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Impact of ectohumus application in birch and pine nurseries on the presence of soil mites (Acari), Oribatida in particular

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Abstract

Intensively used forest nurseries are characterised by degradation processes that lead to a drop in the quality of seedlings. The main reason of this problem is a decrease in biological soil diversity. Therefore, an attempt of nursery soil enrichment by introducing ectohumus – as compost and fresh litter – from the pine forest was carried out. The research was carried out in 2009–2011 in the Bielawy forest nursery near the city of Toruń, Poland. The objective of the study was to determine the impact of organic fertilisation (compost made up of forest humus) and mulching using fresh ectohumus on the density and community composition of Acari mites and on species composition of oribatid mites (Oribatida) in the nurseries of silver birch and Scots pine. Mites, especially oribatid mites, were treated as bioindicators of soil biological activity. Research has shown that mulching using fresh ectohumus caused a multiple increase in the density of mites, especially in saprophagous mites Oribatida. Oribatid mites were clearly more numerous in birch cultivation than in that of pine. Overall, 27 species of oribatid mites were found. Mulching resulted in a significant growth in species diversity in both cultivations. The most numerous oribatid mite in the area under the study was *Oribatula tibialis.* This species was present in all plots and showed clear preference for birch cultivation. *Tectocepheus velatus* and *Oppiella nova,* common and known to be present in a variety of environments, were slightly less numerous.

Key words

forest nursery revitalization, mulching, mineral and organic fertilisation, bioindication, oribatid mites

INTRODUCTION

In intensely explored forest nurseries, degradation processes leading to a drop in biological soil diversity occur. In order to obtain high-quality seedlings, and to prevent soil degradation, regular organic fertilisation is most frequently carried out. Yet, fertilisation (alone) does not usually solve the problem of low biological activity of soil in forest nurseries that lack, for example, the useful soil mesofauna. It should be remembered that

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in natural conditions, seedlings grow amongst numerous soil mesofauna in the forest.

Mites (Acari) are very numerous in forest ectohumus with regard to oribatid mites (Oribatida) classified to saprophagous species. These animals fulfil a number of fundamental functions in forest ecosystems. They decompose organic matter, thus releasing to soil nutrients that are indispensable for plant growth. In addition, they contribute to the spread of soil microorganisms, that is, ectomycorrhizae, which are important for plants (Setala 1995). This indirectly affects plant growth. For instance, Sulkava et al. (2001) found positive influence of soil fauna on birch. Considering the presence of oribatid mites in forest nurseries, it is interesting that they can feed on ectomycorrhizal fungi (Schneider et al. 2004, 2005; Remén et al. 2010). Soil fauna, when preying on mycorrhizae, can stimulate their growth (Hanlon and Anderson 1979, 1980), and it can also inoculate soil with fungal spores through defecation and transferring them on new substrates (Lussenhop 1992). Oribatid mites are diverse in terms of species and a functionally important group of soil animals, and therefore, they are frequently proposed as bioindicators of the condition of the environment (Behan-Pelletier 1999, 2003; Ruf and Beck 2005; Gulvik 2007). Many studies have documented that most oribatid mites with their long life span, low fecundity, slow development and low dispersion can be the robust indicators of the state of the environment (Gulvik 2007).

The quoted facts indicate that forest humus rich in edaphon can be one of the best substrates for soil revitalising. Especially that recently, in a number of regions in Poland, an opportunity arouse to use ectohumus in this application, which can be supported from forest stands scheduled for clearing because of major road investments in forest areas. Forest mulch provides environment for microorganisms and soil fauna (Sayer 2006; Leski et al. 2009), and it is a protective layer for soil against fluctuations in temperature and humidity (Siipilehto 2001). Mulching can be used in two ways in forest nurseries, namely, as a layer spread on the surface of the ground or by uniformly mixing it with surface soil layer (Leski et al. 2009). Ectohumus from forest soil as an inoculum introduces a diverse soil fauna (Haimi 2000). The activities of these animals can render more efficient processes of decomposition of organic matter and ensure environmental sustainability in the soil of forest nurseries as well as enrich the soil with mycorrhizal fungi, which are very important for young trees.

This study is a part of more extensive research on the revitalisation of bare root forest nurseries (Klimek et al. 2008, 2009, 2011a, b, c, 2013). The objective of the present research was to determine the impact of organic fertilisation (compost prepared from forest humus) and mulching with fresh ectohumus on the density and community composition of mites and species composition of oribatid mites in the nurseries of silver birch (*Betula pendula* Roth) and Scots pine (*Pinus sylvestris* L.). In this research, mites, and particularly oribatid mites, were treated as indicators of biological soil activity.

