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IMPACTS OF SILVICULTURAL PRACTICE ON THE GROUND LIVING-SPIDER COMMUNITY (ARACHNIDA: ARANEAE) OF MIXED MOUNTAIN FORESTS IN THE CHIEMGAU ALPS (GERMANY)

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Abstract

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Investigations of long-term effects of clear-cutting, as well as slight and heavy shelterwood cutting, on soil-dwelling spiders were carried out in the mixed mountain forest of the Bavarian Alps. The experimental design included 4 plots (each of 0.5 ha): a control area (0) without intervention, and three plots, submitted in 1976 to different degrees of canopy opening. Slight (30) or heavy (50) shelterwood cutting resulted in a 30 or 50% reduction of basal area. On the clear-cut area (100) trees were completely removed. On each variant a subplot was fenced (Z) subsequently to silvicultural practice in order to prevent cattle and deer from entering. Spiders were collected 22 years after the management by pitfall traps (PT: n=9) from April 1998 to April 1999.
A total of 9750 spiders (97 species, 19 families) was collected, among them 23 Araneae listed in the Red Data Book of Germany and/or Bavaria. Small-sized species of Linyphiidae dominated the spider fauna on each plot. The portion of Lycosidae increased with increasing shelterwood cutting and reached maximum values (18.9%) on 50. The spider community reached its maximum biodiversity on clear-cuts, while the number of specimens as well as the biomass was lowest at these sites. Highest numbers of specimens were found on the unfenced slightly-cut shelterwood plot (30), and the highest biomass on the unfenced plot of heavily-cut shelterwood (50). The Quotient of Similarity (QS), according to Soerensen, decreased with increasing shelterwood cutting and was lowest between 0/Z and 100/Z. The highest similarity was reached between fenced and unfenced plots of the same intensity levels of forestry practice, as well as between the control area (0) and 30% shelterwood cut (30, 30/Z). Using niche width calculations 15 spider species were identified as being characteristic of the clear-cuts (Gnaphosidae: *Gnaphosa bicolor*, Liocranidae: *Agroeca brunnea*, Linyphiidae: *Agyneta ramosa*, *Ceratinella brevis*, *Gongylidiellum latebricola*, *Lepthyphantes flavipes*, *Lepthyphantes mansuetus*, *Lepthyphantes mengei*, *Micrargus herbigradus*, *Pocadicnemis pumila*, *Walckenaeria atrotibialis*, *Walckenaeria antica*, Zoridae: *Zora nemoralis*) and the heavily-cut shelterwood (Linyphiidae: *Diplocephalus picinus*, Lycosidae: *Alopecosa taeniata*). In addition *Micrargus apertus* was recorded for Bavaria for the first time.

Introduction

With respect to sustainable land use concepts in agriculture and forestry high priority is attached to maintaining the ecological integrity of ecosystems. In contrast to agricultural land use systems the effects of silvicultural methods on key biotic processes of ecosystem functioning are largely unknown today, apart from the clear-cutting system, fire application and mineral fertilisation (BEAUDRY et al., 1997; HUTTO, 1995; PAQUIN, CODERRE, 1997; STADDON et al., 1998). In this context measures for the regeneration of stands are particularly interesting, with the natural regeneration obtaining a high ranking, and not only for economic reasons (OTTO, 1994). Regarding the Central European stands that have been mainly grown as high forests, natural regeneration can be controlled especially by operations in the shelterwood (MOSANDL, 1991).

One of the most important faunistic key factors of ecosystem functions and processes operating in forests are predatory arthropods (e.g. NYFFELER, 1982). Species diversity, high abundance, and their sensitivity to alterations of environmental parameters designate the ground-living Araneae as a suitable indicator group (RATSCHKER, ROTH, 1999).

The objective of this study consisted in assessing long-term effects of silvicultural practices of canopy density regulation (clear cutting, removal of 30 or 50% of the stand basal area) on spider assemblages and other predatory arthropods (JUNKER, ROTH, 2000). Montane mixed forest systems were selected as investigation areas in the upper Bavarian lime alpine, which are endangered by an impoverishment of tree species composition (decline of fir) and the absence of natural regeneration (e.g. BURSCHEL et al., 1990; BERNHART, 1988, 1990).

