Earthworm *Lumbricidae* Community in Alder and Aspen Forest: Three Case Studies

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The earthworm community structure was investigated in soil and forest floor of three deciduous forests (*Aegopodium* type). The study areas for investigation of decomposers were: aspen forest in Kärkna Forestry District; grey alder forest on Porijõgi catchment area (unpolluted area); and grey alder forest in Viljandi Forestry District, heavily polluted by pig slurry. All three study areas were characterized by optimal for investigated earthworm species moisture content (24,6...61,2%). In grey alder and aspen forests the number of individuals and species of earthworms per 1 m^2 is high (135...309 individuals, 6...7 species per 1 m^2) due to the character of litter and soil. The common species in aspen and grey alder forests were *Allolobophora caliginosa, Allolobophora rosea, Lumbricus rubellus, Dendrodrilus rubidus*. The species composition of decomposer community was affected by contamination of forest soil with pig slurry, some of earthworm species (*Allolobophora chlorotica, Lumbricus castaneus*) were not found in slurry-contaminated forest floor and soil.

Key words: earthworm community, aspen forest, grey alder forest, pig slurry.

Introduction

The alder forests are typical riparian ecosystems in agricultural landscapes, what are evaluated as buffer zones to protect water bodies against pollution (Mander et al., 1997). Due to their rapid growth, grey alder (*Alnus incana* (L.)Moench. and aspen (*Populus tremula* L.) are also perspective indigenous short rotation species in Baltic countries (Tullus et al., 1996). For environmental reasons and sustainable management of buffer stands, it is important to study the decomposition of litter from grey alder and aspen forests. The litter decomposition process is affected by many factors, among them by soil organisms - decomposers. Biomass and activity of decomposers largely control the rates of mineralization and turnover of organic matter (Brown, 1995). The soil fauna taxonomically is very diverse. The earthworms are the most important group of soil fauna for decomposition process because of burrowing activity and size (White, 1987). In deciduous forests the most important species of decomposers are: endogeic species *Allolobophora caliginosa* and *Allolobophora rosea*, epigeic species *Dendrodrilus rubidus* and *Lumbricus rubellus* (Bell 1974). By contamination with slurry the communities of the soil fauna are strongly influenced, the species of earthworms tolerate it differently (Andersen, 1981).

The aim of present study was to analyse the structure of communities of earthworms in three deciduous forests (*Aegopodium* type) in Estonia: aspen forest and two grey alder forests, one of them heavily contaminated by pig slurry.

Material and methods

Study areas for investigation of litter decomposers were:

1. Aspen forest in Kärkna (aged 42 years, *Aegopodium* type, good developed herb layer) description of the area is published (Tullus and Tamm, 1996).

2. Grey alder forest in Porijõgi location (aged 16 years, *Aegopodium* type, unpolluted area), description of the area is published (Mander et al., 1995).

3. Grey alder forest in Viiratsi location (aged 41 years, *Aegopodium* type, heavily polluted by pig slurry), description of the area is published (Mander et al., 1997).

The forest floor and soil samples for chemical and microbiological analysis were collected in May and June, on the quadrates 50 x 50 cm or on the rings Ø 104 mm. The number of sample areas varied from 10 to 22. Samples were cleaned, sorted, weighed and dried at 75°C. The oven-dry weight and moisture content in all samples, and organic matter content in composite sample (in muffel oven at 360°C) were determined. Soil samples were taken on the same quadrates or the rings, in the upper soil layer 0...15 cm. In all samples the moisture content, in a composite sample the organic matter content (in muffel oven at 360°C) and nitrogen concentration (by the Kjeldahl method) were determined.

Earthworm samples were collected in May and October at the time of maximum density, greatest activity and lowest variability of individuals (Nordström and Rundgren, 1973). Earthworms were collected from soil blocks measuring 50 x 50 x 40 cm by hand sorting (Satchell, 1967), separately from forest floor and soil; they were washed and identified to species. All earthworms were divided into three ecological groups (Bouche, 1977): 1. Epigeics – living in the soil surface (*Lumbricus rubellus, Lumbricus castaneus, Dendrodrilus rubidus*); 2. Anecics – forming deep burrows (*Lumbricus terrestris*); 3. Endogeics – inhabits of mineral soil horizons (*Allolobophora caliginosa, Allolobophora rosea, Allolobophora chlorotica, Eisenia foetida*).

