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Field mesocosms for assessing biotic processes in soils: How to avoid side effects

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Abstract – Field mesocosms can overcome the simplicity and deficiencies of laboratory based experimental designs. This study deals with a number of possible side effects of a mesocosm technique that involves deep-freezing of soil monoliths to eliminate soil fauna, wrapping in nets of various mesh-size to control faunal immigration and replanting in the field. We used Berlese-Tullgren sets in the field to directly inoculate mesocosms with microarthropods. After 6 months of exposure, the number of collembolans equalled control level whereas immigration and inoculation of oribatids accounted for only 30 % of the control. The number of ciliates, their distribution into feeding groups, and the numbers of nematodes, tardigrades and rotifers were not significantly affected by the elimination of mesofauna. We also did not detect significant treatment specific effects on microclimatic conditions within the litter layer of the mesocosms. Furthermore, we compared the monolith approach with a technique using sieved soil as a time-saving alternative. Water capacity and infiltration rate of mesocosms made of sieved soil did not differ from mesocosms made of monoliths, but NH_4^+ losses were significantly higher in sieved soil when defaunated by deep-freezing. We conclude that the investigated mesocosm technique has little side effects and recommend the use of monoliths in mesocosm studies. © 2000 Éditions scientifiques et médicales Elsevier SAS

Mesocosms / spruce forest soil / mesofauna-microflora interaction / Collembola / Acarina / microfauna / colonisation / microclimate / water capacity / infiltration rate / nutrient leaching

Résumé – Mésocosmes au champ et évaluation des processus biotiques dans les sols : comment éviter des effets de bordure. La mise en œuvre de mésocosmes au champ peut être une alternative pour pallier la simplicité et aux imperfections des expérimentations en laboratoire. Cette étude aborde les différents effets secondaires potentiellement générés par une approche en mésocosmes, impliquant successivement i) une défaunation des monolithes de sol par congélation intense, ii) leur enrobage au moyen d'une toile de vide de mailles dans le but de contrôler l'immigration de la faune, iii) leur replacement au champ. À l'aide d'appareils de Berlèse-Tullgren utilisés sur place, les mésocosmes ont été ensuite directement « inoculés » avec les micro-arthropodes extraits. Après 6 mois d'incubation, l'abondance des collemboles est similaire à celle observée initialement dans le sol témoin alors que l'abondance des oribates, par immigration et inoculation, atteint seulement 30 % de l'abondance observée dans le sol témoin. L'élimination de la mésofaune n'a pas affecté le nombre de ciliés et leur distribution dans les différents groupes trophiques, ni le nombre de nématodes, de tardigrades et de rotifères. De même, nous n'avons pas mis en évidence de manière significative d'effets secondaires, spécifiques au prétraitement des monolithes sur les conditions microclimatiques régnant au sein de la couche de litière dans les mésocosmes. L'approche en monolithes de sol est aussi comparée avec une approche par tamisage du sol, en tant que technique

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alternative permettant un gain de temps. La capacité de rétention en eau et le taux d'infiltration mesurés dans les mésocosmes constitués de sol tamisé et ceux constitués de monolithes de sol ne diffèrent pas, mais les pertes en NH_4^+ sont significativement plus élevées dans les mésocosmes faits de sol tamisé, après l'étape de défaunation par forte congélation. Nous concluons que la technique mésocosme proposée ici présente peu d'effets secondaires et nous recommandons l'utilisation de monolithes de sol pour des études en mésocosmes. © 2000 Éditions scientifiques et médicales Elsevier SAS

Mésocosmes / sol forestier sous épicéas / mésofaune-microflore interaction / collembole / acarien / microfaune / colonisation / microclimat / capacité de rétention / infiltration / lixiviation des nutriments

1. INTRODUCTION

We recently have developed equipment and handling methods for the preparation of soil mesocosms [8]. According to Odum [22], mesocosms are enclosed outdoor systems that are partially permeable to their surroundings. They mimic the full complexity of biotic and abiotic soil components and are an attempt to overcome the simplicity of many small-scale microcosm set-ups. Mesocosms thus combine a high degree of realism with repeatability of experimental units.

In particular, we used the mesocosm technique to investigate the interrelations between soil mesofauna and microflora. We defaunated soil monoliths by deep-freezing, wrapped them in nets of various mesh-size to control immigration of fauna of different size-classes and replanted them into the soil. This technique has been successfully used to determine effects of presence and absence of different faunal size-classes on soil microbial biomass, enzyme activity and nutrient balance in spruce forest soil [17, 30, 31].

