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| BIOMANIPULATION OF MACROARTHROPODS – EFFECT ON FOOD WEB | | | | |

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# MINERALIZATION AND HUMIFICATION OF *DACTYLIS GLOMERATA* LITTER IN FIELD EXPERIMENT EXCLUDING MACROARTHROPODS

ABSTRACT: Decomposition rate of *Dactylis glomerata* was compared in two types of field mesocosms – (O – open) accessible for macroartropods active on the grassland soil surface, or not accessible (C – closed) for them. Content of total carbon and nitrogen, as well as carbon incorporated in humus compounds was determined in the litter exposed in litter bags and inside poor in organic matter sandy substratum underlying the litter. Studies were repeated in two experiments, each lasting about a year. At the end of experiments 51–61% of the initial amount of carbon, introduced in the litter was mineralized, 13–19.7% was transformed into humus acids. Mineralization rate was more intense in C mesocosms, higher amount of humus was recorded in mesocosms accessible for macroarthropds (by 2.3 and 14.6% in autumn, respectively in both experiments). This newly formed humus was easily decomposable, part of it, particularly fulvic acids, were mineralized during winter.

KEY WORDS: mineralization, humifacation, grass litter, macroarthropods, grassland, sandy substratum.

## 1. INTRODUCTON

Experiments designed for analysing the role of predatory macroarthropods in detrital food chain, are not numerous. Predation decreased the prey population, but the response in decomposition processes was variable (Huhta *et al.* 1998). In most cases predatory meso- and macrofauna, either suppressed mineralization or no effect on this process was determined (Setälä 1990, Kajak 1995, Laakso *et al.* 1995, Pętal 1998). On the contrary, predatory microfauna, increases the rate of decomposition, enhances mineralization rate of carbon, nitrogen and phosphorus (Santos *et al.* 1981, Moore *et al.* 1988, De Ruiter *et al.* 1993).

The field experiments carried out in grasslands (Kajak and Jakubczyk 1976, and Kajak *et al.* 1991a) showed, that the increase of the number of epigeic, predatory macroarthropds was accompanied by the tendency to restrained development of microbes, the suppressed mass loss of litter and to enhanced organic matter storage. The significantly higher density of mesosaprophages (Collembola and Enchytraeidae) was found in treatments with the limited access of the predators.

The intensive farming, fertilizing, using pesticides and continuous monocultural cropping contribute to impoverishment of

soil community (Ryszkowski 1981, Pętal 1983, Kulińska 1984, Brust 1986, Wasilewska 1987). In consequence changes have been found in the organic matter metabolism i.e. in the mineralization and humification rates (Martin 1982, Kusińska 1991, Makulec and Kusińska 1997, Kusińska 1993, Karg and Ryszkowski 1996). The analysis of these relations in various ecosystems may provide practical guidelines how to regulate the metabolism of organic matter via the regulation of mutual quantitative and qualitative relations between the organisms present in the soil environment.

The aim of our studies was to assess in the field experiment, the influence of macroarthropods, on the mineralization and humification rate of grass litter and on the humus accumulation in soil. During the Experiment I (1992/93), the intensity of area patrolling by predatory arthropods was 3 times higher, than by nonpredatory arthropods. In the Experiment II (1993/94) patrolling by both trophic groups was similar (Kajak 2000).

## 2. STUDY AREA, EXPERIMENTAL DESIGN, METHODS

The field experiment was conducted in a perennial, mown meadow, located at the edge of Kampinos Forest (Central Poland), on the area of the Institute of Parasitology PAS near the village Łomna.

The experiment was set up in field mesocosms containing soil cores (treatment S) or sand (treatment Sd). Soil cores (100 $cm^2$ in area, 15 cm deep) were sampled in the meadow, put into netting exclosures (mesh size 0.24 mm), without changing their structure and inserted in the same places from which they were taken. Two types of mesocosms were applied – closed (C), not accessible to macrofauna, and open (O) – accessible by several (5) holes (each about 2 cm in diameter), cut in the exclosure at the soil/litter interface. The mesocosms were inserted in pairs, open and closed alternately. Samples were taken from each pair of mesocosms simultaneously.

