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# ORIBATID MITES (ACARI, ORIBATIDA) ON PLANTATIONS OF CHOKEBERRY AND BLACKCURRANT UNDER MICROIRRIGATION

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***Summary***

The aim of the present research was to compare the communities of oribatid mites (*Oribatida*) on the plantations of chokeberry (*Aronia melanocarpa* (Michx.) Elliott) and blackcurrant (*Ribes nigrum* L.) as well as to define the effect of microirrigation on those *Acari*. The experiment was performed in degraded Phaeozems formed from sand, on shallow-deposited sand in Kruszyn Krajeński in the vicinity of Bydgoszcz. The soil reaction was slightly acid or acid and the differences in the acidity between chokeberry and blackcurrant were inconsiderable. The abundance of oribatid mites on chokeberry and blackcurrant plantations ranged from 3110 to 5290 individuals · $m^{-2}$ and it was much higher, as compared with the neighbouring set-aside. The density of *Oribatida* on blackcurrant plantation was clearly higher than in chokeberry; however there was recorded no significant effect of the type of irrigation on the density. In total on both plantations there were reported 31 species of oribatid mites; mean species number *s* in blackcurrant was higher than in chokeberry. The dominance structure of oribatid mites on the chokeberry plantation was more even than in blackcurrant and in *Tectocepheus velatus* communities dominated mostly. The species preferred the blackcurrant plantation and irrigation stimulated its abundance. *Chamobates schutzii,* an oribatid mite, came second; it preferred the soil of chokeberry plantation; it was especially numerous on irrigated stands. *Scutovertex sculptus* also demonstrated some preference for chokeberry soil and no tolerance to irrigation. Whereas such oribatid mite species as *Gymnodamaeus bicostatus*, *Metabelba pulverulenta*, *Oppiella nova*, *Quadroppia quadricarinata* and *Damaeus* sp. showed some preference for the blackcurrant plantation.

**Key words:** oribatid mites, *Oribatida*, plantations of chokeberry and blackcurrant, drip irrigation and microsprinkling

## INTRODUCTION

Oribatid mites (*Acari*, *Oribatida*) are a group of soil fauna considerably supporting soil-formation processes, especially humus formation [Seastedt 1984]. Eating dead plant residue, they crush it strongly, the food uptaken does not give them much energy so they must eat a lot. The *Acari* feces are a perfect growth medium especially for aerobic bacteria which release biogens. In the alimentary canals of oribatid mites, there exist bacteria decomposing cellulose and lignin, which accelerates the decomposition of ligneous fractions of dead matter [Stefaniak, Seniczak 1976]. The *Acari*, thanks to vertical migrations, aerate the soil, carry microorganisms as well as mycorrhizal fungi on their body and in the alimentary canal [Schneider et al. 2005]. Soil fertility depends on the content of humus; in field conditions most humus is produced from the decomposition of underground plant parts, less considerably from the residue left on the surface.

Orchards are most stable of all the agroecosystems due to no plough, quite common irrigation application and a considerably high amount of organic litter reaching the soil [Aoki 1979; Hülsmann, Wolters 1998]. Such plants as chokeberry and blackcurrant for many years supply the surface soil layer with dead organic mater in a form of leaves, fragments of twigs or fruits. Oribatid mites are referred to as microorganism catalysts since they participate in the initial phase of decomposition defining the right decomposition rate of dead plant parts. For soil fertility an excessively slow or fast decomposition stimulated with nitrogen fertilisers is not beneficial. A natural mineralization rate is ensured by soil fauna, gradually releasing the nutrients required by plants. One of the most essential factors limiting the development of oribatid mites is moisture; most of them prefer quite high soil moisture [Melamud et al. 2007]. Microirrigation systems standardize moisture thus preventing the substratum getting excessively dry, which should create good conditions for the development of soil fauna.