We emphasise that realism is a crucial feature of mesocosms. Disturbance of biotic and abiotic components due to handling and experimental manipulation should be kept to a minimum, but cannot be avoided completely. This paper reports on several non-target side effects of mesocosm preparation. These investigations aimed at a better understanding of the properties of mesocosms and appraise their value as a tool in ecological research.

Four aspects are considered here:

(1) In a previous experiment, the abundance of Enchytraeidae and Collembola in defaunated mesocosms equalled the control at the end of the study period [3, 14]. In contrast, immigration of oribatid mites to defaunated mesocosms was very low. Since oribatids are a dominant mesofaunal group in many soils, their absence hampers a straightforward interpretation of the effects of microarthropods on soil microflora. In the current study, we therefore artificially introduced ('inoculated') arthropods to previously defaunated mesocosms with Berlese-Tullgren sets directly in the field. After 6 months of exposure, we checked if a natural assemblage of microarthropods was established in the mesocosms.

(2) Several authors described interactions between microfauna and microflora (e.g. [9, 13]). Thus, the effects of mesofauna elimination on the microflora might also be due to an altered microfaunal activity. In order to be able to ascribe elimination effects to the absence of mesofauna in future studies, the density of ciliates, nematodes, rotifers and tardigrades was counted by the method of Berthold and Palzenberger [5] and Lüftenegger et al. [19]. Some researchers reported that manipulations of soil microflora can be followed by shifts in the community structure of ciliates or in the composition of ciliate feeding groups [2, 4, 25]. Therefore, some species were selected as representatives of ciliate feeding groups and counted separately.

(3) Repeatedly our attention has been drawn to the point that the use of nets of various mesh sizes could lead to treatment specific alterations of the microclimatic conditions. This in turn could be responsible for observed treatment effects. As it has already been shown that moisture conditions do not differ between mesocosms with different nets [30], we restricted monitoring of microclimate to the measurement of average soil temperatures within the mesocosms.

(4) Excavation and deep-freezing very likely have some impact on pedological features of the soil monoliths, e.g. on the physical condition of soil organic matter or on soil pore space. To estimate this impact, we determined the effect of monolith manipulation on water capacity, water conductivity and nitrogen leaching which we assumed to be sensitive to alterations of soil structure. We compared mesocosms made of monoliths, prepared according to the technique described by Bruckner et al. [8], with mesocosms composed of sieved soil, a method that needs comparably less expenditure of work. The use of sieved mesocosms could be a time saving alternative to the use of monoliths if the latter turned out to be as sensitive to the physical load at excavation and freezing as the former.

2. MATERIALS AND METHODS

2.1. Study site

Experiments were carried out in the Gleinalm region near Knittelfeld (Styria, Austria). Its climate is characterised by severe winters and cool summers with mean

annual temperatures of only a few degrees above zero (6.2 °C at 700 m above sea level, 2.8 °C at 1 600 m) and mean annual precipitation of 600–850 mm [20].

The study site ('Stanglwald'-forest, 47°13' N, 14°59' E, National Grid Reference BMN 6705-4830-1b, 1 040 m above sea level) is a level, 45-year-old *Picea abies* (L.) Karst forest. The site is bare of ground vegetation. The soil is a loamy sand, classified as Dystric Cambisol (H. Mayer, pers. comm.). Humus form is mor humus with distinct L-, F- and H-layers (thickness variable, up to 6 cm, $pH(H_2O) = 4.7$ in the litter layer).

2.2. Preparation of mesocosms and inoculation with microarthropods

In April 1995, fifteen soil monoliths (250 × 250 × 150 mm) were randomly taken from the ground, deep-frozen to eliminate soil fauna (solidified CO_2, –78.5 °C, 10–12 h), wrapped in nets of various mesh size and replanted at the study site (see [8] for a technical description). In order to establish a natural assemblage of microarthropods in defaunated monoliths, we introduced soil fauna into two mesocosm treatments by means of ten field-run Berlese-Tullgren sets ('inoculation', see [14] for details). Humus material was randomly taken at the study site and slightly mixed. Approximately 3 L H and L/F humus material were filled in each set and processed in successive runs. Microarthropods were forced into the mesocosms by heating with a plastic plate (integrated heating wires) which directly rested upon the humus material. The heating plates were connected with the power supply system via two 24 V-transformators (*figures 1, 2*). The temperature of the humus material was adjusted and automatically levelled with an electronic feedback mechanism (raised from 25 to 35 °C during extraction). After 4 d, the humus material was dry and the extraction stopped.