For all sampling occasions and earthworm species the mean numbers of individuals per 1 m^2 and their standard errors were calculated. One-way analysis of variance and the multiple comparison of means were used for comparison of different communities at the level of significance $p<0,05$.

Results and discussion

Earthworms community is the most important component of the soil fauna attending in the regulation of decomposition and nutrient cycling. All earthworm species are participating in decomposition and mixing the organic and inorganic components (Edwards, 1985). During the unfavourable (cold, drought, flooding) period the endogeic earthworm species live in the soil, while epigeic earthworms are more dependent on the moisture of their habitat (Brown, 1995). They can use a wide variety of organic materials for food and most species of earthworms can distinguish between different kinds of forest litter (Edwards and Bohlen, 1996). Leaf litter of aspen and grey alder is attractive for earthworms and litter with a high protein content is more readily accepted by earthworms (Satchell, 1967, Edwards and Bohlen, 1996). The nitrogen content of forest floor was 2,15...3,28% in grey alder forests and 1,05% in aspen forest, nitrogen content of the soil was 0,7...1,05 and 0,26, respectively. The mean moisture content in the soil of investigated stands (24,6...61,2%) (Table 1) was optimal for earthworm species (Edwards and Bohlen, 1996).

Table 1. Parameters of forest floor and soil of study areas

Parameter	Aspen forest	Grey alder forest (non-contaminated)	Grey alder forest (contaminated)
Number of samples	16	10	22
Soil moisture content, % (mean±SE)	24,6±0,7	61,2±1,7	36,5±1,6
Dry weight of forest floor per 1 m^2, g (mean±SE)	625±85	193±17	43±14

In the Kärkna study area the herb layer under aspen forest is well developed. The common earthworm species (*Allolobophora caliginosa, Allolobophora rosea, Lumbricus rubellus, Dendrodrilus rubidus*) and typical species of grasslands (*Allolobophora chlorotica, Lumbricus castaneus*) were found in this forest. 87...95% of collected earthworms were endogeic and only few individuals (*Dendrodrilus rubidus*) were epigeic (Table 2). In the Porijõgi study area, in non-contaminated grey alder stand the number of individuals (309±24 in May and 232±51 in October) and species (6...7) was high. The reason for this can be nitrogen concentration of litter 2,15...3,28%, indicating high protein content. The species composition in non-contaminated grey alder forest was similar to species living in the soil and forest floor of aspen stand (Table 3). 27...40% of individuals were epigeic.

The total number of individuals was higher in grey alder stand without pollution pressure than in contam-

Table 2. The parameters of earthworm communities

Stand	Material	May		October	
		Individuals per 1 m² (mean±SE)*	Species ocurred on sample area	Individuals per 1 m² (mean±SE)*	Species ocurred on sample area
Aspen forest	forest floor	25±4 [a]	6	8±3 [a]	1
	soil	168±12 [b]	5	176±33 [b]	6
	total	193±42 [b]	6	184±16 [b]	7
Grey alder forest (non-contaminated)	forest floor	29±14 [a]	5	-	-
	soil	280±22 [c]	7	232±51 [b]	6
	total	309±24 [c]	7	232±51 [b]	6
Grey alder forest (contaminated)	forest floor	8±2 [a]	2	-	-
	soil	127±15 [b]	6	168±20 [b]	6
	total	135±18 [b]	6	168±20 [b]	6

* numbers followed by the same letter does not significantly differ (multiple comparison of means, $p<0,05$)

Table 3. Species composition of earthworm communities in deciduous forests in October 1997 (number and % of individuals, collected from forest floor and soil).