In the treatment **S** – soil surface in each mesocosm was covered by litter bag. It was a plastic ring (10 cm in diameter, 4.5 cm high) with bored holes (1 cm diameter, 1.5 cm apart) enabling litter colonization by fauna. The bottom of the ring was covered by the nylon mesh (mesh size 1mm), the top was uncovered. Each ring contained at the beginning of the experiment 9.5 g dry wt. of dead leaves and stems of *Dactylis glomerata*. 75 pairs of mesocosms were applied in each experiment.

In the treatment **Sd** – the substrate of low organic matter content was applied in mesocosms to measure carbon accumulation during the experiment. The exclosures were filled with sand (of predetermined C and N contents) and then inserted into pits done with the same corer as in the treatment S. The top layer (0–3 cm) contained loamy sand, the deeper layer (3–15 cm) loose sand, similarly to the adjacent meadow soil. Two treatments were applied:

$Sd_1$ – sand surface covered by litter bags as in the treatment S applied to analyse litter mass loss, C and humus acid contents in sand and in the litter. 90 pairs of such mesocosms (O and C) were applied.

$Sd_2$ – mesocosms without litter bags, treated as control of organic matter accumulation. 10 pairs (O and C) were applied.

The experiment was repeated twice. Experiment I lasted from June 1992 till April 1993, Experiment II from April 1993 till May 1994. Soil cores and litter bags were changed in every experiment, the same sand was used during both experiments (I and II). Mesocosms of the Sd treatment were filled with sand in June 1992 and lasted till May 1994. The distribution of mesocosms representing different treatments and their sequence in the area were determined using tables of random numbers.

Total carbon and nitrogen content, as well as C incorporated in humus compounds, were measured in the litter and sand (treatments S, Sd1 and Sd2) from three, at random selected mesocosms per treatment, per time. In the Experiment II samples were bulked. Measurements of litter were taken in the Experiment I, on the day of exposure (11–19 June) and after 2, 11 18 and 42 weeks. In the Experiment II litter bags were exposed on 8-14 April, measurements were taken after 4, 10, 24 and 56 weeks.

In the sand measurements were taken in the two layers: 0–3 cm and 3–15 cm in the same periods as in the litter.

Carbon content was determined, using potassium dichromate and humus fractions were isolated with the use of sodium pirophosphate and sodium hydroxide (Kononova 1968). Nitrogen was determined by the Kiejdahl method, using Kieltec instrument of Tecator company. Soil properties were determined according.to the methods, generally accepted in the soil science (Ostrowska *et al.* 1991).

## 3. RESULTS

### 3.1 SOIL PROPERTIES

The meadow soil in the layer up to 50 cm contains 10–14% of separates of size less than 0.02 mm (silt and clay), 4–13 % of fine sand, the remainder consists mainly of medium and coarse sand (0.1–1 mm) (Table 1). Water holding capacity of this soil is low, it is light, periodically overdried with the limited capillary rise due to the coarse sand in deeper horizons. In early spring and during the wet years soil is subjected to gleying, its traces are visible in a profile; they reach the depth of 50 cm from the surface. The gleying was caused by a periodically high ground water-table. In June 1992, the ground water was found on the depth of 150 cm what resulted among others from a low precipitation in the spring.

This soil is acid (pH in KC1 4–5.6), with a thick layer of humus accumulation (34 cm).

In the upper horizon it contains more than 8% of total carbon and 1.8% in the accumulation horizon (Table 2). The carbon to nitrogen ratio in the upper horizon equals 26.7, that is a result of high content of non-humified plant remnants (litter and roots). The content of carbon as well as that of nitrogen was subjected to lowering in the interior of the profile. The cation exchange capacity in the accumulation horizon $A_1$ is equal to about 12 cmol/kg dry soil. The CEC in the upper layer (up to 15 cm) is saturated with hydrogen in > 50 %, while deeper in a profile, the content of base cations is higher, what may result from periodically high content of bases in ground water (Table 2). According to the taxonomy of the soils in Poland, this soil was classified to the type of gleyed black earth.