Material and methods

Site description

The experiment was carried out in 2009–2011 in the Bielawy (53°01’37.2”N 18°42’49.8”E) forest nursery (Dobrzejewice Forest District) near the city of Toruń, Poland. Fine sand prevailed in the area under the study. More data on the soil are provided in a different paper (Klimek et al. 2011a, b).

The experiment was set up in April 2009 by split plot in four repetitions separately for birch and pine. The primary factor was fertilisation carried out before seed sowing in two variants: mineral fertilisation and organic fertilisation with forest humus compost. The secondary factor was mulching carried out in September 2009 in two variants: mulching and non-mulching. A single experimental plot was 1.6 m × 5 m. In total, 32 plots were set up: 16 for birch and 16 for pine.

Organic fertilisation with composted ectohumus was used on selected plots. This material was obtained after the removal of grown-up pine forest stand from the area of A1 motorway under construction near the city of Toruń. Ectohumus was obtained mechanically in the autumn of 2007. Plant roots and small branches present in the soil were grounded with a logging residue shredder. This material was composted on piles near the nursery and in the spring of 2009, before seed sowing, uniformly spread in the amount of 1000 m^3 ha^{-1} and mixed with soil layer to the depth of 10 cm using a cultivating unit. This substrate was strongly acid – its acid reaction (pH_{KCl}) was 3.8. The content of C_{org} was

4.7%, N_{total} was 0.2% and the C:N ratio was high (23:1). Mineral fertilization in the nursery was used in the following doses: 30kg N ha^{-1} (ammonium nitrate 34%) and 55 kg ha^{-1} K_2O (potash salt 60%).

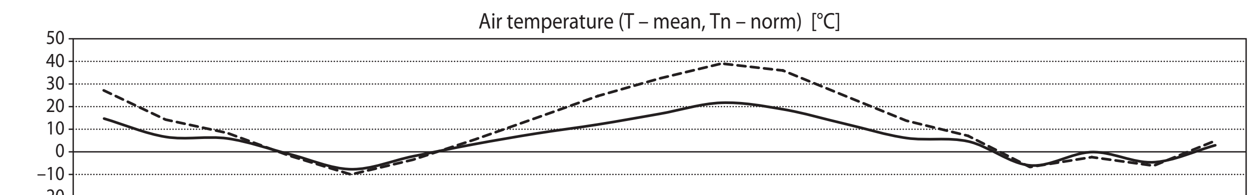
Mulching was carried out on selected plots (either with mineral fertilisation or without it) using fresh ectohumus obtained from under the grown-up pine forest stand. A dose of 100 m^3 ha^{-1} was used by spreading a uniform layer of ectohumus on the whole surface of plots, and then it was mixed with soil to the depth of around 1–2 cm. The whole surface of the experiment was watered with a fixed sprinkler. Sprinkling machines were made using NAAN 5035 sprinklers.

Soil samples for acarological research were taken four times in 2009–2011: 21 October 2009, 9 June 2010, 27 October 2010 and directly before extracting seedlings from the soil on 29 March 2011. From each variant of the experiment, that is, mF (mineral fertilising), oF (organic fertilising), mFM (mineral fertilising and mulching) and oFM (organic fertilising and mulching), 10 soil samples were taken from birch and pine cultivations in four successive terms. Two or three samples were taken from one plot, which constituted 320 samples in total. Soil samples were taken from 17 cm^2 up to 3 cm in depth. The Acari were extracted into 70% ethanol for seven days using Tullgren funnels. Oribatid mites were classified to species or genus, including their young individuals, and the remaining mites were classified to the order level. Overall, 2577 mites, including 761 oribatid mites, were classified. The average mite density (N) was provided, standardised to 1 m^2 of soil and mite communities were characterised by a number of species (S), mean number of species in a sample (s) and Shannon diversity index (H) (Magurran 1988).

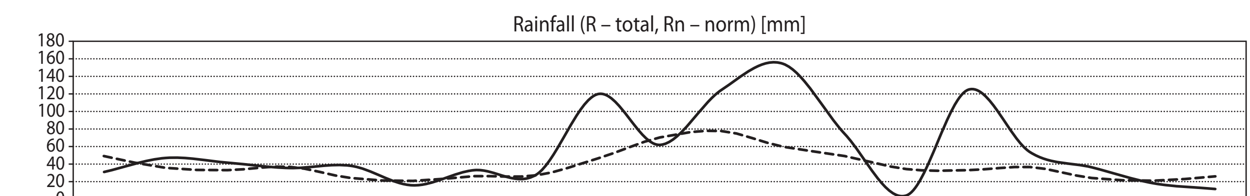
The obtained data, according to the design of the experiment, were tested by two-factor analysis of variance (ANOVA) with post-hoc Tukey's honest significant difference test (Statistica – ANOVA). The data of mites were ln-transformed (x+1) before the analyses (Berthet and Gerard 1965). Similar methodology – including factorial ANOVA – was used by Zhiping et al. (2011) for the evaluation of abundance and diversity indices of soil mites (four orders: Prostigmata, Mesostigmata, Astigmata and Oribatida) under long-term organic and chemical fertiliser treatments.