To verify if additional inoculation may help to generate a mesofauna community in the mesocosm that is closer to a natural one, three different treatments and one control were applied. Fine nets were used to prevent lateral immigration of microarthropods from the surrounding soil, coarse nets should allow for colonisation.

– Treatment **F**: five monoliths were deep-frozen, wrapped in **F**ine nets (mesh size 35 µm) and were not inoculated;

– treatment **FI**: five monoliths were deep-frozen, wrapped in **F**ine nets and **I**noculated;

– treatment **CI**: five monoliths were deep-frozen, wrapped in **C**oarse nets (mesh size 1 mm) and **I**noculated;

– treatment **Ctrl**: five control plots were randomly designated on the study site, but left undisturbed.

In the study, we did not apply a treatment C (coarse netting, no inoculation) because the effects of lateral

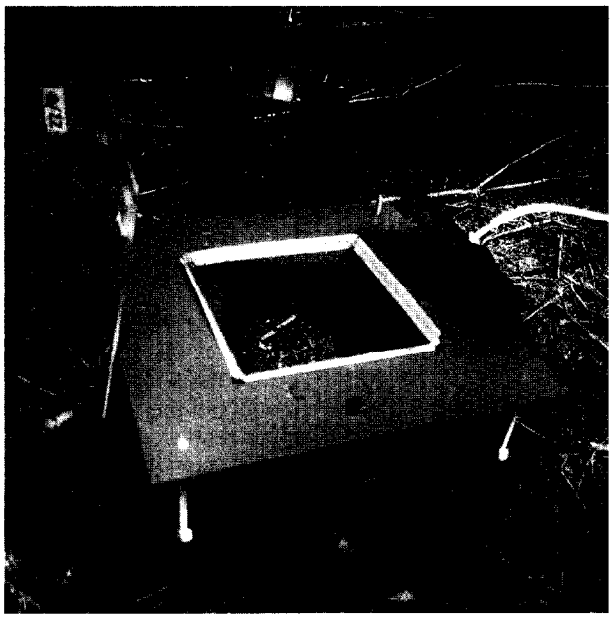

Figure 1. Constituent parts of a field-run Berlese-Tullgren apparatus. The soil monolith into which the microarthropods will be introduced is wrapped in a net like a stocking and is lowered down into a cavity in the ground. A four-legged stand is situated directly above the monolith and holds open the top of the net. Humus material is filled into a sample container with a bottom of wire gauze (in the background), and the container is put on the net opening. Then a heating plate (at the right, wire attached) is put directly upon the humus material. Finally, the apparatus is covered with a transparent plate (at left).

Figure 2. Assembled field-run Berlese-Tullgren apparatus. Note that the net is jammed between the sample container and stand. This prevents arthropods from escaping. The wire connects the apparatus with the transformers and the power supply system.

immigration alone have been determined in a previous study [8, 15].

In October 1995, after an exposure time of 6 months, two soil cores (Ø 7 cm, 10 cm depth) were taken from each mesocosm and extracted for microarthropods in a simple Berlese-Tullgren apparatus for one week into 80 % ethanol.

2.3. Quantification of active microfauna

In October 1995 in the litter layer of each mesocosm, humus material was sampled for microfaunal analysis using a spatula (0–2 cm max. depth). Three 0.1-g fresh subsamples of each mixed mesocosm sample were diluted in pH-adapted soil extract and the active microfauna (ciliates, rotifers, nematodes and tardigrades) were quantified directly under the microscope (see [6, 19] for details). Thirteen trained persons performed the direct counting technique simultaneously [6], giving a total of 63 counts on a single day. Representatives of ciliate feeding groups were selected and counted separately: *Avestina ludwigi* Aescht & Foissner 1990, a fungivorous species found only in fresh coniferous samples [1], *Colpoda* spp. as typical bacterivorous species, and *Spathidium* spp., *Dileptus* spp. and large hypotrichs as main predatory species. The other species were grouped into small (below 45 µm) and rapid fungi- or bacterivors (see survey on feeding specialisation in [11]). The number of counts for the ciliates was reduced to those counts not exceeding 90 min due to the time-dependent excystment of some colpodid species (Ctrl, $n = 9$; F, 10; FI, 13; CI, 8).