Table 1. Texture of meadow soil and of sandy substratum in mesocosms

| | Depth of sampling (cm) | Size distribution of soil particles (mm) % | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1–0.5 | 0.5–0.25 | 0.25–0.1 | 0.1–0.05 | 0.05–0.02 | < 0.02 |
| Meadow soil | 0–3 | 7.2 | 32.0 | 37.8 | 4.0 | 9.0 | 10.0 |
| | 3–15 | 12.5 | 33.1 | 29.4 | 5.0 | 6.0 | 14.0 |
| | 15–34 | 8.5 | 36.9 | 35.6 | 1.0 | 5.0 | 13.0 |
| | 34–50 | 10.9 | 39.8 | 34.3 | 1.0 | 3.0 | 11.0 |
| | 50–80 | 10.6 | 49.3 | 37.1 | 0.0 | 1.0 | 2.0 |
| | 80–101 | 19.4 | 63.6 | 13.0 | 3.0 | 0.0 | 1.0 |
| | 101–145 | 13.4 | 64.8 | 19.8 | 0.0 | 1.0 | 1.0 |
| Mesocosms | 0–3 | 7.0 | 40.5 | 33.5 | 5.0 | 3.0 | 11.0 |
| | 3–15 | 8.0 | 53.8 | 36.2 | 1.0 | 0.0 | 1.0 |

Table 2. Properties of meadow soil

| Depth (cm) | pH | | Total C % | Total N % | Exchangeable bases S | Hydrolytical acidity Hh | Exchange capacity T |
|---|---|---|---|---|---|---|---|
| | $H_2O$ | KCl | | | cmol/kg air dry soil | | |
| 0–3 | 4.4 | 3.9 | 8.3 | 0.3 | 9.2 | 11.9 | 21.1 |
| 3–15 | 4.5 | 4.1 | 1.9 | 0.2 | 4.6 | 6.7 | 11.3 |
| 15–34 | 5.0 | 4.7 | 1.8 | 0.1 | 8.8 | 4.0 | 12.8 |
| 34–50 | 5.2 | 4.5 | 0.5 | 0.0 | 7.0 | 1.6 | 8.6 |
| 50–80 | 4.9 | 4.6 | 0.2 | 0.0 | 5.3 | 0.5 | 6.6 |
| 80–101 | 4.9 | 4.7 | 0.1 | 0.0 | 4.9 | 0.6 | 5.5 |
| 101–145 | 6.1 | 4.6 | 0.0 | 0.0 | 5.8 | 0.6 | 6.4 |

## 3.2. LITTER DECOMPOSITION

### 3.2.1. Total carbon and nitrogen content

The content of carbon in the litter was gradually decreasing in the duration of both the experiments (Tables 3 and 4). In the spring of 1993, after 11 months since the litter exposure, the decrease of carbon content, by 7.7 % in open, and 5.5 % in closed mesocosms in relation to the initial values was found. At the end of the Experiment II, i.e. after 13 months from the exposure, the content of carbon was in both mesocosm types generally lower by about 2–4 % in comparison to the initial material (Tables 3 and 4). The nitrogen content slightly increased, during litter decomposition from initial value 2.4%, before the exposure to maximal 3.2%, reached at the end of the Experiment I, in the litter exposed on the soil cores. The C/N ratio ranged between 12 and 19 in both treatments and experiments (Table 5).

Table 3. Changes in content of humus compounds in litter exposed on the surface of soil cores (treatment $S_2$) in open (O) and closed (C) mesocosms

| Experiment | Weeks after exposure | Type of mesocosm | Total C | $C_{HA}$ | $C_{FA}$ | $C_{HA}/C_{FA}$ |
|---|---|---|---|---|---|---|
| | | | % dry wt | | | |
| I | 0 | – | 41.3 | 2.2 | 10.5 | 0.2 |
| June 92 – April 93 | 2 | **O** | **39.4** | **2.4** | **11.0** | **0.2** |
| | | C | 39.4 | 2.8 | 10.3 | 0.3 |
| | 11 | **O** | **39.2** | **4.0** | **8.7** | **0.5** |
| | | C | 39.2 | 5.0 | 7.9 | 0.6 |
| | 18 | **O** | **40.1** | **6.1** | **7.7** | **0.8** |
| | | C | 40.9 | 6.6 | 7.9 | 0.8 |
| | 42 | **O** | **38.5** | **6.6** | **7.0** | **0.9** |
| | | C | 38.3 | 7.6 | 5.9 | 1.3 |
| II | 0 | – | 41.3 | 2.2 | 10.5 | 0.2 |
| April 93 – May 94 | 3 | **O** | **39.2** | **3.9** | **9.9** | **0.4** |
| | | C | 38.4 | 3.2 | 10.4 | 0.3 |
| | 10 | **O** | **38.0** | **4.3** | **7.2** | **0.6** |
| | | C | 38.4 | 4.3 | 6.8 | 0.6 |
| | 24 | **O** | **39.3** | **7.1** | **8.9** | **0.8** |
| | | C | 39.8 | 7.9 | 7.2 | 1.1 |
| | 56 | **O** | **40.4** | **7.2** | **9.1** | **0.8** |
| | | C | 38.9 | 6.3 | 9.7 | 0.7 |

$C_{HA}$ – carbon of humic acids; $C_{FA}$ – carbon of fulvic acids.

