Abh. Ber. Naturkundemus. Görlitz	Band 78 Heft 1	S. 19 – 30	2006

ISSN 0373-7586

Beitrag zum 5. Milbenkundlichen Kolloquium vom 6. bis 8. Oktober 2005
im NLU-Institut Biogeografie der Universität Basel

The influence of different age stages of forest stands on the oribatid mite community

EILEEN KREIBICH & GERD ALBERTI

Zoological Institute and Museum, Greifswald, Germany

Abstract

Since 1998 the German Ministry of Education and Research (BMBF) has been conducting the research project »Future-oriented forestry management« in collaboration with six federal states, the object of which is to lay the scientific foundations for the forest of the future. Within the project, the research association Northeast-German Lowlands concentrates on the forests in the federal states Mecklenburg-Vorpommern and Brandenburg.

The main aim of this project was to investigate the effects of changing forestry methods on the forest flora and fauna, mainly by introducing beeches to pine monocultures. Another aspect was the investigation of the effects that different age stages of the forest had on the oribatid mite community. This information may help the forestry management to introduce the beeches at the optimal point of time. Samples were taken in the Müritz NP (Mecklenburg-Vorpommern) in six plots in the year 2001. Two plots with pure pine forest – a young stand and one of medium age – and four plots with mixed pine-beech-forest – two of medium age and two older ones – were chosen. Effects on the abundance, diversity and dominance structure could be detected. The development of the humus form in these different stands was probably responsible for these changes. The conclusion of this investigation was that the age structure of a stand has significant effects on the oribatid community inhabiting the humus layer. The point of time for the introduction of beeches into pine stands seems to be very important regarding the development of the humus layer and its inhabiting fauna.

Keywords: soil ecology, forestry management, Oribatida

Zusammenfassung

Der Einfluss verschiedener Altersstufen von Waldbeständen auf die Oribatiden-Gemeinschaft – Seit 1998 führt das Bundesministerium für Bildung und Forschung (BMBF) in Zusammenarbeit mit sechs Bundesländern das Forschungsprojekt »Zukunftsorientierte Waldwirtschaft« durch. Ziel des Projektes ist es, die wissenschaftlichen Voraussetzungen für den Wald der Zukunft zu schaffen. Innerhalb des Projektes konzentriert sich der Forschungsverbund »Nordostdeutsches Tiefland« auf die Wälder in den Bundesländern Mecklenburg-Vorpommern und Brandenburg.

Das Hauptziel des Projektes bestand darin, die Auswirkungen des Waldumbaus – durch

Einbringung von Buchen in Kiefernforste – auf die Waldflora und -fauna zu untersuchen. Ein anderer Aspekt beschäftigte sich mit der Untersuchung der Auswirkungen, die verschiedene Altersstadien des Waldes auf die Oribatidengemeinschaft haben. Dieses Wissen könnte der Forstwirtschaft helfen, Buchen zum optimalen Zeitpunkt einzubringen. Die Proben wurden 2001 auf sechs verschiedenen Beprobungsflächen im Müritz NP (Mecklenburg-Vorpommern) entnommen. Zwei Beprobungsflächen wurden im reinen Kiefernwald – in einem jungen Bestand und in einem Bestand mittleren Alters – und vier Beprobungsflächen im Kiefern-Buchen-Mischwald – in zwei mittleren und zwei alten Beständen – ausgewählt. Auswirkungen auf die Abundanz, die Diversität und die Dominanzstruktur wurden festgestellt. Die Entwicklung der Humusform in den verschiedenen Beständen war vermutlich für diese Veränderungen verantwortlich. Es stellte sich heraus, dass die Altersstruktur der Bestände einen signifikanten Einfluss auf die Zusammensetzung der Oribatidengemeinschaft der Humusschicht hat. Der Zeitpunkt, zu dem die Buchen in die Kiefernforste eingebracht werden, scheint in Bezug auf die Entwicklung der Humusschicht und seiner Bewohner von großer Bedeutung zu sein.

1. Introduction

In 1998 the German Ministry of Education and Research (BMBF) initiated the project »Future-Oriented Forestry Management«. In six federal states the effects of different forestry methods on the flora, fauna and other aspects were investigated. In the north-eastern lowlands of Germany the research concentrated on two areas in Mecklenburg-Vorpommern and Brandenburg and was carried out between 2000 and 2002. The effects of introducing beeches to pine monocultures to create nature-like forests were analysed in both states.

The co-operation partners in both states were interested in other aspects as well. In Brandenburg one aim was to investigate the effects the different availability of nutrients in the soil had on the flora and fauna, whereas in Mecklenburg-Vorpommern the research interest was rather laid on the effects that different age structures of the forests had on the soil, humus and fauna.

This work concentrates on the oribatid mite community inhabiting the soil of pure pine forests and mixed forests of different age stages. The question was whether the different age stages have an effect on the oribatid mite community. This part of the investigation was carried out in the Müritz National Park (Müritz NP) in the year 2001 only.