2.4. Measurement of microclimate

The principle underlying the measurement of soil temperature in the mesocosms is the hydrolysis of saccharose. During this process, a buffered solution of saccharose inverts into a mixture of glucose and fructose. This leads to a change of the polarisation angle of the solution that can be measured. Physical fundamentals and an instruction for preparing the buffered saccharose solution are provided by Schmitz and Volkert [26]. The method permits an easy measurement of 'effective' mean temperatures in the field over time periods of weeks and months.

The saccharose solution was filled into plastic flasks of 25 mL and taken to the field in cooling boxes to minimise partial inversion during transport. One flask was put horizontally in the uppermost 2.5 cm of the L- and F-layer of each mesocosm with coarse nets and in the L- and F-layer of the controls. Five out of the ten mesocosms with fine nets were chosen randomly; into each of these, one flask was placed in the same way. The flasks were taken to the field on 12 August, 15 August and 12 September 1995 and remained in the mesocosms for a month. Polarisation angles were determined with an Atago Polax-D precision polarimeter.

2.5. Measurement of water capacity, water conductivity and nitrogen leaching

In October 1994, twelve mesocosms (250 × 250 × 150 mm) were established at the study site at random. They represented four different types with three replicates each: (1) mesocosms made of frozen monoliths to assess the combined effect of excavation and defaunation; (2) mesocosms made of unfrozen monoliths to assess the effect of excavation alone; (3) mesocosms made of sieved soil (< 5 mm) which were deep-frozen to assess the combined effect of sieving and defaunation; (4) mesocosms made of unfrozen sieved soil (< 5 mm) to assess the effect of sieving alone. We buried three nylon bags containing strongly acidic cation and strongly alkaline anion exchange resins (Amberlite IR-120 pract., 20–50 mesh, Na^+-form and Dowex 1WX8 pract., 20–50 mesh, Cl^--form) under each mesocosm. During incubation, the resin bags adsorbed NH_4^+ and NO_3^- from the soil solution.

After a 7-month exposure, three undisturbed soil cores (70 mm Ø) were taken from each mesocosm and three randomly designated control plots, and resin bags were removed. We measured water capacity (WC) according to Austrian standard specification [24]. The cores were capillary saturated overnight and then allowed to drain on a sand-bed filled with fine sand (0.1–0.2 mm Ø) to a height of 100 mm (equivalent to a low pressure of –10 hPa). Wet mass (WM), oven-dry mass (105 °C, ODM) and actual volume (V) of the core were determined. WC calculates according to

$$\mathrm{WC\ [vol\%]} = 100 \times (\mathrm{WM\ [g]} - \mathrm{ODM\ [g]})/\mathrm{V\ [mL]} \quad (1)$$

We extracted the resin bags twice using 200 mL 1.6 M HCl. The two extracts were pooled, neutralised with NaOH and analysed for NH_4^+ according to Kandeler [16] and for NO_3^- according to Morris and Riley [21].

In May 1995, another twelve mesocosms were established in an identical way (except for the addition of resin bags). These mesocosms were used for in situ measurement of infiltration rate (IR) using a modified double ring infiltrometer method [23]. Metal frames of the size of the mesocosms (250 × 250 × 220 mm) were inserted to a depth of 140 mm. We saturated the adjacent soil with a surplus of water. The penetration time of 1 L water inside the frame, i.e. into the mesocosms and the control, was determined by using a measure on the inner side of the frame. Immediately afterwards, another litre of water was added and infiltration time was measured again. We repeated this procedure until IR was nearly constant. As according to Klaghofer [18], curves of the IR were fitted for each mesocosm and each control plot using the semilogarithmic function:

$$\mathrm{IR} = a + b \times \log \mathrm{time} \quad (2)$$

Constant IR could be reached at least after 45 min, so the theoretical time of equilibrium used for statistical comparison was set at 60 min after starting.

2.6. Statistical analyses

Mesofauna data were tested for overall differences between treatments with the Kruskal-Wallis H statistic due to the limited number of replicates and inhomogeneous variances (Cochran's C, Collembola: $C = 0.643$, $P = 0.049$; mites: $C = 0.982$, $P = 3.133 \cdot 10^{-9}$).