The aim of the present research was to compare the communities of oribatid mites on the orchard plantations of chokeberry (*Aronia melanocarpa* (Michx.) Elliott) and blackcurrant (*Ribes nigrum* L.) as well as to determine the effect of microirrigation on those *Acari*. Detailed data on irrigation, soil properties, chokeberry and blackcurrant plants as well as the effect of the experiment on other orders of the *Acari* have been earlier published [Klimek, Rolbiecki 2009].

## MATERIAL AND METHODS

The acarological research was performed in 2004 in an experimental field of the Department of Land Reclamation and Agrometeorology in Kruszyn Krajeński (N: 53º4'6", E: 17º51'56"), in the vicinity of Bydgoszcz. The research areas were made up by the chokeberry plantation (set up in 1994) and the blackcurrant plantation (set up in 1991). The distance between chokeberry cuttings was 2.4 m × 2 m, blackcurrant 2.5 m × 1 m. The plantations were set up on arable land, deep-fertilised with ploughed-in cattle FYM.

There were applied two irrigation systems; Aqua-Trax drip lines (emitters located 20 cm away from one another), along each row about 30 cm away on both sides and microirrigation using the Hadar system, with the sprinklers sprinkling soil 2.0-2.5 m in diameter away.

The irrigation frequency was determined based on the soil water potential, applying tensiometers. In dry periods, drip irrigation was performed every 2-3 days and microsprinkling – every 4-6 days.

The main factors potentially affecting the occurrence of oribatid mites were: bush species (chokeberry, blackcurrant), and irrigation (C – the control, without irrigation, D – drip irrigation, M – microsprinkled). To investigate the communities of oribatid mites, soil was sampled 3 times a year: in spring (mid-May), in summer (at the beginning of August) and in autumn (in mid-October). In each experimental variant 60 samples were taken (3 × 20). The 17 $cm^2$ samples were taken down to 3 cm deep. The *Acari* were extracted in the Tullgren apparatus, and then prepared. *Oribatida* were determined down to the species or genus, together with juvenile stages (in total 2499 oribatid mites were determined).

The mean density (*N*) of the *Acari* was given per 1 $m^2$ of soil and the species diversity of oribatid mites was expressed with the number of the species (*S*) and the mean number of species per sample (*s*). The experimental data were tested using the two-factor analysis of variance with post-hoc Tukey HSD test (Statistica – ANOVA). The mites data were ln-transformed (x+1) prior to the analyses [Berthet and Gerard 1965].

## RESULTS AND DISCUSSION

Chokeberry and blackcurrant are considered to be berry bushes which are, at present, very important economically [Rolbiecki 2003]. A high biological value of their fruits and quite inconsiderable soil requirements of plants point to the possibility of increasing the plantation acreage even in light and very light soils. In those conditions irrigation is becoming necessary, especially applicable for that purpose, considered as microirrigation, drip system and microsprinkling.

The experiment was performed on degraded black earth formed from sand, on shallow-deposited sand [Klimek, Rolbiecki 2009]. The reaction was slightly acid or acid and the differences in acidity between chokeberry and blackcurrant were inconsiderable. The total precipitation over the 2004 vegetation period (244.5 mm) was lower than the multi-year mean (281 mm).

The oribatid mites abundance on chokeberry and blackcurrant plantations ranged from 3110 to 5290 individuals · $m^{-2}$ and it was much higher as compared with the neighbouring set aside – in the first year of cultivation abandoning [Rolbiecki et al. 2006]. The density of *Oribatida* on the blackcurrant plantation was clearly higher than chokeberry, especially in C and D variants (Table. 1). The statistical analysis showed a significant effect of the bush species on the oribatid mites abundance (Table 2, Figure 1). A greater abundance of the *Acari* in the blackcurrant plantation soil, as compared with chokeberry plantation, can result from the size of the bushes, which were taller, wider and more abundant in the case of blackcurrant [Klimek, Rolbiecki 2009]. Bigger bushes provide a greater leaf litter biomass, providing saprophagic *Acari* with attractive food. Similarly, blackcurrant leaves are richer in nutrients than chokeberry leaves.