2. Materials and Methods

Samples were taken in the Müritz NP (Mecklenburg-Vorpommern) in six plots in the year 2001. Two plots with pure pine forest – a stand of young age and one of medium age – and four plots with mixed forest – two of medium age and two of older age – were chosen. The sampling took place three times – in spring, summer and autumn. A soil corer with a diameter of 6.4 cm was used. The uppermost 5 cm of the soil were sampled.

The soil parameters (pH and C/N ratio) were measured from the soil samples after finishing the extraction of the microarthropods. The pH value was measured by bloating 3 g homogenised soil from the sample in 250 ml saline solution. The pH value of the suspension was then measured with a glass electrode. The C/N ratio was calculated after measuring the content of carbon (C), nitrogen (N) and sulphur (S) in the soil using a CNS analyser.

The animals were separated from the soil by dynamic heat extraction (MACFADYEN 1953) and the oribatids were identified to the species level when possible. The oribatid mites were determined according to WILLMANN (1931) and verified with other descriptions and monographs (MAHUNKA 1986, 1987, WOAS 1986, WUNDERLE et al. 1990, BECK & WOAS 1991, KRATZMANN 1993, OLSZANOWSKI 1996). The juvenile stages and the Brachychthoniidae were not identified further and were left out of the calculations, because the Brachychthoniidae are difficult to separate from the juveniles of some species, especially these of the Tectocepheidae. Suctobelbidae, Belbidae and Damaeidae also were not identified further. Since Damaeidae and Belbidae are in some cases difficult to distinguish they were pooled and in the following referred to as »Belbidae«. The genus *Phthiracarus* was not identified to species level.

The abundance [Ind./m^2], dominance and frequency of each species for each plot was calculated. Furthermore the species numbers and species density for each plot were computed, with the species density being the average species number per sample. To compare the plots the diversity (Shannon-Weaver-Index) (MÜHLENBERG 1989, 1993, REMMERT 1992, SCHAEFER & TISCHLER 1992) and evenness (MÜHLENBERG 1989, 1993, SCHAEFER & TISCHLER 1992) as well as the Wainstein index were used (TISCHLER 1984, MÜHLENBERG 1989, 1993).

3. Sampling plots

The Müritz NP is located halfway between Berlin and Rostock in north-eastern Germany. It is a sparsely populated region with large forest and water areas that offer a habitat for many endangered species. 72 % of the park area is covered by forests. Of these forests 75 % are either pure pine forests or are dominated by pines.

Three of the plots (pi80, pi155be50 and pi190be45) were located in the »Serrahn« area of the Müritz NP south-east of the town Neustrelitz and the other plots just outside the National Park.

The plots were chosen to represent two age stages for pure and mixed stands each. Since no pure pine stand of old age could be found, a very young stand was chosen instead. Plot pi19 resembles the young stand, while plot pi80 is chosen as a stand of medium age. For each stage of the mixed stands two plots were selected. The plots pi51be8 and pi80be40 represent medium-aged stands, while the plots pi155be50 and pi190be45 were stands of old age.

Tab. 1 shows that the humus form in most stands is relatively poor. The best humus form is a moder in the medium-aged mixed stand of plot pi80be40. In most stands a cambisol can be found except in the older pine stand of the plot pi80, where the cambisol begins being podzolised and in the old mixed stand of plot pi190be45, where a true podzol is developed. The C/N-ratio seems to be linked loosely to the humus form (Tab. 2). The widest C/N-ratio was measured in the old mixed stands with 26 and 27, whereas the narrowest C/N-ratio was found in the young pine stand (pi19) and the medium-aged mixed stand with 20 – 22. The lowest soil water content was measured in the stands pi80be40 (19 % – 38 %) and pi19 (17 % – 42 %). Both stands are free of ground vegetation, which may influence the soil's ability to store water. In the other stands the soil water content varied between 37 % and 63 %.

Abundances, species numbers and diversity indices for each plot are shown in Tab. 3.

Tab. 1 Tree composition, humus form and soil type for each plot

plot	tree composition		humus form	soil type
pi19	pine	– 19 yrs	mor-like moder (6 cm)	cambisol
pi80	pine	– 80 yrs	mor (7 cm)	cambisol-podzol
pi51be8	pine	– 51 yrs	mor (9 cm)	cambisol
	beech	– 8 yrs		
pi80be40	pine	– 80 yrs	moder (5 cm)	cambisol
	beech	– 40 yrs		
pi155be50	pine	– 155 yrs	mor (9.5 cm)	cambisol
	beech	– 50 yrs		
pi190be45	pine	– 190 yrs	mor-like moder (11.5 cm)	podzol
	beech	– 45 yrs		

Tab. 2 Abiotic data for each plot

plot	soil water content			pH value				C/N ratio			
	spring	summer	autumn	spring	summer	autumn	**mean**	spring	summer	autumn	**mean**
pi19	42	17	37	3.3	3.4	3.4	**3.3**	20	20	19	**20**
pi80	51	41	59	3.0	3.0	2.9	**3.0**	22	26	25	**24**
pi51be8	50	35	48	3.1	3.2	3.3	**3.2**	21	23	21	**22**
pi80be40	34	19	38	3.5	3.6	3.3	**3.5**	21	20	22	**21**
pi155be50	61	45	63	3.0	3.0	3.1	**3.0**	27	26	27	**27**
pi190be45	53	37	56	2.9	3.0	2.9	**3.0**	25	26	27	**26**