Microfauna data and polarisation angles were tested for homogeneity of variances (Cochran's C) and subjected to one-way ANOVA, followed by Scheffé's multiple range test for pairwise comparison of treatment means. The microfauna data are presented per m^2 of litter layer in the table and figures to allow comparison between micro- and mesofaunal groups. To convert the data to numbers per gram of dry litter (mainly used for some microfaunal groups), a division by a factor of 6 451 has to be applied.

We compared: (1) WC in the four types of mesocosms and the control with an ANOVA with nested design (five treatments, three mesocosms each, three cores each); (2) IR in the four types of mesocosms with a two-way ANOVA (factors sieved/not sieved, frozen/not frozen), comparison to the control by eye; (3) leaching of NH_4^+ and NO_3^- in the four types of mesocosms with an ANOVA with nested design (four treatments, three mesocosms each, three resin bags each).

All statistical analyses were performed with Statgraphics Plus 5.2.

3. RESULTS AND DISCUSSION

3.1. Inoculation of mesocosms with microarthropods

The Berlese-Tullgren sets performed well in practical outdoor test. Despite harsh weather conditions in April, the humus material in the sets dried within 4 d of extraction.

The number of mites and collembolans in the mesocosm after 6 months exposure are shown in *figure 3*. There were highly significant overall differences between treatments in both groups (mites: $H = 16.895$, $P = 0.0007$, Collembola: $H = 11.387$, $P = 0.001$). As in the previous study [8], only a very small number of microarthropods was found in the fine-mesh treatment F. This again confirms that deep-freezing and subsequent wrapping in fine nets is a good method to kill soil arthropods and to prevent immigration to soil monoliths. Treatment FI (fine mesh, inoculated) contained slightly more mites than F (not inoculated), but numbers in both treatments were much smaller than in the control. Immigration and inoculation together (treatment CI) accounted only for about 30 % of the control level. In contrast to the mites, the number of collembolans in CI and in the control were roughly equal. Inoculation alone (treatment FI) accounted for approximately 50 % of control numbers.

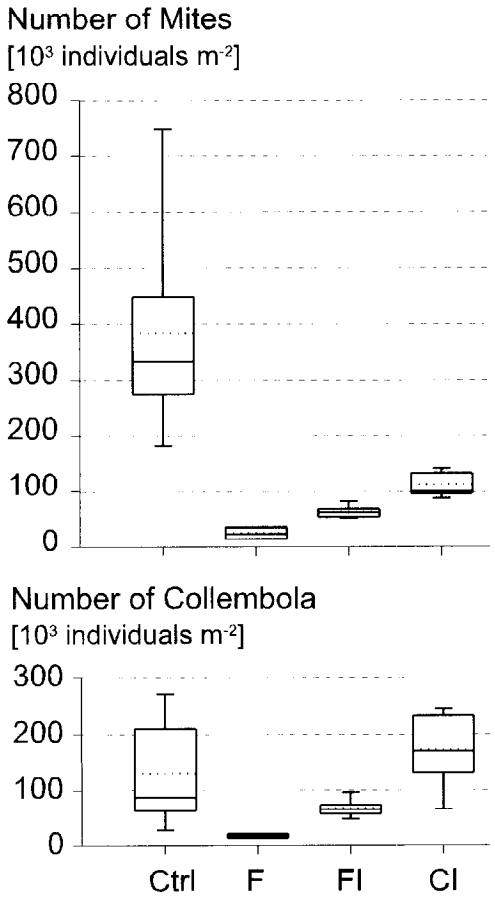

Figure 3. Numbers of mites and collembolans in treatments F (deep-frozen, fine netting, not inoculated), FI (deep-frozen, fine netting, inoculated), CI (deep-frozen, coarse netting, inoculated) and in the control Ctrl (undisturbed soil). Solid lines within a box indicate the median, dotted lines the mean. Boxes indicate the 25 and 75 % percentiles; bar caps indicate the range.

Mesocosms were successfully used to clarify interactive relations between soil biota [17, 30], but may also be valuable tools in applied soil ecology, e.g. in ecotoxicology. The artificial introduction of microarthropods with Berlese-Tullgren sets in the field ('inoculation') offers the opportunity to start experiments immediately after the set-up of mesocosms. Otherwise, experiments must be postponed (presumably for several months) until the numbers of microarthropods in the mesocosms have reached the control level.