Material and methods

The assessment of the Araneae community was performed on four NW-exposed forest plots (71 x 71 m) in the Chiemgau Alps in 1998 (Forest District Ruhpolding, Rauschberg: 47°46' northern latitude – 13°39' eastern longitude, altitude a.s.l.: 890-920 m). The humus form was moder. In 1976 the plots were subjected to shelterwood cutting of various intensity (Table 1). The canopy opening on the plots of slightly- (30, 30/Z) and heavily-cut (50, 50/Z) shelterwood led to a tree species composition that largely resembled that of the control plot (percentages referring to the whole stand: *Picea abies*: 12-36%, *Abies alba*: 33-49%; *Fagus sylvatica*: 20-33%; *Acer pseudoplatanus*: 12-15%, cf. AMMER, 1996). Except for a core area (22 x 33 m) that was fenced (Z) on each subplot to exclude game species, all investigation areas were left to free succession after the silvicultural treatment. As was evident from a comparison of the relative slight intensity in the subplots, the silvicultural canopy density regulatory operations were still obvious 20 years after the practices (Table 1, AMMER, 1996).

The epigeal spider fauna was surveyed using pitfall traps (volume: 370 ml, diameter: 7 cm, number of replicates per variant: n=9) according to MÜHLENBERG (1993). Therefore the data (total of specimens, diversity, biomass) represent the activity of spiders on the ground. Saturated benzoic acid solution with detergent served as a preservative solution. The pitfall traps were placed in the plots each at a distance of 5.4 m in a grid-like pattern. Spiders were sampled at monthly intervals over the investigation period from April 23rd to November 4th 1998, with the winter trapping season lasting from November 5th 1998 to April 22nd 1999.

The Araneae were determined according to HEIMER, NENTWIG (1991), ROBERTS (1985, 1987, 1995), WIEHLE (1956, 1960), KRONESTEDT (1990) and RELYS, WEISS (1997). The nomenclature followed PLATNICK (1998) (in

T a b l e 1. Characterisation of the experimental plots (according to AMMER, 1996).

plot	Silvicultural operation	intensity of cut	altitude a.s.l. [m]	Slope inclination	relative light intensity [%]
0	control area	no intervention	890	22°	10.2
0/Z	control area	no intervention, fence	890	22°	10.2
30	slightly-cut	30 % reduction of basal area	910	24°	14.1
30/Z	slightly-cut	30 % reduction of basal area, fence	910	24°	14.1
50	heavily-cut	50 % reduction of basal area	920	21°	18.4
50/Z	heavily-cut	50 % reduction of basal area, fence	920	21°	18.4
100	clear-cut	100 % reduction of basal area	910	28°	39.1
100/Z	clear-cut	100 % reduction of basal area, fence	910	28°	39.1

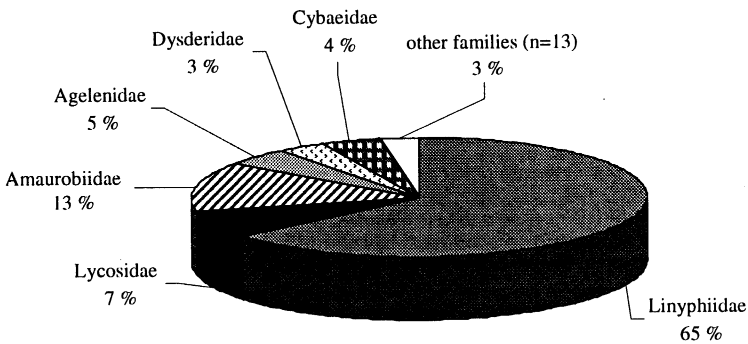

Fig. 1. Dominance structure of spider families in the total catch (n=6159 ind.), sampling period April 23rd 1998 to April 22nd 1999.

JÄGER, 1999). The data were statistically assessed (parameter-free tests: Mann-Whitney-U Test) using the program SPSS 8.0™ for Windows.

For the determination of characteristic species for various silvicultural variants only those species were used which according to ENGELMANN (1978) at least reached subrecedent proportions in the entire catch of spiders and had a niche width <0.3.

Results

As a whole, 9750 spiders were assessed; the juvenile proportion of which accounted for 36.8% (3591 ind.). The adult Araneae belonged to 97 species from 19 families; among them 23 species (23.7%) of the German Red List (PLATEN et al., 1998) or the Bavarian Red List (BLICK, SCHEIDLER, 1996) (Table 2). In addition *Micrargus apertus* (O.P.-CAMBRIDGE) was recorded for Bavaria the first time.

T a b l e 2. Compilation of the assessed species with indication of numerical abundance as well as the status of endangerment according to the German Red List (GRL: PLATEN et al., 1998) and the Bavarian Red List (BRL: BLICK & SCHEIDLER, 1996). 3: endangered, R: extremely rare species or endemic species; G: supposed endangerment, status, however, being unknown; 4S: questionable status, found rarely. * *Coelotes solitarius* was firstly recorded for Germany in 1994 (BLICK, 1994), *Micrargus apertus* was not published for Bavaria until now. Therefore they are not listed in the Bavarian Red List yet.