Table 4. Changes in content of humus compounds of litter exposed on the sand surface in open (O) and closed (C) mesocosms

| Experiment | Weeks after exposure | Type of mesocosm | Total C | $C_{HA}$ | $C_{FA}$ | $C_{HA}/C_{FA}$ |
|---|---|---|---|---|---|---|
| | | | % dry wt | | | |
| I | 11 | **O** | **39.1** | **4.8** | **7.9** | **0.6** |
| June 92 – April 93 | | C | 38.9 | 4.6 | 8.0 | 0.6 |
| | 18 | **O** | **38.5** | **5.4** | **7.3** | **0.7** |
| | | C | 36.5 | 4.8 | 7.9 | 0.6 |
| | 42 | **O** | **33.6** | **6.0** | **5.2** | **1.2** |
| | | C | 36.0 | 6.4 | 5.5 | 1.2 |
| II | 3 | **O** | **39.0** | **3.1** | **9.1** | **0.4** |
| April 93 – May 94 | | C | 39.2 | 3.9 | 9.7 | 0.4 |
| | 10 | **O** | **38.4** | **4.7** | **9.1** | **0.5** |
| | | C | 39.0 | 5.2 | 7.4 | 0.7 |
| | 24 | **O** | **38.4** | **8.3** | **6.3** | **1.3** |
| | | C | 38.6 | 7.6 | 7.0 | 1.1 |
| | 56 | **O** | **39.3** | **6.9** | **9.4** | **0.7** |
| | | C | 37.9 | 7.2 | 8.1 | 0.9 |

$C_{HA}$ – carbon of humic acids; $C_{FA}$ – carbon of fulvic acids.

Table 5. Changes in nitrogen content (% dry wt) and C/N ratio of grass litter exposed in open (O) and closed (C) mesocosms on soil cores or sand surface

| Experiment | Weeks after exposure | Mesocosm type | Litter on soil cores | | Litter on sand | |
|---|---|---|---|---|---|---|
| | | | N | C/N | N | C/N |
| I | 0 | – | 2.4 | 16.4 | 2.4 | 16.4 |
| June 92 – April 93 | 2 | **O** | **2.4** | **16.4** | **n.a.** | **n.a.** |
| | | C | 2.8 | 14.2 | n.a. | n.a. |
| | 11 | **O** | **2.1** | **18.9** | **2.4** | **16.6** |
| | | C | 2.5 | 16.0 | 2.5 | 15.6 |
| | 18 | **O** | **2.5** | **16.0** | **2.3** | **17.0** |
| | | C | 2.5 | 16.4 | 2.3 | 15.8 |
| | 42 | **O** | **3.2** | **12.0** | **2.8** | **12.0** |
| | | C | 3.0 | 12.7 | 2.7 | 13.2 |
| II | 0 | – | 2.4 | 16.4 | 2.4 | 16.4 |
| April 93–May 94 | 4 | **O** | **2.1** | **18.9** | **2.1** | **19.0** |
| | | C | 2.5 | 15.7 | 2.7 | 14.6 |
| | 10 | **O** | **2.1** | **18.4** | **2.5** | **15.5** |
| | | C | 2.0 | 19.5 | 2.1 | 18.2 |
| | 24 | **O** | **2.9** | **13.5** | **2.4** | **16.0** |
| | | C | 2.9 | 13.9 | 2.3 | 16.8 |
| | 56 | **O** | **2.3** | **17.4** | **2.4** | **16.2** |
| | | C | 2.4 | 16.5 | 2.5 | 15.0 |

n.a. – not analysed

Differences between two mesocosm types (O and C) in carbon and nitrogen content and in C/N ratio in the litter were variable over time and treatments (litter on soil or on sand surface) (Tables 3, 4 and 5). In the Experiment I only, significantly higher nitrogen content in closed mesocosms was recorded. ($t = 2.81$, $df = 14$, $P = 0.007$), and in a consequence significantly lower C/N ratio ($t = 2.34$, $df = 14$, $P = 0.007$). In calculations, data from April were excluded, because intensity of patrolling by macroarthropods was extremely low in the preceding winter and early spring, so their activity couldn't influence the decomposition rate in this period (Szanser 2000).