Inoculation in the field seems to be an appropriate technique to set up a full collembolan community. In contrast, neither inoculation nor colonization activity were sufficient to adjust the number of mites to control level in the current study. However, we think that a

complete microarthropod assemblage is a pre-requisite of a 'real-world' mesocosm since faunal effects on soil processes were repeatedly shown to depend on structural features of the fauna, e.g. combination of major taxa, feeding guilds and species composition [10, 27, 28]. The problem of field inoculation is as yet unsolved, at least at temperate forest sites where microarthropod communities are often dominated by oribatids. The introduction of many thousands of living microarthropods by hand or a laboratory Tullgren-apparatus [10, 29] is no reasonable alternative for the field situation because it makes experimentation on a meaningful scale (several different treatments, > ten replicates per treatment) too time-consuming and expensive. Hence, the field inoculation seems worth improving.

We can only speculate on the reasons for the partial failure of our inoculation experiment. We used the same equipment in a pre-test at the university campus. A great number of mites were readily extracted from coniferous humus material into 80 % ethanol (data not presented). Perhaps viability of collembolans and mites is affected by the inoculation in different ways. Possibly also in the field experiment, mites were successfully extracted, but failed to establish in the defaunated mesocosms.

3.2. Abundance of microfauna

No effects of mesofauna elimination on the microfauna were observed after 6 months of exposure. This is true for total microfauna abundance (*figure 4*) as well as for the selected representatives of ciliate feeding groups (*table I*). Possible short-term effects of defaunation on the microfauna may have been levelled out by the formation of resistant stages before freezing (e.g. cysts) and the high reproductive potential of most

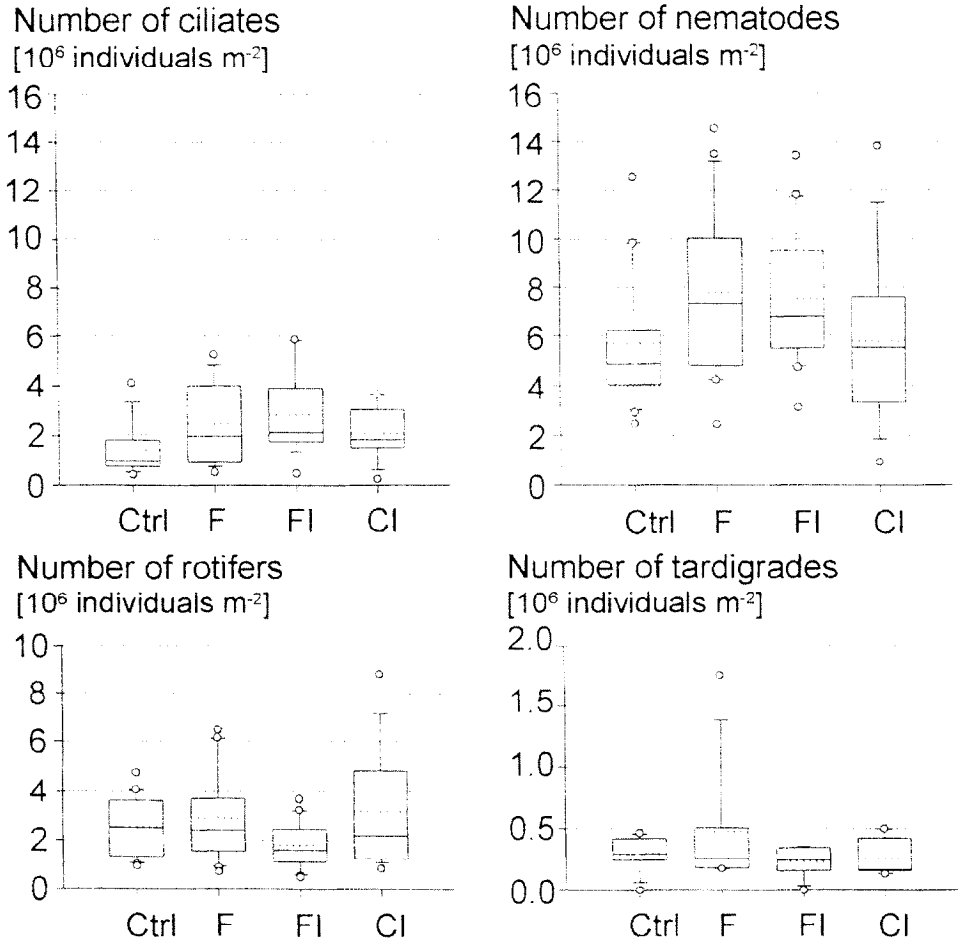

Figure 4. Numbers of ciliates, nematodes, rotifers and tardigrades in the litter layer of treatments F (deep-frozen, fine netting, not inoculated), FI (deep-frozen, fine netting, inoculated), CI (deep-frozen, coarse netting, inoculated) and in the control Ctrl (undisturbed soil). Solid lines within a box indicate the median, dotted lines indicate the mean. Boxes indicate the 25 and 75 % percentiles; bar caps indicate the 5 and 95 % percentiles; points are outliers (values beyond 5 and 95 %-percentiles).

