Abh. Ber. Naturkundemus. Görlitz	Band 78 Heft 1	S. 77 – 91	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 forests in the Müritz National Park (Mecklenburg-Vorpommern) on the gamasid fauna (Acari, Arachnida)

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Abstract

Within the BMBF-research project »Future-Oriented Forestry Management«, the response of soil-inhabiting gamasid mite species to changing forestry methods and to certain age stages of pine and mixed pine/beech forests in the Müritz National Park (Mecklenburg-Vorpommern), north-eastern Germany, was investigated. An unmanaged beech forest was chosen as a reference, as this is the potential natural vegetation in the region. Two pure pine forests of 19 and 80 years, 2 young and 2 older mixed deciduous and coniferous forests and a 188-year-old beech stand were investigated. The gamasid mites occurred altogether with 42 species from 28 genera and 15 families. The structures of communities of predatory mites were very similar between the pine forest of 80 years and the younger mixed forest being composed of pines, which are 51 years old and very young undergrowth of beeches, which is at the age of 8 years. In these stands the gamasid mites were found with their highest abundance of 16 300 and 17 300 ind./m^2 respectively, which were in part significantly different from the other sites. Particularly to the older mixed forest of 190-year-old pines and 45-year-old beeches they showed significant differences. This mixed forest had also little similarity to the natural beech stand. On the basis of variance and correlation analyses the differences could be proved by the significant higher individual numbers or absence of several species in stands of defined age stages which was partly due to the different thickness of the coniferous litter layer in the pure pine and mixed forests.

Keywords: Gamasida, forestry management, soil ecology

Zusammenfassung

Die Gamasidenfauna (Acari, Arachnida) in den Wäldern des Müritz Nationalparks (Mecklenburg-Vorpommern) unter dem Einfluss unterschiedlicher Altersstufen der Bestände – Im Rahmen des BMBF-Teilverbundprojektes »Zukunftsorientierte Waldwirtschaft« wurde im Müritz-Nationalpark (Mecklenburg-Vorpommern), der Einfluss des Waldumbaus von reinen Kiefernforsten zu naturnahen Kiefer-Buchenmischwäldern sowie verschiedener Altersstadien dieser Bestände auf die Gamasidenfauna untersucht. Ein unbewirtschafteter Buchenwald als potenziell natürliche Vegetationsformation der Region diente als Referenzstandort. Hier wurden zwei reine Kiefernflächen, 19 Jahre und 80 Jahre, zwei jüngere und zwei ältere Kiefern-Buchenmischbestände und ein 188-jähriger unbewirtschafteter Buchenwald beprobt. Unter den Gamasiden wurden insgesamt 42 Arten aus 15 Familien und 28 Gattungen gefunden. Die Strukturen der Gamasidenzönosen zeigten zwischen dem 80-jährigen Kiefernbestand und einem der jüngeren Mischbestände mit 51-jährigen Kiefern und 8-jährigem Buchenunterwuchs die größten Übereinstimmungen. Auf diesen beiden Flächen erreichten die Gamasida beispielsweise insgesamt mit 16 300 bzw. 17 300 Ind./m^2 ihre höchsten Individuendichten und unterschieden sich damit teilweise signifikant von den Abundanzen der übrigen Flächen. Deutliche Unterschiede wiesen beide Flächen zu dem älteren Mischbestand mit 190-jährigen Kiefern und 45-jährigem Buchenunterwuchs auf, welcher auch zur Buchenfläche nur geringe Ähnlichkeit zeigte. Anhand von Varianz- und Korrelationsanalysen konnten die Unterschiede vor allem auf das deutlich häufigere Vorkommen bzw. Fehlen einzelner Arten in bestimmten Altersstadien der Bestände zurückgeführt werden, wobei unter anderem auch die Mächtigkeit der Nadelstreu in den Kiefern- und Kiefer-Buchenmischbeständen einen deutlichen Einfluss zeigte.

1. Introduction

North-eastern Germany is a region of potential beech woodlands (*Fagus sylvatica*). The substrate of the soils are periglacial deposited sands. However, since clear-cutting of the woodlands in the Middle Ages and the beginning of regular forestry management 200 years ago, these woodlands have been transformed to mostly pine-forest monocultures (*Pinus sylvestris*), which are often unsuited to the existing habitat conditions. At present, 65 % of the wooded area of the federal state Mecklenburg-Vorpommern are pine forests. Under natural conditions the pine would have a proportion of only 1 %. It is well known that the structural poverty of these pine stands (which are also of monotypical age structure) is a direct cause of the mass reproduction of pests and gales. In order to preserve the variety of functions of woodlands also in the future, it is intended to increase the proportion of structurally rich mixed pine/beech forests to 56 % in the course of the current century. Additionally, to get wood of higher economic value, trees of good quality should be left to grow longer than usual, e.g. pine 130 to 140 years or beech 160 years. It is well known is that the undergrowth of deciduous plants in coniferous forests improves soil chemistry, litter quality and the living conditions for many decomposer species (e.g. SALAMON et al. 2005). However, so far little is known about the response of soil-dwelling gamasid mite species to changing forestry methods and especially to certain age stages of pine and mixed pine/beech forests in north-eastern Germany. Within the BMBF-research project »Future-Oriented Forestry Management« this matter could be investigated. Soil-dwelling predatory mites are an individual and species-rich group in many various open habitats and forest types (e.g. KARG 1993b, RUF 1997a, RUF & BECK 2005). Moreover many species are very sensitive to human impacts like pesticides, heavy metals or structural manipulations of the soil (e.g. SHEALS 1955, BARING 1958, KARG 1961, 1967, 1968, 1993a, BECK et al. 1988, GLOCKEMANN & LARINK 1989, SCHULZ 1991, KOEHLER 1993, SENICZAK et al. 1994, KARG & FREIER 1995, ALBERTI et al. 1996, MADEJ & SKUBALA 1996, RUF 2000b). Changes of the gamasid fauna during a secondary succession were shown by KOEHLER (1998). This led to the assumption that also modified soil conditions and probably food resources that are effected by the aging of a pine forest as well as a pine/beech mixed forest influence the gamasid mite communities in their composition both in number and in structure.