### 3.2.2 LITTER HUMIFICATION

During the decomposition of the litter, its humification proceeded. Humus content was slightly lower in the litter placed on the sand surface (treatment Sd) than on the soil cores (treatment S) and lower in the Experiment I, performed in dry season, than in the Experiment II (Tables 3 and 4). The changes in the total content of carbon in humus acids were slight along time of both experiments. At the end of the Experiment I, carried out during a period of drought, in the litter placed on the sand surface, even a decrease in humus acid content in relation to the initial value was noted (Table 4). In the litter placed on the soil cores, and in the Experiment II, humus content increased, from 12.7% to 16.0% after 56 weeks.

The proportion of humic acid in total carbon content gradually increased, and fulvic acids declined. In Experiment I, after 42 weeks after litter exposure on the soil cores, the amount of humic acids increased three times (from 2.2 to 7.6%); the amount of fulvic acids in open mesocosms declined by 26% and in closed by 38%. The ratio $C_{HA}$ to $C_{FA}$ was regularly growing during the decomposition from 0.21 to 0.94 in open mesocosms and from 0.21 to 1.3 in closed ones. The similar pattern was followed in the litter placed on the sand surface. $C_{HA}$ to $C_{FA}$ ratio increased from 0.21 to 1.16. (Table 4). In the Experiment II, similar pattern of the litter humification, was observed (Tables 3 and 4).

Basing on the data on litter decompostion rate (Szanser 2000) and on the determined by us carbon content in the litter, amount of the carbon remaining in litter bags and amount of mineralized carbon was calculated. The results suggest, that quite intensive humification proceeded from the first days after the litter exposure. The newly formed humus compounds, especially fulvic acids, are subjected to mineralization in further stages of the litter decomposition.

The amount of carbon incorporated in humic acids at the end of the experiment decreased by 30% of initial values, fulvic acids by 67% in the Experiment I and by 71% in the Experiment II (Kusińska and Kwasowski 1997). These results suggest, that fulvic acids were mineralized or leached to sand, underlying decomposing litter. A part of humus compounds is converted into hardly-soluble forms – humins.

Differences between the open and closed mesocosms in respect to humus content in the litter and proportions of humic and fulvic acids were variable along time and treatments.

## 3.3 ACCUMULATION OF HUMUS IN SANDY SUBSTRATUM

In the mesocosms we have applied poor in organic matter (0.0007% C) sandy substratum, to allow recording the rate of the carbon accumulation during the experiment. In the first 11 weeks of the litter decomposition from June till September not any significant changes in the substratum, as compared to the initial values were recorded (Table 6). In October, that is after 18 weeks of the decomposition, the initial carbon content and carbon in fulvic acids in the top sand layer (0–3 cm) was doubled, increase of the content of humic acids was not as high (59% more, compared to the initial value). During the winter period (October till April), decrease in the carbon content was observed. The similar pattern was repeated in the next year. During spring

and summer (from April till October) total carbon content in open mesocosms increased from 101 mg per 100 g of dry sand to 202 g. Increase of humus acid content was even higher (3 times). The decrease of carbon content in the mesocosms was recorded in the period between September and May (Tables 6 and 7).

The proportion of fulvic acids in the total carbon was higher, than humic fraction. The ratio $C_{HA}$ to $C_{FA}$ ranged between 0.34 and 0.59.

In the deeper sand layer (4–15 cm) carbon content fluctuated throughout time of the experiment, but an increase was not detected. Carbon content in the top sand layer was higher in the mesocosms open to macrofauna,

