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Full Length Research Paper

Effect of irrigation and organic fertilization on oribatid mites (Acari, Oribatida) in forest nursery

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The aim of the paper was to determine the effect of microirrigation and organic fertilization on the structure of assemblages of oribatid mites in Silver birch and Scots pine cultivations under conditions of mulching with forest ectohumus. Investigations were conducted at Forest Nursery Białe Błota, Forest District in Bydgoszcz (Poland). Separate experiments in Scots pine and S. birch stands were established in 2003; the single plot area measured 4 m^2 and contained 4 rows (4 m long). The soil samples for mites were taken twice a year (in May and October of 2003 and 2004). A total of 39 oribatid mite species were found in forest nursery cultivations of both tree species. Irrigation was found to be the factor which determined the mean number of species per sample in both plantations, as well as the density of oribatids, which were more numerous in S. birch stands than in that of Scots pine. Eurybionthic populations of oribatids – *Oppiella nova*, *Oribatula tibialis* and *Tectocepheus velatus* – were the most numerous in the study sites. Most of the species preferred specific ecological conditions which were created by high seedlings of S. birch which is characterized by abundant leaf-fall. Only the xerophilous *Scutovertex sculptus* was more abundant in Scots pine cultivation.

Key words: Forest nursery, irrigation, organic fertilization, mulching, oribatid mites.

INTRODUCTION

Forest soils are characterized by abundant and species diversified small animals. These animals, especially saprophage species, play a very important role in the whole forest ecosystem. They participate in decomposition of organic matter releasing into soil nutrients indispensable for plant growth. In addition, they increase spreading of soil microorganisms, among others ectomycorrhizas which are very important for plants (Setala, 1995) indirectly influencing the growth of plants. For example, Sulkava et al. (2001) noted such positive effects of diverse soil fauna on the growth of birch.

One of the most abundant and species-rich group of soil animals is oribatida – which compose mostly from 60 to 90% of all soil mites (Klimek, 2000; Gulvik, 2007). Feeding of oribatids is relatively less recognized. In the opinion of Schneider et al. (2004) oribatids are most often generalists with some degree of specialization in food resources. Oribatid mites are also characterized by feeding on ectomycorrhizal fungi. This is important especially in the case of forest nurseries (Remén et al., 2010; Schneider et al., 2004, 2005). Soil fauna feeding on mycorrhizas can promote the growth of trees (Hanlon and Anderson, 1979 and 1980), and also by defecation and transfer to fresh substrates can inoculate the soil with fungi spores (Lussenhop and Wicklow, 1984; Lussenhop 1992). Oribatid mites are species-rich group of soil animals and because of this they are often evaluated as

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bioindicators of the state of the environment (Behan-Pelletier, 1999 and 2003; Gulvik, 2007; Klimek, 2000; Ruf and Beck, 2005).

Growth conditions of young trees in forest nurseries are distinctly different from typical conditions in forest ecosystems. Such nurseries are most often localized in forest complexes, sometimes even under canopy of mature trees. But because of frequent tillage treatments they are degraded. Forest nurseries used over 20 years are often characterized by degradation processes connected with a decrease of biological activity – among others ectomycorrhizal fungi (Aleksandrowicz-Trzcińska, 2004). The quality of seedlings produced under such conditions is generally lower. Improvement of the biological state of soils can be obtained by enrichment of a nursery in organic matter for example, fertilization of soils with compost or by edafon inoculation including zooedaphon derived from forest soil (that is, by mulching with forest litter).

To make a success of this treatment, suitable ecological conditions for development of fauna should be created. Dunger (1969) considered that fauna should be transported with the top layer of forest soil and, additionally the soil can be enriched in organic matter. Moreover, the forest litter used in this type of treatment constitutes a protective layer for the soil against changes in temperature and humidity. But most of all it creates a suitable environment for microorganisms and soil fauna (Leski et al., 2009; Sayer, 2006).

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 in mycorrhizal fungi which are very important for young trees. Oribatid mites were considered in these trials as bioindicators of the biological activity of soils.

The aim of this paper was to determine the influence of microirrigation and organic fertilization on the structure of assemblages of soil oribatid mites in cultivations of Silver birch (*Betula pendula* Roth) and Scots pine (*Pinus sylvestris* L.) under conditions of mulching with forest ectohumus.

