TERRESTRIAL MODEL ECOSYSTEMS
(TO ASSESS CHANGES OF MICRO-ARTHROPODS COMMUNITY STRUCTURE)

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Introduction

Terrestrial Model Ecosystems (TME) can be defined as open systems equipped with undisturbed soil initially containing the indigenous fauna of the sampling site. They are focused since about 20 years as possible investigation tools for the fate and degradation of agrochemicals and their distribution among compartments of the soil. In the last few years the importance of these systems increased and they were tried to be used for the investigation of initial effects of xenobiotics on the soil mesofauna and the subsequent recovery in case initial effects are observed.
Objective in our study is to establish a system – the TME - which is stable over time under realistic conditions despite enclosure. We focus on the understanding of effects of xenobiotics on communities of Collembolans and Oribatid mites as essential parts of the decomposer food web in soil and the observation of recovery of populations in case initial effects occur. Therefore pre-requisite is to find a diverse and high-abundant natural system to define a state for TME at the starting point. For this reason an undisturbed meadow with homogenous vegetation was chosen which is expected to offer better conditions for the fauna than a cultivated farmland. Initial sampling has elucidated the variability of abundances on the site as well as its species diversity. After that 16 intact soil cores have been sampled from meadow. They have been exposed in a facility under outdoor conditions. The intra- and inter-TME variance has been investigated in a time-series (pre-study), which is supposed helping to decide about the necessary replicate number in future effect testing. Further was examined whether TMEs are stable with respect to abundances and species numbers over time. The poster describes the characteristics of the test site, the sampling methods of soil cores with a diameter of 30 cm and a length of 40 cm and the methods of sub-sampling. The methods for an analysis of variance and the extraction methods to determine the communities of springtails and mites in the test site as well as in the TMEs are presented.

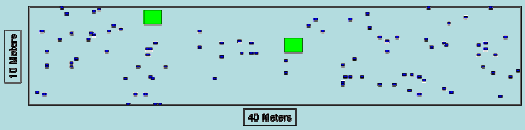
Methods

Sampling Site and Field Sampling

- **Untreated meadow**, situated at the river rhine floodplain near Monheim, Germany
- **Homogenous vegetation**
- **Soil texture**: 50 % sand, 40 % silt, 10 % clay
- **Mowed regularly**, mulch remained on the site

Fig. 1: Sampling grid in the field. The meadow has been divided into 10.000 virtual sample-squares with an edge length of 20 cm.
- By chance 94 samples have been chosen (blue squares) to analyze **big-scale** distribution of species
- To examine the **small-scale** distribution of species two patches of 7 x 7 points have been randomized (green squares)

Soil cores of the first 5 cm-layer have been taken by means of a soil corer of 5 cm in diameter. Sampling has taken place in October 2004.



TME Coring

Fig. 2: The TMEs have been taken without lateral disturbance by means of a modified hydraulic pile pusher. The cylinders are made of stainless steel. They are 30 cm in diameter and the height is 40 cm.

TME Sampling

Field data serve as a reference point (T_0) to investigate the development of the TMEs after isolation. Sampling took place after 80 (T_1), 128 (T_2), 140 (T_3) days after soil coring in winter 2004/2005 in order to investigate intra- and inter-TME variance. In sum sampling results in 192 field-samples and 104 TME samples. Both in the field and in TMEs sub-samples of a height and diameter of 5 cm are taken. Maximum number of sub-samples per TME is seven.

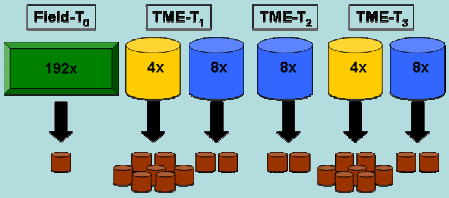


Fig. 5: Sampling scheme in the pre-study. Yellow cylinders are sampled with the maximum number of 7 sub-samples at one time to determine intra-TME-variability. Blue cylinders are sampled in intervals with two sub-samples on each of the three dates (6 samples in sum). Brown are sub-sample soil cores.

