SZENT ISTVÁN UNIVERSITY

EFFECTS OF CLIMATE CHANGE ON SOIL MESOFAUNA COMMUNITIES –NEW METHODOLOGICAL APPROACHES

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1. Background and aims of the research

Climate change is one of the most current issues in ecology. There is a lack of knowledge about the possible effects of climate change and the change of ecological processes in the future. It is especially true for the biotic and abiotic changes and their interactions in the soil. Soil mesofauna (mostly mites and springtails) occupies a central position in soil food web. Involving this group into the investigation of climate change effects on soil biota is needed from several aspects. It can influence the ways and regulate the speed of decomposition and exert a strong feedback on plants and trough these processes influences the CO_2 emission of soil.

To improve the understanding of the reaction of soil living mesofauna and relating soil processes to climate change, continuous monitoring is needed. Traditional techniques in soil sampling methods are destructive and it may complicate to conduct long term manipulations without the problem of disturbance. EDAPHOLOG probes developed by our research group is dedicated to solve this problem.

For Central Europe, regional climate change models predict warmer and drier summers and milder but wetter winters (Pieczka et al., 2015) causing severe droughts especially in the sand dunes region in Hungary, called Sand Ridge (Ladányi et al., 2015). Extreme conditions are usual in sand steppes, thus biota of these ecosystems can cope with extremities to a certain level. In the field of climate change and soil ecology, several research deal with the drought effect on soil mesofauna. But only few studies have focussed on the altered magnitude or frequency of precipitation in arid or semi-arid ecosystems. There is a lack of knowledge, how populations of soil living micro-arthropods can recover after a drought stress. With EDAPHOLOG probes, we were able to monitor processes in the soil mesofauna communities for two years.

I set out to find out how the diversity and number of individuals of springtails and mites would change after different levels of drought treatments (1, 2, 5 months) in a semi-arid habitat of Kiskunság. Furthermore, I was interested to learn if there are any effects of the previous extreme (5 months long) drought on the answers of mesofauna to the shorter (1, 2 months) drought periods.

The aim of my research was to compare catching efficiency of the new (EDAPHOLOG traps working with clay granules) and the traditional methods.

2. Material and Methods

2.1. Structure of EDAPHOLOG probes

EDAPHOLOG probes were developed to collect and automatically detect soil surface living (epedaphic) and soil dwelling (hemi- and euedaphic) micro-arthropods (Dombos et al. 2017). The probes with an opto-electronic sensor continuously detect microarthropods falling down into the trap. Animals are trapped into a sample-container, thereby their identification is also possible.

2.2. Test of representability and catching efficiency of EDAPHOLOG probes

Comparative studies were done to evaluate the catching efficiency and representability of EDAPHOLOG probes in two different soil types (loamy and sandy soil). EDAPHOLOG probes were compared with pitfall traps and the soil extraction method.

2.2.1. Catching efficiency in brown earth

To compare sampling by pitfall trap, soil extraction and EDAPHOLOG, we established a 50 x 50m plot in an alfalfa field (brow earth) at Bajna. 20-20 pcs of EDAPHOLOG and pitfall traps were placed along five lines that were 12.5 m apart. In each line, four pitfall traps (10 cm diameter cup filled with preservative) and four EDAPHOLOG probes (with clay granules) were placed in an alternating pattern. Samples were collected at the end of a 18-day period, and twenty soil cores (diameter: 8 cm, depth: 8 cm) were also taken between the lines and extracted in a Berlese funnel extractor.

2.2.2. Catching efficiency in sandy soil

The experiment took place in an open sand steppe near Fülöpháza, outside the fence of the EXDRAIN manipulation sites. Trap pairs (EDAPHOLOG and pitfall; at least 1 m far from each other) were inserted into to the soil at ten localities at least 5 m apart from each other. In addition, soil cores (diameter: 8 cm, depth: 8 cm; 2/single locality) were taken at the end of the experiment.

2.2.3. Microhabitat effect of the clay granules

To investigate the effects of humidity on the use of microarthropods of clay granules as microhabitat, comparison were made between the sampling methods: extraction of soil cores and the same volume of clay granule bags in different environmental conditions (humid and dry weather). Twenty-twenty bags of clay granules were inserted into the soil (2 samples × 10 localities) at the beginning of each of the two time periods and were collected at the end of each time period. 20-20 soil cores (2 × 10 localities) were taken at the end of each time period also within 1 m distance from the traps of previous experiment. The samples were extracted in a Berlese funnel extractor. Daily total precipitation (mm) and mean soil moisture (kg/kg) data were gained from a meteorological station (OMSZ) located 10 meters away from the experimental site.