Table I. Mean numbers × $10^4 \cdot m^{-2}$ ± standard errors of selected representatives of ciliate feeding groups in the litter layer of the control Ctrl and of the treatments F, FI, CI.

Feeding group	Ctrl	F	FI	CI	F	P
Bacteriophagous	15.0 ± 8.1	33.0 ± 30.1	22.0 ± 9.0	6.0 ± 4.1	0.42	0.74
Mycophagous	3.0 ± 2.5	17.0 ± 9.6	37.0 ± 16.3	3.0 ± 2.9	2.02	0.12
Predatory	15.0 ± 8.2	6.0 ± 5.6	25.0 ± 11.8	16.0 ± 4.7	0.49	0.82
Other species	198.0 ± 55.1	326.0 ± 66.2	357.0 ± 68.9	298.0 ± 59.2	1.23	0.31

microfaunal species. Our results imply that microfaunal activity is not likely to significantly superimpose the effects of mesofauna elimination. At least in long-term experiments, future researchers may confidently assign observed effects to the presence or absence of mesofauna.

3.3. Effects on microclimate

Average temperatures of litter layers were never statistically different when comparing (1) mesocosms of treatments F or FI (fine nets) and mesocosms of treatment CI (coarse nets), and (2) mesocosms of treatment CI (coarse nets) and the control (undisturbed forest soil); mesocosms of treatment F or FI (fine nets) and undisturbed soil differed only at a single period of measurement (*table II*). The difference in polarisation angle represents a difference in temperature of approximately 0.5 °C.

Treatment specific alteration of microclimatic conditions which could mask the exclusion effect of selected size-classes of soil fauna in mesocosms appears to be a negligible risk. However, this conclusion may only be valid for forested sites. Nets with different mesh-sizes shade the soil to a different extent. Thus, we recommend that in open sites, the effect of direct sunlight on the temperatures at the mesocosm surface should be evaluated prior to a study.

3.4. Effects on water capacity, water conductivity, and nitrogen leaching

Water capacity (WC) was about the same range in all treatments (*table III*). No statistically significant differences between treatments could be detected (% of variance of the nested factors: treatment 1.9 %; mesocosm 0.0 %; error 98.1 %). We were surprised by this result, as we expected the sieved mesocosms to differ from mesocosms made of monoliths and from undisturbed soil. If WC was different immediately after establishment of the mesocosms, the 7-month exposure allowed the soil physical properties affecting WC to equilibrate at the initial conditions.

Infiltration rates were more variable (*figure 5*), but no differences (sieved/not sieved: $F = 4.344$, $P = 0.145$; frozen/not frozen: $F = 0.941$, $P = 0.481$; interaction: $F = 0.053$, $P = 0.864$) were detected. The high variation of IR was most probably due to the high heterogeneity of the forest floor. If IR was actually affected by sieving and/or freezing, effects would not be detectable at the number of replicates feasible in a mesocosm study.

Applied separately, freezing and sieving had no effect on NH_4^+ mineralisation whereas their combination led to a significant increase of NH_4^+ loss from the mesocosm ($F = 15.83$, $P < 0.001$) (*figure 6*). NO_3^- losses from frozen monoliths and from sieved soil are much larger than from unfrozen monoliths (*figure 6*). However, the variability of NO_3^- leaching among the mesocosms of the same type was so high that it concealed any treatment effect ($F = 4.07$, ns).

Mechanical forces like freezing or sieving can lead to the exposure of binding sites of NH_4^+ on humus and clay that were formerly not accessible to microbial attack. This in turn may result in enhanced nitrogen mineralization [12]. NH_4^+ accumulation on resin bags is dependent on NH_4^+ delivery to the bags by percolating water [7]. Although water infiltration rates were not

Table II. Means of polarisation angles after partial inversion of a buffered saccharose solution in the litter layer of mesocosms wrapped with fine and coarse nets and of undisturbed forest soil. Treatments sharing the same superscripts are not statistically different ($P < 0.05$).