MATERIALS AND METHODS

Experiments were carried out in the area of Forest Nursery Białe Błota, Forest District Bydgoszcz, Poland (Longitude 17º 55' E; Latitude 53º 06' N). Separate experiments on Scots pine and S. birch were established in 2003 and they lasted 2 years. These experiments were run in a *split-plot* system with four replications. Two different factors were compared:

(i) the first row factor – irrigation, used in the three following treatments: without irrigation (control – Co), drip irrigation (Dr), microjet sprinkling (Mi),
(ii) the second row factor – fertilization, used in the two variants: mineral fertilization (standard applied in forest nurseries – M), organic fertilization (compost – O).

The plot area was 4 m^2 and contained 4 rows (4 m long) of seedlings. Total number of plots in each experiment was 24 (3 × 2 × 4).

Drip irrigation was done with the use of drip lines „T-Tape" (in-line emitters spaced 20 cm apart). Microjet irrigation was done with the use of microjets "Hadar". Terms of irrigation and water rates were established according to directives for irrigation of forest nurseries on bare areas (Pierzgalski et al., 2002). It should be mentioned that the region of Bydgoszcz is characterized by high irrigation requirements (Żarski and Dudek, 2009; Żarski, 2011).

Organic fertilizer was produced on the basis of sewage sludge (80%) and highmoor peat (20%). This fertilizer was spread (dose: 100 t ha^{-1}) in spring and mixed with the topsoil (10 cm deep) before establishing of exact field experiments.

Mulching was done after organic fertilizer application, but before sowing of Scots pine and S. birch seeds. Forest litter was obtained in Scots pine coniferous forest from layers with superiority of moss. A thin layer (1 cm) of forest litter was scattered on the whole surface of the experiment, immediately after it has been obtained from the forest. Next, it was delicately mixed with the top 2 cm layer of the forest nursery soil.

The soil samples for investigation on mites were taken twice a year (in May and October in 2003 and 2004). The samples of 17 cm^2 and 3 cm deep were taken from all plots in 3 replications. A total of 48 soil samples were taken from each variant of the experiment. Mites were extracted from the material in Tullgren funnels for 7 days. Overall, 3682 Oribatida were determined to species or genus (also taking juvenile stages into account). The density (N) of mites was calculated per 1 m^2 of soil. Species diversity of oribatid mites was determined as the total number of species (S), the mean number of species per sample (s), as well as the Shannon index of species diversity (H) (Magurran, 1988).

The experimental data were tested by two-factor analysis of variance with post-hoc Tukey HSD test (ANOVA) (Bruchwald, 1997). The data of mites were ln-transformed (x+1) prior to the analyses (Berthet and Gerard, 1965).

RESULTS

Species composition of oribatida

In this trial, after treatment of mulching in forest nursery cultivations of pine and birch, a total of 39 species of oribatid mites (Table 1) have been identified. In cultivation of pine in two-year's cycle of investigation, the number of oribatid species, depending on experimental variant, ranged from 8 to 15 (Table 2). In the first year of pine cultivation, the average number of species *s* in the analyzed variants was slightly different. In the second year of the study the average number of species *s*, on most the irrigated plots, increased, but on control plots this number was similar to that in the first vegetation season.

In birch cultivation, with the exception of the CoM variant, the number of species of oribatid mites was higher at the same treatments than that in pine cultivation (Table 2). The average number of species *s* for a two-year's cycle of investigation was in comparison to Scots

Table 1. List of species of oribatid mites under different variants of the experiments.