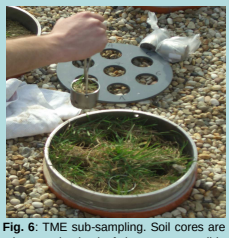


Fig. 6: TME sub-sampling. Soil cores are taken randomized of the seven possible slots (see the positioning device disk in the background.) Remaining cavities have been filled with watertight sand bags.

TME Facility

Fig. 3: Outdoor experimental set-up. Disturbance by non-original fauna has been prevented by two fences and an avifauna-shield. Vegetation has been cut before sampling.

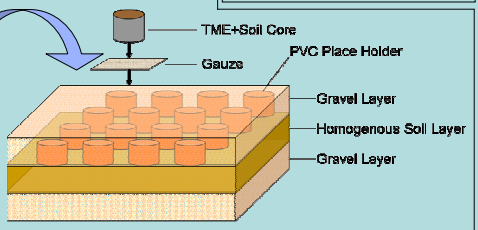


Fig. 4: Schematic view on the experimental set-up. The area is drained by a basic 30 cm layer of gravel, soil water tension is ensured by a homogenous sieved sand-soil mixture layer of 30 cm. Invasion of non-original fauna from below is avoided by a 120 µm gauze inlay.

Sample Treatment

- **Microarthropods extraction**
  - **First step:** Soil cores are treated by a modified high-gradient method (MacFADYEN 1961) for 14 days with an increasing temperature from 16°C at the start up to 60°C at termination
  - **Second step:** After that the **same** soil-cores have been **Heptane-flotated** twice (WALTER et al. 1987)
- **Sorting, Counting, Determination**
  - Animals have been preserved in an appropriate fixation solvent (70 % ethanol) and sorted and counted by hand in Collembolans, Oribatid mites and Mesostigmatid mites
  - Collembolans have been prepared for microscopy and determined to species level by means of modern species keys

Statistical Evaluation

- **Distribution fitting:** Abundances of several groups or taxa of the mesofauna have to be analyzed for their distribution fitting. It has to be found an appropriate statistical test system for detecting significant differences between samples. Analyzes have been both performed with the **raw data** and **transformed** abundances
- **Friedmanns ANOVA:** The significance of overall differences in abundances between field (T_0) and TME and between different sampling dates (T_1-T_3) have been tested by non-parametric tests for dependent samples
- **Mann-Whitney U-Test, Wilcoxon Matched Pair Test:** The significance of differences between single dates has been examined by using both tests for independent (Field vs. TME) and dependent (TME vs. TME) samples
- **Power Analysis:** The data (overall and species abundances) is to be used to estimate the required sample size in further investigations or to calculate the detectable effect size in a given sampling design

Measurements

- **Matrix potential** with help of equitensiometers as a measure of bio available water in depths of 5 and 20 cm below-ground is determined online: to define a **trigger value** for irrigation in case of permanent wilting (soil moisture is assumed as to be the most important factor in maintaining stable mesofauna populations)
- **Temperature** in depths of 5 and 20 cm below-ground to estimate in conjunction with matrix potential the homogenous conditions of TMEs

Literature cited:

WALTER, D.E., KETHLEY, J. & J.C. MOORE 1987: A heptane flotation method for recovering microarthropods from semiarid soils, with comparison to the Merchant-Crossley high-gradient extraction method and estimates of microarthropod biomass. Pedobiologia **30**: 221-232

MACFADYEN, A. (1961): Improved funnel type extractors for soil arthropods. Journal of Animal Ecology **30**: 171-184

Results &Discussion

Mesofauna Abundance

Springtails

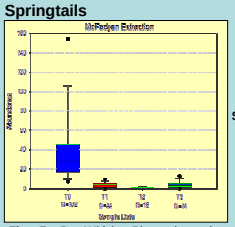


Fig. 7: Box-Whisker-Plots show the abundance distribution of collembolans in the field and in TMEs at different sampling dates. The abundance is significantly lowered in the TMEs (winter sampling!). Differences between TME samples are not significant (Friedmann-ANOVA). This indicates a stable population over time.