Species	Aspen forest		Grey alder forest (non-contaminated)		Grey alder forest (contaminated)	
	Number (mean±SE)	%	Number (mean±SE)	%	Number (mean±SE)	%
Allolobophora caliginosa	111,0±7,1	60,3	136,9±49,7	59,0	108,0±16,0	64,3
Allolobophora rosea	13,3±1,3	7,2	21,3±14,1	9,2	9,3±3,5	5,5
Allolobophora chlorotica	16,0±8,5	8,7	18,7 ±7,1	8,1	-	-
Lumbricus rubellus	6,7±1,3	3,6	9,8±4,5	4,2	6,7±0,9	4,0
Lumbricus castaneus	1,3±1,0	0,7	16,0±9,2	6,9	-	-
Lumbricus terrestris	-	-	-	-	5,3±1,3	3,2
Dendrodrilus rubidus	6,7±4,8	3,6	24,0±6,1	10,3	7,7±9,3	4,6
Eisenia foetida	-	-	-	-	8,0±2,3	4,8
undetermined	29,0±4,8	15,9	5,3±1,8	2,3	23,0±13,3	13,6
Total	184±16	100,0	232±51	100,0	168±20	100,0

inated one (309±24 and 135±18 in May, respectively, and 232±51 and 168±20 in October, respectively) (Table 2). The structure of earthworm community in contaminated grey-alder stand differed significantly ($p<0,001$) from that in clean grey-alder stand. The grassland species were not found because they are not able to live in the soil contaminated by slurry. 8,6...10,5% of individuals were epigeic and 1,9...4,5% were anecic. The typical inhabitant of decaying manure and compost, *Eisenia foetida,* was present.

All the same species of earthworms were found in clean forests; in our cases tree species was not an important factor for community structure. By comparing the total numbers of individuals per 1 m² of three deciduous forests the statistically significant difference between non-contaminated forests and contaminated grey alder forest was found (one-way-analysis of variance, the level of significance $p<0,05$).

The common earthworm species (endogeic *Allolobophora caliginosa*, *Allolobophora rosea* and epigeic *Lumbricus rubellus*) were living in all three stands. Species *Allolobophora chlorotica* lived only in clean habitats. Epigeic species *Lumbricus castaneus* was found in non-contaminated areas only, but the difference between the numbers of individuals per 1 m² was statistically insignificant. Two species (anecic *Lumbricus terrestris* and endogeic *Eisenia foetida)* were found only in contaminated forest. The numbers of individuals per 1 m² of *Eisenia foetida, Lumbricus terrestris* and *Allolobophora chlorotica* were different in contaminated and non-contaminated stands, significance levels were $p<0,001$, $p<0,005$ and $p<0,05$, respectively.

Conclusions

1. In grey alder and aspen forests (*Aegopodium* type) the number of earthworms (135...309 individuals per 1 m²) and species (from 12 species, found in Estonia, 8 were presented) is high.

2. Earthworm species composition was changed and total number of individuals decreased in the floor and litter of grey alder forest contaminated with pig slurry.

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СООБЩЕСТВА ДОЖДЕВЫХ ЧЕРВЕЙ В ОСИННИКЕ И СЕРООЛЬШАИНИКАХ

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Резюме

Структура сообщества дождевых червей исследовалась в лесной подстилке и гумусовом горизонте трёх лиственных лесов: незагрязненных осинника (Кяркна) и сероольшайника (Порийыги) и загрязненного жидким свиным навозом сероольшанника (Вийратси). Влажность почвы всех изученных древостоев была оптимальной для жизни дождевых червей. Вид дерева (серая ольха, осина) не оказал влияние на видовой состав сообщества дождевых червей. Численность особей в лесной подстилке и гумусовом горизонте варьировала в пределах 135-309 экз/м$^{-2}$. Загрязнение жидким навозом оказало влияние на структуру сообщества разлагателей. Некоторые виды (*Allolobophora chlorotica, Lumbricus castaneus*) не выносили загрязнения навозом.

Ключевые слова: дождевые черви, лесная подстилка, гумус, осинник, сероольшанник, загрязнение.