S/No.	Species	Occurrence in the variants of the experiments
1	*Adoristes ovatus* (C.L. Koch)	Scots pine: MiM; Birch: DrO
2	*Brachychthonius* sp.	Scots pine: DrO-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
3	*Camisia biurus* (C.L. Koch)	Birch: MiO
4	*Camisia segnis* (Hermann)	Scots pine: MiM
5	*Camisia spinifer* (C.L. Koch)	Scots pine: MiM-MiO; Birch: CO-MiM
6	*Carabodes labyrinthicus* (Michael)	Scots pine: CoM-MiO
7	*Carabodes subarcticus* Trägårdh	Birch: DrM-DrO-MiO
8	*Chamobates schuetzi* (Oudemans)	Scots pine: CoM-CoO-DrM-MiM; Birch: CoM-CoO-DrM-DrO-MiM-MiO
9	*Damaeus* sp.	Scots pine: MiM; Birch: MiO
10	*Damaeus verticillipes* (Nicolet)	Birch: MiO
11	*Diapterobates humeralis* (Hermann)	Scots pine: MiO
12	*Eremaeus oblongus* C.L. Koch	Scots pine: DrO
13	*Eupelops torulosus* (C.L. Koch)	Scots pine: DrM-DrO-MiM-MiO; Birch: MiM-MiO
14	*Galumna lanceata* Oudemans	Scots pine: DrO; Birch: DrM-DrO-MiM-MiO
15	*Galumna* sp.	Scots pine: CoM
16	*Gymnodamaeus bicostatus* (C.L. Koch)	Scots pine: MM; Birch: CoO-DrO-MiM-MiO
17	*Hemileius initialis* (Berlese)	Scots pine: DrO; Birch: MiM
18	*Heminothrus peltifer* (C.L. Koch)	Birch: DrM
19	*Licneremaeus licnophorus* (Michael)	Birch: MiO
20	*Liochthonius* sp.	Scots pine: DrO-MiM-MiO; Birch: CoO-DrM-DrO-MiM-MiO
21	*Metabelba pulverulenta* C.L. Koch	Scots pine: DrM-DrO-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
22	*Micreremus brevipes* (Michael)	Scots pine: CoM-CoO; Birch: CoO
23	*Nothrus silvestris* Nicolet	Scots pine: DrO
24	*Oppiella minus* (Paoli)	Scots pine: MiM Birch: DrM-MiM
25	*Oppiella neerlandica* (Oudemans)	Scots pine: CoO; Birch: DrO-MiM-MiO
26	*Oppiella nova* (Oudemans)	Scots pine: CoM-CoO-DrM-DrO-MiM-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
27	*Oppiella subpectinata* (Oudemans)	Scots pine: CoM
28	*Oribatula tibialis* (Nicolet)	Scots pine: CoM-CoO-DrM-DrO-MiM-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
29	*Pergalumna nervosa* (Berlese)	Scots pine: CoM-DrO
30	*Phthiracarus longulus* (C.L.Koch)	Birch: DrM-MiM-MiO
31	*Punctoribates punctum* (C.L. Koch)	Birch: DrM-DrO-MiO
32	*Quadroppia quadricarinata* (Michael)	Scots pine: MiM; Birch: DrM-DrO-MiM
33	*Rhysotritia duplicata* (Grandjean)	Birch: CoO-DrM-MiO
34	*Scheloribates latipes* (C.L. Koch)	Scots pine: CoM-CoO-DrM-DrO-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
35	*Scutovertex sculptus* Michael	Scots pine: CoO-DrM-DrO-MiM-MiO; Birch: CoM-CoO-DrM-DrO-MiM
36	*Suctobelba* sp.	Scots pine: DrM-DrO; Birch: CoM-DrM-DrO-MiM-MiO
37	*Tectocepheus velatus* (Michael)	Scots pine: CoM-CoO-DrM-DrO-MiM-MiO; Birch: CoM-CoO-DrM-DrO-MiM-MiO
38	*Trichoribates novus* (Sellnick)	Scots pine: CoM-DrM; Birch: DrO
39	*Trichoribates trimaculatus* (C.L. Koch)	Scots pine: CoM

Co – control, Dr – drip, Mi – microjet, M – mineral fertilization, O – organic fertilization.

pine always higher, and these differences were statistically significant (Figure 1).

Irrigation was the factor which influenced both in Scots pine as well as in S. birch cultivations the mean number of species per sample (Table 3, Figure 1). Influence of fertilization was not noted. In turn, the Shannon index *H'* was in both cultivations generally lower in the second year compared with the first.

Density of oribatid mites and some populations of oribatida

The density of oribatid mites in the studied forest nursery

Table 2. Number of species (*S*), average number of species (*s*) and Shannon index (*H*) of oribatid mites under different variants of the experiments.

Index	Species of plant	Year	Variants					
			CoM	CoO	DrM	DrO	MiM	MiO
S	Scots pine	2003	9	5	7	9	11	8
		2004	6	4	6	8	5	6
		Total	12	8	10	15	14	12
	Birch	2003	9	11	14	10	13	16
		2004	5	8	13	17	16	15
		Total	9	13	18	18	19	21
s	Scots pine	2003	1.0	0.6	0.9	1.0	1.3	0.7
		2004	0.7	0.6	1.8[(2)]	1.7[(2)]	1.3	1.8[(2)]
		Total	0.8	0.6	1.4	1.3	1.3	1.2
	Birch	2003	1.6[(1)]	1.4[(1)]	1.9[(1)]	1.0	2.5[(1)]	3.0[(1)]
		2004	1.4[(1)]	1.5[(1)]	2.5[(2)]	3.6[(1,2)]	3.8[(1,2)]	3.2[(1)]
		Total	1.5[(1)]	1.4[(1)]	2.2[(1)]	2.3[(1)]	3.1[(1)]	3.1[(1)]
H	Scots pine	2003	1.38	0.88	1.40	1.76	1.56	0.74
		2004	0.98	0.73	1.17	0.99	0.85	0.90
		Total	1.64	1.32	1.59	1.35	1.47	1.28
	Birch	2003	1.49	1.46	1.43	1.62	1.71	1.57
		2004	0.71	0.57	1.36	1.57	1.65	1.45
		Total	1.31	1.03	1.44	1.60	1.70	1.55