Tab. 3 Abundances, species numbers and diversity indices for each plot

	pi19	pi80	pi51be8	pi80be40	pi155be50	pi190be45
adults	38 317	127 604	115 383	68 620	176 617	234 125
juveniles	42 545	75 329	91 973	51 737	76 195	95 870
sum	80 862	202 933	207 356	120 357	252 812	329 994
% juveniles	53	37	44	43	30	29
species no.	37	46	37	43	28	44
sp. density	17.1	19.7	17.9	14.6	13.1	15.9
diversity	2.57	2.04	1.71	1.88	1.43	1.37
evenness	0.71	0.53	0.47	0.50	0.43	0.36

4. Results

Altogether 64 394 oribatid mites were found in the samples. Of those 23 222 were juveniles and Brachychthoniidae. A complete list of all taxa is given in Tab. 4.

As can be seen in Tab. 3 the abundance of oribatid mites was lowest in the youngest stands and highest in the oldest stands. An exception was the plot pi80be40, where the abundance was far lower than in the other stands of medium age, though this difference was not significant. Furthermore the ratio of adults : juveniles shifted towards a higher percentage of adults with increasing mean age of the stand.

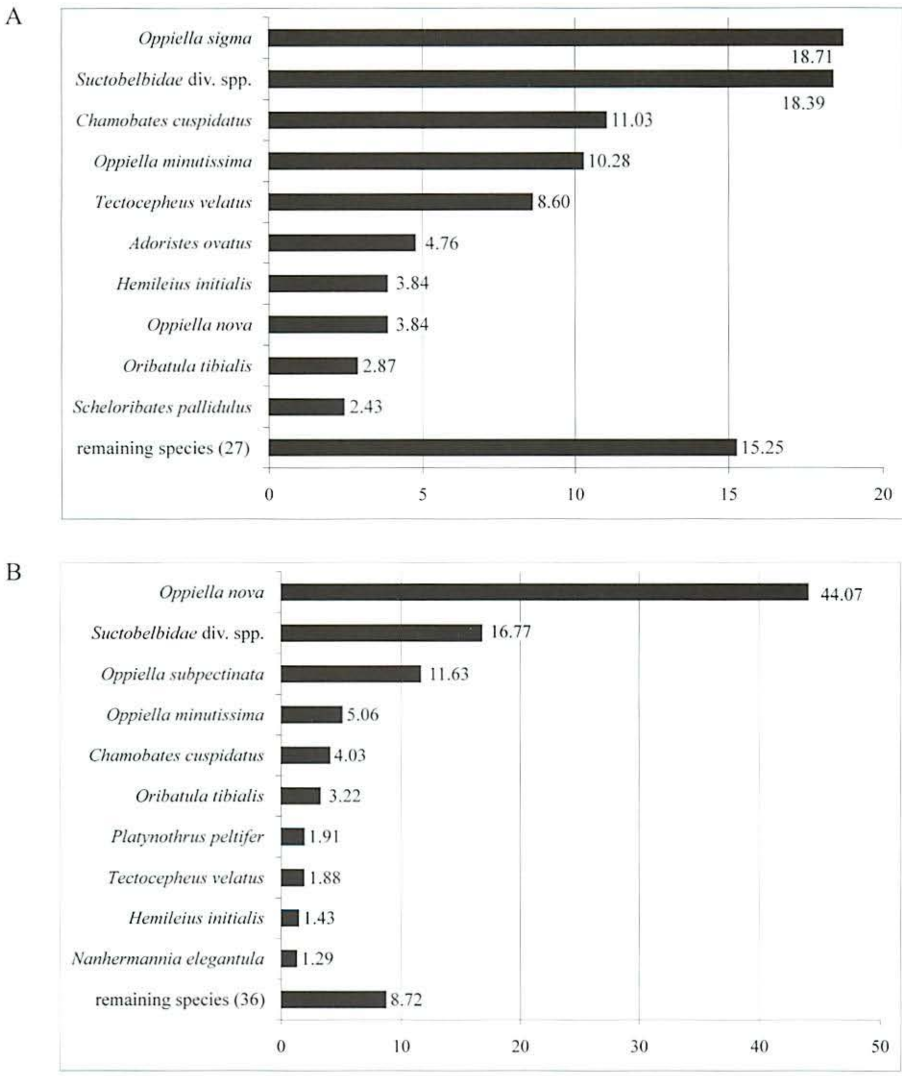
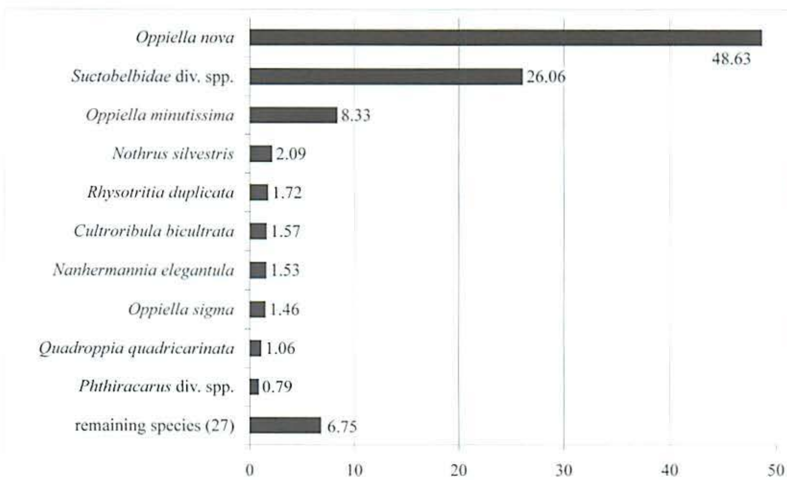