A further aspect of this study was to compare the gamasid mite communities of the different stand ages of a pine and mixed forest with the gamasid mite community of a near-natural pure beech forest to determine how far they differ from the potential natural forest vegetation type.

2. Materials and Methods

2.1. Sites

The investigations took place in the Müritz National Park. Two pure pine forests and four mixed deciduous and coniferous forests of different stand ages were compared. A natural unmanaged beech forest was chosen as a reference. All sites with the age of their pine and/or beech trees, humus type, thickness of humus layer as well as the C/N-ratio and pH are shown in Tab. 1. The data of the humus layer were taken in May 2002. Additionally in July 2002 a floristic characterisation was done.

Tab. 1 Characteristics of the investigated sites
Age data of pine and beech in the different sampling sites according to Müller-Motzfeld et al. (2004)
rh mor = raw humus-like mor, rh = raw humus

Forest composition	Sampling site (abbreviation)	Age (years) of		Humus type	Thickness of humus layer (cm)	C/N	pH
		pine	beech				
pine	pi I	19		rh mor	6.0	20	3.4
	pi II	80		rh	7.0	24	3.0
mixed (pine and beech)	pi/be I	51	8	rh	9.0	22	3.2
	pi/be II	80	40	mor	5.0	21	3.5
	pi/be III	155	50	rh	9.5	26	3.0
	pi/be IV	190	45	rh mor	11.5	27	3.0
beech	be		188	f-mull	2.5	17	3.6

2.2. Sampling and processing of predatory mites

Sampling was done three times in 2001 in spring (7 May), summer (11 July) and autumn (15 October). At each forest stand, two replicate sites ($d = 3$ m) were marked. Three samples were taken per replicate site and date by using a steel cylinder ($d = 6.4$ cm and 5 cm depth). In the laboratory, soil arthropods were extracted from the samples by using a high-gradient Macfadyen-type-extractor (Macfadyen 1953, 1961). The C/N-ratio and pH were measured from each sample by using a CNS-analyser and a glass electrode respectively. The gamasid mites were mounted in Faure's medium. Then, except for juvenile stages and the individuals of the family Phytoseiidae, they were identified to species level.

For the identification of the gamasid mites the keys of Bregetova & Koroleva (1960), Bregetova (1961, 1977), Evans & Till (1979), Karg (1989, 1993b), Błaszak (1974), Hyatt (1980) and Hyatt & Emberson (1988) were used. The nomenclature is according to Błaszak et al. (1997).

2.3. Statistics

To describe the communities of predatory mites in the different sampling sites, abundances (in ind./m^2, which were calculated from the geometric means of all samples from each stand) and dominances of all gamasid mites and of numerous species from Parasitidae, Zerconidae and Uropodina as well as species numbers and species densities were compared. Moreover, assemblages were characterised by the diversity index according to Shannon & Weaver (1949) and the evenness index. Significant differences of these structural characteristics between the investigated sites were established by multiple and nonparametric comparison test statistics (Tukey's honestly significant difference test, Mann-Withney-U-test) using the program SPSS 12.0. The figures 1 – 2 and 4 – 6 focussed on the significances between the different investigated age stages within one forest type, pure pine or mixed forest respectively. Therefore, the beech stand (be) is not included there. Relations between the sites, species and environmental factors were analysed by a canonical correspondence analyses (CCA) using abundances of the observed species. The analysis was done by the software CANOCO for Windows 4.02. Correlations between the environmental data and species as well as between single species were tested with the Spearman rank correlation analysis (r_{sp}^2). To show the dominance similarities between the sampling sites, the Renkonen-index (Renkonen 1938), was calculated. Additionally the maturity-index for Gamasina mites (Ruf 1997a, 1998) was used to estimate the state of the Gamasina mite communities. On the data basis of the biology of reproduction and colonisation ability of gamasina mite species they are ranked in a numerical r/K-scale. That means that species in the r-scale are reproduction strategists whereas species in the K-scale are adaptation strategists. For taxa that are missing in this scale, information about their life history is still insufficient to date.