The course of weather conditions and irrigation

In the vegetation period (April–September) of 2009, the average air temperature was 15.2°C (0.9°C above standard) and the total rainfall was 320.9 mm, that is, 94.4% of standard (Agrometeorological… 2009–2011). April was the least favourable month for plant growth, as only one day with poor rainfall was noted (0.5 mm) (Fig. 1). Different pluvio-thermal conditions were in the vegetation period of the second year of the research, that is, 2010. The total monthly rainfall noted was 562.6 mm



	IX.09	X.09	XI.09	XII.09	I.10	II.10	III.10	IV.10	V.10	VI.10	VII.10	VIII.10	IX.10	X.10	XI.10	XII.10	I.11	II.11	III.11
--- Tn	13	8	3	0	–2	–1	3	8	13	16	18	18	13	8	3	0	–2	–1	3
— T	15	7	6	–1	–8	–2	3	8	12	17	22	19	12	6	5	–6	0	–5	3



	IX.09	X.09	XI.09	XII.09	I.10	II.10	III.10	IV.10	V.10	VI.10	VII.10	VIII.10	IX.10	X.10	XI.10	XII.10	I.11	II.11	III.11
— R	31	47	42	36	38	16	33	28	120	62	125	154	74	4	125	54	36	18	12
--- Rn	51	37	35	39	26	23	28	29	48	72	79	61	51	36	35	38	26	23	28

Figure 1. Pluvio-thermal conditions the vicinity of Toruń (norm – long-term average value)

(165.5% standard). May, July, August and September were especially rich in rainfall, because 119.8, 124.5, 154.3 and 74.2 mm of rainfall was noted, respectively, which constituted 249%, 157%, 251% and 146% of the perennial standard, respectively.

The irrigation process was strictly dependent on the rate and distribution of the rainfall, on the one hand, and, on the other hand, it relied on exact guidelines regarding irrigation for nurseries in the first or second year of production (Żarski and Dudek 2009; Rolbiecki et al. 2010; Stachowski and Markiewicz 2011; Żarski 2011). Consequently, in the first year of research, 81 mm was applied with the use of sprinkling machine (spraying) in total, whereas in the second year, it was only 6 mm.

Results

Effects of treatments on density of mites

In birch cultivation, the average mite density in mulched areas was three times higher than that in non-mulched soil, and these differences were statistically significant (Tab. 1). In pine cultivation, high density of these arthropods was observed in the mFM variant (12,450 individuals m^{-2}). Yet, when compared with the density in birch cultivation in the same variant, these differences were not statistically significant. In birch cultivation, communities of mites Actinedida prevailed on all plots, comprising 56.4–85.6% of all Acari. Mites from this community also prevailed on non-mulched plots in birch, and upon the application of mulching, oribatid mites were the most numerous mites in this cultivation (47.9–61.8%). The density that was much lower and varied than in Oribatida was noted in predatory Mesostigmata (20–1630 individuals m^{-2}). Tarsonemida were rare in the examined variants of the study.

The statistical analysis conducted shows that the factor to positively shape mite density (including Oribatida and Actinedida) was mulching. A positive impact of organic fertilisation on these mites was in turn not observed, and in case of Actinedida and Mesostigmata, it was negative.

Seasonal dynamics of mites in examined variants of the experiment

In birch cultivation, a total density of mites in successive terms of experiments (from October 2009 to March 2011) in an option excluding organic fertilisation and mulching (mF) was varied, namely, it was higher in spring seasons than in the autumn (Fig. 2). In the variant with organic fertilisation, mite density in the period of the experiment gradually increased to reach the maximum value in March 2011 (3250 individuals m^{-2}). In turn, when mulching was applied (mFM and oFM options), mite density was high at the beginning of the re-

Table 1. Abundance (*N* in 1000 individuals · m^{-2}) of mites in birch (B) and pine (P) nurseries