Fig. 1 Dominance structure in the pure pine stands, A) pi19, B) pi80

Altogether 60 species from 38 genera and two families, not further separated, were found. Neither species numbers nor species density were influenced by the age of the stands (Tab. 3). The species numbers varied between 37 and 46, except on plot pi155be50, where the species number was very low with 28. The diversity and evenness decreased with increasing age of the stands.

Species richness, diversity and evenness were higher in the medium-aged pure stand than in both mixed stands of medium age as could be expected (SKUBALA 1999).

A



B

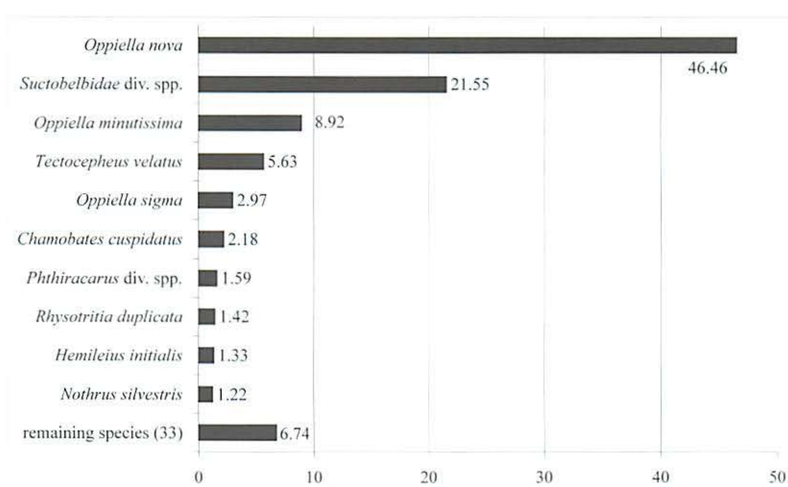


Fig. 2 Dominance structure in the mixed pine stands of medium age, A) pi51be8, B) pi80be40

Figures 1 to 3 show the dominance structure of the oribatid mite community. It can be clearly seen that the dominance structure was shifted toward an uneven distribution with growing age by an increasing percentage of *Oppiella nova* (Oudemans, 1902) already indicated by the evenness. The Suctobelbidae were the second most abundant taxon and were dominant in all plots. *Oppiella minutissima* (Sellnick, 1951) was dominant in the young pine stand (plot pi19) and the old mixed stands (plots pi155be50 and pi190be45), but subdominant in the stands of medium age (plots pi80, pi51be8 and pi80be40). The abundant species were common to all plots (Tab. 4).