Co, Dr, Mi, M, O – see Table 1; [(1)] – significant between plot Scots pine and a birch plot at $p < 0.05$, [(2)] – significant between 2003 and 2004 year at $p < 0.05$.

after treatment of mulching ranged from 590 (CoO) to 3800 individuals per square metre (MiO), on average for 2 year's cycle of Scots pine cultivation (Table 4, Figure 1). This density, in each investigated variant of S. birch cultivation, was distinctly higher than that in the pine cultivation – these differences were statistically significant. The highest density of these mites (12010 individuals per square metre) was noted on the stand MiM.

Oribatula tibialis or *Tectocepheus velatus* were dominant in communities of oribatid mites dependending on the experimental treatment, except the MiM stand in cultivation of Scots pine where *Scutovertex sculptus* dominated (Table 5). Additionally, *Chamobates schuetzi*, *Metabelba pulverulenta*, *Oppiella nova* and *Scheloribates latipes* were relatively numerous on the studied area.

DISCUSSION

Soils in forest nurseries do not possess a layer of ectohumus which is specific for forest areas. This layer is strictly connected with most of the microorganisms and small soil animals. Therefore edafon including Acari in forest nurseries is less numerous than in forests (Rolbiecki et al., 2006b, 2007).

This unfavorable situation can be improved by introduction of fresh ectohumus obtained from forest soils to soils of forest nurseries. The main aim of this treatment is revitalization of soils in forest nurseries which are degraded by long-term cultivation. Recently in many regions of Poland there is an opportunity to use ectohumus for this treatment. This ectohumus can be obtained without damage to forests from forest stands destined to be cut in connection with road investments conducted on a large scale and often situated in forest areas.

On the basis of the previously published data concerning this experiment it was found that the soil pH was in particular combinations neutral and alkaline (Klimek et al., 2008, 2009). The values of pH measured in H_2O and in 1 molar solution of KCl, ranged from 6.95 to 7.39 and from 6.70 to 7.13, respectively. Obviously, the organic carbon content was higher on plots with organic