2.3. Drought treatments in the EXDRAIN experiment

2.3.1. Study site and experimental design

Our experiment took place in an open sand steppe near Fülöpháza in the Kiskunság National Park in the frame of EXDRAIN long term experiment. Six blocks were selected, ca. 12 x 6 m in size. Each block contained eight, 3 x 3 m plots. Within each block at the first year (2014), an extreme drought pre-treatment (two levels: extreme drought (X) vs. control (C)) was applied. In the consecutive year (2015), mild precipitation manipulations were applied with four levels: severe drought (S), moderate drought (M), control (C, ambient precipitation) and water addition (W) on both of the previously X and C treated plots. This way the two factors (i.e. extreme drought and mild precipitation change) were combined in a full factorial design resulting in eight treatment combinations (CC, CS, CM, CW, XC, XS, XM, XW) with six replications resulted in a total of 48 study plots.

The extreme drought was simulated by excluding all rain from 24 April 2014 to 18 September 2014 (5 months). Severe drought was simulated by covering the respective plots for two months in 2015 (23 June to 25 August in 2015), while moderate drought was simulated by covering these plots for one month in 2015 (from 20 July to 25 August). Water addition was applied four times, 25 May, 22 June, 21 July and 25 August. A total of 98.5 mm water was added in four approximately equal parts, imitating the amount of precipitation during a thunderstorm.

2.3.2. Measuring environmental variables

Soil humidity was measured at each plot in-situ at 0-30 cm. The instruments provided data in every 10 minutes and mean values were counted for each day.

Extreme drought treatment (X) was effective in 2014 as soil humidity dropped markedly during and after the treatment. We excluded 64.1% of the annual precipitation. However, extreme drought treatment had an opposite effect in 2015. During vegetation period, soil moisture was higher in the previously (in 2014) extreme drought treated plots (XC) compared to the control plots (CC).

Concerning the effects of the second factor, in 2015 soil moisture at severe drought treatment (CS) sank to the values measured on extreme drought plots in 2014 (XC). In 2015, 23.3% of the yearly precipitation (121.8 mm) was excluded in severe drought treatment. In moderate drought treatment (M), 18.2% of the yearly precipitation (95.4 mm) was excluded. In soil moisture we received the same level of drought as in S treatment, but for a shorter period (one month). By water addition treatment (W), we added extra precipitation (a total of 98.5 mm) which caused no increase in soil moisture in the longer period, only immediately after sprinkling.

2.3.3. Substrate Induced Respiration

To estimate soil microbial biomass, we monitored the metabolic activity of soil microbial communities by substrate induced respiration (SIR), based on the method of Anderson and Domsch (1978). Soil samples were taken monthly from May to November, adapting to the time frame of the treatments. We took small subsamples of soil from all of the plots using plastic tubes with 12 cm length and 0.5 cm diameter. This method allowed us to take soil samples from the upper 10 cm of the soil with small disturbance effect. In that way we got circa 30 g soil representing the whole plot.

2.3.4. Sampling of micro-atrhropods

In our experiment, the mesofauna was sampled by using EDAPHOLOG probes (Dombos et al., 2017). With this, at one hand we caught micro-arthropods and analysed these data and in the other hand, in case of catching, the device sensored the animals falling in so the number of individuals was also estimated in that way. The first year (2014) was considered as pre-treatment year and the traps were inserted into the soil at the beginning of July and samples were collected ones at the end of November. In 2015, sampling happened monthly, following the time schedule of the experimental actions in the treatments.

Collembola and Oribatida were identified to species level. For further analysis, Collembolan species were categorized into four groups, namely surface living (epedaphic), vegetation living, soil living (hemiedaphic and euedaphic). Mites, except Oribatida, were identified to main groups (Mesostigmata, Prostigmata, Astigmata).

Sensoring data were downloaded monthly.

2.4. Data analysis

2.4.1. Analysis of data of the sampling procedures

From alfalfa field, individuals captured by the 20 EDAPHOLOG and 20 pitfall traps and 18 extracted samples were available for the analyses. In case of sandy soil, I had 10 EDAPHOLOG and 10 pitfall traps and 20 extracted soil cores. Animals were categorized into 5 groups: surface living mesofauna, soil living mesofauna, surface living not mesofauna, soil living, not mesofauna, other invertebrates. To test the difference in the number of captured individuals between the three methods, a MANOVA model was built separately for samples deriving from alfalfa field and sand steppe. Data were ln(x+1) transformed. The response variables were the number of captured individuals in the above mentioned five groups, whereas the explanatory factor was the type of the trap (EDAPHOLOG, pitfall or soil extraction).