Species	Red Data List		Study sites								Total
	GRL	BRL	0/Z	0	30/Z	30	50/Z	50	100/Z	100	
SEGESTRIIDAE (1 species)											
Segestria senoculata (L.)					2		2				**4**
DYSDERIDAE (1 species)											
Harpactea lepida (C. L. K.)			14	14	23	20	40	24	41	23	**199**
THERIDIIDAE (3 species)											
Episinus angulatus (BL.)									1		**1**
Robertus lividus (BL.)						1	9	3	9	8	**30**
Robertus truncorum (L. K.)	**R**	**4S**	1	1	3	3	2			2	**12**
LINYPHIIDAE (51 species)											
Agyneta ramosa JACK.					1				33	7	**41**
Asthenargus perforatus SCHEN.	**R**	**4S**					2				**2**
Bolyphantes alticeps (SUND.)							1	12	6	9	**28**
Centromerus cavernarum (L. K.)		**4S**	9	11	18	19	26	8	5		**96**
Centromerus incilium (L. K.)									1		**1**
Centromerus pabulator (O. P.-C.)			84	44	33	51	7	11			**230**
Centromerus sellarius (SIMON)	**G**	**4S**	10	29	5	25	19	15	2	2	**107**
Centromerus silvicola (KULC.)	**3**	**3**	1	4	19	2	12		5		**43**
Centromerus sylvaticus (BL.)			1	2	2	3	11	39	11	43	**180**
Ceratinella brevis (WIDER)					1	1			19	2	**23**
Dicymbium tibiale (BL.)										1	**1**
Diplocephalus latifrons (O. P.-C.)			84	92	20	75	3	2		1	**277**
Diplocephalus picinus (BL.)					9	2	44	25		1	**81**
Diplostyla concolor (WIDER)			4		18	61	57	43	25	17	**225**
Drapetisca socialis (SUND.)			1								**1**
Erigone atra BL.						1		2			**3**
Erigone dentipalpis (WIDER)			1		1						**2**
Gonatium paradoxum (L. K.)	**3**	**4R**							3	4	**7**
Gongylidiellum latebricola (O.P.-C.)								1	4	10	**15**
Lepthyphantes alacris (BL.)			6	1	12	18	16	1			**54**
Lepthyphantes cristatus (MENGE)				3	8	8	49	147	34	75	**324**
Lepthyphantes flavipes (BL.)						1			13	8	**22**
Lepthyphantes fragilis (TH.)	**R**	**4S**			1	1					**2**
Lepthyphantes lepthyphantiformis (ST.)	**G**	**4S**	3	8	13	5	10	7	11	17	**74**
Lepthyphantes mansuetus (TH.)					1				21	1	**23**
Lepthyphantes mengei KULC.				2					5	3	**10**
Lepthyphantes montanus KULC.	**R**	**4S**	3	5	13	15	10	2	4	9	**61**
Lepthyphantes nodifer SIMON		**4S**		2	9	10	34	1			**56**
Lepthyphantes tenebricola (WIDER)			156	178	184	193	153	60	3	5	**4**
Linyphia triangularis (CL.)							1				**1**
Macrargus rufus (WIDER)			54	85	65	46	19	24	1		**294**
Maso sundevalli (WEST.)						1		1	1		**3**
Mecopisthes silus (O. P.-C.)						1					**1**
Meioneta innotabilis (O. P.-C.)		**4S**		1							**1**
Micrargus apertus (O. P.-C.)	**R**	*					4				**4**
Micrargus herbigradus (BL.)							2	1	10	43	**56**

Table 2. (cont.)