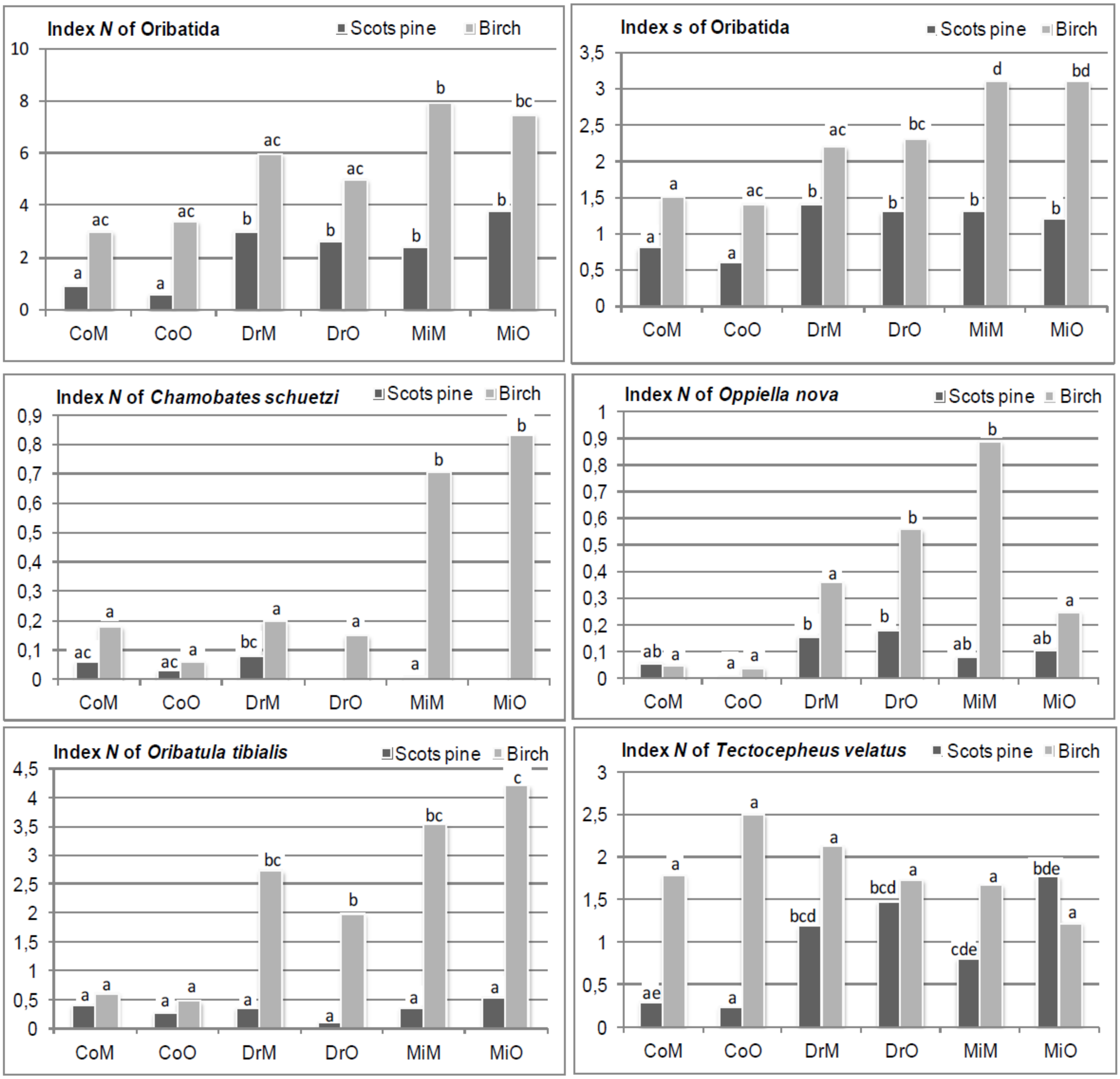

Figure 1. Index of density of total Oribatida and selected species (*N* in 1000 individuals per m^2) as well as mean number of species (*s*) for the 2-year cycle of research in the variants of experiments. Explanation: [a] – the same letter means lack of significant differences (separately for Scots pine and Silver birch), $p < 0.05$.

fertilization as compared to those without this fertilization. The factors of the experiment – irrigation and organic fertilization – positively influenced the growth of Scots pine and S. birch seedlings. The total number of mites was positively affected only by irrigation.

In birch cultivation, like in that of Scots pine, the average number of species *s* increased under the influence of irrigation in the second year of the experiment. This indicator was always distinctly higher in birch cultivation – even on non-irrigated plots – than that

Table 3. *F* and *p* values from two-factor analysis of variance (ANOVA) for irrigation factor for selected species and for oribatid mites total.

Index – taxon of Oribatida	Species of plant	*F*	*p*
N – *Chamobates schuetzi*	Scots pine	4.97752	0.026465
	Birch	18.01965	0.000000
N – *Oppiella nova*	Scots pine	4.02429	0.018913
	Birch	7.19251	0.000898
N – *Oribatula tibialis*	Birch	29.5991	0.000000
N – *Scutovertex sculptus*	Scots pine	15.27049	0.000001
	Birch	11.86494	0.000011
N – *Scheloribates latipes*	Birch	11.71448	0.000013
N – *Tectocepheus velatus*	Scots pine	9.5058	0.000101
N – Oribatida total	Scots pine	15.2591	0.000001
	Birch	11.6131	0.000014
N – Oribatida juvenile	Scots pine	12.6589	0.000005
	Birch	4.9132	0.007990
s of Oribatida	Scots pine	10.4469	0.000042
	Birch	19.0015	0.000000

The table included data on the influence of irrigation because the influence of the second factor (fertilization) was not significant; interaction between the two factors was also insignificant.

Table 4. Abundance (*N* in 1000 individuals per m^2), percent of juvenile forms of oribatid mites under different variants of the experiments.