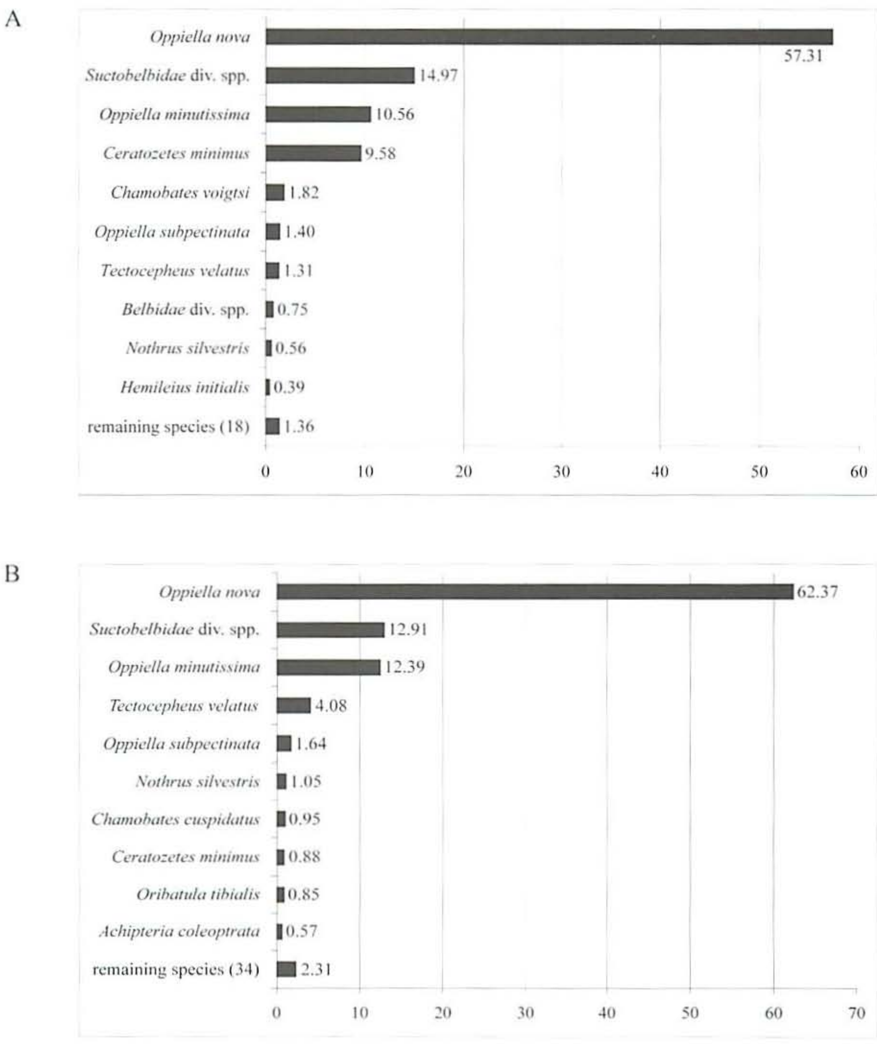


Fig. 3 Dominance structure in the mixed pine stands of old age, A) pi155be50, B) pi190be45

The Wainstein index as displayed in Fig. 4 shows that the age of the pine trees had a strong influence. The mixed stands of medium age (pi51be8 and pi80be40) had an identity of almost 60 %. The similarity to the medium-aged pure pine stand was still 50 %. The mixed stands of old age (pi155be50 and pi190be45) also formed a cluster and had a similarity of 50 %. The young pure pine stand (pi19) on the other side was clearly separated from the older stands.

5. Discussion

The abundances in these stands were higher than those reported by most other authors for coniferous forests (e.g. Huhta & Koskenniemi 1975, Wallwork 1983, Sylwestrowicz-Maliszewska et al. 1993, Seniczak et al. 1994, 1998, Dunger et al. 2001), but unfortunately the age of the investigated stands is often not recorded in the papers. Those authors who mentioned the age of the stands only investigated pure pine stands of young age and medium age. Seniczak et al. (1994) found in a 20-year-old pure pine stand ca 150 000 ind./m², while in ca 80-year-old pine stands between 80 000 ind./m² (Seniczak et al. 1994) and 110 000 ind./m² (Seniczak et al. 1995) were recorded. Sylwestrowicz-Maliszewska et al. (1993) obtained their material from pure pine stands or mixed stands in which pine dominated that were between 90 and 110 years old and found between 65 000 and 120 000 ind./m². Unfortunately, data from old stands are not available.

Comparing the mixed stands of medium and old age, a striking difference is found in the time at which the beeches were introduced to the pine stands. In the younger stands, beeches were introduced when the pines were about 40 years old. In the stand pi51be8 the beeches are

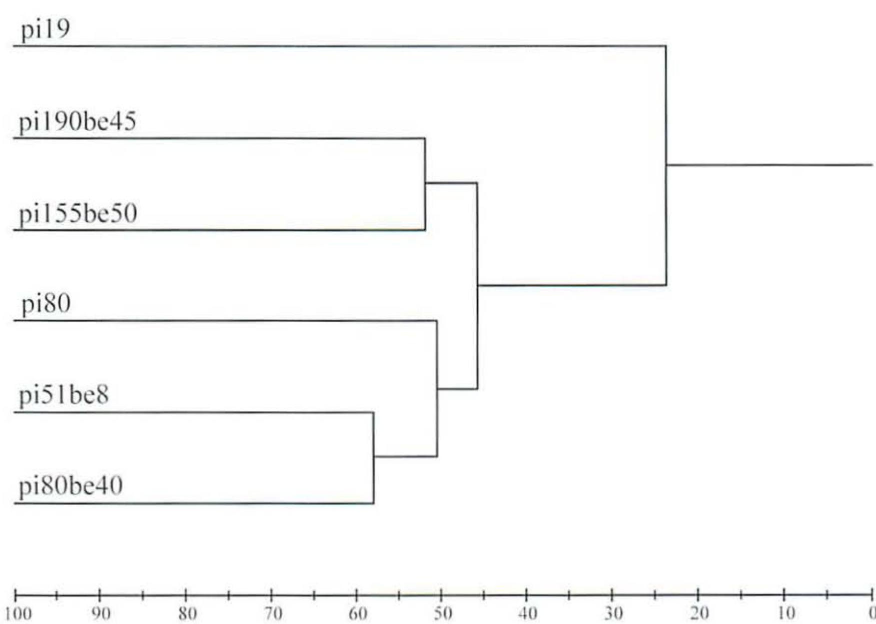


Fig. 4 Cluster diagram for the Wainstein index

Tab. 4 Abundance (white background) and frequency (grey background) for each species and each plot; ° - A ≤ 1 000 * m^{-2}, * - A ≤ 5 000 * m^{-2}, + - A ≤ 10 000 * m^{-2}, ++ - A > 10 000 * m^{-2}