2.4.2. The effect of humidity on the microhabitat effect of clay granule bags

To test the difference of microhabitat effect of clay granule bags in two different conditions of humidity, individuals extracted from 20-20 clay granule bags and 20-20 soil cores were available for the analyses. Captured animals were categorized into 11 groups: 1. soil living Collembola, 2. surface living Collembola, 3. vegetation living Collembola, 4. Mesostigmata, 5. Astigmata, 6. Prostigmata, 7. Oribatida, 8. soil living other mesofauna, 9. soil living not mesofauna, 10. surface living not mesofauna, 11. other invertebrates.

To test the difference in the number of captured individuals between the two methods, in two different conditions of humidity, a two-way MANOVA model was built (IBM SPSS (V23) software), where the response variables were the numbers of individuals of the above mentioned animal groups, whereas the explanatory factors were the two methods (soil core, bag of clay granules) and the two level of humidity (dry, humid). The response variables were ln(x+1) transformed.

2.4.3. Transformations and analysis of the data deriving from the drought treatments

In 2014, I obtained data with distribution skewed to the right that were corrected by ln(x+1) transformation before performing comparisons of extreme drought treated and control sites by Student's t-tests (Bonferroni's Type I error correction was made).

Data from 2015 had to be also transformed. I applied two different methods: 1. normalization (relative activity density, RAD) and 2. ordinal scaling (activity density difference, ADD). To make the data of different order to be comparable, I applied the normalized (relative) activity densities (RAD).

Activity density difference (direction and magnitude, ADD): Species from soil mesofauna, assumed they are present, usually are able to establish an extremely large population size within a short time. To express the direction and the magnitude of the relevant difference between two values, first I converted the activity density data to ordinal scale defining activity density rate categories. From the ordinal data, I defined the ADD (as their direction and magnitude) while comparing the activity density values of factor combinations CW, CM, CS (control in 2014, treated in 2015) to CC (control in both years), and XW, XM, XS (treated in both years) to XC (treated in 2014, control in 2015) in each block. The values are negative if the control value is higher. I calculated the proportions of the negative ADD values before and after the beginning of the treatments of 2015. These proportions were compared by Z-tests and Fischer's exact tests to reveal whether AD in relation of control vs. treated significantly changed after treatment or not.

To explore the differences in RAD and SIR data in 2015, I used MANOVA with factors: F1 (with or without drought treatment of 2014: X, C) and F2 (C, W, M, S of 2015). MANOVA was followed by ANOVA with Bonferroni's Type I error correction for each month to find out the effect of F1 and F2.

Collembolan and Oribatida diversity was calculated with Shannon-Wiener diversity index and evenness with Buzas and Gibson's evenness. To test whether extreme drought impacted Shannon-Wiener diversity, evenness and species richness in 2014, I used Student's t-tests with Bonferroni correction. I performed a two-way MANOVA with block design model to test the factor effects on Shannon-Wiener diversity indices, evenness and number of taxa of Collembola and Oribatida for the data set of 2015.

2.4.4. Sensoring data

During the study conducted with EDAPHOLOG probe, sensoring data of 48 probes were monthly downloaded (one-one in each plot). Malfunction occurred in several cases. 136 datasets had to be excluded from the investigations. In case of the remaining 248 datasets environmental and electronic noise was filtered. After that the sum of monthly detection was compared the number of caught animals. Correlation between detection and real caught was low (r^2 = 0.586). Detection proved to be higher than actual caught. For that reason data were filtered further. Data with lesser differences than 10 % were only counted. That way altogether 50 dataset were received.

3. Results

3.1. Comparison of the three sampling methods

Catches of the three sampling types in alfalfa field differed significantly: pitfall traps captured much more individuals than the other two methods (MANOVA, Wilk's $\lambda = 0.061$, $F_{10,102} = 31.16$, $p < 0.001$). In sandy soil the three sampling types differed also significantly. In that case I also found that pitfall traps captured much more individuals than the other two methods (MANOVA, Wilk's $\lambda = 0.083$, $F_{10,46} = 11.37$, $p < 0.001$).