Index	Species of plant	Year	Variants					
			CoM	CoO	DrM	DrO	MiM	MiO
N	Scots pine	2003	1.20	0.70	1.30	0.98	1.53	1.25
		2004	0.65	0.48	4.77$^{(2)}$	4.29$^{(2)}$	3.29	6.35$^{(2)}$
		Mean	0.93	0.59	3.04	2.63	2.41	3.80
	Birch	2003	2.83$^{(1)}$	2.08$^{(1)}$	3.96$^{(1)}$	1.61	3.86$^{(1)}$	6.52$^{(1)}$
		2004	3.16$^{(1)}$	4.69$^{(1,2)}$	7.98$^{(2)}$	8.40$^{(1,2)}$	12.01$^{(1,2)}$	8.45
		Total	3.00$^{(1)}$	3.39$^{(1)}$	5.97$^{(1)}$	5.00$^{(1)}$	7.94$^{(1)}$	7.49$^{(1)}$
% of juvenile forms	Scots pine	2003	58.3	89.3	84.6	43.6	59.0	80.0
		2004	42.3	31.6	46.3	67.3	60.3	71.5
		Mean	52.7	66.0	54.5	62.9	59.9	72.9
	Birch	2003	82.3	61.4	63.9	45.3	57.8	63.5
		2004	70.6	65.2	33.0	31.6	42.6	55.2
		Mean	76.2	64.1	43.3	33.8	46.3	58.8

See Tables 1 and 2.

Table 5. Abundance (*N* in 1000 individuals per m^2) of some Oribatida species under different variants of the experiments.

Species of orbatid mites	Species of plant	Year	Variants					
			CoM	CoO	DrM	DrO	MiM	MiO
Chamobates schuetzi	Scots pine	2003	0.13	0.05	0.15	-	0.03	-
		2004	-	-	-	-	-	-
		Mean	0.06	0.03	0.08	-	0.01	-
	Birch	2003	0.35	0.10	0.25	0.08	0.50(1)	0.63
		2004	-	0.03	0.15	0.23	0.93	1.05
		Mean	0.18	0.06	0.20	0.15	0.71(1)	0.84
Metabelba pulverulenta	Scots pine	2003	-	-	-	0.03	-	0.03
		2004	-	-	0.03	-	-	-
		Mean	-	-	0.01	0.01	-	0.01
	Birch	2003	0.03	0.08	0.08	0.03	0.03	0.18(1)
		2004	-	-	0.03	0.03	0.03	0.10
		Mean	0.01	0.04	0.05	0.03	0.03	0.14(1)
Oppiella nova	Scots pine	2003	0.05	-	0.03	0.15	0.08	0.03
		2004	0.08	0.03	0.30	0.20	0.08	0.20
		Mean	0.06	0.01	0.16	0.18	0.08	0.11
	Birch	2003	0.03	0.03	0.10	0.13	0.23	0.25
		2004	0.08	0.05	0.63(2)	1.00(1,2)	1.56(1,2)	0.25
		Mean	0.05	0.04	0.36	0.56(1)	0.89(1)	0.25
Oribatula tibialis	Scots pine	2003	0.75	0.53	0.70	0.15	0.68	1.05
		2004	0.03(2)	-	-	-	-	-
		Mean	0.39	0.26	0.35	0.08	0.34	0.53
	Birch	2003	1.03	0.80	2.21(1)	0.60	1.86	3.81
		2004	0.18(2)	0.13	3.24	3.34(2)	5.19(2)	4.62
		Mean	0.60	0.46	2.72(1)	1.97(1)	3.52(1)	4.2(1)
Scutovertex sculptus	Scots pine	2003	-	-	-	-	-	-
		2004	-	0.03	1.88	1.40	2.03	2.53
		Mean	-	0.01	0.94	0.70	1.02	1.27
	Birch	2003	-	-	-	-	-	-
		2004	0.35	0.25	0.05(1)	0.03(1)	0.03(1)	-
		Mean	0.18	0.13	0.03(1)	0.01(1)	0.01(1)	-
Scheloribates latipes	Scots pine	2003	0.05	0.03	0.10	0.05	-	0.03
		2004	-	-	-	-	-	-
		Mean	0.03	0.01	0.05	0.03	-	0.01
	Birch	2003	0.05	0.03	0.15	0.08	0.18	0.33
		2004	0.03	0.05	0.15	0.28	0.88(2)	0.15
		Mean	0.04	0.04	0.15	0.18(1)	0.53	0.24(1)
Tectocepheus velatus	Scots pine	2003	0.10	0.08	0.25	0.40	0.50	0.05
		2004	0.48	0.38	2.11(2)	2.53(2)	1.10	3.49(2)
		Mean	0.29	0.23	1.18	1.47	0.80	1.77
	Birch	2003	1.03	0.88	0.93	0.55	0.60	0.70
		2004	2.53(1,2)	4.11(1,2)	3.31(2)	2.91(2)	2.73(1,2)	1.73(2)
		Mean	1.78(1)	2.50(1)	2.12	1.73	1.67(1)	1.22