species	pi19		pi80		pi51be8		pi80be40		pi190be45		pi155be50	
Achipteria coleoptrata (Linnaeus, 1758)			°	6			°	22	*	50	°	41
Acrogalumna longipluma (Berlese, 1904)			°	22	°	76	°	11				
Adoristes ovatus (C. L. Koch, 1840)	*	88	°	61	°	59	°	50	°	44	°	35
Autogneta longilamellata (Michael, 1885)			°	11	°	6						
Belbidae div. spp.	°	63	°	67	°	53	°	72	°	22	*	65
Calaremaeus monilipes (Michael, 1882)			°									
Camisia biurus (C. L. Koch, 1839)			°	6	°	6			°	11		
Camisia spinifer (C .L. Koch, 1835)	°	31	°	22	°	12	°	6	°	6	°	6
Carabodes areolatus Berlese, 1916	°	6	°	39	°	53	°	33	°	11	°	18
Carabodes coriaceus C. L. Koch, 1836	°	6	°	6					°	6		
Carabodes femoralis (Nicolet, 1855)	°											
Carabodes labyrinthicus (Michael, 1879)	°	6	°	17	°	29	°	22	°	6		
Carabodes ornatus Storkán, 1925	°	6	°	22	°	12	°	11	°	11	°	29
Carabodes subarcticus Trägardh, 1902			°	6								
Cepheus cepheiformis (Nicolet, 1855)	°	19					°	6	°	6		
Cepheus dentatus (Michael, 1888)	°											
Ceratoppia spec.			°	6	°	18						
Ceratozetes minimus Sellnick, 1928							°	6	*	28	++	100
Chamobates cuspidatus (Michael, 1884)	*	100	+	94	°	65	*	83	*	78	°	24
Chamobates subglobulus (Oudemans, 1900)							°	6				
Chamobates voigtsi (Oudemans, 1902)	°	6	°	6	°	18	°	22	°	22	*	100
Cultroribula bicultrata (Berlese, 1904)			°	56	*	76	°	6	°	11	°	24
Diapterobates humeralis Sellnick, 1924	°	6	°	11								
Eniochthonius minutissimus (Berlese, 1904)	°	75	°	67	°	18	°	22	°	33	°	18
Eupelops hirtus Berlese, 1916			°	11	°	6	°	17	°	22	°	18
Eupelops torulosus (C. L. Koch, 1840)	°	19	°	44	°	59	°	39	°	44	°	47
Euphthiracarus cribrarius (Berlese, 1904)	°	6	°	6			°	6				
Euzetes globulus (Nicolet, 1855)			°	17								
Galumna lanceata (Oudemans, 1900)	°	13			°	29	°	28	°	56		
Hemileius initialis (Berlese, 1908)	*	100	*	89	°	82	°	78	°	83	°	71
Heminothrus longisetus Willmann, 1925									°	6		
Hypochthonius rufulus C. L. Koch, 1836			°	22	°	24	°	6	°	11		
Liacarus coracinus (C. L. Koch, 1840)											°	12
Licneremaeus licnophorus (Michael, 1882)									°	6		
Micreremus brevipes (Michael, 1888)	°	6	°	6					°	17		
Microtritia minima (Berlese, 1904)	°	69	°	67	°	12	°	17	°	39	°	59
Nanhermannia elegantula Berlese, 1913	°	81	*	83	*	71	°	22	°	17	°	6
Nothrus palustris C. L. Koch, 1840							°	6				
Nothrus silvestris Nicolet, 1855	°	31	°	83	*	100	°	33	*	94	°	76
Oppiella minutissima Sellnick, 1950	*	88	+	94	+	88	+	78	++	100	++	100
Oppiella nova (Oudemans, 1902)	*	88	++	100	++	100	++	100	++	100	++	100
Oppiella ornata (Oudemans, 1900)			°	50			°	11				
Oppiella sigma (Strenzke, 1951)	+	94	*	56	*	71	*	67	°	11	°	6
Oppiella splendens (C. L. Koch, 1841)							°	6				
Oppiella subpectinata (Oudemans, 1900)	°	6	++	100	°	18	°	17	*	100	*	71
Oribatula tibialis (Nicolet, 1855)	*	94	*	100	°	24	°	33	*	89	°	18
Phthiracarus div. spp.	°	19	°	56	°	88	°	89	°	17		
Platynothrus peltifer (C. L. Koch, 1839)	°	25	*	83	°	47	°	22	*	67	°	24
Quadroppia paolii (Paoli, 1908)	°	13					°	6	°	6		
Quadroppia quadricarinata (Michael, 1888)	°	69	°	56	*	71	°	44	°	17	°	35
Rhysotritia ardua (C. L. Koch, 1841)			°	33					°	6		
Rhysotritia duplicata (Grandjean, 1953)	°	69	°	67	*	65	°	61	°	56	°	35
Scheloribates pallidulus (C. L. Koch, 1840)	°	75			°	29	°	6				
Steganacarus applictus (Sellnick, 1920)					°	12			°	6		
Steganacarus magnus (Nicolet, 1855)			°	22	°	18	°	11				
Steganacarus spinosus (Sellnick, 1920)			°	6			°	6	°	6		
Steganacarus striculus (C. L. Koch, 1836)	°	19					°	33				
Suctobelbidae div. spp.	+	100	++	100	++	100	++	100	++	100	++	100
Tectocepheus sarekensis Trägardh, 1910	°	50	°	11	°	12			°	6		
Tectocepheus velatus (Michael, 1880)	*	94	*	72	°	59	*	89	+	100	*	76