3. Results

3.1. Floristic characterisation of the sites

For the sampling sites pi-II, pi/be-I and pi/be-III very dense herb- and moss layers (covering ≥ 60 %) mainly composed of *Deschampsia flexuosa*, *Vaccinium myrtillus*, *Pleurozium schreberi* and *Scleropodium purum* respectively were recorded. The same species occurred in pi-I, but the covering had a lower density (3 % herb layer, 30 % moss layer). In the shrub and herb layer of pi/be-I also a lot of *Rubus idaeus* was growing. The herb layer of pi/be-II and pi/be-IV covered the soil only with 5 and 1 % respectively, but the species richness in pi/be-II was with 10 species (e.g. *Anemone nemorosa*, *Dryopteris carthusiana*, *Oxalis acetosella*, *Vaccinium myrtillus*) much higher than in pi/be-IV with only 3 species (*Fagus sylvatica*, *Pinus sylvestris*, *Vaccinium myrtillus*). In the moss layer of pi/be-IV only *Brachytecium rutabulum* was found (covering 1 %), pi/be-II had no moss layer. In the beech stand the herb layer with *Anemone nemorosa* and the moss layer with 4 species (*Atrichium undulatum*, *Lophocotea heterophylla*, *Orthodicranum montanum*, *Polytrichum formosum*) were also very sparsely developed (1 %). There was, however, a large amount of dead wood in this unmanaged site.

3.2. Gamasid mites

In comparison of both pure pine forests, significantly more individuals were found in the samples of the older site pi-II (17 300 ind./m^2) ($P < 0.001$). Within the mixed forests the youngest site pi/be-I showed a significantly higher abundance compared to all other sites (16 300 ind./m^2) ($P < 0.01$) (Fig. 1). The abundance values of gamasid mites in the young pine forest and the three older mixed forests were between 8000 and 9000 ind./m^2 and of the beech stand 10 500 ind./m^2 without significant differences.

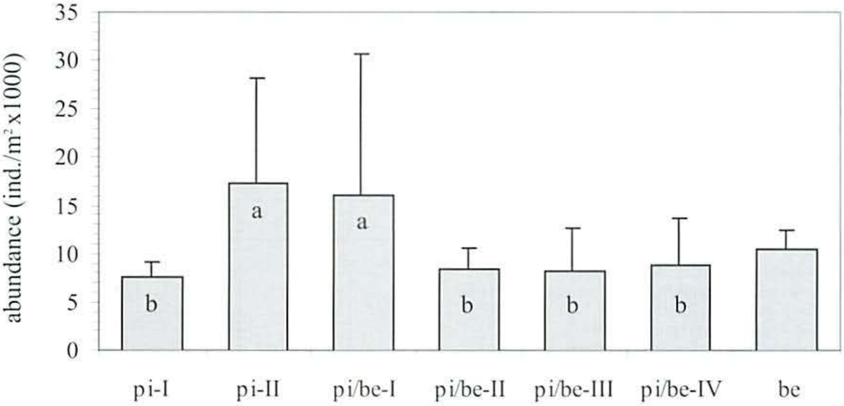

Fig. 1 Abundances of gamasid mites in the investigated sites; bars sharing the same letter do not differ significantly ($P > 0.05$, Tukey's honestly significant difference test)

In the samples of all investigated sites 42 species from 28 genera and 15 families (incl. Phytoseiidae) were found (Tab. 2). Here above all the high dominance of the Zerconidae in the pi-II and pi/be-I as well as in pi/be-III and pi/be-IV was remarkable, whereas in pi/be-II the specimens of the Parasitidae were most dominant. In the young pine forest pi-I and the pure beech stand the Uropodina showed higher dominances. Furthermore, the very low dominances of the Ascidae in the pure pine forests were obvious. In the youngest mixed forest pi/be-I this family was completely absent.

Fig. 2 shows the species number and species density of the sites. Most species (26) occurred in the samples of the beech stand. In the pine forests the older site pi-II had a higher species number and density than pi-I. In comparison with the mixed forests most species were found in the samples of the site pi/be-II (23), but the highest species density was observed for the youngest site pi/be-I, where 17 species were found. The same species number was also recorded in the oldest site pi/be-IV, but here the species density was significantly lower than in pi/be-I ($P < 0.01$).

In the ordination diagram of the canonical correspondence analyses the distribution of the observed species and the influence of the environmental data upon it can be seen (Fig. 3). Here the strongest separation between the oldest mixed forest pi/be-IV and the pure beech stand along the first axis could be seen. Besides the different age of the respective tree species,