Species	Red Data List		Study sites								Total
	GRL	BRL	0/Z	0	30/Z	30	50/Z	50	100/Z	100	
Microneta viaria (BL.)			40	12	27	24	65	27	21	7	**223**
Neriene peltata (WIDER)					1			1			**2**
Neriene radiata (WALC.)									1		**1**
Oedothorax retusus (WEST.)							1				**1**
Pocadicnemis pumila (BL.)								10	12	13	**35**
Saaristoa firma (O. P.-C.)	**3**	**4S**			1	1					**2**
Saloca diceros (O. P.-C.)			49	19	17	34	19	7	14	14	**173**
Scotargus pilosus SIMON	**R**	**4S**			1	3					**4**
Tapinocyba pallens (O. P.-C.)			6	3	23	21	15	25	27	13	**133**
Thyreosthenius biovatus (O. P.-C.)	**G**	**4S**	1								**1**
Walckenaeria antica (WIDER)							3	14	13	28	**58**
Walckenaeria atrotibialis O. P.-C.				2	1	1	11	8	20	42	**85**
Walckenaeria cucullata (C. L. K.)									15	1	**199**
Walckenaeria furcillata (MENGE)									5	2	**7**
Walckenaeria obtusa BL.									1		**1**
TETRAGNATHIDAE (3 species)											
Metellina merianae (SCOP.)			1								**1**
Metellina segmentata (CL.)				1			1				**2**
Pachygnatha clercki SUND.										1	**1**
ARANEIDAE (1 species)											
Araneus diadematus CL.						1		1			**2**
LYCOSIDAE (6 species)											
Alopecosa taeniata (C. L. K.)		**4S**			1	1	5	48	9	2	**66**
Arctosa maculata (HAHN)	**2**	**3**								1	**1**
Aulonia albimana (WALC.)									1		**1**
Pardosa alacris (C. L. K.)				1	3	1	16	26	40	45	**132**
Pardosa riparia (C. L. K.)									1		**1**
Trochosa terricola TH.			9	10	26	12	45	80	38	36	**256**
AGELENIDAE (2 species)											
Histopona torpida (C. L. K.)			85	66	33	49	27	17	5	4	**1**
Tegenaria silvestris L. K.			2	1				1			**4**
CYBAEIDAE (1 species)											
Cybaeus tetricus (C. L. K.)	**G**	**4S**	42	22	45	53	25	25	28	22	**262**
HAHNIIDAE (2 species)											
Cryphoeca silvicola (C. L. K.)			3	3	1	1	2				**10**
Hahnia ononidum SIMON					1						**1**
DICTYNIDAE (1 species)											
Cicurina cicur (FABR.)			1	1	1				1	2	**6**
AMAUROBIIDAE (4 species)											
Amaurobius fenestralis (STRO.)				1	2						**30**
Callobius claustrarius (HAHN)			36	48	12	27	9	7			**139**
Coelotes inermis (L. K.)			73	73	82	89	51	60	35	70	**533**
Coelotes solitarius L. K.	**R**	*	27	28	29	32	14	17	6	3	**156**
LIOCRANIDAE (2 species)											
Agroeca brunnea (BL.)				1				1	5	2	**9**
Phrurolithus festivus (C. L. K.)										1	**1**
CLUBIONIDAE (4 species)											
Clubiona caerulescens L. K.			2	1							**3**
Clubiona comta C. L. K.			3	2	3	2	1			1	**12**
Clubiona frutetorum L. K.		**4S**			1						**1**
Clubiona terrestris WEST.				1	1		1	1			**4**

Table 2. (cont.)

Species	Red Data List		Study sites								Total
	GRL	BRL	0/Z	0	30/Z	30	50/Z	50	100/Z	100	
CORINNIDAE (1 species)											**41**
Ceto laticeps (CANE.)		**4S**								1	**2**
GNAPHOSIDAE (8 species)											**28**
Drassodes pubescens (TH.)									1	1	**96**
Gnaphosa bicolor (HAHN)	**3**	**3**					1	1	6	1	**1**
Haplodrassus signifer (C. L. K.)								1			**230**
Haplodrassus silvestris (BL.)							2			2	**107**
Micaria fulgens (WALC.)									2		**43**
Zelotes clivicola (L. K.)							1	5	2	3	**11**
Zelotes petrensis (C. L. K.)			1								**1**
Zelotes subterraneus (C. L. K.)			2				4		3	2	**11**
ZORIDAE (2 species)											
Zora nemoralis (BL.)				2					6	1	**9**
Zora spinimana (SUND.)				1			1	1		4	**7**
THOMISIDAE (2 species)											
Xysticus cristatus (CL.)							1				**1**
Xysticus luctuosus (BL.)	**3**	**4R**						1	1		**2**
SALTICIDAE (2 species)											
Euophrys frontalis (WALC.)									1		**41**
Evarcha falcata (CL.)					1				1	1	**3**
Total	**17**	**21**	**815**	**781**	**774**	**915**	**854**	**814**	**589**	**617**	**6159**

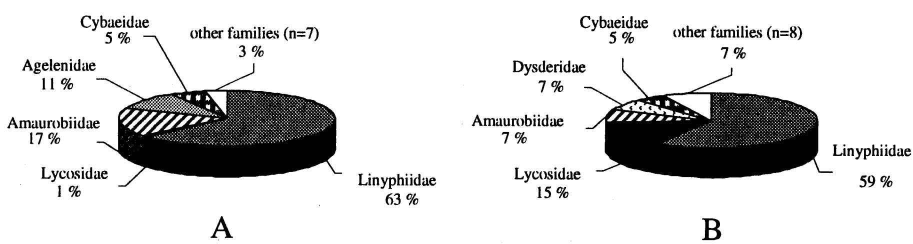

Fig. 2. Percentages of spider families in (a) plot 0/Z (n=815 ind.) and (b) plot 100/Z (n=589 ind.), sampling period: April 23rd 1998 to April 22nd 1999.