only 8 years old and therefore no significant changes regarding the oribatid community could be found so far compared to the pure pine stands. In the stand pi80be40 on the other side the introduction of beeches 40 years ago showed first results. The higher quality of the beech litter (C/N ratio of beech ca 40, C/N ratio of pine ca 50; SCHEFFER & SCHACHTSCHNABEL 1982, GISI et al. 1990) probably caused the humus form to revert back into a moder of a thickness of only 5 cm. In this humus form the fungi play a less important role in the decomposition process than in raw humus (SCHEFFER & SCHACHTSCHNABEL 1982, DUNGER 1983, GISI et al. 1990). This can explain the lower abundance of oribatid mites, though also in the samples from this plot the fungivorous oribatids such as *Oppiella nova* or the Suctobelbidae are the dominant taxa. However, these taxa were less abundant here than in the stands with mor as the humus form.

In the older stands the beech trees were not introduced to the stands before the pines were 105 years (pi155be50) or even 145 years (pi190be45) old. Therefore the low-quality pine litter could accumulate over a period of more than a hundred years and form a thick layer of raw humus. Two scenarios for the further development of the humus are possible. In the first scenario the beech litter is quickly decomposed in these stands leading to an improved humus quality. This could open new ecological niches for the other members of the decomposer fauna who may increase the decomposition rate in these stands. In the other scenario the low quality of the existing humus may prohibit other decomposers than those already present. In this case the beech litter will probably be quickly decomposed while the pine litter can further accumulate without any improvement of the humus form as a whole unless the pines are eliminated from these stands. Which scenario comes true may be depending on the climatic conditions as well as the substrate, but for a more specific proposition more data are needed. But under the acid and sandy conditions in the Müritz NP the second scenario seems to be more likely.

The dominance structure in these old stands is typical for a mor. There are many fungivorous species, mainly oppiid and suctobelbid mites. Especially *Oppiella nova* benefits from these conditions and appears in huge numbers. The input of beech litter, however, also increases the opportunities for other species such as *Achipteria coleoptrata* (Linneus, 1758) or *Chamobates voigtsi* (Oudemans, 1902) that seem to prefer litter from deciduous trees (MORITZ 1963, 1965, LUXTON 1981, WUNDERLE 1992, IVAN 1995, ALBERTI et al. 1996, FABIAN 1997, MELAMUD 1998, SKUBALA 1999).

In summary, the age structure of a stand had significant effects on the oribatid community inhabiting the humus layer. The point of time for the introduction of beeches into pine stands seems to be very important regarding the development of the humus layer and its inhabiting fauna. The results indicate that an early introduction of beeches to pine stands is favourable.

6. References

ALBERTI, G., B. HAUK, H. R. KÖHLER & V. STORCH (1996) (eds): Dekomposition – Qualitative und quantitative Aspekte und deren Beeinflussung durch geogene und anthropogene Belastungsfaktoren. – Ecomed Verlagsgesellschaft, Landsberg, 490 pp.

BECK, L. & S. WOAS (1991): Die Oribatiden-Arten (Acari) eines südwestdeutschen Buchenwaldes I. – Carolinea **49**: 37 – 82

DUNGER, W. (1983): Tiere im Boden. – Neue Brehm-Bücherei. – A. Ziemsen Verlag, Wittenberg, 280 pp.

–, M. Wanner, H. Hauser, K. Hohberg, H.-J. Schulz, T. Schwalbe, B. Seifert, J. Vogel, K. Voigtländer, B. Zimdars & K. P. Zulka (2001): Development of soil fauna at mine sites during 46 years after afforestation. – Pedobiologia **45**: 243 – 271

Fabian, L. (1997): Oribatid mite communities (Acari, Oribatida) from the Anina Mountains (The Carpatians, Romania). – Abh. Ber. Naturkundemus. Görlitz **69** (6): 41 – 51

Gisi, U., R. Schenker, R. Schulin, F. Stadelmann & H. Sticher (1990): Bodenökologie. – Georg Thieme Verlag, Stuttgart, New York, 304 pp.

Huhta, V. & A. Koskenniemi (1975): Numbers, biomass and community respiration of soil invertebrates in spruce forests at two latitudes in Finland. – Ann. Zool. Fenn. **12**: 164 – 182

Ivan, O. (1995): Recherches écologique concernant le communautés d'oribates des fôrets de chęne avec tilleul situées dans le plateau central Moldava (Roumanie). – Ann. Muz. Nat. Bucovinci **13**: 45 – 58

Kratzmann, M. (1993): Oribatidengesellschaften (Acari) ausgewählter Waldstandorte unter Berücksichtigung verschiedener Umweltveränderungen und Belastungsfaktoren. – Thesis, University of Heidelberg, 255 pp.