Taxon of mites	Plant	Variants (Plots)				*P* value	
		mF	oF	mFM	oFM	F	M
Actinedida	B	1.26±1.96^{a}	1.17±0.93^{a}	2.06±2.41^{a}	1.51±1.26^{a}	ns	<0.001
	P	2.44±6.97^{a}	1.34±1.40^{a}	8.07±18.88^{b*}	1.87±1.82^{a}	0.042	<0.001
Mesostigmata	B	0.72±1.40^{a}	0.69±1.13^{a}	1.26±1.95^{a}	0.87±1.57^{a}	ns	ns
	P	1.08±1.57^{a}	0.20±0.37^{b}	1.63±3.03^{a}	0.35±0.89^{b}	<0.001	ns
Oribatida	B	0.09±0.35^{a}	0.39±1.20^{a}	3.13±4.08^{b}	4.11±6.96^{b}	ns	<0.001
	P	0.02±0.10^{a}	0.03±0.13^{a}	2.66±5.56^{b*}	1.02±1.59^{b*}	ns	<0.001
Tarsonemida	B	0	0.11±0.33^{a}	0.08±0.24^{a}	0.17±0.39^{a}	ns	ns
	P	0.30±1.90^{a}	0	0.09±0.40^{a}	0.08±0.24^{a}	ns	ns
Acari (total)	B	2.08±2.24^{a}	2.36±2.43^{a}	6.53±5.56^{b}	6.65±8.50^{b}	ns	<0.001
	P	3.84±8.18^{a}	1.57±1.54^{a}	12.45±20.86^{b}	3.31±3.75^{a*}	<0.001	<0.001

Variants: mF – mineral fertilizing, oF – organic fertilizing, mFM – mineral fertilizing and mulching, oFM – organic fertilizing and mulching; ANOVA: F – fertilization effect, M – mulching effect, ^{a,b} – the same letters in a row mean lack of significant differences , * – significant between plot of Scots pine and birch plot at $p < 0.05$.

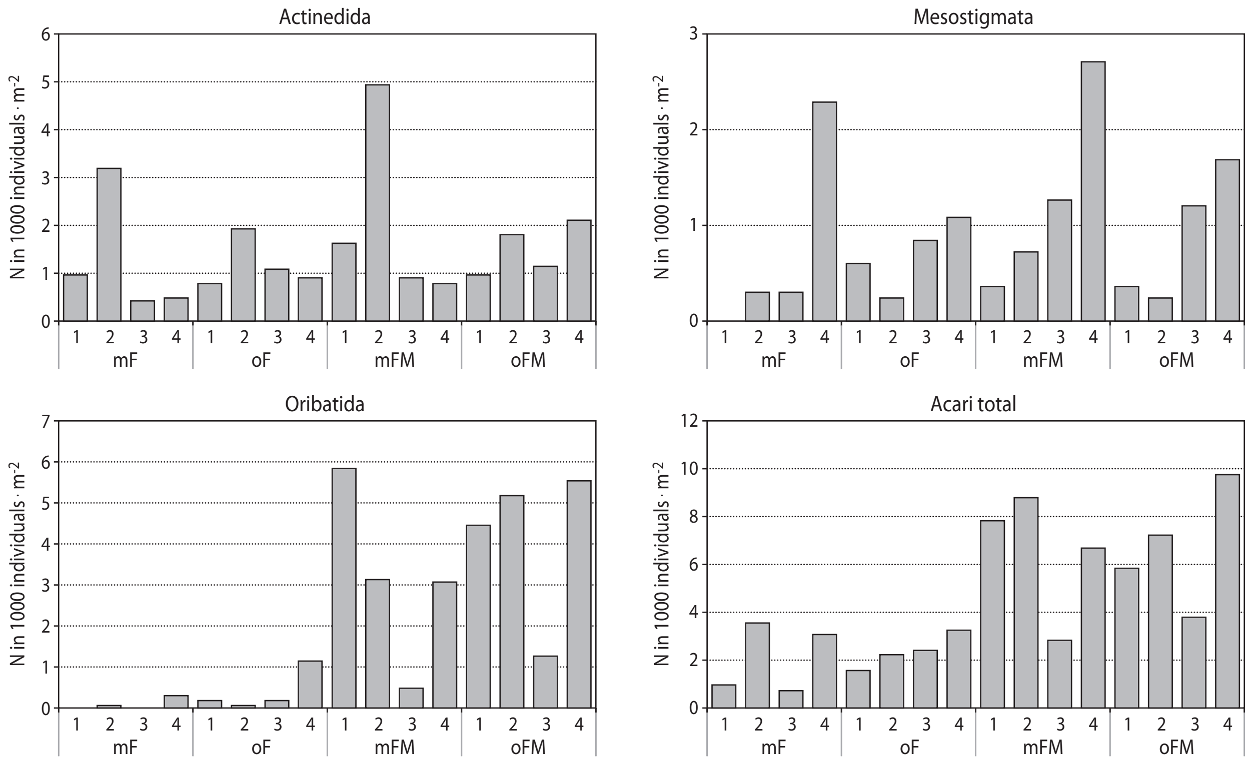


Figure 2. Seasonal dynamics (*N* in 1000 individuals · m^{-2}) of chosen communities of mites in consecutive terms of the study (1 – 21.10.2009, 2 – 9.06.2010, 3 – 27.10.2010, 4 – 29.03.2011) in birch cultivation of forest nursery. Variants: mF – mineral fertilizing, oF – organic fertilizing, mFM – mineral fertilizing and mulching, oFM – organic fertilizing and mulching