Pitfall traps caught three times more arthropods than EDAPHOLOG traps; however, these samples also included insects other than microarthropods. Pitfall traps were more effective in the sampling of surface- and plant-living Collembola and Oribatida in case of sandy soil. The number of individuals extracted from the soil cores was the lowest among the three sampling types. However, this method – unlike pitfall trap and EDAPHOLOG – measures the density and does not include activity density from the sampling period. The relative abundances of soil-living microarthropods were the highest at soil extraction.

3.2. The effect of humidity on the refuge effect of clay granule bags

According to the two-way MANOVA, the effects of state of humidity (f1) and of the sampling methods (f2) on the number of captured individuals and the interaction between f1 and f2 were significant (MANOVA, f1: Wilk's $\lambda = 0.420$, $F_{11,65} = 8.16$, $p < 0.001$; f2: Wilk's $\lambda = 0.556$, $F_{11,65} = 4.71$, $p < 0.001$; f1*f2: Wilk's $\lambda = 0.571$, $F_{11,65} = 4.44$, $p < 0.001$).

Follow-up ANOVA models gave different results for animal groups. Although, more surface living Collembola were extracted from the clay granule bags compared to the soil, it was independent from humidity state. In case of Oribatida, although in dry conditions they were present with higher abundance, I did not find significant difference between the two sampling methods. By contrast, in case of groups which presented in a lower number, from the clay granule bags sampled from dry period, significantly more Mesostigmata and not significantly but also more soil living macroarthropods and vegetation living Collembola were extracted than from humid period. For clay granule bags in dry period, the number of soil living Collembola and Prostigmata tended to be lower than in humid period. Macroarthropods, belonging to either surface living or the other category, used the clay granule bags differently under dry and humid conditions.

3.3. Results of the drought treatments

3.3.1. Description of the soil mesofauna

Overall in our study site, we found 22 species of Collembola. Total number of individuals in Collembola throughout the two years were 74400, of which 89.5% belonged to surface living, 8.6% to soil dwelling and 1.9% to vegetation living group. Total number of individuals in mites was 12250 in the two years. Acari was dominated by mesostigmatid (52 %) and prostigmatid (23 %) mites, but Oribatida (11 %) was presented also in a considerable number. Oribatida contained 22 species.

3.3.2. Dynamics of mesofauna

According to the activity density peaks of the different soil microarthropod groups in the control plots in 2015, epedaphic Collembola populations were abundant from the mid of April to the end of September in no treated plots that coincided with the S and partly with M drought treatments. Whereas among other microarthropod groups, population increases occurred only partly during the time of these treatments. The timing of extreme drought treatment (X) in the previous year seems to overlap the active periods at all of the microarthropod groups.

3.3.3. Effects of drought and water addition treatments on activity densities and diversity

Due to extreme drought treatment (X), activity density of all Collembolan groups decreased in 2014. But due to the large standard deviations, significant decrease could be proved only in vegetation living Collembola. By contrast, activity density of all mite groups increased significantly in response to extreme drought.

In 2015 MANOVA has not found significant difference among the relative activity density values (RAD). Following that I continued the analysis with the activity density differences (ADD). Based on this method, negative ADD proportions showed significant increase (Z-tests) after treatments in case of epedaphic Collembola compared severe drought to control (CS-CC, $p<0.01$) in 2015. This result was confirmed by Fischer's exact test ($p<0.01$). Though, not significantly, proportions of negative values before treatment were lower than after treatment also in cases of moderate and severe drought treatments. Therefore, I conclude that the activity density relevantly decreased after the drought treatments in treated examples. Other mesofauna groups showed no significant differences in this approach.

MANOVA for SIR showed significant difference between treatments of the previous year (F1: X and C of 2014) with $p<0.01$; follow-up ANOVA models for months May, June, July and August revealed that SIR in previously X treated sites was significantly higher ($p<0.05$), however, for later months, no significant differences were found ($p>0.05$). No significant differences were detected between treatments C, W, M, S of year 2015 ($p>0.05$) independently whether an earlier stress effect were assumed in 2014 (X) or not (C).

In the first year at extreme drought treatment, Collembolan diversity decreased significantly whereas evenness and species richness did not change significantly. I did not find any significant difference in case of Oribatida ($p>0.05$). In case of the second year, two-way MANOVA did not reveal significant differences in Collembolan and Oribatida diversity, evenness and species richness among the previously X and C treated (F1) nor among C, W, M, S treated (F2) sites.

3.4. Results of automatic sensoring

In the plots treated with moderate drought (XM and CM), sensored number of specimens began to decline after the first two weeks of the drought treatment. After that the number of detections remained constantly low. Similar tendency was observed in the case of plots treated with severe drought (XS). This observed decline in activity may indicate the negative reaction of the arthropod populations.