Same soil cores!

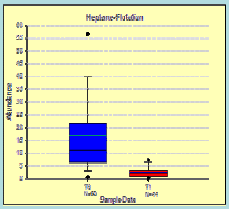


Fig. 8: The amount of collembolans is similar to the MacFadyen-extraction while soil cores are heptane flotated twice. Similar to the MacFadyen results the abundances at T_0 are much higher than at T_1.

Only a part of the samples has been treated!

Oribatids

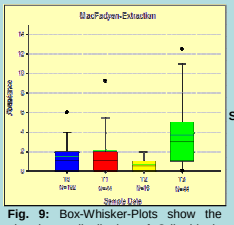


Fig. 9: Box-Whisker-Plots show the abundance distribution of Oribatids in the field (T_0) and in TMEs (T_1-T_3) on different sampling dates. Abundances are low but there is no obvious lowering in the TMEs.

Same soil cores!

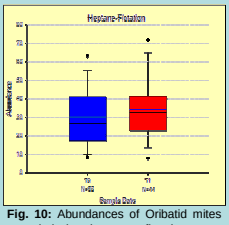


Fig. 10: Abundances of Oribatid mites recorded in the two flotations are several times higher than in the MacFadyen extraction. The MacFadyen-extraction is not efficient enough to extract a representative part of the Oribatid fauna.

Intra- and Inter-TME Variability

Fig. 11-12: Box-Whisker Plots of mesofauna abundances at dates T_1 and T_3 show low intra-TME variability for Collembolan and Oribatid numbers. Differences between TMEs at one sample date are not significant (Friedmann-ANOVA). In general abundances are very low, probably due to the adverse weather conditions. TMEs offer homogenous living conditions and deliver comparable results.

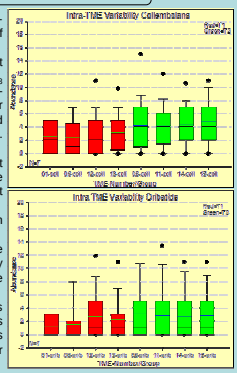
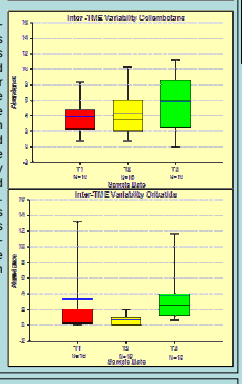


Fig. 13-14: Inter-TME variability is low, the systems can be considered as stable over time, because abundances are constant for both Collembolan and Oribatids despite disturbance by sampling and remaining cavities. Species numbers are also low as seen in Figs. 11-12. All results are derived from MacFadyen extraction.



Springtail communities

Field community

Taxon	Abundance	Dominance / % of overall abundance	Steadiness per sample
Isotomurus palustris	499	40,1	87,5
Desoria trispinata	320	25,7	56,3
Isotoma viridis	312	25,1	85,4
Parisotoma notabilis	35	2,8	29,2
Sminthurinus aureus	25	2,0	35,4
Sphaeridia pumilis	15	1,2	14,6
Lepidocyrtus lanuginosus	10	0,8	18,8
Brachystomella parvula	5	0,4	6,3
Lepidocyrtus cyaneus	4	0,3	6,3
Tomocerus vulgaris	2	0,2	4,2
Desoria propinqua	1	0,1	2,1
Desoria tigrina	1	0,1	2,1
Dicyrtoma saunderi/minuta	1	0,1	2,1
Entomobrya multifasciata	1	0,1	2,1
Entomobrya spec.	1	0,1	2,1
Folsomia quadrioculata/manolachei	1	0,1	2,1
Friesea spec.	1	0,1	2,1
Heteromurus nitidus	1	0,1	2,1
Isotoma anglicana	1	0,1	2,1
Isotoma spec.	1	0,1	2,1
Lepidocyrtus lignorum	1	0,1	2,1
Orchesella frontimaculata	1	0,1	2,1
Orchesella spec.	1	0,1	2,1
Pogonognathellus flavescens	1	0,1	2,1
Pseudosinella alba	1	0,1	2,1
Willemia spec.	1	0,1	2,1
Sum	1243	100,0	