search cycle (5840–7830 individuals m^{-2}), and it further increased in the spring 2010 to clearly drop in October 2010. In the spring 2011, in the mFM and oFM options, the density raised more than twofold when compared with the autumn season of 2010.

Saprophagous mites had a main impact on mite density as a community. In non-mulching variants, throughout the whole cycle of the research, their density was low. The last term with fertilisation using composted ectohumus (oFM) was an exception, as the density increased to 1140 individuals m^{-2}.

The dynamics of density of predatory Mesostigmata in birch was interesting to observe. The mites displayed a clear tendency to grow in density throughout the two-year research cycle. However, no clear tendency was concluded in case of Actinedida's population dynamics.

In pine cultivation, fluctuations in mite density in the research period were more diverse than those in birch cultivation and did not display any marked tendency (Fig. 3). A relatively high mite density, stable over the research period, was observed in the mFM variant only. In this variant, mites were numerous only right after mulching in October 2009 – 7890 individuals m^{-2}. Their density was low on mulched plots in the last term of research (1080–1140 individuals m^{-2}).

Effects of treatments on diversity of oribatid mites

Oribatid mites were far more numerous in birch cultivation than in pine – on mulched plots, these differences were statistically significant (Tab. 1). In the area under study, a total of 27 species of oribatid mites were found: 27 in birch and 23 in pine (Tab. 2). On non-mulched plots, depending on the variant, 1–6 species were found, whereas on mulched ones, it was between 13 and 23. After mulching, a significant increase in species diversity indices for oribatid mites (*s* and *H*) was observed, and a higher increase was observed in birch. In the case of an *s* index, the differences in both cultivations between mulched and non-mulched plots were statistically significant.