Table 3. Structural parameters of the spider assemblages of the study plots according to the catch-results of pitfall traps (n=9) - dominance classification according to ENGELMANN (1978); activity biomass [mg dry weight] according to HENSCHEL et al. (1996). Period of investigation: April 23rd 1998 – April 22nd 1999

	plot							
	0/Z	**0**	**30/Z**	**30**	**50/Z**	**50**	**100/Z**	**100**
number of specimens	815	781	774	915	854	814	589	617
number of species	34	39	46	41	48	45	54	52
number of main species	10	10	16	14	19	17	27	18
activity biomass [mg dry weight]	3109	3075	3194	3298	2715	3664	2343	2320
diversity index α (log series)	7.15	8.69	10.27	8.78	10.99	10.30	14.48	13.62

A	0/Z	0	30/Z	30	50/Z	50	100/Z	100
0/Z	xxx	xxx	xxx	xxx	xxx	xx	x	x
0	0.70	xxx	x	x	xxx	xxx	xx	xx
30/Z	0.65	0.71	xxx	x	xxx	xxx	xx	xx
30	0.65	0.71	0.76	xxx	xxx	xxx	xx	xx
50/Z	0.62	0.66	0.65	0.69	xxx	x	xx	xxx
50	0.53	0.62	0.63	0.67	0.71	xxx	xxx	xxx
100/Z	0.42	0.53	0.53	0.54	0.53	0.63	xxx	x
100	0.45	0.54	0.55	0.57	0.61	0.61	0.75	xxx

B	0/Z	0	30/Z	30	50/Z	50	100/Z	100
0/Z	xxx	xxx	xxx	xx	xxx	x	xxx	xxx
0	1.00	xxx	xxx	xx	xxx	xx	x	xx
30/Z	0.96	0.98	xxx	xx	xxx	xxx	xx	xx
30	0.83	0.86	0.84	xxx	xx	xx	x	xxx
50/Z	0.92	0.94	0.97	0.85	xxx	xxx	x	xx
50	0.77	0.88	1.00	0.82	0.97	xxx	x	xx
100/Z	0.67	0.76	0.84	0.75	0.75	0.76	xxx	xxx
100	0.62	0.81	0.84	0.65	0.84	0.85	0.99	xxx

legend:

QS	0-0.1	>0.1-0.2	>0.2-0.3	>0.3-0.4	>0,4–0.5	>0.5–0.6	>0.6–0.7	>0.7–0.8	>0.8–0.9	>0.9–1.0
symbol		x	xx	xxx	x	xx	xxx	x	xx	xxx

Fig. 3. Trellis schematic outline for comparing the faunal similarity on the basis of species (A), using the Soerensen index (QS), and with inclusion of numerical abundance (B) according to BRAY & CURTIS (1957).

In the overall trapping, as well as in the catch results of all subplots, the Linyphiidae were dominant with proportions ≥359% (Fig. 1). Furthermore, the different shelterwood cutting intensities up to clear-cutting have led in the 22 years following the operations to a distinct shift in dominance structure. Thus, the proportion of Lycosidae increased with the intensity of opening up the canopy cover. Starting from the subrecedent dominance position (1%) on the control plot (0/Z), Lycosidae were the second most frequent spider family after the Linyphiidae on the heavily-cut shelterwood plot (50) (18.9%) and the clear-cut areas (100, 100/Z) (13.6%, 15.1%) (Fig. 2). Contrary effects were demonstrated for the Agelenidae and the Amaurobiidae: their dominance position decreased with increase in intensity of silvicultural measures (Fig. 2).

The highest relative abundance of Araneae was achieved on the slightly opened-up plot (30). The lowest population densities were found in the clear-cut areas (100, 100/Z), with, in part, highly significant differences to the other experimental variants ($P<0.01$, Mann-Whitney-U test). The increase in stand opening was accompanied by a rise in species richness, which was also reflected by the diversity indices. So, the clear-cuts (100, 100/Z) comprising 52 and 54 species, respectively, appeared to have the highest diversity values α (log series, Table 3).

Likewise, the number of leading species (according to ENGELMANN, 1978) increased with an enhancement of the opening-up of canopies (Table 3). While on 0/Z ten species accounted for 85% of the individuals, the equivalent figure for 100/Z was 27 species of which as many as 12 species (from the families Dysderidae, Lycosidae, Amaurobiidae, Cybaeidae and Linyphiidae) obtained dominant positions while only one species (*Lepthyphantes tenebricola* (WIDER)) reaching 19.1% in the fenced control plot.