Tab. 2 Dominances of the observed species in the investigated sites, the allocation of the species to the life history classes according to Ruf (1998) and the values of the maturity index, (for the explanation of »K« and »r« see 2.3. statistics)

				pine		mixed pine/beech				beech
	abbr.	**K**	**r**	**pi-I**	**pi-II**	**pi/be-I**	**pi/be-II**	**pi/be-III**	**pi/be-IV**	**be**
Gamasina										
Ascidae										
Arctoseius magnanalis Evans, 1958	a mag		1	0.5			1.1		3.1	3.6
Asca aphidioides (Linné, 1758)	a aph		1		0.2				2.3	
Gamasellodes bicolor (Berlese, 1918)	g bic		1		0.4		1.4	5.5	0.6	0.8
Lasioseius lawrencei Evans, 1958	l law		1				2.1	0.7		0.3
Zerconopsis remiger (Kramer, 1876)			1							0.3
total Ascidae				**0.5**	**0.6**		**4.6**	**6.2**	**6.0**	**4.9**
Eviphididae										
Eviphis ostrinus (C. L. Koch, 1836)	e ost			3.9	0.2	0.7	0.4			
Iphidosoma fimetarium (deutonymphs) (J. Müller, 1859)								0.7	0.3	
Laelapidae										
Hypoaspis aculeifer (Canestrini, 1883)	h acu		1	3.9	1.2	0.5	4.6	5.1		
Hypoaspis forcipata Willmann, 1956			1			0.2	1.1		0.3	
Ololaelaps placentula (Berlese, 1887)	o pla		1			2.8	0.4			
Macrochelidae										
Geholaspis longispinosus (Kramer, 1876)						0.5				
Macrocheles opacus (C. L. Koch, 1839)										1.3
Pachylaelapidae										
Pachylaelaps longisetis Halbert, 1915		1					0.7	1.8		0.5
Parasitidae										
Holoparasitus calcaratus (C. L. Koch, 1839)		2					1.4			
Leptogamasus suecicus Trägardh, 1936	l sue	2					23.1			10.9
Paragamasus conus (Karg, 1971)		2		10.3			13.5	6.9	28.0	
Paragamasus lapponicus (Trägardh, 1910)		2								1.0
Paragamasus jugincola (Athias-Henriot, 1967)		2			0.2					
Paragamasus robustus (Oudemans, 1902)	p rob	2		4.4	1.8		0.7	1.8	4.3	
Paragamasus runcatellus (Berlese, 1903)	p run	2		2.5			0.4	16.4		9.9
Paragamasus vagabundus (Karg, 1968)	p vag	2		13.2	13.8	14.8	11.7			1.3
Pergamasus crassipes (Linné, 1758)		2						0.4		
Pergamasus quisquiliarum (Canestrini, 1882)		2								0.5
Pergamasus septentrionalis (Oudemans, 1902)		2		0.5						0.3
Vulgarogamasus kraepelini (Berlese, 1905)	v kra		4	2.5	0.2	2.1	1.1	2.2	0.6	1.3
total Parasitidae				**33.3**	**16.0**	**16.9**	**52.0**	**27.6**	**32.9**	**25.2**
Phytoseiidae			2	0.5	0.4				0.6	
Rhodacaridae										
Rhodacarus coronatus Berlese, 1921	r cor	2			1.6		0.7			2.9
Rhodacaridae cf. Karg (1993) ssp. (1 female)		2			0.2					
Veigaiaidae										
Veigaia cerva (Kramer, 1876)	v cer	2		0.5	1.6	1.2	0.7	0.4	0.6	0.5
Veigaia exigua (Berlese, 1916)	v exi	2				1.0				0.5
Veigaia kochi (Trägardh, 1901)	v koc	2			0.6	1.4			0.3	
Veigaia nemorensis (C. L. Koch, 1839)	v nem	2		11.3	10.6	10.6	8.5	12.4	11.1	7.5
Veigaia transisalae (Oudemans, 1902)					0.2					
total Veigaiaidae				**11.8**	**13.0**	**14.3**	**9.3**	**12.7**	**12.0**	**8.6**
Zerconidae										
Parazercon radiatus (Berlese, 1910)	p rad	3			22.0	1.4	0.7	10.5	33.4	
Prozercon kochi Sellnick, 1943	p koc	3		9.3	26.9	30.0	2.1	3.3	6.6	0.3
Zercon gurensis Mihelčič, 1962	z gur	3		6.4	6.6	16.9	13.2	21.1		17.1
Zercon peltatus peltatus C. L. Koch, 1836	z pel	3								4.2
total Zerconidae				**15.7**	**55.5**	**48.3**	**16.0**	**34.9**	**40.0**	**21.6**
Uropodina										
Polyaspidae										
Polyaspinus cylindricus Berlese, 1916	p cyl									13.5
Trachytidae										
Trachytes aegrota (C. L. Koch, 1841)	t aeg			14.2	2.0	5.2	5.3	6.5	6.6	1.6
Trematuridae										
Trichouropoda ovalis (C. L. Koch, 1839)										0.3
Urodinychidae										
Urodiaspis tecta (Kramer, 1876)	u tec			1.0	0.6	0.9		1.8	0.9	0.3
Uroobovella pulchella (Berlese, 1904)					0.4					0.3
Uropodidae										
Uropoda minima Kramer, 1882	u min			15.2	8.4	9.8	5.0	2.5	0.6	19.2
total Uropodina				**30.4**	**11.4**	**15.9**	**10.3**	**10.9**	**8.0**	**35.1**
Maturity-Index				**0.69**	**0.75**	**0.73**	**0.74**	**0.76**	**0.62**	**0.79**