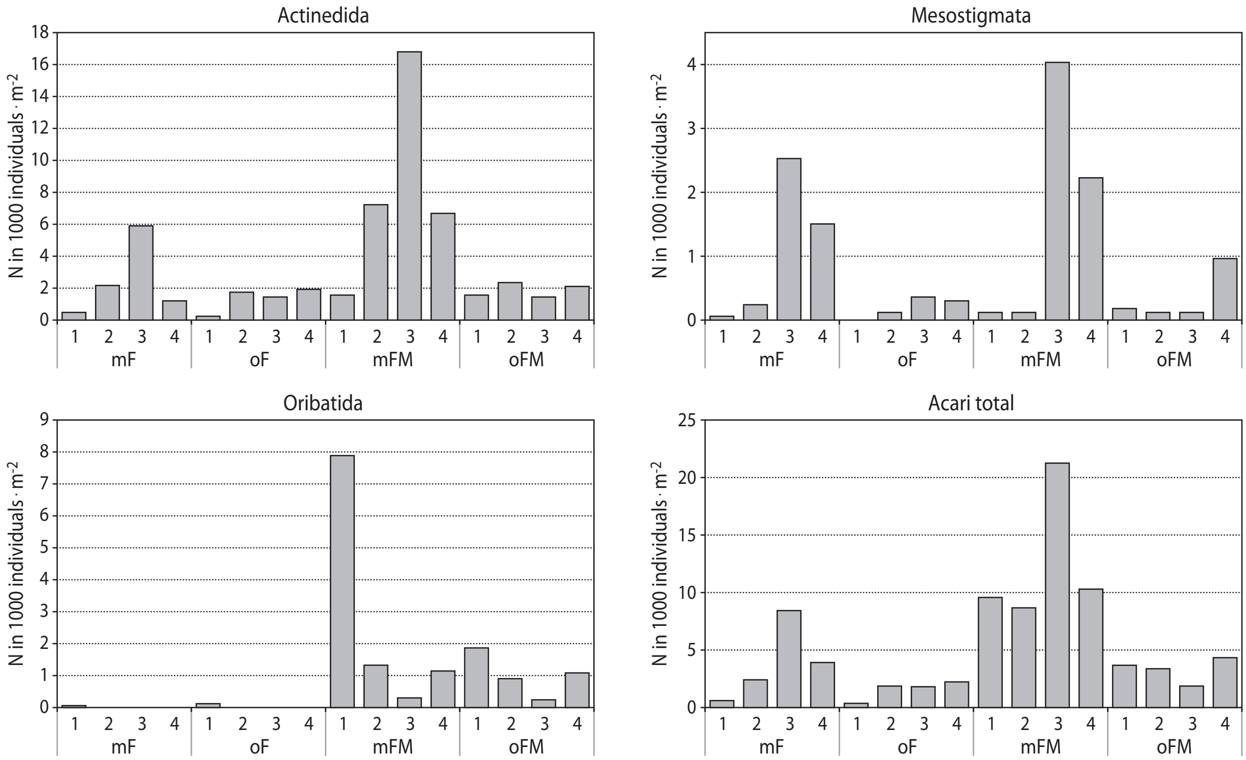


Figure 3. Seasonal dynamics (*N* in 1000 individuals · m^{-2}) of chosen communities of mites in consecutive terms of the study (1 – 21.10.2009, 2 – 9.06.2010, 3 – 27.10.2010, 4 – 29.03.2011) in pine cultivation of forest nursery. Variants: mF – mineral fertilizing, oF – organic fertilizing, mFM – mineral fertilizing and mulching, oFM – organic fertilizing and mulching

Effects of treatments on density of some species of oribatid mites

The most numerous mite in the area under study was *O. tibialis* – its maximum density was observed in the oFM variant (Tab. 3). This species was present on all plots and showed clear preference towards birch cultivation. The factor to clearly shape the presence of *O. tibialis* in both cultivations was mulching with fresh forest ectohumus. In the population of the studied species in birch cultivation, young forms prevailed (61%), whereas in pine cultivation, grown forms were more numerous (57%).

In the area under study, *T. velatus* (*N* in birch in the mFM variant was 710 individuals m^{-2}) was slightly less numerous than *O. tibialis*. The statistical analysis shows that the factor shaping its density was mulching, but only in the birch cultivation. In case of a different mite – *F. furcillata* – mulching had an impact on the density in both cultivations. This species was similar in birch and pine in terms of density. Species such as *O. nova*, *P. nervosa* and *R. duplicata* were less numerous in the area under study.

Table 2. Number of oribatid mites species (*S*), average number of species (*s*) and Shannon (*H*) index in birch (B) and pine (P) nurseries

Index	Plant	Variants (Plots)				*P* value
		mF	oF	mFM	oFM	M
S	B	2	6	20	23	–
	P	1	2	21	13	–
s	B	0.08±0.27[a]	0.35±0.66[a]	2.55±2.46[b]	2.78±2.54[b]	<0.001
	P	0.03±0.16[a]	0.05±0.22[a]	1.90±2.64[b*]	1.10±1.52[b*]	<0.001
H	B	0.45	0.98	2.32	2.32	-
	P	0	0.69	2.28	2.18	-

Variants: mF – mineral fertilizing, oF – organic fertilizing, mFM – mineral fertilizing and mulching, oFM – organic fertilizing and mulching; ANOVA: M – mulching effect, [a,b] – the same letters in a row mean lack of significant differences, [*] – significant between plot of Scots pine and birch plot at $p < 0.05$.

Table 3. Abundance (*N* in 1000 individuals · m^{-2}) species of oribatid mites in birch (B) and pine (P) nurseries