TME community

Taxon	Abundance	Dominance / % of overall abundance	Steadiness per sample
Isotomurus palustris	163	41,9	62,5
Desoria trispinata	63	16,2	31,7
Parisotoma notabilis	43	11,1	26,9
Isotoma viridis	36	9,3	31,7
Sphaeridia pumilis	30	7,7	21,2
Lepidocyrtus lignorum	15	3,9	11,5
Dicyrtoma fusca	10	2,6	5,8
Brachystomella parvula	7	1,8	4,8
Heteromurus nitidus	6	1,5	4,8
Isotoma anglicana	6	1,5	1,0
Entomobrya spec.	2	0,5	1,9
Isotoma anglicana/viridis	2	0,5	1,9
Lepidocyrtus cyaneus	2	0,5	1,9
Sminthurinus aureus	2	0,5	1,9
Lepidocyrtus lanuginosus	1	0,3	1,0
Oligaphorura spec.	1	0,3	1,0
Sum	389	100,0	

Tab. 1: The dominance spectrum of springtail community in the field shows three highly dominant species which contribute about 90 % of all species. They occur also with a high steadiness in the samples. A total of 48 samples has been yet determined.

Tab. 2: In the TMEs six species contribute about 90 % of the community abundance. Besides *Isotomurus palustris* they dominate to a fewer extent than species in the field. A total of 104 samples has been analyzed. Species composition in the TMEs is similar to the field, but species is number lowered. See "TME Sampling" for a detailed view on sample dates.

Species Abundance Variability

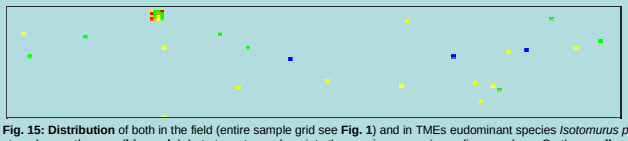


Fig. 15: Distribution of both in the field (entire sample grid see **Fig. 1**) and in TMEs eudominant species *Isotomurus palustris* over the area. Abundance varies strongly over the area (**big-scale**), but at most sample points the species occurs in medium numbers. On the **small-scale** patch the abundance per sample shows a high degree of variation.

Conclusions and Outlook

- System development is at the starting point, studies since yet are mostly focused on feasibility
- **Sampling site** offers a sufficient diverse and abundant mesofauna
- **Variability** in the field is high, especially concerning single species
- **TME coring** method feasible and TME **outdoor facilities** installed
- The sampling and extraction methods are established and considered to be **suitable** to record important taxa of the soil mesofauna like Collembolans and Oribatid mites
- Existing results indicate that a **combination** of the **MacFadyen-extraction** and the **Heptane-flotation** is necessary to extract sufficient numbers of both, Collembolans and Mites
- Data on Intra-TME sampling demonstrate **sufficient homogeneity** of TMEs and point at **comparable results**
- Preliminary data on Inter-TME sampling show a **relative low variability** of abundances at different sample dates, the systems can be considered as **stable over time** and indicate the **suitability** of the **sub-sampling method**
- **Species composition** in the field and TMEs is similar
- Dominance spectra comparable, but species number lowered in TMEs

Further data generation will allow to define the appropriate TME sample size to make effects observable!