Luxton, M. (1981): Studies on the oribatid mites of a Danish beech wood soil. III. Introduction to field populations. – Pedobiologia **21**: 301 – 311

Macfadyen, A. (1953): Notes on methods for extracting soil arthropods. – J. Anim. Ecol. **22**: 65 – 77

Mahunka, S. (1986): A survey of the family Carabodidae C. L. Koch, 1836 (Acari: Oribatida). – Acta Zool. Hung. **32** (1 – 2): 73 – 135

– (1987): A survey of the family Carabodidae C. L. Koch, 1836 (Acari: Oribatida), II. – Acta Zool. Hung. **33** (3 – 4): 399 – 434

Melamud, V. V. (1998): Oribatida (Acariformes) of forest coenoses in the »Roztochia« Reserve (Ukraine). – Frag. Faun. **41** (2): 9 – 14

Moritz, M. (1963): Über die Oribatidengemeinschaften (Acari, Oribatei) norddeutscher Laubwaldböden, unter besonderer Berücksichtigung der die Verteilung regelnden Milieubedingungen. – Pedobiologia **3**: 412 – 243

– (1965): Untersuchungen über den Einfluß von Kahlschlagmaßnahmen auf die Zusammensetzung von Hornmilbengemeinschaften (Acari, Oribatei) norddeutscher Laub- und Kiefernmischwälder. – Pedobiologia **5**: 65 – 101

Mühlenberg, M. (1989): Freilandökologie. 2nd Edn. – Quelle & Meyer Verlag, Heidelberg-Wiesbaden, 430 pp.

– (1993): Freilandökologie. 3rd Edn. – Quelle & Meyer Verlag, Heidelberg-Wiesbaden, 512 pp.

Olszanowski, Z. (1996): A monograph of the Nothridae and Camisiidae of Poland (Acari: Oribatida: Crotonioidea). – Wrocław, Poland, 201 pp.

Remmert, H. (1992): Ökologie. 5th Edn. – Springer Verlag, Berlin, Heidelberg, New York, Tokyo, 363 pp.

Schaefer, M. & W. Tischler (1992): Wörterbuch der Biologie – Ökologie. 3rd Edn, UTB. – Gustav Fischer Verlag, Stuttgart, 354 pp.

Scheffer, F. & P. Schachtschnabel (1982): Lehrbuch der Bodenkunde. – Ferdinand Enke Verlag, Stuttgart, 442 pp.

Seniczak, S., A. Klimek & S. Kaczmarek (1994): The mites (Acari) of an old Scots pine forest polluted by a nitrogen fertilizer factory at Włocławek (Poland). II Litter/soil fauna. – Zool. Beitr. N. F. **35** (2): 199 – 216

–, S. Kaczmarek & A. Klimek (1995): The mites (Acari) of an old Scots pine forest polluted by a nitrogen fertilizer factory at Włocławek (Poland). III. – Zool. Beitr. N. F. **36** (1): 11 – 28

–, J. DABROWSKI, A. KLIMEK & S. KACZMAREK (1998): Effects of air pollution by a nitrogen fertilizer factory on the mites (Acari) associated with young Scots pine forests in Poland. – Appl. Soil Ecol. **9**: 453 – 458

SKUBALA, P. (1999): Colonization of a dolomitic dump by oribatid mites (Acari, Oribatida). – Pedobiologia **43**: 145 – 159

SYLWESTROWICZ-MALISZEWSKA, Z., Z. OLSZANOWSKI & J. BLOCZYK (1993): Moss mites (Acari: Oribatida) of pine forests from Poland. – Frag. Faun. **12**: 185 – 199

TISCHLER, W. (1984): Einführung in die Ökologie. 3rd Edn – Gustav Fischer Verlag, Stuttgart, 437 pp.

WALLWORK, J. A. (1983): Oribatids in Forest Ecosystems. – Ann. Rev. Entomol. **28**: 109 – 130

WILLMANN, C. (1931): Moosmilben oder Oribatiden (Oribatei). In: DAHL, F.: Die Tierwelt Deutschlands und der angrenzenden Meeresteile nach ihren Merkmalen und ihrer Lebensweise – 22. Teil: Spinnentiere oder Arachnoidea. – Gustav Fischer Verlag, Jena, 200 pp.

WOAS, S. (1986): Beitrag zur Revision der Oppioidea sensu Balogh, 1972 (Acari, Oribatei). – Andrias **5**: 21 – 224

WUNDERLE, I. (1992): Die Oribatiden-Gemeinschaften (Acari) der verschiedenen Habitate eines Buchenwaldes. – Carolinea **50**: 79 – 144

–, BECK, L. & S. WOAS (1990): Ein Beitrag zur Taxonomie und Ökologie der Oribatulidae und Scheloribatidae (Acari, Oribatei) in Südwestdeutschland. – Andrias **7**: 15 – 60

Manuscript accepted: 31 May 2006

Authors' address:

Dipl.-Biol. Eileen Kreibich* / Prof. Dr Gerd Alberti
Ernst-Moritz-Arndt-University Greifswald
Zoological Institute and Museum
Johann-Sebastian-Bach-Straße 11/12
17489 Greifswald, Germany
e-mail: eileen_kreibich@hotmail.com

* corresponding author