Date	Fine nets	Coarse nets	Undisturbed forest soil	$F_{2,10}$	P
12 July–15 August	46.99° a	46.89° ab	46.78° b	4.267	0.046
15 August–12 September	48.07°	48.13°	48.20°	1.012	0.396
12 September–11 October	48.23°	48.11°	48.22°	0.242	0.789

Table III. Means and standard deviations of water capacity in four types of mesocosms after 7 months of exposure and in undisturbed soil (control) in a spruce forest.

	Monoliths		Sieved soil		Control
	Not frozen	Frozen	Not frozen	Frozen	
Water capacity (vol%)	28.64 ± 4.75	28.29 ± 6.29	29.05 ± 5.56	26.96 ± 4.38	25.22 ± 5.61

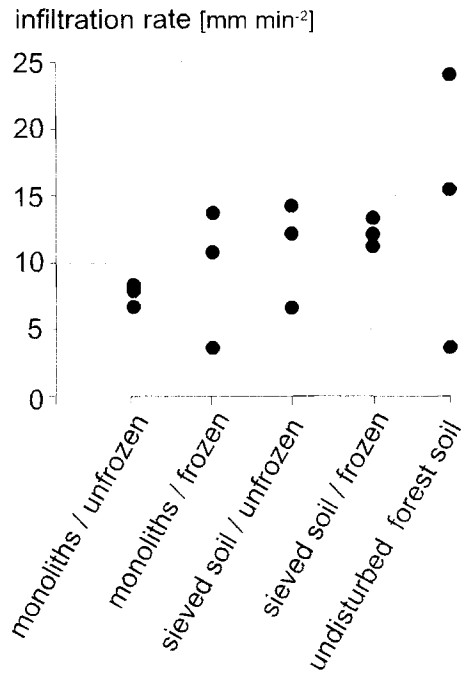

Figure 5. Infiltration rate in four types of mesocosms (three replicates each) after 7 months of exposure and in undisturbed soil in a spruce forest.

significantly different from the sieved soil after an exposure time of 7 months (see above), a quicker water transport to the resin bags from the sieved soils at the beginning of the experiment seems a possible explanation. NO_3^- is more mobile in the soil and therefore more NO_3^- than NH_4^+ can be accumulated in the resin bags [7] even if the concentrations of NO_3^- are lower in the soil.

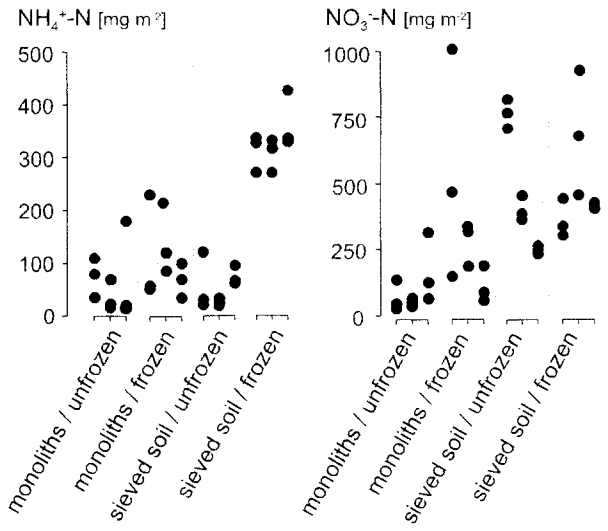

Figure 6. Losses of NH_4^+-N and NO_3^--N from four types of mesocosms (three replicates, represented by ticks on the *x*-axis; three resin bags each, represented by circles) in a spruce forest soil.

4. CONCLUSIONS

Although densities of mites in mesocosms cannot be adjusted to the abundance in undisturbed soil even by the use of field based Berlese-Tullgren sets, the technique presented by Bruckner et al. [8] meets the requirement of resembling undisturbed conditions to a high degree. After a time period of 6 months, microfauna does not seem to be affected by the manipulation (digging, freezing) of the monoliths. At least in forested sites, no treatment specific alteration of microclimatic conditions is to be expected which could mask the exclusion effect of selected size-classes of soil fauna. A time-saving technique based on mesocosms set-up of sieved soil is no alternative because NH_4^+ loss from these mesocosms is significantly higher than from monoliths. As realism is a crucial feature of mesocosms, we strongly recommend the use of monoliths in mesocosm studies leaving soil structure and texture largely undisturbed.

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