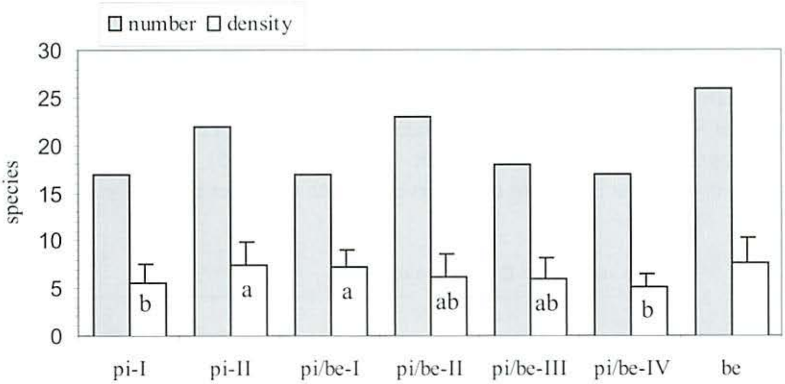

Fig. 2 Observed species numbers of gamasid mites and the species densities in the investigated sites; bars sharing the same letter do not differ significantly (P > 0.05, Tukey's honestly significant difference test)

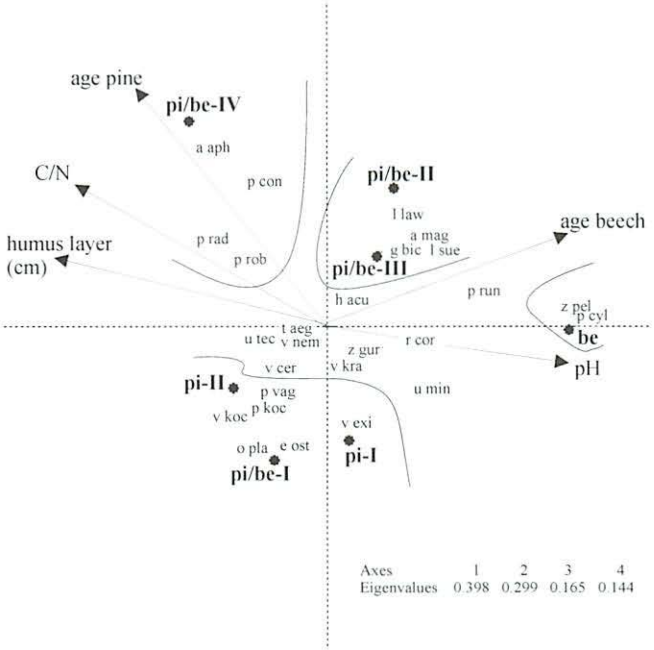

Fig. 3 Ordination diagram of the Canonical Correlation analyses; for abbreviations of the species see Tab. 2, only species which were found with more than 5 individuals in a site are shown

the separation gradients were the lower C/N-ratio, the higher pH-value and the thinner humus layer in the beech stand. Close groupings resulted between both pine forests and the youngest mixed forest pi/be-I as well as between the pine/beech forests pi/be-II and pi/be-III. The first group was characterised for example by *Paragamasus vagabundus* (Karg, 1968) and *Prozercon kochi* Sellnick, 1943, which had their highest abundance each in the older pine site pi-II and the youngest mixed forest pi/be-I (Figs 4 and 5). It was remarkable that *Paragamasus vagabundus* could not be observed in both the older mixed forests pi/be-III and pi/be-IV.

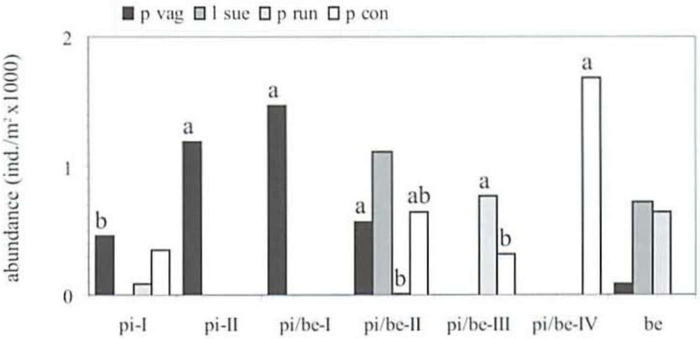

Fig. 4 Abundances of selected species of family Parasitidae in the investigated sites; for abbreviations of the species see Table 2; bars sharing the same letter do not differ significantly (P > 0.05, Tukey's honestly significant difference test)

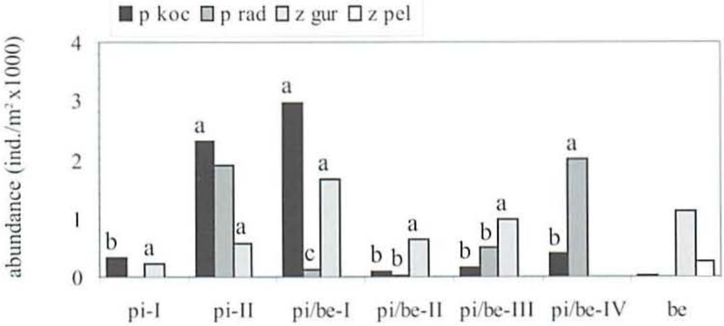

Fig. 5 Abundances of selected species of the family Zerconidae in the investigated sites; for abbreviations of the species see Table 2; bars sharing the same letter do not differ significantly (P > 0.05, Tukey's honestly significant difference test)

