analysis of our data set, which prefer the common ash tree, or four species, respectively, which preferred the winter lime tree; but only one species, which significantly prefers the common oak (Table 2). This surprising result clearly contradicts both values expected due to indications from the literature and the results in Heteroptera from the same traps (Arndt *et al.*, this volume). In addition to the species, which significantly prefer one tree species, a number of xylobiontic species known to be oak specialists were detected by us only as individual specimens or in extremely low abundances on *Q. robur* (Table 4).

The comprehensive trap set, covering seven tree species, brought not only surprising results concerning specialised xylobiontic species, but also concerning generalists, which are found on all trees. The comparison of several tree species distinctively indicates that generalists prefer, or respectively avoid, individual tree species. Most impressive is the example of the dominant species pair *Dasytes plumbeus* and *D. aeratus*. These *Dasytes* species under close examination, largely avoid each other in terms of territory (see Fig. 3) and tend to develop tree preferences, even though both are supposed to be generalists.

Several times, neophytic species have been planted in the structure-rich Leipzig flooplain forest by forestry measures (Seele and Parolin *et al.*, this volume). These trees, introduced to the existing system by man, differ from native species in respect of their xylobiontic fauna. Thus, neophytes hosts fewer species than their native relatives, but they do exhibit a comparably high number of individuals (Fig. 1). One possible reason for this is the absence of specialists (Moren & Southwood 1982). Thus, for example, no specialists were brought to Europe along with the red oak *Quercus rubra* (Gossner 2002). Potential reasons for the lack of specialists are the small dispersion radii and the strict habitat association of xylobiontic species. Therefore, neophytes are primarily colonised by generalists, as demonstrated impressively by the two *Dasytes* species discovered on *Quercus rubra* (Fig. 3). Further, neophytes are colonised by a few specialists from native tree species, which can hence be described as genus-specific. One example is *Leperisinus fraxini* (Fig. 4 and Table 3) on *Fraxinus excelsior* and *F. pennsylvanica*. The cluster representation of the Euclidean Index (Fig. 2; others, such as the Renkonen Index, show the same results) of individual tree species underlines that the neophytic trees and their native relatives host very similar species and that the tree species introduced by man can be regarded as an impoverished variant of autochthonous trees regarding their xylobiontic fauna.

In the crane plot investigation area, a special position is assumed by the rapidly spreading sycamore (*Acer pseudoplatanus*). This tree, not native to central Germany but introduced by the forestry industry, currently already makes up 20% of canopy coverage with its low but wide treetops. The species structure of its xylobiontic fauna cannot be assigned precisely to either of the two groups (native tree species or neophytes) and appears to assume an intermediate position between the two tree groups.

In the present examination, an astonishingly high number of xylobiontic species known as generalists (Köhler 2000) predominantly colonised *Acer pseudoplatanus*. In the species indicator analysis, nine beetle species achieved significance on this tree species; on calculation of specialists at the tree genus level, 12 species were even identified as significant for *Acer*. Indicator values for all species were between 45 and 67%. They are, therefore, comparatively low (see Table 2 and 3) and confirm that the beetle species concerned are probably generalists, which, in the area of investigation, have developed a preference for *Acer*. Yet the sycamore, strictly speaking a neophytic tree species (Kowarik 2003), hosts by far the most tree-specific species among the xylobiontic beetles in our examination, in addition to its in any case high number of species and individuals (Fig. 1). This result is extraordinarily surprising, thus also contradicting (see above) the current opinion regarding particularly high colonisation umbers on common oak. So far, no satisfactory explanation for this result can be presented; the phenomenon should form the subject of further examinations, in a larger geographical context if possible, e.g. the whole of Europe.

Overall, our investigations confirm the high nature conservational significance of the Burgaue nature reserve. We were able to detect a high number of xylobiontic beetle species, of which many are on the Endangered Lists of Saxony (Klausnitzer 1994; 1995) and Germany (Geiser 1998). Further, the results confirm that investigations of xylobiontic species are indispensable for nature conservational surveys in canopy space.

ACKNOWLEDGEMENTS

We thank Prof. W. Morawetz and P. J. Horchler for co-ordinating the LAK project, Prof. M. Schlegel (University of Leipzig) for financially supporting our work, and Prof. J. Adis (Plön) for his support during the preparation of the project. Some of the traps used were kindly provided by Dr. U. Simon (Freising; branch eclectors) and Dr. M. Verhaagh (Karlsruhe; window traps). We would also like to thank numerous students from the University of Leipzig and Anhalt University (Bernburg) for their assistance in surveying the crane plots and sorting the trap catches. Our work would also not have been possible without the support of numerous colleagues in determining difficult beetle taxa. We would therefore like to express our particular thanks to Mrs. B. Büche (Berlin; Mordellidae, Anaspidae), H. Bussler (Feuchtwangen; Troscidae), J. Esser (Berlin; Cryptophagidae), U. Holter (Leipzig; Cisidae), J. Reibnitz (Stuttgart; Cisidae), W. Rose (Tübingen; various taxa), Dr. J. Schmidl (Erlangen; Troscidae), M. Schülke (Berlin; Staphylinidae) and Dr. C. Wurst (Heilbronn; Elateridae).