There was found, however, no significant effect of the irrigation type on the *Oribatida* density. Better conditions for those *Acari* were provided by micro-sprinkling in chokeberry, while in blackcurrant – by drip irrigation. The research results published by other authors most frequently point to a positive effect of irrigation on the abundance of oribatid mites as well as other soil animals [Lindberg et al. 2002, Tsiafouli et al. 2005].

**Table 1.** Mean abundance of *Oribatida* (in $10^3$ individuals · $m^{-2}$) under different irrigation systems in plantations of chokeberry and black currant

| Species of oribatid mites | Chokeberry | | | Blackcurrant | | |
|---|---|---|---|---|---|---|
| | C | D | M | C | D | M |
| *Adoristes ovatus* (C.L.Koch) | 0.02 | - | 0.01 | - | - | - |
| *Autogneta traegardhi* Forsslund | - | - | - | - | - | 0.01 |
| *Brachychthonius* spp. | 0.11 | 0.01 | 0.14 | - | 0.01 | 0.01 |
| *Camisia biurus* (C.L.Koch) | 0.01 | 0.01 | | 0.03 | 0.01 | |
| *Chamobates schutzii* (Oudemans) | 0.99 | 1.33 | 1.27 | 0.69 | 0.84 | 0.55 |
| *Cymbaeremaeus cymba* (Nicolet) | 0.01 | - | - | 0.01 | 0.01 | |
| *Damaeus* spp. | 0.02 | 0.03 | - | 0.37 | 0.47 | 0.43 |
| *Eupelops occultus* (C.L. Koch) | - | 0.01 | - | - | - | - |
| *Galumna lanceata* (Oudemans) | - | - | - | 0.06 | 0.03 | 0.01 |
| *Gymnodamaeus bicostatus* (C.L. Koch) | 0.03 | 0.03 | 0.08 | 0.35 | 0.47 | 0.26 |
| *Hemileius initialis* (Berlese) | 0.01 | - | - | - | - | - |
| *Heminothrus peltifer* (C.L. Koch) | - | 0.01 | - | - | - | - |
| *Liochthonius* spp. | 0.06 | 0.03 | 0.07 | 0.01 | 0.05 | 0.01 |
| *Metabelba pulverulenta* (C.L. Koch) | - | - | - | 0.31 | 0.18 | 0.14 |
| *Micreremus brevipes* (Michael) | 0.01 | - | 0.01 | 0.06 | 0.03 | 0.04 |
| *Microzetorchestes emeryi* (Coggi) | - | - | - | - | - | 0.01 |
| *Oppiella minus* (Paoli) | 0.23 | - | 0.06 | 0.07 | 0.04 | 0.03 |

| Species of oribatid mites | Chokeberry | | | Blackcurrant | | |
|---|---|---|---|---|---|---|
| | C | D | M | C | D | M |
| *Oppiella nova* (Oudemans) | 0.01 | - | 0.03 | 0.31 | 0.73 | 0.13 |
| *Oribatella berlesei* (Michael) | - | - | - | 0.01 | - | - |
| *Oribatula tibialis* (Nicolet) | - | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| *Peloptulus phaenotus* (C. L. Koch) | 0.09 | - | 0.01 | - | - | - |
| *Punctoribates punctum* (C.L. Koch) | - | - | 0.01 | - | 0.04 | - |
| *Ramusella michelcici* (Perez-Ińigo) | - | - | 0.01 | 0.02 | - | - |
| *Quadroppia quadricarinata* (Michael) | 0.02 | 0.01 | 0.01 | 0.05 | 0.07 | 0.13 |
| *Scheloribates latipes* (C. L. Koch) | - | - | - | - | - | 0.01 |
| *Scutovertex sculptus* Michael | 0.46 | 0.19 | 0.21 | 0.27 | 0.02 | 0.11 |
| *Suctobelba* spp. | 0.01 | 0.03 | 0.11 | 0.02 | - | 0.02 |
| *Tectocepheus velatus* (Michael) | 0.93 | 1.65 | 1.94 | 1.66 | 2.11 | 2.44 |
| *Trichoribates novus* (Sellnick) | 0.01 | 0.02 | 0.03 | 0.02 | - | 0.01 |
| *Trichoribates trimaculatus* C.L. Koch | 0.07 | 0.06 | 0.08 | 0.24 | 0.15 | 0.19 |
| *Zygoribatula cognata* (Oudemans) | - | - | - | 0.01 | - | - |