Table 6. Content of humus compounds in the sand from mesocosms accessible (O) and not accessible (C) to macroarthropods (Experiment I, 1992/93)

| Weeks after exposure | Date of sampling | Depth (cm) | Total C | | $C_{HA}$ | | $C_{FA}$ | | $C_{HA}/C_{FA}$ | | Total N (mg 100 $g^{-1}$ dry sand) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (mg C 100 $g^{-1}$ dry sand) | | | | | | | | | |
| | | | O | C | O | C | O | C | O | C | O | C |
| | | | Sand from under litterbags ($Sd_1$) | | | | | | | | | |
| 0 | Jun 92 | 0–3 | **70.6** | 70.6 | **7.6** | 7.6 | **29.8** | 29.8 | **0.3** | 0.3 | **19.7** | 19.7 |
| | | 4–15 | 47.9 | 47.9 | 4.0 | 4.0 | 11.1 | 11.1 | 0.4 | 0.4 | 9.4 | 9.4 |
| 11 | Sep 92 | 0–3 | **67.4** | 63.1 | **7.4** | 6.9 | **20.8** | 19.3 | **0.4** | 0.4 | **20.1** | 20.0 |
| | | 4–15 | 32.3 | 32.6 | 6.2 | 3.3 | 11.1 | 13.2 | 0.6 | 0.3 | 11.1 | 9.4 |
| 18 | Oct 92 | 0–3 | **133.8** | 94.1 | **11.5** | 7.4 | **27.1** | 22.0 | **0.4** | 0.3 | **26.8** | 20.9 |
| | | 4–15 | 58.9 | 53.4 | 5.3 | 5.3 | 13.5 | 14.1 | 0.4 | 0.4 | 12.7 | 11.6 |
| 42 | Apr 93 | 0–3 | **101.1** | 101.3 | **11.3** | 12.4 | **16.1** | 20.8 | **0.7** | 0.6 | **10.2** | 12.4 |
| | | 4–15 | 42.0 | 48.3 | 6.1 | 5.8 | 8.7 | 9.0 | 0.7 | 0.7 | 2.9 | 2.3 |
| | | | Sand control ($Sd_2$) | | | | | | | | | |
| 42 | Apr 93 | 0–3 | **58.4** | 61.4 | **7.2** | 6.4 | **12.6** | 14.9 | **0.6** | 0.5 | **n.a** | n.a. |
| | | 4–15 | 55.5 | 54.7 | 5.8 | 6.1 | 12.3 | 10.6 | 0.5 | 0.6 | n.a. | n.a. |

n.a. – not analysed.

Table 7. Content of humus compounds in the sand from mesocosms open (O) and closed (C) to macroarthropods (Experiment II, 1993/94)[a]

| Weeks after exposure | Date of sampling | Depth (cm) | Total C | | $C_{HA}$ | | $C_{FA}$ | | Total N (mg 100 $g^{-1}$ dry sand) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (mg C 100 $g^{-1}$ dry sand) | | | | | | | |
| | | | O | C | O | C | O | C | O | C |
| | | | Sand from under litterbags ($Sd_1$) | | | | | | | |
| 24 | Sep 93 | 0–3 | **202.0** | 136.6 | **35.6** | 21.1 | **53.4** | 33.5 | **25.9** | 16.8 |
| | | 4–15 | 41.6 | 47.5 | 5.1 | 8.0 | 18.6 | 17.5 | 10.9 | 10.7 |
| 56 | May 94 | 0–3 | **148.7** | 130.6 | **18.9** | 16.1 | **43.5** | 40.6 | **18.9** | 16.6 |
| | | 4–15 | 44.8 | 35.4 | 6.7 | 6.7 | 20.3 | 17.4 | 8.2 | 11.4 |
| | | | Sand control ($Sd_2$) | | | | | | | |
| 24 | Sep 93 | 0-3 | **136.6** | 130.7 | **17.5** | 14.5 | **35.3** | 38.2 | **16.3** | 17.5 |
| | | 4-15 | 29.7 | 35.6 | 3.6 | 3.6 | 7.3 | 7.3 | 7.4 | 7.9 |
| 56 | May 94 | 0–3 | **134.5** | 125.8 | **16.1** | 11.6 | **34.9** | 40.3 | **17.7** | 15.3 |
| | | 4–15 | 40.1 | 33.8 | 4.5 | 5.0 | 15.3 | 16.3 | 6.5 | 8.6 |

[a]The litterbags were exposed in Apr 1993; the same sand mesocosms (Sd) were used in both the experiments