Species	Species of plant	Variants (Plots)				*P* value
		mF	oF	mFM	oFM	M
1	2	3	4	5	6	7
Autogneta traegardhi Forsslund	B	0	0	0.02	0	ns
Brachychthonius sp.	B	0	0	0	0.02	ns
Camisia spinifer (C.L. Koch)	B	0	0	0.02	0	ns
	P	0	0	0.02	0	ns
Carabodes forsslundi Sellnick	B	0	0	0.08^{a}	0.09^{a}	ns
	P	0	0	0.02^{a}	0.05^{a}	ns
Carabodes minusculus Berlese	B	0	0	0.02^{a}	0.02^{a}	ns
Carabodes subarcticus Trägårdh	B	0	0	0.05^{a}	0.06^{a}	ns
	P	0	0	0.03^{a}	0.03^{a}	ns
Chamobates schuetzi (Oudemans)	B	0	0	0.05^{a}	0.12^{a}	ns
	P	0	0	0.02	0	ns
Eupelops torulosus (C.L. Koch)	B	0	0	0	0.03	ns
	P	0	0	0.03	0	ns
Furcoribula furcillata (Nordenskiöld)	B	0	0.02^{a}	0.36^{b}	0.59^{b}	<0.001
	P	0	0.02^{a}	0.60^{b}	0.26^{b}	<0.001
Hemileius initialis (Berlese)	B	0	0	0.03^{a}	0.03^{a}	ns
	P	0	0	0.03	0	ns
Lauroppia neerlandica (Oudemans)	B	0	0	0.06^{a}	0.02^{a}	ns
	P	0	0	0.02	0	ns
Liochthonius sp.	B	0	0	0	0.02	ns
	P	0	0	0	0.06	ns
Metabelba pulverulenta C.L. Koch	B	0	0	0.06^{a}	0.02^{a}	ns
	P	0	0	0.14^{a}	0.03^{b}	ns
Microtritia minima (Berlese)	B	0	0	0.03^{a}	0.02^{a}	ns
	P	0	0	0.02	0	ns
Nothrus silvestris Nicolet	B	0	0	0.02	0	ns
	P	0	0	0.03	0	ns
Oppiella nova (Oudemans)	B	0.08^{a}	0.29^{a}	0.12^{a}	0.50^{a}	ns
	P	0	0	0.12^{a}	0.15^{a}	ns
Oribatula tibialis (Nicolet)	B	0.02^{a}	0.05^{a}	0.75^{b*}	1.07^{b*}	<0.001
	P	0.02^{a}	0.02^{a}	0.23^{b}	0.08^{a}	0.002
Pergalumna nervosa (Berlese)	B	0	0	0.27^{a}	0.45^{a}	ns
	P	0	0	0.21^{a}	0.12^{a}	ns
Phthiracarus longulus (C.L. Koch)	B	0	0	0.17^{a}	0.08^{a}	ns
	P	0	0	0.02^{a}	0.03^{a}	ns
Quadroppia quadricarinata (Michael)	B	0	0	0.03	0	ns
Rhysotritia duplicata (Grandjean)	B	0	0	0.18^{a}	0.17^{a}	ns
	P	0	0	0.17^{a}	0.02^{a}	ns
Scutovertex sculptus Michael	B	0	0.02^{a}	0	0.08^{a}	ns
	P	0	0	0.02^{a}	0.02^{a}	ns
Suctobelba spp.	B	0	0.02^{a}	0.14^{a}	0.18^{a*}	0.009
	P	0	0	0.21^{a}	0.02^{a}	ns
Tectocepheus velatus (Michael)	B	0	0.02^{a}	0.71^{b}	0.53^{b}	0.001
	P	0	0	0.69^{a}	0.18^{a}	ns
Trhypochthonius tectorum (Berlese)	B	0	0	0	0.03	ns
	P	0	0	0.06	0	ns

Variants: mF – mineral fertilizing, oF – organic fertilizing, mFM – mineral fertilizing and mulching, oFM – organic fertilizing and mulching; ANOVA: M – mulching effect (*p*), ^{a,b} – the same letters in a row mean lack of significant differences, * – significant between plot of Scots pine and birch plot at $p < 0.05$.

Discussion

This experiment was set up in early spring 2009, and the preliminary acarological tests were carried out on all plots in June, before mulching. Mite density on all plots was low at that time – 240–1140 individuals m^{-2}. In that period, the most numerous mites were Actinedida (in birch, they made up 50–100%, and in the pine, 91–100% of all mites). Mesostigmata, Oribatida and Tarsonemida were occasionally present in the studied area. Only two species of oribatid mites were found: *O. nova* and *S. sculptus*.

In the study of Hasegawa et al. (2013), forest-floor litter weight (including leaves and twigs) and water content in broad-leaved sites was correlated with densities, species richness and species composition of several taxa of mites. The forest-floor litter is the source of food and a habitat for soil mites and has been shown to be an important limiting factor for soil microarthropods. In our study, the treatment of mulching with fresh ectohumus, carried out in September on relevant plots, caused a multiple increase in mite population, especially in saprophagous Oribatida. In similar earlier research carried out in the Białe Błota forest nursery, mulching in early spring before seed sowing had a slightly better effect on mite population (Klimek et al. 2008, 2009). In this research, oribatid mite density clearly increased in the second year of the study in pine cultivation on irrigated plots, unlike in the present experiment in the Bielawy nursery, where an attempt to maintain high population after soil inoculation with edaphon was unsuccessful. It should be mentioned that in the Białe Błota nursery, extensive irrigation through an independent watering system was used in the second year of cultivation. In turn, in the present research in the Bielawy nursery, this treatment was not administered in the second year, which resulted from plots being already connected to a computer-controlled sprinkling system of the nursery. This was in accordance with the guidelines for forest nursery watering procedures.