C – without irrigation, D – drip irrigation, M – micro-jet sprinkling

**Table 2.** *F* and *p* values from two-factor analysis of variance (ANOVA) for species of oribatid mites, species of bush and irrigation

| Taxon of oribatid mites | Influence of species of bush | | Influence of irrigation | |
|---|---|---|---|---|
| | F | p | F | p |
| *Chamobates schutzii* | 7.9126 | 0.005 | ns | ns |
| *Damaeus* spp. | 48.35311 | <0.001 | ns | ns |
| *Gymnodamaeus bicostatus* | 31.56281 | <0.001 | ns | ns |
| *Metabelba pulverulenta* | 36.38589 | <0.001 | ns | ns |
| *Oppiella nova* | 12.59529 | <0.001 | ns | ns |
| *Quadroppia quadricarinata* | 11.53851 | <0.001 | ns | ns |
| *Scutovertex sculptus* | 8.14922 | 0.005 | 5.9623 | 0.003 |
| *Tectocepheus velatus* | 7.6103 | 0.006 | 7.5498 | <0.001 |
| *Oribatida* (all) | 4.8928 | <0.001 | ns | ns |
| Species number per sample *s* of *Oribatida* | 32.421 | <0.001 | ns | ns |

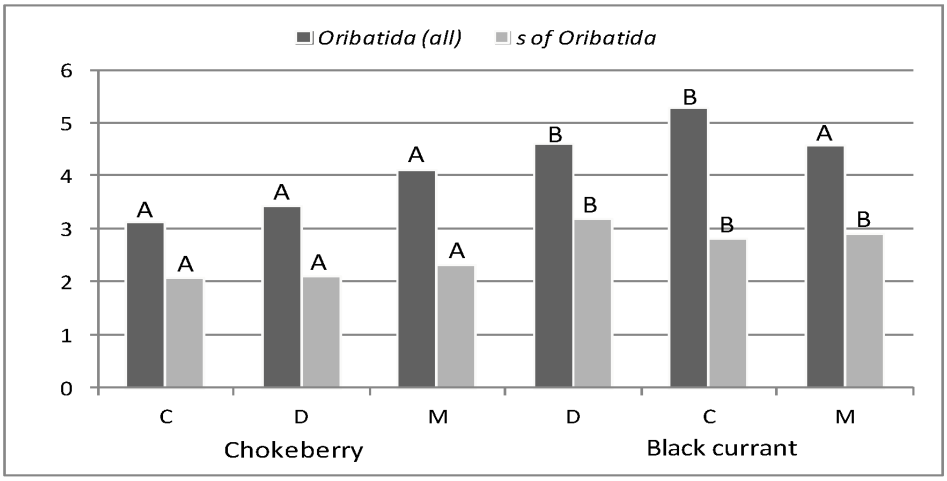


**Figure 1.** Mean abundance (in $10^3$ individuals · $m^{-2}$) and species number per sample *s* of *Oribatida* under different irrigation systems in plantations of chokeberry and black currant, C – without irrigation, D – drip irrigation, M – micro-jet sprinkling, A, B – the same letters (in the irrigation variants C, D and M) mean lack of significant difference (at $p < 0.05$)

In total on both plantations there were found 31 oribatid mites species, 11 common for both bushes, 4 which occurred only in chokeberry, 7 in blackcurrant only. Most species were noted on control areas (19-21) fewer in microsprinkled (18-20), and the least in drip-irrigated (15-18). Mean species number *s* was determined by 'species of bush' factor (Table 2). As for blackcurrant, the said factor ranged from 2.08 to 2.32, in blackcurrant was higher – 2.80-3.17, and mean differences were significant (Figure 1). For comparison, in the neighbouring set-aside field there were identified only 4 species of oribatid mites, and index *s* ranged from 0.25 to 0.55 [Rolbiecki et al. 2006].