T a b l e 4. Characteristic species for respective intensities of opening-up canopies: Niche width, number of individuals, dominance of individuals [%] and dominance classification according to ENGELMANN (1978) based on the catch-results of pitfall traps (n=9); sampling period: April 23rd 1998 – April 22nd 1999.

species	niche width	No. of individuals				dominance of individuals [%]	dominance classification
		0	30	50	100		
Walckenaeria atrotibialis O. P.-C.	0.24	2	2	19	62	1.40	subdominant
Diplocephalus picinus (BL.)	0.11	0	11	69	1	1.32	
Alopecosa taeniata (C. L. K.)	0.16	0	2	53	11	1.10	recedent
Micrargus herbigradus (BL.)	0.06	0	0	5	53	0.90	
Walckenaeria antica (WIDER)	0.24	0	0	17	41	0.90	
Agyneta ramosa JACK.	0.02	0	1	0	40	0.67	
Pocadicnemis pumila (BL.)	0.23	0	0	10	25	0.57	
Lepthyphantes mansuetus (TH.)	0.03	0	1	0	22	0.37	subrecedent
Ceratinella brevis (WIDER)	0.06	0	2	0	21	0.37	
Lepthyphantes flavipes (BL.)	0.03	0	1	0	21	0.36	
Gongylidiellum latebricola (O.P.-C.)	0.05	0	0	1	14	0.24	
Lepthyphantes mengei KULC.	0.16	2	0	0	8	0.16	
Gnaphosa bicolor (HAHN)	0.18	0	0	2	7	0.15	
Zora nemoralis (BL.)	0.18	2	0	0	7	0.15	
Agroeca brunnea (BL.)	0.20	1	0	1	7	0.15	

The highest activity biomass occurred in the unfenced heavily-cut shelterwood plot (50). Here too the clear-cuts significantly differed, with the lowest activity biomass being found in the control plots as well as in the unfenced opened-up areas (30, 50).

The estimation of the index of similarity using the Soerensen-quotient, according to MAGGURRAN (1988), yielded medium to high levels of coincidences between the plots (Fig. 3A). The clear-cut areas (100, 100/Z) were an exception. They clearly differed from the rest of the experimental variants, with the degree of faunal similarity decreasing with increasing levels of canopy opening. Thus, the lowest coincidence in species structure of spider assemblage was between 0/Z and 100/Z.

As it has been proven by the high Soerensen indices between the fenced and unfenced plots of the same management variant, the exclusion of game had hardly any effect on the faunal similarity of the plots. Also, the control (0) and the plots subjected to slightly-cut shelterwood (30, 30/Z) were largely congruent regarding species structure. Similar tendencies became apparent when including the activity densities of the species in the algorithm of the similarity index, according to BRAY, CURTIS (1957), with an overall trend of higher similarity values (Fig. 3B).

Out of the 15 characteristic species (Table 4) 13 taxa were specifically dependent on the clear-cut area (100, 100/Z). Only two species had high preferences for the heavily-cut shelterwood (50, 50/Z), whereas no characteristic species could be identified for the other plots.

Discussion

With a total of 97 species from 19 families the study plots were characterised by a spider assemblage of high species richness, with a dominance structure typical for forests (HUHTA, 1965). Using pitfall traps, STEINBERGER, MEYER (1993) sampled in similar studies carried out on comparable sites of Vorarlberg (beech mixed forest, northern aspect, elevation: 870 m a.s.l.) 40 species from nine families (diversity index α (log series): 7.93) – a result coinciding well with the species richness of the control plots (34 or 39 species). Thus, the high species diversity of the present investigation is chiefly attributable to plots with silvicultural operations and the resultant alterations in structural (vegetation layer) and microclimatic parameters. As compared with the control, opening-up canopies led to a denser and more structured ground vegetation as well as to an increase in irradiation intensity beneath the soil surface (Table 1, BURSCHEL et al., 1992). Species such as *Micaria fulgens* (WALCKENAER), *Xysticus luctuosus* (BLACKWALL) and *Lepthyphantes flavipes* (BLACKWALL), which, according to their autecological demands are classified as steno- or mesoxerophilic (MAURER, HÄNGGI, 1990), were largely found on the plots with a high degree of canopy opening, and thus preferred thermal relations (50, 50/Z, 100, 100/Z).