For the second group of pi/be-II and pi/be-III a closer relation to the beech site can be considered. This was due to the occurrence of *Leptogamasus suecicus* Trägardh, 1936 and *Paragamasus runcatellus* (Berlese, 1903), which showed in the site pi/be-II and pi/be-III respectively similar abundances as in the beech forest (Fig. 4). Furthermore *Lasioseius lawrencei* Evans, 1958 was found only in these three sites. For *Leptogamasus suecicus* and

Paragamasus runcatellus a negative correlation with *Prozercon kochi* was observed ($P < 0.05$). Additionally *Leptogamasus suecicus* was negatively correlated with the C/N-ratio ($r_{sp}^2 = -0.579$, $P = 0.173$) and the thickness of the humus layer ($r_{sp}^2 = -0.757$, $P < 0.05$) and positively correlated with the pH-value ($r_{sp}^2 = 0.786$, $P < 0.05$).

In the oldest mixed forest pi/be-IV especially smaller gamasid mite species (< 0.6 mm) like *Asca aphidioides* (Linné, 1758), *Paragamasus conus* (Karg, 1971) and *Parazercon radiatus* (Berlese, 1910) occurred more numerously, the occurrence of *Asca aphidioides* and *Parazercon radiatus* were strongly correlated ($r_{sp}^2 = 0.809$, $P < 0.05$). All three species were absent in the beech site, which also led to the strong separation of both these sites by the CCA. Furthermore, *Paragamasus conus* was absent in the older pine site pi-II and the youngest mixed site pi/be-I. *Parazercon radiatus* could not be recorded in the young pine site pi-I, but in the 80-year old pine forest this species showed a comparable abundance to that in pi/be-IV. For *Parazercon radiatus* strong correlations with the C/N-ratio ($r_{sp}^2 = 0.955$, $P < 0.001$), the thickness of the humus layer ($r_{sp}^2 = 0.829$, $P < 0.05$) and the age of pine ($r_{sp}^2 = 0.873$, $P < 0.05$) as well as a very strong negative correlation with the pH-value ($r_{sp}^2 = -0.898$, $P < 0.01$) were proved. The species *Zercon gurensis* Mihelčič, 1962 was with exception of the oldest mixed forest pi/be-IV regularly present in the compared sites of pine and mixed forests. Therefore this species is integrated between the three site groupings pi-I, pi-II, pi/be-I and pi/be-II, pi/be-III and the beech stand. A similar position in the diagram of the CCA is taken by *Uropoda minima* Kramer, 1882, but it was found in significantly lower abundances in both older mixed forests than in the youngest mixed site pi/be-I and the beech stand ($P < 0.001$). Thus, the species was also negatively correlated with the increasing age of pine ($r_{sp}^2 = -0.865$, $P < 0.05$), the C/N-ratio ($r_{sp}^2 = -0.714$, $P = 0.071$) and the thickness of the humus layer ($r_{sp}^2 = -0.643$, $P = 0.119$). Six species, *Zerconopsis remiger* (Kramer, 1876), *Macrocheles opacus* (C. L. Koch, 1839), *Paragamasus lapponicus* (Trägardh, 1910), *Pergamasus quisquiliarum* (Canestrini, 1882), *Zercon peltatus peltatus* C. L. Koch, 1836 and *Polyaspinus cylindricus* Berlese, 1916, occurred only in the samples of the beech forest. In higher abundances (more than 5 individuals) were *Zercon peltatus peltatus* and *Polyaspinus cylindricus* (Tab. 2).

The very different species composition of the beech stand and the oldest mixed forest pi/be-IV and therefore their strong separation in the CCA can be seen also in the lowest Renkonen-index value of 15 % (Tab. 3). The dominance structure of the beech stand was most similar to pi/be-II and pi/be-III with values of 45 % and 42 % respectively. The highest dominance similarity of 73 % was calculated between the pure pine site pi-II and the youngest mixed site pi/be-I.