See Table 1 and Table 2.

of Scots pine growing because birch creates different ecological conditions for the development of Acari as compared to those of pine. Two-year old plants of Scots pine were characterized by a height from 29.0 to 39.4 cm (Klimek et al., 2008), and two-year old plants of S. birch on irrigated plots were distinctly higher – 127.5 - 175.5 cm (Klimek et al., 2009). It is well known that irrigation influenced on the woody plant growth (for example, Senyigit and Ozdemir, 2011). According to Lindberg and Bengtsson (2005), large seedlings create the possibility to shelter the soil and neutralize overdrying of the surface soil layer which can be harmful for soil fauna, especially for oribatids which are recognized as sensitive to drought. In addition, birch seedlings already in the first year provide appreciable amounts of organic matter (leaf litter), thereby improving feeding conditions for saprophages.

On the basis of our previously published studies carried out in the same forest nursery, it is shown that the number of species of Oribatida on non-mulched plots in two-year's crops, Scots pine and S. birch was low – only 4 and 3 species, respectively (Rolbiecki et al., 2006, 2007).

In traditional forest nurseries which were established after cutting trees on forest soils, the density of oribatid mites as a result of intensive agrotechnical/sylvotechnical treatments is low: 670-1050 individuals per square metre (Rolbiecki et al., 2006b, 2007). In soils of pine forests, which are not deformed by anthropogenic factors, the density of these mites range mostly from tens to hundreds of thousand individuals per square metre (Seniczak et al., 1995, 1997, 1998, 1999). However, the influence of some economic treatments in forestry, for example, removal of tree stands, ground vegetation, etc. can cause the decrease of the soil mesofauna, especially oribatids, even by 93% (Battigelli et al., 2004).

The high density and species diversity of oribatid mites in the cultivation of S. birch as well as the distinct increase during the two-year cycle of experiment may indicate a positive influence of this tree species on the biological activity of soils. This observation can be relevant in practice of forest nurseries, especially in view of the need to revitalize the soils in degraded forest nurseries.

The average share of juvenile stages of oribatids in Scots pine cultivation was 61.5 %, and in the S. birch growing was lower – 53.8%. It is interesting that also under difficult environmental conditions which were created by industrial pollution share of the juvenile stages of common forest species was higher than that in less contaminated soils (Klimek, 2000).

Chamobates schuetzi

Only few individuals were found in the cultivation of pine, only in the first year of cultivation (Table 5). On the other hand, in cultivation of birch the species was more numerous, particularly on stands irrigated with micro-sprinklers. The statistical analysis shows that irrigation was the factor which influenced on the density of this species (Table 3). Seniczak and Solhøy (1988) found that *C. schuetzi* is the oribatid commonly occurring in Polish territory. This species has not been previously shown as a result of erroneous incorporation to other species. *Ch. schuetzi* is classified to the group of oribatid mites of pine forest (Usher, 1975).

Metabelba pulverulenta

It is considered a forest species, also occurring in mid-forest meadows, peats and moors (Hammen and Strenzke, 1953). It is the species demonstrating a positive response to soil acidification but also tolerating higher pH values (Rajski, 1961). *M. pulverulenta* occasionally occurred in the cultivation of pine, and slightly more numerous in that of birch (Table 5).

Oppiella nova

This is one of the most common in Poland and in the world eurytopic species (Skubała, 2002; Weigmann, 1991; Weigmann and Kratz, 1981), preferring forest biotopes (Rajski, 1968). Its density in the cultivation of pine seedlings was quite low – to 200 individuals per square metre (Table 5). In the cultivation of birch seedlings its density was considerably higher on most irrigated surfaces and irrigation was the factor significantly influencing its abundance in both cultivations (Table 3).

Oribatula tibialis

This species occurred on all stands in the cultivation of pine in 2003 (Table 5). In the next year this species was found (in this cultivation) only in the variant CoM. In the first year in the cultivation of birch as in that of pine, *O. tibialis* was found at all sites, and the maximum abundance (3810 individuals per square metre) was considerably higher in comparison with pine. In 2004 in the cultivation of birch on non-irrigated plots there was a decrease of its abundance, and increase on irrigated plots, especially in the case of microjet sprinkling. *O. tibialis* is a eurytopic species (Weigmann, 1991; Weigmann and Kratz, 1981), also counted among forest oribatids (Rajski, 1968).