The structural parameters (total individuals, species richness) of the spider assemblage, as well as the data of the similarity indices, corroborate the results obtained by HUHTA (1965). This author found, subsequent to clear cutting measures in coniferous stands, a decrease in relative abundance as well as a change of the spider fauna, which correlated with the intensity of cut. This agrees in this study with the relationship that an increasing intensity of cut results in decreasing similarity values (according to Soerensen) between the control and the treated plots. As short-term effects, JENNINGS et al. (1988) ascertained both a higher numerical abundance and numbers of species on clear-cut areas as compared with forest stands. The significantly reduced activity biomass of the spiders on the clear cut plots (100, 100/Z) contrasts with the results obtained by HUHTA (1965, 1971), who found after an initial breakdown of the original spider population an increase in biomass due to an increased occurrence of wolf spiders on the clear-cuts. In this study the increased occurrence of Lycosidae on the plots with heavily-cut shelterwood (50, 100, 100/Z) could not compensate for the decline of Agelenidae and Amaurobiidae.

The absence of characteristic species in the control (0, 0/Z) or in the slightly opened-up plots (30, 30/Z) can be explained by the fact that silvicolous spider species in most cases are habitat generalists (VÄISÄNEN, BISTRÖM, 1990) which are also able to colonise open habitats, thus being likewise represented on the treated areas.

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References

AMMER, C., 1996: Konkurrenz um Licht – zur Entwicklung der Naturverjüngung im Bergmischwald. Schriftenreihe der Forstwissenschaftlichen Fakultät der Universität München und der Bayer. Landesanstalt für Wald und Forstwirtschaft, *158*, p. 1-198.

BEAUDRY, S., DUCHESNE, L.C., CÔTÉ, B., 1997: Short-term effects of three forestry practices on carabid assemblages in a jack pine forest. Can. J. For. Res., *27*, p. 2065-2071.

BERNHART, A., 1988: Waldentwicklung, Verjüngung und Wildverbiss im oberbayerischen Bergwald. Schweizer Zeitschrift für Forstwesen, *139*, 6, p. 463-484.

BERNHART, A., 1990: Entwicklung der Bestockung im Bergwald Oberbayerns. Forstwissenschaftliche Forschung – Beihefte zum Forstwissenschaftlichen Zentralblatt, *40*, p. 19-29.

BLICK, T., 1994: *Erigonella subelevata*, *Coelotes solitarius* und *Xysticus gallicus* neu für Deutschland, sowie witere bemerkenswerte Spinnenarten aus dem Berchtesgadener Gebiet (Bayern) (Araneae). Arachnol. Mitt., 7, p. 45-49.

BLICK, T., SCHEIDLER, M., 1996: Spinnen (Araneae). In Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (Hrsg.): Rote Liste gefährdeter Tiere in Bayern, p. 22-32.

BRAY, J.R., CURTIS, C.T., 1957: An ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr., *27*, p. 325-349.

BURSCHEL, P., BINDER F., EL KATEB, H., MOSANDL, R., 1990: Erkenntnisse zur Walderneuerung in den bayerischen Alpen. A. Die Verjüngung des Bergmischwaldes in den Bayerischen Alpen. Forstwiss. Forsch.- Beihefte zum Forstwiss. Cbl., *40*, p. 40-49.

BURSCHEL, P., EL KATEB, H., MOSANDL, R., 1992: Experiments in mixed mountain forests in Bavaria. The ecology and silviculture of mixed-species forests: a festschrift for David M. Smith, p. 183-215.

ENGELMANN, H.-D., 1978: Zur Dominanzklassifizierung von Bodenarthropoden. Pedobiologia, *18*, p. 378-380.

HEIMER, S., NENTWIG, W., 1991: Spinnen Mitteleuropas: ein Bestimmungsbuch. Parey Verlag, Berlin, 543 pp.

HENSCHEL, J., STUMPF, H., MAHSBERG, D., 1996: Mass-length relationships of spiders and harvestmen (Araneae and Opiliones). Rev. suisse Zool., Hors série, *1*, p. 265-268.

HUHTA, V., 1965: Ecology of spiders in the soil and litter of Finnish forests. Annales Zoologici Fennici, *2*, p. 260-308.

HUHTA, V., 1971: Succession in the spider communities of the forest floor after clear-cutting and prescribed burning. Annales Zoologici Fennici, *8*, p. 483-542.

HUTTO, R.L., 1995: Composition of bird communities following stand-replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology, *9*, 5, p. 1041-1058.

JÄGER, P., 1999: Korrekte Zitierweise des neuesten Katalogs von PLATNICK. Arachnol. Mitt., *17*, p. 78.