Tab. 3 Trellis diagram of the dominance similarities (Renkonen-Index) between the investigated sites

	pi-I	pi-II	pi/be-I	pi/be-II	pi/be-III	pi/be-IV	be
pi-I	x	■	■	■	▩	▩	▒
pi-II	54.8	x	■	▩	▩	▩	░
pi/be-I	59.2	73.0	x	▩	▩	░	▒
pi/be-II	56.8	40.8	49.7	x	▩	▒	▩
pi/be-III	48.6	40.1	43.8	49.3	x	▩	▩
pi/be-IV	42.3	46.1	26.9	34.6	43.5	x	□
be	37.5	28.9	39.9	45.0	42.4	15.0	x

□	< 20
░	< 30
▒	< 40
▩	< 50
■	> 50

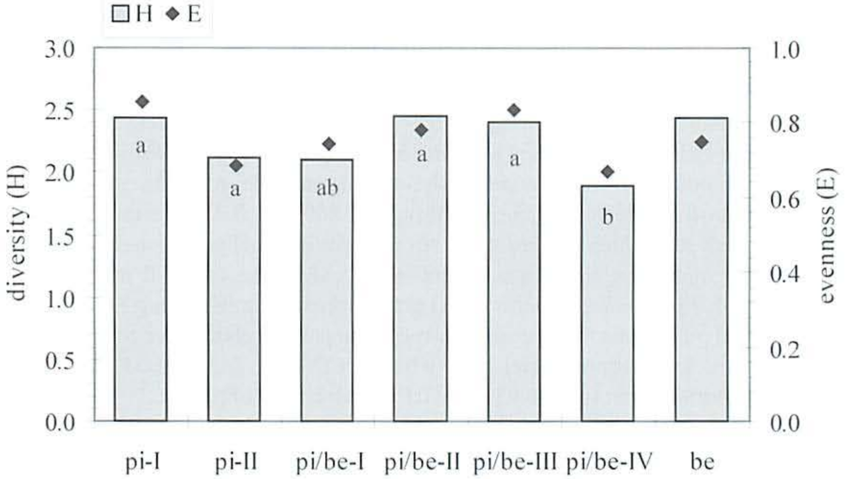

Fig. 6 The calculated diversity and evenness values for the investigated sites; bars sharing the same letter do not differ significantly ($P > 0.05$, Tukey's honestly significant difference test)

The Shannon-Weaver-diversity index resulted in the lowest values for the oldest mixed forest pi/be-IV, which was slightly significant different to the younger pine/beech sites pi/be-II and pi/be-III ($P < 0.05$) (Fig. 6). This is confirmed by the lowest evenness value (0.67), because the dominances of the two species *Paragamasus conus* and *Parazercon radiatus* amounted already to about 60 % of all 17 species (see Tab. 2). Also in the calculation of the maturity index the somewhat peculiar state of this site was obvious. This was due to the comparable ratio of the K- and r-groups, whereas in all other sites a higher proportion of taxa in the K-groups was noticed (see Tab. 2).

4. Discussion

The results show that the increasing age of pure pine forests and pine/beech mixed forests seems to have an important influence on composition and distribution of species in gamasid mite communities, because for some species a strong correlation to a certain stand age was observed. In the two investigated pine forests, this can be stated especially for the 80-year-old site pi-II, the components of which had already a more mature state of succession than the 19-year-old site pi-I. Above all, this is indicated by the more developed plant cover. In comparison of the gamasid mite communities, this is confirmed by the significantly higher abundance and species density in the older pine site and its more uneven distribution of the individuals to the species, because of the very dominant species *Prozercon kochi* and *Parazercon radiatus*. Many literature data, which were summarised by MADEJ & SKUBAŁA (1996) and RUF (1997b) also showed that predatory mites often have high abundances in pine forests, whereas in young plantations they are less numerous.

In the mixed pine/beech forests the described preferences of species were, as one reason, surely due to the ratio of accumulated pine and beech litter in the different time periods. Thus, the high similarity of the youngest mixed site pi/be-I to the pure pine sites, especially to the older pine forest mainly because of the dominant occurrence of *Prozercon kochi* and *Paragamasus vagabundus* in both sites, can be assumed. Because of the very young beech undergrowth of only 8 years in pi/be-I, the litter layer of this site still mainly consists of pine needles, whereas in the sites pi/be-II and pi/be-III, in which the beech was planted 40 and 50 years ago, more beech litter had accumulated. This resulted in a higher similarity of the gamasid fauna compared with the pure beech stand. Apparently with time the habitat conditions had improved, approximating the conditions of a natural beech stand, this being most evident for the site pi/be-II. Here the beech was planted when the pine was 40 years old. Hence, due to the relatively well-balanced ratio of pine and beech litter, a better humus type (mor) with a higher pH- and a lower C/N-value, indicating a higher organic matter content, especially in comparison with the two older mixed sites, could develop (see Tab. 1). This development can also be expected in the next 30 years for mixed site pi/be-I, in which the beech was planted 8 years ago when the pine had also an age of 40 years.

From the significant correlations with a thinner humus layer and a higher pH-value as well as its occurrence only in pi/be-II and the beech stand, *Leptogamasus suecicus* seems to be a species that prefers such improved conditions. Christian (1993) found this species most numerous in a 33-year-old mixed deciduous stand (C/N-ratio: 19) and for instance also in a 33-year-old pine forest with deciduous tree undergrowth in the shrub layer (C/N-ratio: 23). It was observed eudominantly and subdominantly in different beech stands by Alberti et al. (1996) and Schulz (1991) (C/N-ratios between 15 and 16). Furthermore, Ruf (2000a) proved *Leptogamasus suecicus* to be an indicator species for higher organic matter content. Another species that seemed to favour the improved soil conditions of pi/be-II and pi/be-III was *Lasioseius lawrencei*. According to Karg (1993b) and Hutha (1996) this species occurs mostly in the litter of deciduous and coniferous/deciduous forests.