The dominance structure of oribatid mites on chokeberry plantation was more even than in the blackcurrant; on the latter plantation the first species in the hierarchy, which had always been *Tectocepheus velatus*, demonstrated a considerable advantage over the others (*D* = 36.1-53.4, Figure 2). In the irrigated areas on both plantations the advantage of the dominating species was greater, as compared with non-irrigated areas. The greatest differences between the first and the second species in the oribatid mite dominance hierarchy were recorded on the M stands. On the chokeberry plantation on irrigated areas there clearly dominated *Tectocepheus velatus* which, however, in the control stand was slightly dominated by *Chamobates schutzii*.

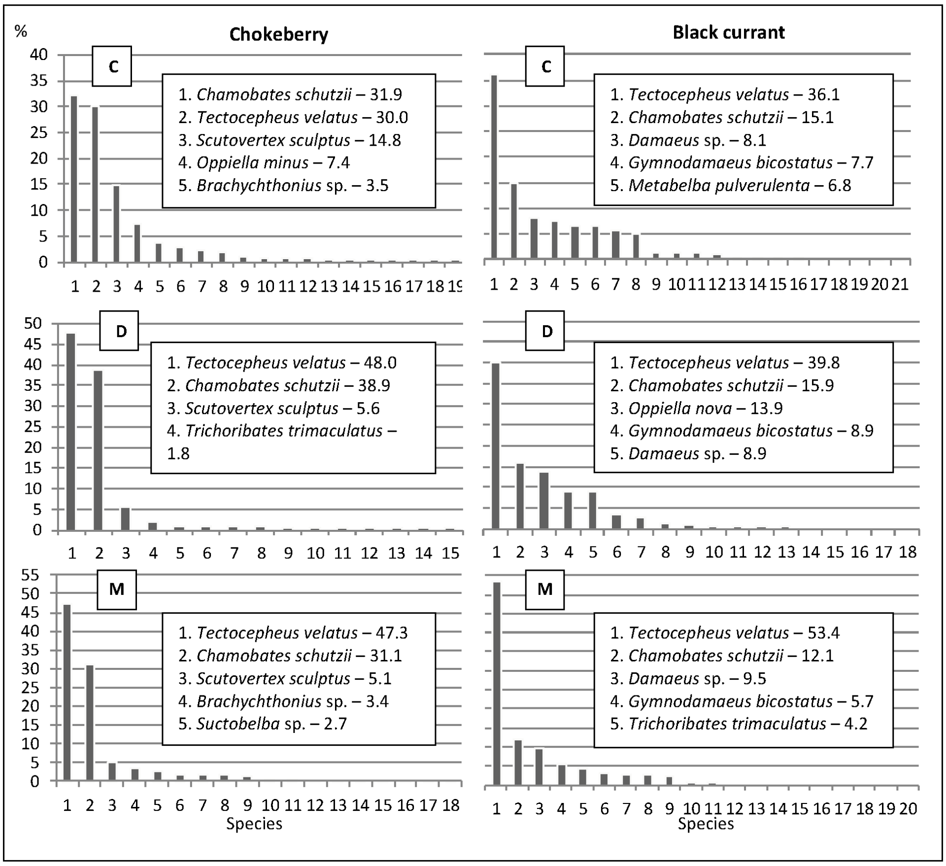


**Figure 2.** The structure of *Oribatida* domination (*D* in %) on the plantations of chokeberry and blackcurrant, C – without irrigation, D – drip irrigation, M – micro-jet sprinkling

*Tectocepheus velatus* was the most abundant oribatid mite on the plantations analysed. Both experimental factors (bush species and irrigation) made its density higher (Table 2). The species clearly preferred the blackcurrant plantation and irrigation stimulated its abundance; on both plantations it was most abundant in the microsprinkled stands. As for that oribatid mite, a similar effect was reported while pine growing in nurseries; the highest density in the second year of growing was noted on the plots with organic fertilisation and microsprinkling [Klimek et al. 2013]. *T. velatus* is a common soil oribatid mite which occurs in various biotopes [Weigmann & Kratz 1981], shows a high reproduction index and a high capacity for colonization of new environments [Siepel 1994, Skubała & Gulvik 2005]. Among the individuals of that oribatid mite there dominated adult forms and larvae and nymphs accounted for 16.5 to 29% of its population (Table 3).