Table 8. Transformations of carbon introduced with the litter into mesocosms with sand accessible (O) and not accessible (C) for macroarthropods

| Exp. | Date of sampling | Weeks after litter exposure | Type of mesocosm | Carbon (g 100 cm$^{-2}$) | | | | % of initial carbon introduced in litter | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Introduced in litter at exposure time | Accumulated in sand (0–3 cm) | Mineralized | HA + FA in litter and sand (0–3 cm) | Mineralized | In HA+FA | Remaining |
| I | Oct 92 | 18 | **O** | **1.88** | **0.34** | **0.55** | **0.44** | **29.2** | **23.4** | **47.4** |
| | | | C | 1.88 | 0.15 | 0.78 | 0.40 | 41.4 | 21.1 | 37.5 |
| | Apr 93 | 42 | **O** | – | **0.19** | **1.14** | **0.24** | **60.9** | **12.9** | **26.2** |
| | | | C | | 0.18 | 1.09 | 0.28 | 58.3 | 14.8 | 26.9 |
| II | Sep 93 | 24 | **O** | **1.96** | **0.29** | **0.61** | **0.51** | **31.4** | **26.0** | **42.6** |
| | | | C | 1.96 | 0.03 | 0.90 | 0.35 | 46.0 | 17.8 | 36.2 |
| | May 94 | 56 | **O** | – | **0.06** | **0.99** | **0.39** | **50.7** | **19.7** | **29.6** |
| | | | C | | 0.02 | 1.02 | 0.33 | 52.1 | 16.6 | 31.3 |

than in closed series. Differences between these series were significant (Wilcoxon signed rank test, n = 9, T = 3, $P < 0.05$). In calculations data from the treatments $Sd_1$ and $Sd_2$ in both experimen ts have been pooled. Humic acid content was also higher in the open mesocosms (n = 9, T = 3, $P < 0.05$). Differences in the content of fulvic acids were not significant. In the lower sand layer not any differences between mesocosms were detected.

Increase in the total carbon content and in humus acids in the top layer was recorded also in mesocosms without litter bags. This increase was however lower and generated probably from decomposition of roots ingrowing from the surrounding soil.

Considering not only carbon content, but total amount of carbon in mesocosms *i.e.* carbon remaining in the litter bags and accumulated in sand, it can be stated that mineralization rate during summer months was more intensive in mesocosms closed for macrofauna. Mineralization recorded in closed mesocosms was higher than in open ones by 12% in the Experiment I and by 14.6% in the Experiment II (Table 8). On the contrary, the amount of carbon accumulated in humus acids was higher in mesocosms open for macrofauna (by 2.3 and 14.6% respectively in Experiments I and II in autumn). During winter, the amount of carbon incorporated in humus declined. At early spring (April) the amount of humus reached only about a half of the autumnal values. In this period, of low activity of macroarthropods, less humus contained open than closed mesocosms (Table 8).

In this experiment, to measure the litter decomposition, not only changes of the amount of carbon in the litter but also amount of carbon accumulated in an underlying poor sandy substratum of the mesocosms was estimated. At the end of both experiments, in spring i.e. after 42 and 56 weeks respectively, 51–61% of the initial amount of carbon exposed in the litter, was mineralized, 13–19.7% was transformed into humus acids (Table 8). Higher amount of humus (17.8 – 26%) was recorded after shorter period (18 and 24 weeks respectively in the two experiments) in autumn, than in the following spring. Humus was partly mineralized during winter.

Differences between open and closed mesocosms were also more important in autumn i.e. after a period of high faunal activity. In both years, in this period, higher amount of humus acids was recorded in open mesocosms, accessible for macrofauna. More carbon was mineralized in closed mesocosms (Table 8). In one analysis only, performed at early spring, higher content of humus acids was found in closed than in open series. This analysis was done at the end of cold season, when activity if epigeic fauna was very scarce. All the analysis performed in periods of faunal activity showed higher amount of humus and higher total carbon content in open mesocosms.

## 4. DISCUSSION

Very often litter bag method is applied to analyse decomposition rate of litter (Curry 1969, Seastedt 1984, Striganova and Kozlovskaja 1985, Beare *et al.*1992 Dziadowiec 1990, Tian *et al.* 1993, Heneghan *et al.* 1998). In our analysis we used sandy, poor in organic matter susbstratum underlying litter bags to record not only mass loss of the litter remained inside bags but also amount of carbon translocated down, during decomposition. Mineralization of carbon estimated basing on the difference between the amount of carbon introduced in the litter and the amount remained after time in the litter bags, was in the Experiment I by 10% higher, than in the case when amount translocated into the substratum was included. In the Experiment II difference between these estimates was not as high, equaled 1–3% only. Our data suggest, that particularlly using bags of large mesh apertures, utilised for example to analyse contribution of fauna to decomposition, obtained results must be treated with caution.