Scutovertex sculptus

It is interesting that in the first year of studies its occurrence was not reported. In the second year this species quite frequently appeared on the irrigated sites in the cultivation of pine – 1400 - 2530 individuals per square metre, and in the cultivation of birch it was clearly less numerous. It is a species adapted to life in initial soils under conditions of high insolation, for example, on industrial landfill (Klimek et al., 1991; Skubała and Gulvik, 2005), and in the vicinity of Bydgoszcz this species occurred in fallow soil (Rolbiecki et al., 2006a) and on reclaimed post-military area (Klimek and Rolbiecki, 2011). So, it is likely that this species occurred on the studied area before the establishment of the experiment, and irrigation has created favorable conditions for its development (Table 3).

Scheloribates latipes

This species is classified to forest-meadow mites (Rajski, 1968). An analysis of its occurrence indicates that it is a species of relatively wide ecological tolerance (Rajski, 1968; Olszanowski et al., 1996). On the studied area in the cultivation of pine it occurred only in the first year of the study (Table 5). In the cultivation of birch it occurred on all the stands, although it was not too numerous – its maximum abundance was found in the MiM variant in 2004 (880 individuals per square metre). Irrigation was the factor that influenced its abundance (Table 3).

Tectocepheus velatus

It is the common soil oribatid species occurring in various biotopes (Weigmann and Kratz, 1981). In the pine forests *T. velatus* often dominated gatherings of oribatid mites (Klimek, 2000). It is a parthenogenetic species, which is among oribatids characterized by a short life cycle, high rate of reproduction and high colonisation ability of new habitats (Gulvik, 2007; Skubała and Gulvik, 2005). Due to prevalence and usually high abundance, *T. velatus* can be a good bioindicator (Gulvik, 2007; Klimek, 1999). In 2003 *T. velatus* was found at all stands, however its abundance was differentiated and relatively low – 100-1030 individuals per square metre (Table 5). In 2004 in the cultivation of pine its density increased, at irrigated variants in particular. In the cultivation of birch its density also increased, also on non-irrigated stands. Maximum abundance (4110 individuals per square metre) of *T. velatus* was obtained at CoO variant. Its density was significantly shaped only by the factor of irrigation in the cultivation of pine (Table 3).

The analysis of oribatid species abundance indicates that after mulching with forest ectohumus and inoculation of soil fauna, the eurytopic populations – *Oppiella nova*, *Oribatula tibialis* and *T. velatus* – were best adapted to new conditions of forest nursery. These species are pioneer species which can be classified as so-called “long-distance runners” being in gatherings for a longer time. *O. nova* and *T. velatus* are parthenogenetic and develop according to r-life strategy (Siepel, 1994; Skubała and Gulvik, 2005). These species are also included as fungivorous organisms (Luxton, 1972; Ponge, 1991), and may prey on ectomycorrhizal fungi (Remén et al., 2010; Schneider et al., 2005).

In the examined forest nursery most species preferred specific ecological conditions created by abundant fall of leaves produced by birch seedlings. Only the xerophilous *Scutovertex sculptus* occurred numerously in the cultivation of pine seedlings.

In summary it can be concluded that larger total abundance and diversity of oribatid mites prefering the cultivation of birch seedlings as compared with those of pine indicate the beneficial influence of S. birch on the biological activity of soils. Such reasoning is legitimate because oribatids as we have previously shown are trophicaly connected with numerous microorganisms. In addition, the determinant of the occurrence of oribatids is considered the availability and quality of organic matter in a soil (Hasegawa, 2001). Rapidly growing young birch seedlings are a source of organic matter. Birch is a pioneer species growing well in conditions of insolation and tolerant of different soil moisture levels (Giertych et al., 2006). Therefore this species may be important in revitalization of degraded soils.

It should also be noted that the melioration treatments in the experiment were planned in order to develop effective methods for revitalization of forest nurseries – oribatid mites were regarded as bioindicators of biological conditions of soils. The influence of oribatids on the quality of production in forest nurseries is indirect. It mainly consists of increasing the activity of soil microflora (Wallwork, 1983) and acceleration of decomposition of organic matter by its crushing. These mites by continuously reducing populations of bacteria and fungi, keep them in the growth phase (so-called ’compensative growth’). Some researchers hold that oribatid mites mainly feed on mycelium (Lindberg and Bengtsson, 2005), and the environmental conditions supporting mycelial growth, also positively influence on their populations (Blakley et al., 2002; Pollierer et al., 2007).

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