Lack of watering in the second year of the research, despite high level of natural rainfall, seems to be the main cause of a rapid fall in mite abundance, especially in oribatid mites in the autumn 2010 (Figs. 2 and 3). It should also be highlighted that in October that year, the rainfall was exceptionally low, that is, only 12% of the standard for that month (Fig. 1). The sensitivity of soil mesofauna, especially of Oribatida, to low humidity is known in the literature (Lindberg and Bengtsson 2005). It is interesting that in March 2011, before cuttings were removed from soil, the population of oribatid mites in birch cultivation reconstructed to even exceed the level noted at the beginning of the research, that is, straight after mulching. A positive impact of birch on the population of species diversity of oribatid mites was concluded in earlier research as well (Klimek et al. 2009). This might stem from ecological conditions that this species provides – large birch plants shade the soil better than young pines and prevent extensive dry-up of its top layer. In addition, birch as early as in its first year of cultivation (autumn) provides significant amount of organic matter in the form of fallen leaves that create favourable trophic conditions for saprophagous species. In the experiments carried out in the Białe Błota forest nursery, two-year old pines were between 29.0 and 39.4 cm tall (Klimek et al. 2008) and birches in the same age were far taller, that is, 127.5–175.5 cm (Klimek et al. 2009). Also in the study conducted by Bernier and Gillet (2012), variations in the local composition of plant communities influenced the four soil fauna communities (including Oribatida) through differences in litter composition.

A positive impact of forest ectohumus, that is, composted organic fertiliser, on the density and diversity of mites was not confirmed in the present research. Yet, the population dynamics in the two-year research cycle in birch cultivation and an increase in Oribatida species population on the oF plot from 2 to 5 can indicate a positive tendency. From the present research, it can be concluded that over the two-year composting cycle in a pile, mites that were present there before died out and settling nursery soils with oribatid mites, despite the improvement in trophic conditions, occurs relatively slowly without introduction.

O. tibialis, the most numerous oribatid mites on experimental plots, is ranked as a eurytopic species (Weigmann and Kratz 1981; Weigmann 1991) that prefers forest soils (Rajski 1968). Over the two-year cycle, however, this mite showed a clear fall in density, from the maximum of 1570–3070 individuals m^{-2} (spring 2010) in mulched areas in birch cultivation to just 240 individuals m^{-2} on these plots a year later. It is remarkable that the same species, when examined in earlier research in Białe Błota (Klimek et al. 2013), similar to the present experiment, preferred birch cultivation, and it showed a fall in population in non-watered areas in a two-year cycle. On the other hand, its density increased on watered plots. A decrease in *O. tibialis* population, as well as in other mites, for example *F. furcillata* and *T. velatus,* can be caused by the lack of watering in the vegetation season of 2010 and drought in October that year.

The sole mite that increased its density over the two-year period of the research was *O. nova*. This is one of the most common eurytopic species in Poland and in the world (Weigmann and Kratz 1981; Weigmann 1991; Skubała 2002) that prefers forest biotopes (Rajski 1968).

O. nova or *O. tibialis* and *T. velatus* mentioned earlier are pioneering species that can be called 'long-distance' ones, as they reside in communities for a long time. *O. nova* and *T. velatus* are parthenogenetic, and they develop according to r-strategy (Siepel 1994; Skubała and Gulvik 2005). The species mentioned earlier belong to fungivorous mites too (Luxton 1972; Ponge 1991) and can also feed on ectomycorrhizal fungi (Schneider et al. 2005; Remén et al. 2010).

In the present experiment, mites were treated as bioindicators of soil biological condition. Oribatid and astigmatic species and species assemblages offer several advantages for assessing the quality of terrestrial ecosystems: their diversity is high; they occur in high numbers; they are easily sampled; they can be sampled in all seasons; adult identification, at least in central Europe, is relatively easy; most live in the organic horizons; the site of soil fertility; and they represent a trophically heterogeneous group (Behan-Pelletier 1999). The impact of mites on the quality of production in forest nurseries is indirect – it consists primarily in increasing the activity of soil microorganisms (Wallwork 1983) and accelerating the processes of decomposition of organic matter through its shredding. These mites, by continuous reduction of bacteria and fungi population, maintain them in a stage of growth (compensatory growth). A more favourable impact of birch cuttings rather than pine cuttings on soil acarofauna, as concluded in the paper, might be of practical importance. In order to revitalise soil system of forest nurseries using forest ectohumus, we should pay attention to species composition of nurseries and prefer birch over pine. Birch is a pioneering species that grows well in sun and tolerates varied soil humidity (Giertych et al. 2006). For that reason, this species might be of a great importance not only in revitalising forest nurseries but also other degraded soils.

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