3.5. New scientific results

1. Direct and indirect effects of extreme drought: I have shown, that in sand steppes of Kiskunság extreme drought (5 months) negatively affects the activity density and diversity of springtails. Activity density of all three vertical groups (vegetation living, surface living, soil dwelling) declined, however the decline was only significant in the case of vegetation living group. Conversely, activity density of all studied Acari groups (Astigmata, Mesostigmata, Oribatida and Prostigmata) significantly increased due to the drought treatment. In the next vegetation period these effects were no longer detectable, but significantly positive effect was observed in substrate induced respiration, which was used to estimate microbial biomass

2. Effects of the less pronounced drought treatments: I demonstrated, that in sand steppes of Kiskunság moderate drought (1 months) had no significant effect on the activity density of soil mesofauna. The naturally less frequently occurring, stronger (2 months) drought influenced negatively the activity density of surface living springtails. I did not find any effects on other groups.

3. Effects of irrigation: I stated, that in sand steppes of Kiskunság, large amount of extra precipitation (repeated 4 times, monthly; 98.5 mm in total) had no significant effect on activity density of soil mesofauna.

4. Synergistic effects: In case of sand steppes of Kiskunság, considering soil mesofauna, I did not find any enhancing effect of the extreme drought and the subsequent precipitation manipulations in the consecutive year (1 month moderate, 2 months severe drought and irrigation).

5. **Role of timing and duration of the treatments:** I observed that in case of sandy steppes of Kiskunság, duration combined with the timing of the manipulations is more important for soil mesofauna than their severity (i.e. the level of soil moisture decrease).

6. EDAPHOLOG: With EDAPHOLOG probes it is possible to conduct experiments with low disturbance, especially in places were disturbance should be minimalized, like in a long term climate change experiments. But the trap part of the probes has to be developed. The large amount of clay granules around the probes may affect the catching ability and also the estimation of population size may be distorted. For that reason at the development of new probes, amount of clay granules have to be minimalized or totally excluded and have to be find a new method to filter out soil particles falling in.

4. Discussion and conclusion

4.1. Comparison of trapping methods

4.1.1. Comparison of the three sampling methods

In terms of total abundance, pitfall traps appeared to be more efficient than EDAPHOLOG probes. Pitfall traps caught more typical surface-living species and macroarthropods of bigger size. However, euedaphic microarthropods, which are not typically sampled by pitfall traps, could be sampled by EDAPHOLOG. Apterygote groups, like Diplura, Pauropoda, Protura and Symphyla were caught by EDAPHOLOG with higher efficiency in alfalfa field compared to pitfall traps. As expected, the relative number of soil-living microarthropods was the highest in the soil extraction samples in case of both habitats. Considering catching rates, EDAPHOLOG traps have an intermediate state between pitfall traps used for trapping surface living species and soil extraction which is used to extract animals living in the soil.

4.1.2. The use of sand and clay granule bags as microhabitat among different environmental conditions.

In case of EDAPHOLOG probes, clay granules are used as medium matrix between soil and the trap to prevent soil particles falling in. In our investigation some mesofauna groups used the granules differently compared to sandy soil. However in case of surface living Collembola, which had the highest abundance in the area there was no significant effect found. These observations have to be considered in case of analysis of data derived from EDAPHOLOG probes. Especially it is true in case of those groups, where the probes caught different numbers in case of changing environmental conditions, like in case of vegetation living Collembola, Mesostigmata and macroinvertebrates. To minimize the refuge effects of clay granules by using EDAPHOLOG probes, size of clay granules bags around the probes have to be kept as low as possible.

4.1.3. Sensing of EDAPHOLOG in sandy soil

With automatic invertebrate detection there is a great potential to renew the method of data collection of population size and activity of invertebrates. In earlier field studies compared the sensoring data and the actual number of caught animals, EDAPHOLOG system proved to have a high accuracy, However, I did not find the same in the sandy soil of Kiskunság. Because of environmental conditions, I got many additional false detections. This failure can be resolved only with a type of sensor which is able to distinguish arthropods and other particles. For that problem one solution could be the digital photography. With that, on the one hand, animals could be identified with higher accuracy (at least at higher taxonomic level), on the other hand, animate and inanimate incidences could be distinguished. We want to implement it in a new project, which aims to improve the current probes. Furthermore, at the development of new probes the aims was not only the clear separation of the particles but also we aim to remove actively the captured specimens or soil particles from the sensoring field to a sample container with a vacuum tube. With this, hopefully, the accuracy of the instrument will be considerably improved.