In the other investigated mixed sites as well as in the 80-year-old pine forest with higher percentages of pine needles in the humus layer or only pine litter respectively, the smaller individuals of the family Zerconidae were found in their highest dominances. Here *Parazercon radiatus* even showed a strong correlation to the thickness of the pine litter layer. From the very dominant occurrence of *Prozercon kochi* in pi-II and pi/be-I, it can be concluded according to Karg (1982) that in these two sites processes of the decomposition are stagnate. However, it seems that the species of this family somewhat replace other species with an increasing proportion of pine litter as in, e.g., the case of *Paragamasus vagabundus*, which had a higher dominance than *Prozercon kochi* in the 19-year-old pine forest, but lower dominances in the older pine forest and the youngest mixed site pi/be-I than *Prozercon kochi* or *Parazercon radiatus* respectively. This interpretation can be confirmed with data of the work of Christian (1993). He found *Paragamasus vagabundus* to be eudominant in the already mentioned 33-year-old pine forest with an initial deciduous tree undergrowth, which had a total number of 13 species. Among them no species of the Zerconidae occurred, which is possibly due to the thinner pine-litter layer in connection with the young stand age, and which is moreover already mixed with deciduous litter. In the older mixed forest pi/be-III, the beech stand, and in the oldest mixed site pi/be-IV, *Paragamasus vagabundus* seems to be replaced by other species of the same family like *Paragamasus runcatellus* and *Paragamasus conus*. With an increasing accumulation of pine litter in the oldest pine/beech mixed stand pi/be-IV, which had a raw humus layer of 11.5 cm, there was a decreasing diversity both of the vegetation composition and of the gamasid mite community. The lower species density and the dominance of smaller species and species in the r-groups of the maturity index could indicate relatively variable habitat conditions and poor habitat structures, probably also poorer food resources. The last interpretation could be inferred from the very low occurrence of *Uropoda minima* in this site, which prefers habitats with a rich supply of food resources (Huţu 1982). The maturity index value of 0.62 was a little out of the range of tolerance for mor humus soils (as well as for raw humus soils), which was specified between 0.63 and 0.87 (0.68 and 0.93) (Ruf 1998). This could explain the fact that the soil of this site strongly differs from stable conditions. Furthermore, the very low dominance similarity of pi/be-IV to the beech stand confirms the strong influence of a higher thickness of the pine-litter layer resulting from the advanced pine age. In terms of the biotic »long-term memory« according to Dunger (1982), the influence of the pine growth in the mixed stands could strongly reflect the first planting of these sites, since the soil fauna responds very slowly to changes of habitat conditions.

A diversity of habitat structures can be assumed for the 188-year-old beech stand. This can be concluded from the higher number of observed species, comprising especially species in lower dominances, which are able to coexist in a structurally rich mull humus form (e.g. Odum 1971, Schaefer & Schauermann 1990, Skorupski 2001).

In this unmanaged beech stand of the Müritz National Park, especially the large amount of deadwood contributes to the structural richness. A species that seems to prefer this habitat structure is *Polyaspinus cylindricus* (Skorupski, pers. comm.). According to Błoszyk & Athias-Binche (1998), this species feeds on fungal hyphae and probably other organic liquid substrates. Therefore, fungi that colonise deadwood could be an important food resource for this species in the beech stand. Accordingly, this species was also found numerously in rotten tree trunks. Moreover, it occurred numerously in soil samples of a pine/spruce site taken in 2003 on the peninsula Darß (Wegener, ined.) which was completely destroyed by a gale in winter 1999/2000 and left over to natural succession. Thus, a very high proportion of deadwood was also found there. This example shows that there seem to be very specific traits of the gamasid mite community in an old uninfluenced beech forest in the lowlands of north-eastern Germany.

However, from the results it could be stated that if beech trees are planted into an about 40-year-old (up to 100-year-old) pine site, it would allow the development of mixed forests with natural-like habitat conditions. There the gamasid mite community reflected partly that of Baltic beech woodlands, because the influence of the pine was obviously weaker than in the managed pure pine forests or the investigated very old mixed forest pi/be-IV.

5. Acknowledgements

I thank Prof. Dr G. Alberti, Dr D. J. Russell and Dipl. Biol. E. Kreibich for the sampling, Dipl. Biol. H. Schulz for the pH- and C/N-measurements, Dipl. Geogr. H. Rudolphi for the analyses of the soil profiles, M.A. A. Friedel for the floristic characterisation, TA C. Putzar and many volunteers for the separation of the animals in the soil samples.

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Manuscript accepted: 12 July 2006

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Zeitschrift/Journal: Abhandlungen und Berichte des Naturkundemuseums Görlitz

Jahr/Year: 2006

Band/Volume: 78

Autor(en)/Author(s): Wegener Annett

Artikel/Article: The influence of different age stages of forest in the Müritz National Park (Mecklenburg-Vorpommern) on the gamasid fauna (Acari, Arachnida) 77-91