REFERENCES

Bense, U. & Geis, K.-U. (1998) Holzkäfer. In: Bücking, W. Faunistische Untersuchungen in Bannwäldern. Holzbewohnende Käfer, Laufkäfer und Vögel. In: Bückling, W. (Ed.) Mitteilungen Forstlichen Versuchs- und Forschungsanstalt Baden-Württemberg, Faunistische Untersuchungen in Bannwäldern **203**: 45–117.

Bense, U. (1998) Ein Beitrag zur Holzkäferfauna von Nordwest-Sachsen. *Veröffentlichung Naturkundemuseum Leipzig* **16**: 56–84.

Bussler, H., Müller, J, & Simon, U. (2004) Erfassung xylobionter Käfer in Waldökosystemen. Ein Methodenvergleich unter besonderer Berücksichtigung der Kronenfauna. *Naturschutz und Landschaftsplanung* **37**: 197–201.

Dufrêne , M. & Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs* **67**: 345–366.

Freude H., Harde, K. W. & Lohse, G. A. (1964–1982) (Eds.) Die Käfer Mitteleuropas, Bände **4–10**. Krefeld.

Geiser, R. (1998) Rote Liste der Käfer (Coleoptera). In: Binot, M. Bless, R., Boye, P., Gruttke, H. & Pretscher, P. (Eds.) Rote Liste der gefährdeten Tiere Deutschlands. Schriftenreihe für Landschaftspflege und Naturschutz (Bonn-Bad-Godesberg) **55**: 168–230.

Gossner M. (2002) Arthropoden auf Neophyten. In: Ammer, U. & Schmidt, O. (Eds.) Vergleichende waldökologische Untersuchungen in Naturwaldreservaten (ungenutzten Wäldern) und Wirtschaftswäldern unterschiedlicher Naturnähe (unter Einbeziehung der Douglasie) in Mittelschwaben. Forschungsvorhaben des BMBF (0339735A), 216 pp.

Grüne, S. (1979) Handbuch zur Bestimmung der europäischen Borkenkäfer – Brief Illustrated Key to European Bark Beetles. Verlag M. & H. Schoper Hannover.

Jansen E. & Kirmse K. (2002) Das Naturschutzgebiet "Burgaue". In: StUfa Leipzig (Ed.) Materialien zu Naturschutz und Landschaftspflege. Leipzig, pp. 43.

Klausnitzer, B. (1994) Rote Liste Bockkäfer, Arbeitsmaterialien Naturschutz, Sächsisches Landesamt für Umwelt und Geologie. Radebeul.

Klausnitzer, B. (1995) Rote Liste Blatthornkäfer und Hirschkäfer, Arbeitsmaterialien Naturschutz, Sächsisches Landesamt für Umwelt und Geologie, Radebeul.

KÖHLER, F. (2000) Totholzkäfer in Naturwaldzellen des nördlichen Rheinlandes. Landesanstalt für Ökologie, Bodenordnung und Forsten/ Landesamt für Agrarordnungen NRW, LÖBF– Schriftenreihe, Band **18**.

KOWARIK, I. (2003) Biologische Invasionen: Neophyten und Neozoen in Mitteleuropa. Ulmer, Stuttgart.

LOHSE, G.A. & LUCHT, W. (1989) Die Käfer Mitteleuropas, **1.** Supplementband mit Katalogteil. Krefeld.

LOHSE, G.A., LUCHT, W. (1992) Die Käfer Mitteleuropas, **2.** Supplementband mit Katalogteil. Krefeld.

LOHSE, G.A. & LUCHT, W. (1993) Die Käfer Mitteleuropas, **3.** Supplementband mit Katalogteil. Krefeld.

LOZÁN, J. & KAUSCH, H. (1998) Angewandte Statistik für Naturwissenschaftler. *Pareys Studientexte* **74**. Blackwell Wissenschafts-Verlag, Berlin, Wien.

LUCHT, W., & KLAUSNITZER, B. (1998) Die Käfer Mitteleuropas, 4. Supplementband. Jena.

MORAN, V.C. & SOUTHWOOD, T.R.E. (1982) The Guild Comosition of Athropod Communities in Trees. *Journal of Animal Ecology* **51**: 289–306.

PALM, T. (1959) Die Holz- und Rindenkäfer der süd- und mittelschwedischen Laubbäume. *Opuscula entomologica (Lund)*, supplementum **16**: 1–374.

SIMON, U. & LINSENMAIR, K. E. (2001) Arthropods in tropical oaks: differences in their spatial distributions within tree crowns. *Plant Ecology* **153**: 179–191.