Studies on the effect of various taxa of macroarthropods on litter decomposition rate show in most cases, that they accellerate decompositon rate (Witkamp and Ausmus 1976, Pętal 1998, Scheu 1993, Tian *et al.*1993, Wise and Schaefer 1994). In our investigations the carbon mineralization rate was either not affected or retarded by the exclusion of macroarthropods. Important changes were noted in the amount of newly formed humus. The proportion of humus acids recorded in autumn was by 2–8% higher in the mesocosms accessible for macroarthropods than in closed ones. The differences between mesocosms in the total amount of carbon (C undecomposed and incorporated in humus fractions) were even higher (12–15%). The humus formed in sandy substratum of mesocosms is not resistant for decomposition. The amount found after winter was lower, than in the proceeding autumn, especially proportion of fulvic acids declined.

Little is known about the role of macroarthropods for humus formation. It is known however, that fecal pellets of these invertebrates contain humus compounds (Striganova 1980, Van Amelsvoort *et al.* 1988, Martin and Marinissen 1993). In our studies, among excluded macrofauna, important was the proportion of predatory arthropods. They can contribute to humus formation not by their liquid excrements, but rather by reducing number of microbial grazing mesofauna as in a consequence, by modification of microbial communities.

## 5. CONCLUSIONS

1. In the decomposing *Dactylis glomerata* litter the proportion of carbon in humic acids systematically increased with time and the content of fulvic acids declined. The $C_{HA} : C_{FA}$ ratio increased from 0.21 to 1.3.

2. During approximately a year, 51–61% of the carbon included in exposed litter, was mineralized, 13–19.7% was incorporated into humus acids.

3. Mineralization rate was higher in the mesocosms not accessible to macroarthropods, on the contrary, more humic acids and higher total carbon content (2–8%) were recorded in the top layer of open mesocosms patrolled by macroarthropods.

## 6. SUMMARY

The effect of macroarthropod exclusion on mineralization and humification of *Dactylis glomerata* litter was studied in mesocosm field experiment. Two types of mesocosms (100 $cm^2$ 15 cm deep) were compared: closed (C) not accessible for macrofauna, and open (O) patrolled by these invertebrates. Mesocosms were made of nylon mesh (mesh size 0.24 mm), contained soil cores (treatment S), or sand (treatment Sd). On the soil or sand sufrace litter bags with 9.5 g dry mass of litter were placed. Carbon, nitrogen and humus content were determined in the litter and in the sand. The two, aproximately annual experiments were performed in the meadow, in the successive years, both started in spring (June, April respectively).

The meadow soil was classified according to taxonomy used in Poland as the gleyed black earth, it contained 8% of carbon in upper horizon, consisted mainly of medium and coarse sand (Tables 1 and 2).

The content of carbon in the litter gradually decreased during decomposition and was lower by 2–7.7% in the particular treatments at the end of the experiments (Tables 3 and 4). The nitrogen content slightly increased in time of litter decomposition, from initial value – 2.4% to 3.2 maximal value (Table 5). The total humus content changed slightly along time, proportion of fulvic acids declined and of humic acids gradually increased (Tables 3 and 4). The ratio $C_{HA}$ to $C_{HF}$ was regularly growing from 0.21 at the beginning of the experiment to 1.3 at the end.

Sandy substratum, poor in organic matter content (0.0007% C) was applied in mesocosms to record the accumulation rate of carbon during litter decomposition. In the October, 18 weeks after litter exposure, the initial carbon content of fulvic acids in the top sand layer was doubled. The content of humic acids increased by 59%. (Table 6). In the deeper layer accumulation of carbon was not detected.

During winter accumulated organic matter was partly mineralized The content of fulvic acids was by 11% lower in April than in preceding October (Table 6). The similar pattern was repeated in both experiments (Tables 6 and 7).

At the end of the experiments 51–61% of the initial amount of carbon, introduced in the litter, was mineralized, 13–19% was incorporated in humus acids.

Differences between open and closed mesocosms showed, that intensity of mizeralization was higher in mesocosms not accessible for macroauna (12 and 14.6% higher amount of initial carbon was mineralized in closed mesocosms, respectively in the two experiments) (Table 8).

The amount of accumulated humus acids was higher in the mesocosms accessible for macroarthropods (by 2.3 and 8.2% more humus in open mesocosms) (Table 8). Differences between mesocosms were significant and were restricted to the top sand layer.

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