*Chamobates schutzii,* in most stands was the second oribatid mite in terms of abundance (Table 1, Figure 2). The statistical analysis shows that its density depended on the bush species; it preferred the chokeberry plantation soil (Table 1 & 2). It was especially abundant there in irrigated stands; 1270-1330 individuals·$m^{-2}$. Seniczak & Solhøy [1988] found that *C. schutzii* is a common oribatid mite in Poland which has not been listed earlier as a result of its mistaken classification to other species. The juvenile forms of that species showed a much higher share in the population on the chokeberry plantation (42.1-51.5%) than on the blackcurrant plantation (7.1-21.7) (Table 3). In other studies *C. schutzii* was classified as representing the species tolerating industrial emissions in which sulphur compounds prevailed [Klimek 2000]. Interestingly in the soils with the highest level of pollution there were recorded an especially high share of juvenile forms of that oribatid mite.

*Scutovertex sculptus* is a species adapted to live in initial soils in the conditions of high insolation, e.g. on fallow land and industrial heaps [Klimek et al. 1991, Chachaj et al. 2006, Rolbiecki et al. 2006, Skubała 1999]. It also occurred in the former rehabilitated post-military-training-area in Bydgoszcz-Jachcice [Klimek et al. 2009; Klimek, Rolbiecki 2011]. This oribatid mite dominated in the set-aside soil, in the field located in the vicinity of the chokeberry and blackcurrant plantations investigated [Rolbiecki et al. 2006]. In the present study there was found a significant effect of both factors on its abundance; it preferred the chokeberry soil plantation and showed a lack of tolerance to irrigation (Table 1 & 2). Larvae and nymphs accounted for 18.5 to 36.8% of its population.

**Table 3.** Percentage of juvenile forms in populations of oribatid mites under different irrigation systems in plantations of chokeberry and black currant

| Species | Chokeberry | | | Black currant | | |
|---|---|---|---|---|---|---|
| | C | D | M | C | D | M |
| *Chamobates schutzii* | 51.52 | 42.11 | 45.67 | 21.74 | 7.14 | 14.55 |
| *Gymnodamaeus bicostatus* | - | 33.33 | 50.00 | 48.57 | 34.04 | 53.85 |
| *Scutovertex sculptus* | 19.57 | 36.84 | 33.33 | 18.52 | - | - |
| *Tectocepheus velatus* | 23.66 | 23.17 | 29.02 | 18.18 | 26.67 | 16.46 |
| *Oribatida* (all) | 28.71 | 32.16 | 32.35 | 25.38 | 23.53 | 20.66 |

C – without irrigation. D – drip irrigation. M – micro-jet sprinkling

Such oribatid mite species as *Gymnodamaeus bicostatus*, *Metabelba pulverulenta*, *Oppiella nova*, *Quadroppia quadricarinata* as well as *Damaeus* sp. showed a preference for blackcurrant plantation (Table 2).

The abundance of oribatid mites in the study areas was lower than in the forests or permanent grasslands, however, it was higher than in arable fields [Behan-Pelletier 1999]. Agrotechnical practises are not favourable to edaphon [Perdue, Crossley 1989], except for the adequate organic fertilisation and irrigation. Under bushes the *Acari* find dead plant litter; the soil is shaded and not threatened with mechanical structure changes. Oribatid mites are abundant in acid soils with a high abundance of fungi, ectohumus and free distribution of plant litter [Seniczak 1978].

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