JENNINGS, D.T., HOUSEWEART, M.W., DONDALE, C.D., REDNER, J.H., 1988: Spiders (Araneae) associated with strip-clearcut and dense spruce-fir forests of Maine. Journal of Arachnology, *16*, 1, p. 55-70.

JUNKER, E.A., ROTH, M., 2000: Auswirkungen waldbaulicher Eingriffe in die Überschirmung auf ausgewählte Gruppen epigäischer Regulatoren im Bergmischwald (Arachnida: Araneae; Coleoptera: Carabidae). Mitt. Dtsch. Ges. allg. angew. Ent., 12, p. 61-66.

KRONESTEDT, T., 1990: Separation of two species standing as *Alopecosa aculeata* (Clerck) by morphological, behavioural and ecological characters, with remarks on related species in the *pulverulenta* group (Araneae, Lycosidae). Zoologica Scripta, *19*, 2, p. 203-225.

MAGURRAN, A.E., 1988: Ecological diversity and its measurement. Croom Helm, London, 179 pp.

MAURER, R., HÄNGGI, A., 1990: Katalog der schweizerischen Spinnen. Documenta Faunistica Helvetiae, 12.

MOSANDL, R., 1991: Die Steuerung von Waldökosystemen mit waldbaulichen Mitteln-dargestellt am Beispiel des Bergmischwaldes. Mitt. Staatsforstverwaltung Bayern, *46*, p. 1-246.

MÜHLENBERG, M., 1993: Freilandökologie. UTB Quelle & Meyer Verlag, 3. Auflage, 512 pp.

NYFFELER, M., 1982: Die ökologische Bedeutung der Spinnen in Forst-Ökosystemen, eine Literaturzusammenstellung. Anz. Schädlingskde., Pflanzenschutz, Umweltschutz, *55*, p. 134-137.

OTTO, H.-J., 1994: Waldökologie. Ulmer Verlag, Stuttgart, 391 pp.

PAQUIN, P., CODERRE, D. ,1997: Deforestation and fire impact on edaphic insect larvae and other macroarthropods. Enviromental-Entomology, *26*, p. 21-30.

PLATEN, R., BLICK, T., SACHER, P., MALTEN, A., 1998: Rote Liste der Webspinnen Deutschlands (Arachnida: Araneae). In Bundesamt für Naturschutz (Hrsg.): Rote Liste gefährdeter Tiere Deutschlands. Schr.-R. f. Landschaftspflege u. Naturschutz, *55*, p. 268-275.

PLATNICK, N.I., 1998: Advances in Spider Taxonomy 1992-1995 with redescriptions 1940-1980. New York Entomological Society, 846 pp.

RATSCHKER, U.M., ROTH, M., 1999: Die Auswirkung unterschiedlicher Nutzungsintensität auf die Spinnenfauna von Ackerflächen. Verh. Ges. Ökol., 29, p. 299-307.

RELYS, V., WEISS, I., 1997: *Micrargus alpinus* sp. n., eine weitere Art der *M. herbigradus*-Gruppe aus Österreich (Arachnida: Linyphiidae). Revue suisse de Zoologie, *104*, 3, p. 491-501.

ROBERTS, M.J., 1985: The spiders of Great Britain and Ireland. Vol. 1: Atypidae to Theridiosomatidae. Harley Books, Colchester, 229 pp.

ROBERTS, M.J., 1987: The spiders of Great Britain and Ireland. Vol. 2: Linyphiidae. Harley Books, Colchester, 204 pp.

ROBERTS, M.J., 1995: Spiders of Great Britain and Northern Europe. Harper Collins Publishers, London, 383 pp.

STADDON, W.J., DUCHESNE, L.C., TREVORS, J.T., 1998: Impact of clear-cutting and prescribed burning on microbial diversity and community structure in a Jack pine (*Pinus banksiana* Lamb.) clear-cut using Biolog Gram-negative microplates. World Journal of Microbiology & Biotechnology, *14*, p. 119-123.

VÄISÄNEN, R., BISTRÖM, O., 1990: Boreal forest spiders and the preservation of biotic diversity: results from Finnish primeval forests. Acta Zoologica Fennica, *190*, p. 373-378.

WIEHLE, H., 1956: Spinnentiere oder Arachnoidea. Linyphiidae – Baldachinspinnen. In DAHL, F. (ed.): Die Tierwelt Deutschlands und der angrenzenden Meeresteile, 44, Fischer Verlag, Jena, 337 pp.

WIEHLE, H., 1960: Spinnentiere oder Arachnoidea. XI: Micryphantidae – Zwergspinnen. In DAHL, F. (ed.): Die Tierwelt Deutschlands und der angrenzenden Meeresteile, 47, Fischer Verlag, Jena, 620 pp.