However, in case of sandy soils of Kiskunság, the probes worked with low accuracy, the trap part of it provide a considerable alternative of traditional methods. With it, because of the low disturbance, even long term monitoring is possible by using the probes. Moreover, EDAPHOLOG provides samples which are not contaminated by soil particles.

4.2. Effects of repeated drought treatments

4.2.1. Immediate effects of extreme drought treatment

In our study, due to extreme drought treatment (X), activity density was reduced for all Collembolan groups. In most of the field experiments, precipitation reduction induced negative change in abundance or density of

Collembola (Makkonen et al. 2011, Petersen 2011, Lindo et al. 2012). Adding extra precipitation induced positive responses (Wu et al. 2014). However, all of these results, except Wu et al. (2014) derived from soils with good water retention ability. Whereas our study derives from sandy soil which has a low water holding capacity.

Interestingly, unlike Collembola, all Acari groups showed an increase in their AD in extreme drought plots. Adverse effects of mites and Collembola were reported in several cases (Tsiafouli et al., 2005), but in many other cases they responded in the same direction (Chikoski et al. 2006, Xu et al. 2012, Wu et al. 2014).

4.2.2. Legacy effects of extreme drought

Although extreme drought had significant effect on the soil arthropod communities in the first year, in the subsequent year, we did not find any significant effect in AD or diversity between previously treated and control sites. The effect of extreme drought on the measured parameters of microarthropods disappeared.

Surprisingly, in the second year, soil moisture was higher at extreme drought treated sites. It might have been derived from the mulching effect of dead plant material on the ground and from decreased evapotranspiration since a lot of perennial plants died. This moisture surplus and increased dead material could imply the higher microbial biomass (SIR) found in X treated sites in the second year. Detritus and increased microbial biomass as food resource could have a positive bottom up effect (Wu et al., 2014). Higher moisture and resource content of soil could lead to higher activity densities of Collembola. The mulching effect may compensate the loss of springtail AD of the previous year and may promote the regeneration of soil Collembolan communities.

4.2.3. Effects of mild precipitation changes

In the second year, we found differences only in the activity density of surface living Collembola. It was affected negatively by severe drought treatment. The other groups did not show any change in response to moderate and severe drought treatments neither in activity density nor in diversity. In our experiment, the different effects of extreme, moderate and severe drought can be attributed to the duration of the treatments rather than their severities, i.e. the changes in soil moisture contents themselves. In 2014 extreme drought treatment was running for five months and overlapped the seasonal dynamics and peaks of AD of all soil mesofauna groups investigated. Whereas moderate and severe drought events lasted for one and two months, respectively and overlapped with the peak of epedaphic Collembola and were out of the climate window of other species. This result suggests that the timing of drought also has an important effect. Independently of treatment duration, decrease of soil moisture in each drought treatments (X, M, S) similarly reached permanent wilting points in soil moisture content. Even after extra precipitation, water infiltrates or evaporates rapidly. In the water addition plots, 18.8% of the annual precipitation was added and in spite of this mean monthly soil moisture did not change during the year. Accordingly, precipitation quantity is not the only limiting factor in these ecosystems, the frequency and timing of precipitation events seem to also influence the assemblages of soil mesofauna.

Water addition did not affect the microbial biomass nor the mesofauna. It demonstrates that sporadic extra precipitation in semiarid sandy ecosystems cannot compensate the effects of drought and is not sufficient to increase microbial biomass or mesofaunal AD. However, precipitation experiments usually have larger effect in a long-term (Blankinship et al., 2011). Comparing to treatments, where positive effects were shown, our experiment may have been too short to detect changes.

With traditional statistical design and methods, we were unable to show any response of soil communities in the second year of manipulations. With our new approach (relative activity density and activity density difference) some of the hidden differences could be detected.

Repeated drought did not amplify the effects of previous extreme drought. In each of our drought treatment during the two years, time periods between repeated treatments may have been long enough for recovery of the populations.

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6. List of publications related to the thesis

IF articles:

Dombos, M., A. Kosztolányi, K. Szlávecz, C. Gedeon, **N. Flórián**, Z. Groó, P. Dudás and O. Bánszegi. 2017. EDAPHOLOG monitoring system: automatic, real- time detection of soil microarthropods. *Methods in Ecology and Evolution* 8:313-321.

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